2021

Shadow Banks and the Collateral Multiplier

Thomas R. Michl
Colgate University, Economics Department

Hyun Woong Park
Denison University, Department of Economics

Shadow Banks and the Collateral Multiplier

Thomas R. Michl* Hyun Woong Park†

Abstract

With an emphasis on contributing to macroeconomic pedagogy we examine the collateral multiplier by comparing it to the traditional money multiplier in a simplified framework of traditional banking and shadow banking in which government bonds are the core assets. While the money multiplier is a measure of the ability of the banking system to intermediate sovereign debt by creating deposits, the collateral multiplier is a measure of the shadow banking system's ability to intermediate sovereign debt by creating shadow money. It also measures the degree of re-use of sovereign debt as collateral. In this setup, the collateral multiplier is defined as the ratio between dealer banks' matched book repo activity relative to their trading book. Using the New York Fed's Primary Dealer Statistics data, we empirically estimate the collateral multiplier for U.S. Treasury repo collateral. Our model and empirical results shed light on the transmission mechanisms of monetary policy channeled through shadow banks and on the U.S. Treasuries market turmoil induced by COVID-19 in March 2020.

Keywords: shadow banks, collateral multiplier, rehypothecation, Treasury bond, repo.

JEL Classication: A2, E51

*Colgate University, Department of Economics; tmichl@colgate.edu

†Denison University, Department of Economics; parkhw@denison.edu

Instructors of macroeconomics have traditionally included some discussion of how banks create money through the money multiplier process although recent changes in the curriculum as well as in the monetary system itself (such as the ample reserve regime followed by the U.S. Fed) have made this choice less attractive. This note is intended to provide a framework for teaching how the modern banking system operates by using the money multiplier as a prologue to understanding that the now-prevailing shadow banking system generates new forms of money and presents monetary policymakers with new challenges. Hopefully, the framework will prove useful to practitioners and economists who take an interest in the financial side of macroeconomics as well.

Shadow banking can be defined as "money market funding of capital market lending" (Mehrling et al., 2013).[1] A substantial amount of money market funding for shadow banks takes place through the repo market where agents exchange cash for collateral, usually Treasury debt and typically overnight or for short term. Dealer banks, also called broker-dealers or investment banks, use the repo market to fund the assets in their trading book. In addition, they provide funding to leveraged asset managers through reverse repos. The collateral that dealers take in through reverse repos ("reverse in") can be re-pledged as collateral to borrow cash, or rehypothecated. Dealer banks use rehypothecated collateral to provide "money market funding for money market lending" to other shadow banking institutions through their matched book repo operations.

Just as traditional banking dominated by depository institutions can be usefully characterized by the money multiplier, the shadow banking system can be characterized by a collateral multiplier. Fed economists using confidential survey data have reconstructed the collateral record (i.e., the accounts showing sources and uses of collateral rather than the assets and liabilities on a traditional balance sheet) for the major dealer banks in the U.S., and calculated the collateral multiplier for recent years.[2] Their estimates help illuminate the sources of instability in the market for U.S. debt—the world's

[1] The capital market refers by convention to securities with maturities of one year or more and the money market to short-term loans or securities with maturities of less than one year.

[2] Infante and Saravay (2020a) report their most recent results and Infante et al. (2020) explain the methodology and theory of the collateral multiplier. For an explanation of the relation between the collateral record and traditional balance sheet accounting, see Kirk et al. (2014).

largest security market—during the COVID-19 crisis of March 2020. They document a decline in the multiplier that was subsequently reversed by the aggressive open market operations of the Fed. In this note, we provide an analytical framework for understanding the mechanisms through which balance sheet policies of the central bank operate in a world of shadow banks by exploring the similarities and differences between the money multiplier and the collateral multiplier. In addition, we also report our estimate of the collateral multiplier associated with primary dealers' repo and reverse repo activities, utilizing New York Fed's Primary Dealer Statistics. Because this data is publicly available, our methodology could be used by instructors for lectures or student projects.

1 Jimmy Stewart banking and the money multiplier

In order to see the relationship conceptually between the collateral multiplier and the money multiplier, it will be useful to begin with a model with no shadow banks, so that the monetary system is dominated by traditional depository institutions or Jimmy Stewart banks to use more colorful terminology.[3] In this note, we will adopt the convention that bank and depository institution are synonyms and later use the term dealer bank or just dealer to refer to investment banks that do not issue deposits.

There are three agents or sectors in the Jimmy Stewart model: a monetary authority or central bank (m), a bank (b), and a household sector (h). There are three assets: sovereign bonds (B), reserves (RE), and deposits (D). Superscripts identify the agent holding a bond or other instrument. The central bank monetizes some of the supply of sovereign bonds by offering reserve accounts to the bank, which in turn accepts deposits from households. Banks are typically fractional reserve banks that maintain a reserve ratio, RE/D, whose mathematical reciprocal is the money multiplier, μ, that is a staple of many undergraduate textbooks: $D = (D/RE)RE = \mu RE$. The whole

[3] Jimmy Stewart played George Bailey, the manager of a small bank in Bedford Falls in the famous Frank Capra movie, "It's A Wonderful Life." He is a fitting symbol for traditional banking. In a bold display of poetic license his little savings and loan experiences a bank run at a time in history when deposit insurance would have made that all but impossible.

Central Bank		Bank		Household	
B^m	RE	RE	D	D	J^h
		B^b		B^h	

Table 1: Traditional Jimmy Stewart banking. Bonds are represented by B, reserves by RE, deposits by D and net wealth by J^h.

system is best visualized by a set of interlocking balance sheets as in Table 1.

The household sector does no borrowing in this stripped-down set-up so its net worth, J^h, consists of its holdings of money and bonds. A natural extension of the model adds loans to the private sector to the liability side of the household balance sheet. The term household is just illustrative and the sector could include corporate businesses or non-bank financial institutions.

It is customary to ignore bank capital (aka equity) in accounting exercises involving the T-accounts of a banking system. Presumably the banks do generate a return on equity through the net interest margin between the return on their assets and the cost of funding through deposits. The idealized world portrayed here might represent the real world of U.S. banking immediately after World War II when commercial banks held sizeable amounts of war debt in the form of Treasury bonds. It is also customary to emphasize the role of new loans to the private sector in generating a money multiplier but we have abstracted from that choice in order to keep the focus on the parallel between the money multiplier under Jimmy Stewart banking and the collateral multiplier under shadow banking.

The reserve ratio can be set by central bank policy but that is not necessary or even realistic.[4] In many countries (including the U.S. after March 26, 2020), there is no official reserve ratio and banks find their own desired ratio based on liquidity management practices. While in old textbooks and in some banking systems (particularly in emerging market countries) reserve ratios are used for conducting monetary policy, this has not been common practice in the developed economies. We simply take the reserve ratio as

[4] In practice, before the global financial crisis of 2008-09 the reserve ratio facilitated control by the Fed over the overnight interbank market for fed funds. By maintaining a controlled scarcity of reserves that forced the banks to trade funds in order for the system to settle in the fed funds market, the Fed was able to manage the policy rate effectively by injecting or draining reserves through overnight repo operations. This note is focussed on balance sheet policies and leaves interest rate policy aside.

fixed and ask how the credit system accommodates changes in the central bank balance sheet. The money multiplier is a useful tool for framing the answer. Importantly, like all accounting tools its causal structure is open to alternative interpretations.

The money multiplier has drifted out of favor in macroeconomics (Carpenter and Demiralp, 2012), perhaps because of its association with old-fashioned monetarism, but that should not deter us from embracing it as a useful statistic.[5] Most modern macroeconomics treats the money supply as a residual and regards money as effectively endogenous in a world where central banks target interest rates (prices) and let quantities adjust. Yet Adrian and Shin (2010) argue that in a world of shadow banking, monetary aggregates (and, we will see, derivative statistics like the collateral multiplier) assume *increased* significance, not so much for monetarist or quantity-theoretic reasons but because they register prevailing credit conditions, and we will try to remain mindful of this perspective.

It is easy to show using the balance sheet identities that the money multiplier in a world of Jimmy Stewart banking expresses a ratio between monetized debt and the debt that is held by the banking system as a whole or specializing to our model:

$$\mu = \frac{B^m + B^b}{B^m}$$

An open market operation, ΔB^m, initiates a balance sheet adjustment by the banks that creates or extinguishes their deposit liabilities. This is the basis for the money multiplier. Textbook accounts usually assume that an open market purchase will generate excess reserves that give rise to loans to the private sector. Each new loan then creates a deposit elsewhere which redistributes some of the excess reserves and generates yet more loans and yet more deposits, thus creating a multiple deposit creation process. Yet the same logic works in our model where excess reserves purchase bonds, subject to the proviso that households own sufficient bonds to accommodate

[5]The quantity theory of money proferred by monetarists asserts that the monetary authority controls reserves and that reserves make loans and thus deposits; money is exogenous. In a world of endogenous money, loans make deposits and reserves either adjust or banks innovate to economize on existing reserves. This clash of visions is as old as economics, going back before the Currency and Banking Schools of the nineteenth century. Both visions agree on basic accounting principles so they offer alternative interpretations of the causal structure of the money multiplier.

a bank balance sheet expansion that generates an increase in deposits.[6] If, for example, the central bank buys a bond from a bank, the excess reserves that result will be used to purchase a bond from the private sector, resulting in a deposit and the migration of some excess reserves to another bank perhaps. These reserves will also be used to purchase a bond, thus resulting in a cascade of loans and deposits through a system of multiple banks. Yet the logic works just as well if there is just one single "Wicksellian" bank on whose books all transactions clear and settle.

The money multiplier can also be interpreted as a measure of the balance between "outside money" (deposits that fund bank reserves) and "inside money" (deposits that fund the bank's securities holdings) in the manner of Gurley and Shaw. This distinction is clearest when the banks lend to the private sector, generating money that is inside because it transforms the private liabilities of one agent into the assets of another. But sovereign bonds are at some level the responsibility of the private sector which must pay taxes to service them (we have abstracted from this), so they are in a sense being transformed into inside money. Reserves, on the other hand, are outside assets that are no one's liability.

In this model, it is clear the money multiplier measures the ability of the banking system to intermediate sovereign debt by issuing short term liabilities (deposits) against its long term assets. If more sovereign debt is held in the banks proper, open market operations have greater leverage over the portfolios of households as a result of this maturity transformation. For a given open market operation, ΔB^m, we have:

$$\Delta D = \mu \Delta B^m \qquad \Delta B^h = -\Delta D \qquad \Delta B^b = (\mu - 1)\Delta B^m \,.$$

Notice that monetary policy works by forcing the households to rebalance their portfolios (their net worth is held constant) which presumably will result in the kind of asset market effects captured by the LM curve.[7] The presence

[6] If households own no bonds, an open market purchase will only allow for an increase in deposits if the private sector is allowed to borrow from the banks, giving them an asset to support lengthening of their own balance sheets. This is the traditional textbook approach. Note that it requires a strong assumption that there is a robust demand for new loans.

[7] Many modern texts do not cover the LM curve these days since it assumes monetary authorities target the money supply rather than the interest rate. For readers unfamiliar with the LM curve, it represents asset market clearing, with $L = M$ representing money demand and supply. An increase in the supply of money and corresponding decrease in the

of a banking system in effect amplifies these portfolio shifts, relative to a baseline world with no maturity transformation performed by banks at all (in which case the multiplier is just unity). In the case of a stimulative open market purchase, this is because the banks are also buying bonds from households (the last term above), thus increasing the amount of sovereign debt that is monetized. In the case of a shortening of the central bank balance sheet, the same logic works in reverse of course.

If we included loans to the private sector in the model, we would see that monetary policy also works by freeing up or restricting the balance sheet space of banks. An open market purchase of bonds from banks (or households) frees up space for loans. This is a slightly different, possibly complementary way of thinking about the transmission mechanism of monetary policy, in this case through its direct quantity effects on the provision of credit rather than through asset prices. This mechanism is sometimes called the bank lending or credit channel in macroeconomics (Adrian and Shin, 2010). The last equation in the list above could be modified to reflect how the money multiplier expresses the capacity of banks to lend (assuming banks hold only reserves and loans): $\Delta(LOANS) = (\mu - 1)\Delta B^m$.

The money multiplier is best understood as an accounting metric that describes how a financial system generates liquidity given its main structural elements, such as the bank reserve ratio, capital, and leverage.

If the banking system is not intermediating sovereign debt, the money multiplier is unity. In this case, the bank is providing clearing and settlement services, full stop. For purposes of constructing a model of a shadow banking system, this is an appropriate abstraction that we take up in the next section.

2 Shadow banking and the collateral multiplier

The term shadow banking was apparently coined only a few years before the global financial crisis of 2008-09 brought this new species of credit system to our attention.[8] Traditional banks originate loans to the private sector

supply of bonds should lower the market-clearing interest rate, all else equal. An increase in the level of output, holding asset supplies constant, should result in a higher interest rate due to the increased transactions demand for money.

[8]Paul McCulley is usually credited with this neologism when he was an economist at PIMCO.

and hold them to maturity, and indeed Jimmy Stewart's character George Bailey explains that business model better than most textbooks. Shadow banks by contrast originate loans but then distribute (sell) them, typically to investment banks which securitize a pool of loans (or other revenue stream generators) and issue tranches of bonds to the capital markets. The credit system provides capital market lending but relies heavily on money market funding of the securities it creates.

Perhaps nothing better symbolizes the transition from the traditional bank-centered credit system to shadow banking than the Federal Reserve's decision to compile and publish prevailing rates in the three most visible segments of the repo market (tri-party, bilateral, and GCF). These repo rates, including the Secured Overnight Funding Rate (SOFR) that has been selected to become a reference rate in place of LIBOR, are closely watched as became apparent during the money market turbulence of September 2019. The fed funds market, once the center of attention, is now only one of several money markets competing for the attention of monetary policy makers.[9]

We can model a shadow banking system by treating the banks as warehouse banks or narrow banks that hold reserves and issue deposit liabilities. The banks perform the critical functions of clearing and settlement for the shadow banking complex. The money multiplier is thus unity. In life, of course, banks do hold sovereign debt securities, for example as a form of the high quality liquid assets (HQLA) required by Basel III's Liquidity Coverage Ratio (LCR), as well as other assets including loans.

The household sector holds deposits and shadow bank deposits, S. It now makes sense to think of the "household" sector as a cash portfolio manager (cash PM) like an institutional cash pool.[10] Shadow money takes the form of shares, S, in an intermediary like a money market mutual fund, mf, which invests cash in the repo market. This is the proximate source of money market funding for the shadow banking system shown as the last row in

[9]The model that follows abstracts from two features of the shadow banking system that are significant: its global nature, and its extensive use of derivative instruments like interest rate or exchange rate swaps. While the domestic system settles through the repo market that we will highlight, the global eurodollar market settles through FX swaps. Moreover, dealer banks make markets in derivative instruments by intermediating between both sides of swap trades for example.

[10]Pozsar (2011, 2014) describes how institutional cash pools have driven the rise of shadow banking through their need for safe cash equivalents. The terms cash PM and risk PM are also his.

Central bank	
B^m	RE

Bank	
RE	D

Household	
D	J
S	

Hedge fund	
B^{hf}	R^{hf}

Dealer bank	
B^d	R_T
RR^d	R_M

Money fund	
RR^{mf}	S

Table 2: Shadow banking. Money market mutual fund shares are represented by S, repo borrowing by R, and repo lending by RR, with T and M identifying the trading book or the matched book. The dealer bank funds the asset manager, $R^{hf} = RR^d$. The money market mutual funds the dealer bank, $R^d = R_T + R_M = RR^{mf}$.

Table 2.

We represent repo borrowing with the symbol R and reverse repo lending with the symbol RR. In repo borrowing, cash lenders receive securities as collateral so that in the event of default on the cash loan they can sell the collateral and recover their funds. In practice, repo borrowing is overcollateralized by an amount known as the haircut, which provides an extra margin of safety for cash lenders. Indeed, there is a structure to haircuts, and in some markets such as GCF Repo they are zero. We abstract from haircuts in our model at the cost of ignoring the inherently hierarchical nature of money.[11]

At the heart of the shadow system lie the dealer banks, d. They are market makers in the capital markets. As such, they hold an inventory of bonds in their trading book and finance them with repo borrowing, $B^d = R_T$. The dealer banks are also market makers in money markets, supplying reverse repo funding, RR^d, to the risk portfolio managers we will label hedge funds (hf) for concreteness. Dealers supply reverse repo loans to the risk PMs by sourcing repo funds from the cash PMs. They run a matched book in

[11] See Mehrling (2012) for insight into the hierarchical nature of money and credit. Some repo lending is motivated by a desire to obtain a specific security, for example to cover a short position, and in this case the interest rate (called a special repo rate) will lie below the rate for repo trades where any security in a broad class such as Treasury bonds is accepted (called general collateral or GC repo). We are assuming all trades take place in this GC repo market. At the other extreme are securities lending trades, where cash is the collateral and the haircut is often greater than one to protect the securities lender. Securities lenders in effect then "rehypothecate" much of the cash collateral into the triparty repo market.

repo, so we label dealer bank matched book borrowing $R_M = RR^d = R^{hf}$. Total dealer repo is $R^d = R_T + R_M$. Obviously, shadow banking institutions maintain accounts with the banks for clearing and settlement purposes but we can abstract from those in what follows because their balances net out in the transactions we cover. Repo lending and borrowing is short-term, typically overnight, so positions are being rolled on a continuous basis.[12]

This schematic representation maps faithfully into real-world U.S. financial institutions. Dealer banks typically lend substantially to risk PMs, and take in collateral that is eligible for rehypothecation. Much of this activity takes place in the bilateral sponsored repo space where trades clear through FICC on a "delivery versus payment" basis, but there is also a substantial bilateral repo market which clears on the books of the dealers.[13] Dealers use the collateral in to raise funds in the tri-party repo market, mostly from money market mutual funds.[14] In tri-party repo, a custodian bank (Bank of New York Mellon in the U.S.) settles trades, as well as provides various other back-office services such as valuation or margining, but unlike GFC and FICC DvP repo there is no CCP. Once the collateral originating in the bilateral repo market reaches the tri-party platform, the chain of rehypothecation ends.[15]

Moreover, the Fed's serial Quantitative Easing (QE) programs after the global financial crisis of 2008 did rely heavily on purchases of U.S. Treasuries from primary dealers and from the "household and nonprofit institution" sector in the Financial Accounts of the U.S., which includes domestic hedge funds and other leveraged asset managers, as Carpenter et al. (2015) report.

One important way in which this model departs from real-world structures is that it ignores intrasectoral trading among dealer banks. In practice,

[12] Stigum and Crescenzi (2007) provides a detailed account of the repo market, including the instrumentalities of matched book dealing.

[13] One advantage of the FICC DvP repo platform is that dealers can net offsetting trades since all trades are novated to FICC, making them nettable under GAAP rules. FICC acts as a central clearinghouse or counterparty (CCP). Tri-party agents do not act as central counterparties. Tri-party and sponsored repo are measured well but uncleared bilateral repo remains statistically unreported.

[14] Securities lenders are the other main source of funding in tri-party repo.

[15] There is also an interdealer market attached to the tri-party platform, the GCF Repo market, where non-primary dealers who don't have ready access to tri-party repo can borrow from primary dealers who do. This was the market where the stresses in the shadow system first surfaced in the repo spikes of December 2018 and famously September 2019.

collateral circulates within the dealer bank network through chains of rehypothecation. Thus, the matched book of the sector as a whole can exceed the repo lending to the asset managers, or $RR^d > R^{hf}$. We provide a formal model of intrasectoral matched book trading in section 4. Another omission, stemming from our narrow-bank simplification, is that in practice large money center commercial banks hold substantial reserves in excess of their deposits and they play an important role in the repo markets, particularly in the inter-dealer GCF repo segment. This became apparent during the September 2019 repo spike that was widely discussed in the financial press.

When the dealer banks take long positions in securities that are eligible for use as collateral, those securities are unencumbered. In our model, unencumbered collateral is hypothecated in repo borrowing to fund the trading book of the dealers. This repo borrowing uses unrehypothecated collateral. The dealers matched repo book, on the other hand, is entirely supported by collateral sourced through reverse repo trades with asset managers and then rehypothecated (making it encumbered).[16] The collateral multiplier proposed by Infante et al. (2020) is the ratio of the total repo liabilities of the dealer banks to their unrehypothecated repo or

$$c = \frac{R_T + R_M}{R_T}. \tag{1}$$

One way of conceptualizing this accounting ratio is that it effectively measures (one plus) the ratio of the dealer bank's matched book to its trading book.[17] An alternative interpretation might be extended to the categories of outside money (bonds held outright) and inside money (rehypothecated bonds) that we applied to the traditional banking system.

[16]Some repo agreements may encumber collateral by design.

[17]In reality, there are other sources and uses of collateral through securities financing transactions, including securities borrowing, collateral swaps, prime brokerage loans, variation and initial margin for derivatives, customer shorts, and firm shorts. As an aside, it is worth observing that the multiplier for non-Treasury collateral reported by Infante et al. (2020) is considerably lower than the multiplier for Treasury securities. This is another example of the hierarchical nature of money and credit that has been suppressed in the model.

3 The multipliers compared and contrasted

As Infante et al. (2020) point out, there is a parallel between the collateral multiplier and the money multiplier. The shadow banking system generates a money-like liability, dealer repo, using a base of securities held outright that are analogous to bank reserves (base money) in the traditional banking model. We can go a step further since the liquidity created through shadow banking shows up on the balance sheet of the cash PM as shadow money, S. And we can see by looking through the balance sheets that $S = cB^d$.[18]

From this it follows that open market operations have opposite effects on the two forms of money since

$$\Delta S = c\Delta R_T = \Delta R^d = -\Delta B^m = -\Delta D.$$

Infante and Saravay (2020b) present one interpretation of the collateral multiplier based on the length of the chain of rehypothecation, which we explore below in section 4. This is perhaps analogous to the textbook narrative in which the money multiplier emerges through a series of loan-deposit-loan transactions which distribute new reserves from bank to bank through the banking system. But there is nothing about either multiplier that demands this interpretation. It is indeed true that the same security can be and usually is used as collateral in multiple repo trades simultaneously, but the collateral multiplier is best seen as an accounting measure of the ability of the shadow system to intermediate sovereign debt securities by creating shadow money, just as the money multiplier measures the ability of a traditional banking system to intermediate debt by creating deposits.[19] It works just fine with Wicksellian shadow banks and short chains of rehypothecation.

But there is a critical difference in how central bank balance sheet operations work in the two idealizations. Consider a reduction in the central bank's

[18]In practice, the shadow banking system creates shadow money by monetizing a range of private assets, including various forms of asset-backed securities, so the shadow money system is *not* limited by the dealers' bond holdings, B^d. In the Jimmy Stewart world, the money supply is limited by the reserves injected by monetizing sovereign debt, $B^m = RE$, assuming a constant reserve ratio.

[19]The minimal representative collateral chain might involve a non-primary dealer reversing in a Treasury in the bilateral repo market, rehypothecating that to raise funds from a primary dealer, perhaps in the GCF Repo market, which then reuses/repledges it in the tri-party market, for a total of two links.

balance sheet, as in the reversal of QE called taper.[20] In a Jimmy Stewart world, this would drain reserves, reduce deposits, and effect a rebalancing of household balance sheets toward bonds. For every dollar of open market purchases, banks would need to sell off $\$(\mu - 1)$ of bonds to households. The policy works by shifting assets out of the banking system.

In a shadow banking world, reverse QE (selling bonds) works by shifting assets out of the warehouse bank into the shadow banking system, putting pressure on it to monetize the bonds that must be absorbed on the balance sheets of dealers and risk PMs.[21] The cash PMs experience taper as a forced rebalancing of their portfolios, away from deposits and toward shadow money.

Indeed, in this stylized shadow banking model, the money supply consists of the sum of deposits and shadow money, and it is unaffected by traditional open market operations.[22] The supply of money depends only on the (assumed fixed) supply of sovereign debt: $D + S = RE + R^d = B^m + B^d + B^{hf}$. In contrast to the traditional banking system, where the supply of money depends on a specific form of state liability, central bank reserves, in an idealized shadow banking world the supply of money depends on the *total* liabilities of the consolidated government.[23] This insight would of course need to be modified in practice to account for sovereign debt held outside the shadow banking complex.

Open market sales (taper) require the shadow bank complex to absorb more bonds, and issue more shadow bank money. The collateral multiplier measures how that absorption is distributed between the dealer banks and risk PMs. From this perspective, it is not surprising that the collateral multiplier has declined substantially over the period of large fiscal deficits

[20]Strictly speaking, taper refers to reducing new purchases of bonds and letting the existing stock of securities "run off" the balance sheet as they mature. The net result is a smaller balance sheet.

[21]See section 5.1 for a more detailed demonstration of the consequence of reserve QE in a shadow banking world.

[22]In the U.S., deposits and currency are captured by the M1 measure and retail money market funds are included in M2. Institutional money market funds are reported as a memorandum item and are not included in existing money measures; they had been included in the discontinued series M3. In December 2020, the Fed reports total checkable deposits to be about \$4.1 trillion and money market funds (including institutional funds) about \$3.9 trillion.

[23]In a sense, this model bears resemblance to the national bank era before the Federal Reserve was created. New York banks and money center banks used Treasuries as reserve assets, and country banks used deposits in money center banks for reserve purposes.

and tapering by the Fed, as the shadow system's capacity to absorb securities has been tested.[24] It is also illuminating that the turbulence in the Treasury market caused by the COVID-19 shock of March 2020 brought down the multiplier further, since the shadow system was asked to digest a bolus of U.S. sovereign debt being unloaded by central banks, corporations, and hedge funds among others seeking to liquidate their bond holdings. Only after the Fed reversed course and initiated open market purchases in size did the multiplier begin to recover. In effect, the Fed used its balance sheet to backstop the bond market by acting as dealer of last resort (Mehrling, 2010).

Two institutional features of the Basel III regulatory framework have been particularly significant recently. The extended Supplementary Leverage Ratio, which limits the overall ratio of assets to bank capital for large bank holding companies, has constrained banks and dealers alike in their ability to take on more assets of any kind. The LCR, mentioned earlier, has encumbered collateral and inhibited dealers' ability to expand their matched book operations. Our model abstracts from bank capital (equity) and leverage. It also abstracts from the unsecured money market where the HQLA for dealer banks (US Treasuries) must be funded. Large bank holding companies include depository banks and dealer banks among their subsidiaries, and subject to some restrictions can source liquidity internally. Taken together, these restrictions suggest that the collateral multiplier is an important indicator of the balance sheet capacity of the shadow sector that might forewarn policy makers of impending dangers.

From the point of view of macroeconomics, open market purchases are putting pressure on the asset managers to take on more securities, presumably putting the same kind of pressure on asset markets (to raise prices and lower yields) that traditional LM-curve reasoning emphasizes.[25] But it is also clear that open market purchases free up balance sheet in the shadow bank complex and augment its ability to support capital market lending to the private sector. An important point dramatized by the collateral multiplier is that in our brave new world the bank lending channel of monetary policy

[24]See section 6 where we report our measure of collateral multiplier. As can be seen, the overall trend is similar to the one reported inInfante and Saravay (2020b).

[25]QE and its unwinding are aimed at changing the slope of the yield curve, mainly by affecting the term premia on longer duration bonds. Short term interest rates in the modern developed-world financial system are managed through central bank standing facilities, such as interest on reserves or central bank repo and reverse repo facilities. We have abstracted from these in our model in order to focus on balance sheet policies.

runs through shadow banks.[26]

So far, to better focus on the shadow banks, we have treated Jimmy Stewart banks simply as warehouse banks or narrow banks by assuming the money multiplier to be unity. We can relax this assumption and easily merge the basic Jimmy Stewart banking model with the shadow banking model by returning bonds to the balance sheet of the bank. As in section 1, as long as the reserve ratio remains constant, deposits will be a constant multiple of reserves, $D = \mu RE = \mu B^m$ and bonds will be $B^b = (\mu - 1)B^m$. The total amount of money created by this generalization will be $D + S = \mu B^m + B^d + B^{hf}$.

As before, an open market operation by the central bank reallocates money between deposits and shadow money. The difference is that the money multiplier amplifies the effects. To see this, start from the balance sheet of the household or cash PM. With net worth constant, changes in deposits must be exactly offset by changes in shadow money, $\Delta D = -\Delta S$. An open market purchase increases reserves and induces the bank to expand its balance sheet, buying bonds and multiplying deposits in the process. Because it is sourcing bonds from the shadow bank complex, a given open market purchase results in a larger reduction in bond holdings of dealers and risk PMs (hedge funds) than would have occurred with narrow banks and a money multiplier equal to one. To be precise, the changes are

$$\Delta B^m + (\mu - 1)\Delta B^m = \mu \Delta B^m = -(\Delta B^d + \Delta B^{hf}).$$

The distribution of changes in bond holdings between dealers and hedge funds is, as before, determined by the collateral multiplier.[27]

4 Rehypothecation chains

Rehypothecation chains bear resemblance to the multiple endorsements that characterized bills of exchange in pre-modern finance.[28] However, the cred-

[26]Adrian and Shin (2010) emphasize that the bank lending channel in the context of shadow banks is more appropriately considered to be a risk-taking channel since dealer banks respond to monetary easing by increasing leverage in order to take on more risky assets.

[27]From the change in deposits, we can work out the details: $\Delta B^d = -(\mu/c)\Delta B^m$ and $\Delta B^{hf} = -(\mu(c-1)/c)\Delta B^m$.

[28]The bill of exchange more than any other financial instrument underwrote the Industrial Revolution, but like its cousin the banker's acceptance it dwindled in significance in

itworthiness of a bill increases with the list of endorsers, while lengthening a chain of rehypothecation raises the possibility of a cascade of settlement failures (also known technically as "settlement fails"). Hence, some of the interest in re-use of collateral stems from its possible role fostering financial fragility.

4.1 A model of interdealer repo

As mentioned, the basic model of shadow banking ignores repo trades among the dealer banks, which are important in practice. Here we provide some modeling of the multiplier in relation to the length of the collateral chains– i.e., the number of simultaneous repo trades supported by one security on average. Infante and Saravay (2020b) offer a formal model of interdealer repo that underwrites an interpretation of the collateral multiplier as a measure of the average chain of rehypothecation. Their exposition leaves out some mathematical details which we will provide using our own notation, dropping identifying superscripts and subscripts that are irrelevant.

Their model assumes no outside source of collateral such as the hedge funds in our basic model in section 2; all bonds are held by the system of dealers. One dealer bank borrows from outside the dealer network (from the money fund in our model), using as collateral its own bond holding, B_1, and collateral reversed in from a second dealer, which is also holding a bond, B_2, using it and collateral reversed in to borrow from yet a third dealer, and so on. Thus, the dealer system is structured like a series of Matryoshka dolls.

Assume all dealers in the system maintain the same collateral ratio, $c = R_i/B_i$ where $R = R_T + R_M$ is total repo borrowing. Then dealer one's repo position is $R_1 = cB_1$ and its reverse repo to dealer two is $R_1 - B_1 = (c-1)B_1 = R_2$ (recall that a reverse repo loan is booked as a repo liability for the counterparty). Dealer two can thus finance $B_2 = (1/c)R_2 = ((c-1)/c)B_1$. Continuing in this way through the dealer network, we can see that the total amount of bonds held by the system will be:

$$B = \sum_{i=1}^{k} B_i = B_1 \sum_{i=1}^{k} \left(\frac{c-1}{c}\right)^{i-1}.$$

In the limit as $k \to \infty$, this reduces to

---

the twentieth century.

$$B = cB_1.$$

Notice that dealer one's outright holdings of bonds are only hypothecated once for a unit chain length. Dealer two's outright holdings are reypothecated, for a chain length of two, and dealer three's for a chain length of three, etc. Infante and Saravay (2020b) propose a measure of the volume weighted average collateral chain we will call λ:

$$\lambda = \sum_{i=1}^{k} \frac{iB_i}{B}.$$

Again, in the limit as $k \to \infty$ we can substitute into this expression, use $B_1 = B/c$ to simplify[29], and see that:

$$\lambda = \frac{1}{c} \sum_{i=1}^{\infty} i \left(\frac{c-1}{c} \right)^{i-1} = c.$$

Thus, in the idealization considered here, the collateral multiplier accurately measures the average collateral chain as the number of Matryoshka dolls approaches infinity. However, the relation between bonds held outright and shadow money created outside the dealer network is altered since only dealer one borrows from an external source (the money fund) re-using all the securities held by the network: $S = R_1 = cB_1 = B$.

Note that all this is consistent with our understanding that the multiplier measures the ratio of matched book to trading book; in this model all the matched book trading is with other dealers within the network. If we aggregate (without consolidation) over all the dealers, the total matched book repo will be $R_M = R - B = (c-1)B$.

The consistency does not go in the other direction, however, because for a small discrete network (with k a small integer), the value of λ will typically be less than the collateral multiplier since the system will be unable to absorb the full complement of bonds through nested repo. The kth bank has no one to lend to, so it will fund its bondholdings with repo from the $k-1$th bank; it is effectively a hedge fund. For example, if $c = 5$ and $B_1 = 1$, the full complement of bonds is $B = 5$. With a discrete network, say $k = 3$, we find that $B_1 + B_2 = 1.8$ and $\lambda = 2.44$, even though by assumption

[29]To see that the convergent series below equals c^2, subtract out the known convergent series $\sum ((c-1)/c)^i = c$ from $\sum i((c-1)/c)^{i-1} = A$ to find $A = c^2$.

$c = 5$. However, with $k = 10$ we find $\sum_1^9 B_i = 4.33$ and $\lambda = 4.46$, which is getting us closer to 5. It would seem that this idealization is useful because it dramatizes the role that interdealer trading plays in lengthening the chain of rehypothecation and absorbing more bonds within the dealer network. In this sense, it is intuitive that the collateral multiplier does convey some information about chain length given sufficient circulation of collateral within the dealer network. We return to the small discrete network below.

This model also illustrates the parallel between repo and deposit money created by a traditional bank. Lending cash in a reverse repo is like depositing cash in a Jimmy Stewart bank; rehypothecating the collateral is like writing a check against a traditional deposit account. The repo/reverse trades within the dealer network are generating a form of shadow money. The outright position of the dealer complex generates "outside" shadow money that escapes the dealer network but the network itself generates "inside" shadow money that remains within it.

4.2 A general model

The Infante-Saravay model can be generalized to describe a system with a discrete number of rehypothecations, k. The basic model in section 2, for example, is a special case with $k = 2$. The model in the previous section describes an infinite series of rehypothecations. We can use the intermediate cases in order to illustrate another measure of rehypothecation chains offered by Singh (2011) and Singh (2017). Singh defines the "velocity" of collateral as the ratio of total collateral received by dealers to collateral provided by hedge funds and securities lenders (which are not considered here).[30] In terms of the basic model in section 2, this would by assumption be equal to unity, $V = R_M/R^{hf} = 1$, while in the Infante-Saravay model it would be undefined since there is no collateral received from hedge funds.

Adding a network of interdealer repo to our basic model drives a wedge between hedge fund borrowing and the size of the matched book since some repo activity gets trapped within the dealer network. The amount of matched book repo lending generated through intrasectoral trades is $RR^d - R^{hf}$ and

[30] He also calls this the "reuse rate" of collateral. His terminology seems meant to invoke a parallel with the velocity of money showing how many times a banknote turns over per year, but Singh's velocity does not have a time dimension so that parallel seems less than accurate. What he is trying to capture is how many trades a security supports as collateral at a point in time or the length of the collateral chain of rehypothecation.

in this extended model taking into account intrasectoral repo Singh's velocity measure becomes

$$V = \frac{R_M}{R^{hf}} = \frac{RR^d - R^{hf}}{R^{hf}} + 1.$$

In other words, V measures the proportion of matched book repo that is generated within the dealer network, which as we have seen does expand as the average length of the rehypothecation chain, λ, and the number of rehypothecations, k, rise. Singh (2017) reports that his velocity measure declines sharply after the GFC, falling from 3.0 in 2007 to 1.8 in 2015. It is important to be aware that as well as repo trades his data includes the whole spectrum of securities financing transactions that bring collateral into dealer banks, including securities lending, collateral swaps, customer shorts, prime brokerage, and firm shorts. Still, this suggests that a fairly large amount of rehypothecation takes place within the dealer network.

Curiously, increasing the length of the rehypothecation chain keeping c constant does not affect the amount of shadow money held outside the dealer network. This is because increasing k merely shifts bonds out of the kth bank (which is effectively a hedge fund) onto the books of the dealers, without affecting the amount of repo business with the money fund. Details are provided in the appendix. It follows that the relationship between dealer bond holdings and shadow money changes, going from $S = cB^d$ when $k = 2$ (our basic model) to $S = B^d$ as $k \to \infty$. In this latter case, *all* the matched book of the dealers is taken up by intrasectoral trades.

Interpreted through this extended model then, the collateral multiplier expresses two different aspects of the shadow banking system. First, it reflects its role in generating money market funding for capital market positions held by risk PMs and other asset managers. Increased activity in this space (greater R^{hf} relative to the size of the dealers' trading book) will raise the multiplier, signalling an enhanced capacity to absorb sovereign debt just as in the basic model. Second, it reflects the extent to which intrasectoral trades generate a form of shadow money (repo) that remains within the dealer network through lengthened chains of rehypothecation (greater V or k). From this perspective, Singh's V unambiguously expresses variations in the extent of collateral re-use if that is the object of interest.

Central bank	
B^m	RE

Bank	
RE	D

Household	
D	J^{hh}
S	

Hedge fund	
B^{hf}	R^{hf}
	J^{hf}

Dealer bank	
B^d	R_T
RR^d	R_M
	J^d

Money fund	
RR^{mf}	S

Table 3: Shadow banking extended to incorporate net worth, or equity, of the hedge fund and dealer bank. The hedge fund's equity and dealer bank's equity are represented by J^{hf} and J^d, respectively.

5 Extensions and applications

In order to understand more concrete environments in which the collateral multiplier evolves in close relation to the central bank's asset purchase programs and the shadow banks' leveraging and deleveraging processes, let us introduce equity for the risk PM and the dealer sector explicitly, denoting former's equity by J^{hf} and the latter's equity by J^d. The sectoral balance sheet is shown in figure 3. The risk PM's bond holding is now financed by equity and repo borrowing. Suppose the risk PM's repo requires a haircut h^{hf}. Then for a given equity, the bond holdings of the risk PM are

$$B^{hf} = \frac{J^{hf}}{h^{hf}} \tag{2}$$

and its leverage ratio is[31]

$$\lambda^{hf} = \frac{B^{hf}}{J^{hf}} \tag{3}$$

The dealer sector's positions in repo lending RR^d and bonds B^d are funded by matched book repo and trading book repo, respectively, along with equity J^d. Suppose that the matched book repo borrowing has the same haircut imposed on the risk PM's repo borrowing so that $RR^d = R_M$ with B^{hf} rehypothecated. On the other hand, the dealer's bond holdings are financed by trading book repo and equity. If the haircut on the dealer's

[31] Note that a haircut sets a constraint on a leverage ratio. That is, the inverse of the haircut is the maximum leverage ratio a borrower can have. In this regard, the expression in equation (3) is the maximum leverage ratio for the risk PM.

repo is h^d, then with its equity, the bond holdings of the dealer are $B^d = \frac{J^d}{h^d}$. Note that one portion of B^d financed by R_T is encumbered, while the other financed by J^d is unencumbered. The dealer sector's leverage ratio is[32]

$$\lambda^d = \frac{B^d + RR^d}{J^d}. \tag{4}$$

The collateral multiplier is measured as

$$c = \frac{R_M + R_T}{B^d}. \tag{5}$$

To see how the dealer sector's balance sheet capacity and the collateral multiplier change, below we examine a reverse quantitative easing and deleveraging by the risk PM.

5.1 A reverse quantitative easing

In reverse QE, the central bank conducts an open market sale, $\Delta B^m < 0$. It is absorbed by the dealer balance sheet funded by new trading book repo of $\Delta R_T = \Delta B^d = -\Delta B^m$. The dealer balance sheet is expanded and so is the cash PM's by the same amount, $\Delta RR^{mf} = \Delta S = -\Delta B^m$.

Given the household's equity (net worth), its portfolio rebalances from deposits to shadow money by $-\Delta D = \Delta S$. Since the open market sale via the dealer is cleared by the warehouse bank, the latter's balance sheet shrinks by $\Delta RE = \Delta D = \Delta B^m$, which matches the size of the household sector portfolio rebalancing.

The dealer sector's leverage ratio is now higher at

$$\lambda^d = \frac{B^d + RR^d + \Delta R_T}{J^d}$$

since $\Delta R_T = -\Delta B^m > 0$.

This weakens the dealer balance sheet capacity and the collateral multiplier is now

$$c = \frac{R_M + R_T + \Delta R_T}{B^d + \Delta B^d} \tag{6}$$

[32]By substituting $B^d = \frac{J^d}{h^d}$ into equation (4) we can see that the leverage ratio is inversely related to the haircut.

which is lower than before since $\Delta R_T = \Delta B^d = -\Delta B^m > 0$. Furthermore, the dealer' new, higher leverage ratio may not be sustainable from the regulatory perspective unless the leverage constraint such as the Supplementary Leverage Ratio in the Basel III is relaxed, which is what the Fed did[33]

5.2 Deleveraging

One of the first things observed in the financial markets in the first week of March 2020 was a Treasury sell-off, which is quite unusual since Treasury bonds, considered as the safest asset, typically are the most demanded in times of stress.[34] Among many reasons for the Treasury market disruption, one is the flight to quality, i.e. cash, with even Treasury bonds considered as not liquid enough. Our model is limited in describing this phenomenon since the bond is the safest and the most liquid asset in the model. Therefore, if the bond sell-off takes place in the model, it would have to do with deleveraging rather than the flight to quality.

Suppose the haircut on the risk PM's repo borrowing increases, in which case the risk PM is forced to deleverage; see equation (2). The risk PM liquidates bonds, i.e. $\Delta B^{hf} < 0$, the size of which is determined by the new haircut. The risk PM does this by ceasing to roll over its repo borrowing by the same volume, i.e. $\Delta R^{hf} = \Delta B^{hf}$, thereby repurchasing the corresponding volume of the collateral pledged in the repo transaction which is then liquidated. The risk PM's new leverage ratio is now

$$\lambda^{hf} = \frac{B^{hf} + \Delta B^{hf}}{J^{hf}} \tag{7}$$

which is lower than its initial level in equation (3) since $\Delta B^{hf} < 0$.

The reduction in the risk PM's repo borrowing is reflected in a decline in the dealer sector's reverse repo and hence the matched book repo by $\Delta RR^d = \Delta R_M = \Delta B^{hf}$. The risk PM liquidates the repurchased collateral to the dealer, which finances the extra position in the bond by expanding its trading book repo by $\Delta R_T = \Delta B^d = -\Delta B^{hf}$. As can be seen, the decrease in matched book repo and the increase in trading book repo are the same size of $\left|\Delta B^{hf}\right|$ and hence exactly offset each other. Therefore, the dealer sector's leverage ratio remains the same.

[33]In March 2020, the Fed exempted Treasuries from computing the Supplementary Leverage Ratio, thereby relaxing the leverage constraint.

[34]Reference: Duffie 2020, "Still the world's safe heaven?"

On the asset side, this is reflected in a portfolio rebalancing from reverse repo to bonds, which undermines the balance sheet capacity of the dealer sector. This can be seen from the fact that the collateral multiplier is now lower at

$$c = \frac{R_T + R_M}{B^d + \Delta B^d} \tag{8}$$

since $\Delta B^d = -\Delta B^{hf} > 0$.

6 Data

Infante and Saravay (2020a)'s estimation of the collateral multiplier uses firm-level data of the FR 2052a Complex Institution Liquidity Monitoring Report, which presents comprehensive view of liquidity profiles of individual financial institutions supervised by the Federal Reserve. However, FR 2052a is considered confidential and hence not publicly available. Therefore, in this section we present our estimate of the collateral multiplier relying on the Primary Dealer Statistics data published by the Federal Reserve Bank of New York.[35] Included in the data set is weekly data of primary dealers' incoming and outgoing collateral, and within each group of collateral a distinction is made between collateral from repo activities and that from other financial activities such as security lending, margin borrowing, etc. However, as there are some missing values for the collateral from the other financial activities due to disclosure rules, we have estimated the collateral re-use of U.S. Treasuries in repo activities only. The period of analysis runs from January 2015 to May 2021.

To help explain our approach to using the New York Fed's Primary Dealer Statistics in constructing the time series of the collateral multiplier, figure 1 schematically organizes the components of the data set. There is incoming collateral of Treasuries through reverse repo positions and there is outgoing Treasuries collateral through repo borrowing. The repo borrowings are mostly overnight while the reverse repos are mostly term, including the maturities less than 30 days and those more than 30 days, implying that even for shadow banking an interest rate spread is an important source of bank profit.

[35] The link is the following. https://www.newyorkfed.org/markets/counterparties/primary-dealers-statistics

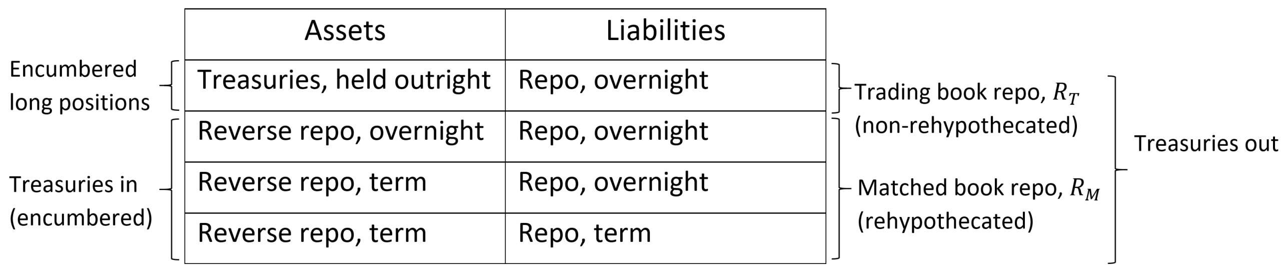

Figure 1: Sorting out trading book and matched book repo from the Primary Dealer Statistics. This figure visualizes how we organized the incoming and outgoing repo data from the New York Fed's Primary Dealer Statistics to identify trading book repo and matched book repo. The difference between outgoing repo and incoming repo corresponds to Treasuries held outright and hence trading book repo, while the repo that finances incoming collateral corresponds to matched book repo.

Treasuries held outright by the primary dealers and financed by repo borrowing, which is trading book repo, are not readily available from the data.[36] We estimated the trading book repo by subtracting the total incoming Treasury collateral of all maturities from the total outgoing Treasury collateral of all maturities. The rest of the total outgoing Treasury bonds is the matched book repo. From this, the collateral multiplier can be measured according to equation (1).

First, figure 2 plots the total flows of U.S. Treasury collateral for the dealers associated with repo activity. It shows that primary dealers re-use most of Treasuries through repos, which is in line with the result in Infante et al. (2018), where the importance of repo for U.S. Treasury intermediation is highlighted.

Next, figure 3 displays the total volume of outgoing Treasury through repos and the total volume of non-rehypothecated Treasuries, i.e. U.S. Treasuries the primary dealers owned but financed through repos. According to the definition presented in equation (1), the collateral multiplier is estimated by the ratio of these two, i.e. the ratio of the outgoing collateral to non-rehypothecated outgoing collateral.

[36]Other limitations of the NY Fed's data set are that collateral related to derivatives activity is excluded and that financing activities of U.K. broker-dealer subsidiaries of U.S. bank holding companies are excluded. Nonetheless, these data provide a useful source to roughly generate a general trend of collateral multiplier of the primary dealer network.

The result is reported in figure 4 which shows that primary dealers have been able to create up to five times as many repo liabilities backed by U.S. Treasuries as they owned for the last six years. Note that there was a downward trend in the collateral multiplier starting from late 2015 through June 2019. This period corresponds to the Federal Reserve ending the seven years of zero rate policy and gradually lifting the target range until reversing course back in July 2019 through March 2020. See figure 5. In line with our analysis in section 5.1, during this period of reverse QE, the collateral multiplier declined over time, and then in July 2019 as the Fed started to lower the target again the collateral multiplier also started to rise.

A more recent episode of turmoil in Treasury markets in March 2020 is also worth noting. To closely observe how the collateral multiplier reacted to the start of the COVID-19 pandemic, figure 6 separately charts it from the last week of February 2020 to the first week of April 2020. Reflecting the Treasury sell-off in the first weeks of March 2020, the figure exhibits a drop in the collateral multiplier during this period. It corresponds to our analysis in section 5.2 of hedge fund deleveraging through Treasury sell-offs leading to a decline in collateral multiplier. Since the dealers absorb Treasuries dumped in the market through repos, the trading book repo rises, undermining the dealers' balance sheet capacity, and hence the collateral multiplier falls. In response, the Fed took swift action, among others, to purchase Treasuries and agency mortgage-backed securities on a massive scale. According to our analysis in section 5.1, the Fed's asset purchase program will lead to an increase in the collateral multiplier. The drastic bouncing back of the collateral multiplier in the last two weeks of March 2020 reflects this account.

7 Summary

In this paper, we intentionally work with two idealized credit systems in which government bonds are the core assets in order to facilitate comparison between the traditional money multiplier and the collateral multiplier in a shadow banking world. Real economies combine aspects of both idealizations so presumably the insights have some practical value.

The money multiplier is a useful accounting measure of the structure of a traditional banking model. We interpret it as a measure of the ability of the banking system to intermediate sovereign debt by creating deposits; to be precise, it measures the ratio of total sovereign debt held by the banking

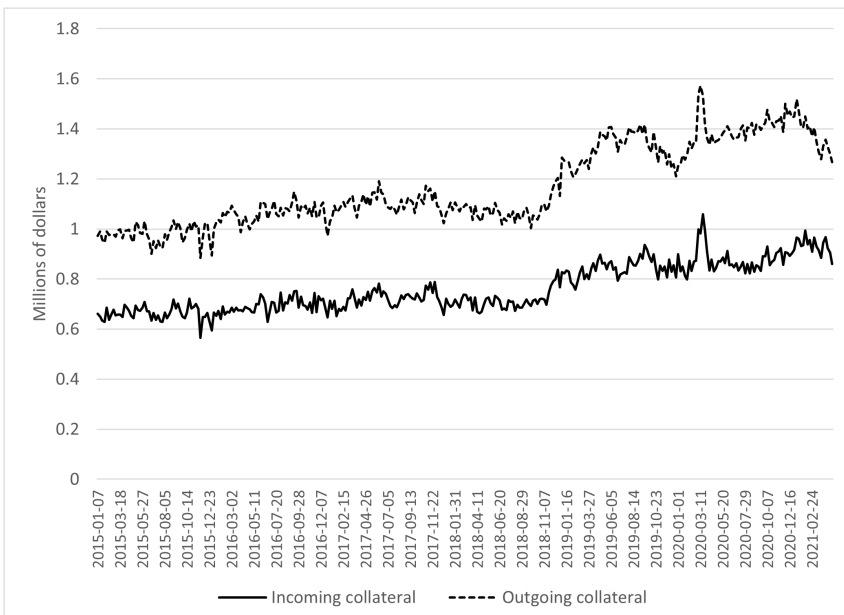

Figure 2: U.S. Treasury Incoming and Outgoing Collateral Volumes. This figure shows the total volume of incoming and outgoing U.S. Treasury collateral for the primary dealers. (Source: New York Federal Reserve Bank, Primary Dealer Statistics)

Figure 3: U.S. Treasury Outgoing Repo. This figure shows, in addition to the total volume of U.S. Treasury repo outgoing, the volume that was sourced from the dealers' outright holdings, i.e. non-rehypothecated. The collateral multiplier reported in figure 4 is computed as the ratio between the dotted line and the solid line. (Source: New York Federal Reserve Bank, Primary Dealer Statistics)

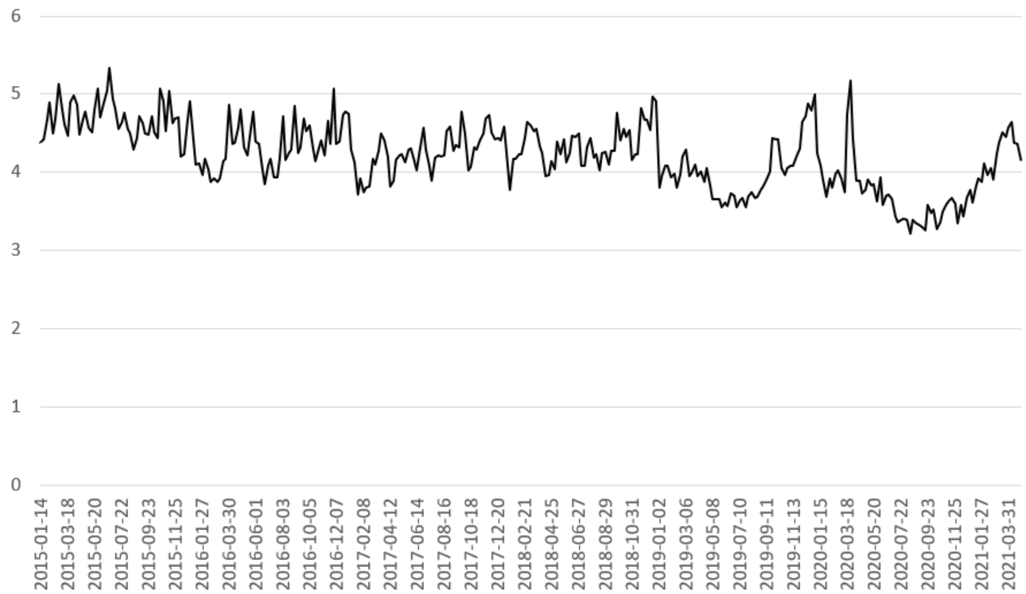

Figure 4: Collateral multiplier for repo Treasury collateral. This figure shows our estimate of the collateral multiplier for U.S. Treasury repo collateral computed as the ratio between outgoing repo collateral to non-rehypothecated outgoing repo collateral. (Source: New York Federal Reserve Bank, Primary Dealer Statistics)

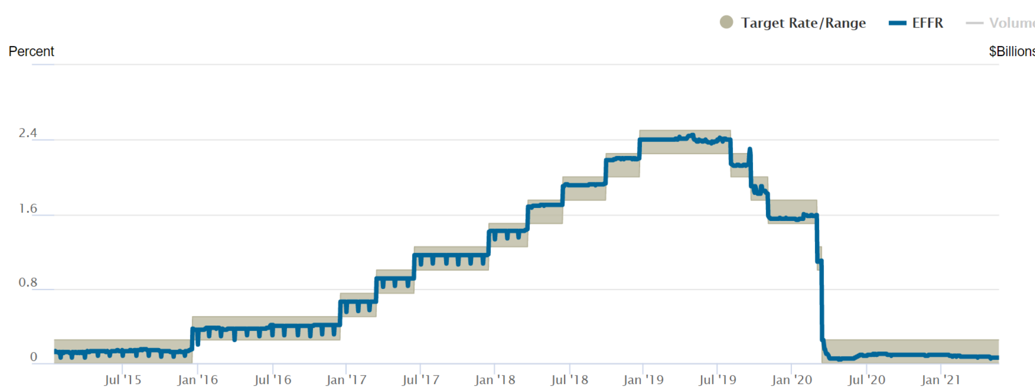

Figure 5: Federal funds rate. This figure shows the target range of federal funds rate and the effective federal funds rate. (Source: The website of the Federal Reserve Bank of New York)

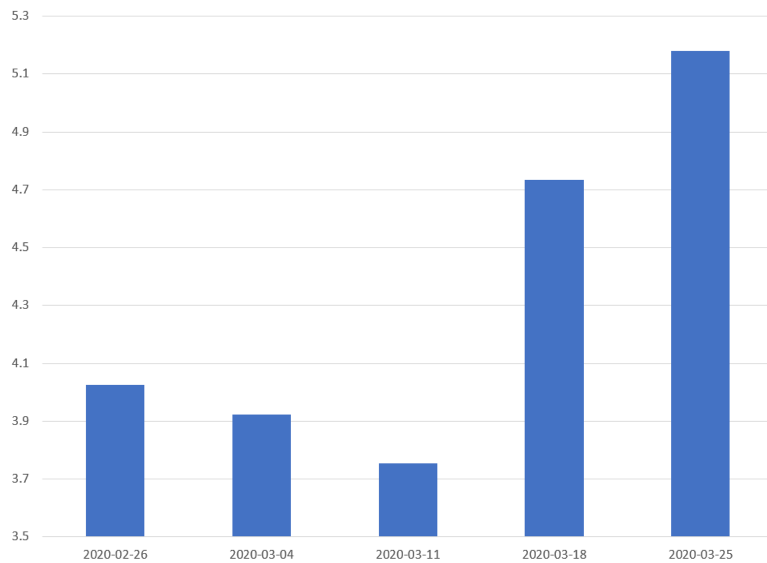

Figure 6: Collateral multiplier for repo Treasury collateral in March 2020. This figure shows the collateral multiplier in March 2020 when the COVID-19 pandemic started. (Source: New York Federal Reserve Bank, Primary Dealer Statistics)

system, including the central bank, and debt held by the central bank (i.e., monetized). The money multiplier has become somewhat obsolete as the financial system has evolved.

In a modern shadow banking system defined by money market funding of capital market positions, the collateral multiplier is a useful accounting measure. It measures the ability of the shadow banking system to create shadow money, but in this idealized model open market operations shift assets into or out of the shadow complex, rearranging the form in which money appears (shadow money versus deposits) rather than changing the total amount. The model elaborated here helps make sense out of the transmission mechanisms of monetary policy channeled through shadow banks, as well as shedding light on prominent events such as the turbulence in the U.S. Treasuries market induced by COVID-19 in March 2020. The collateral multiplier can be understood generally as a measure of the size of dealer banks' matched book repo activity relative to their trading book.

We also propose a novel and accessible way of estimating the collateral multiplier, using the Primary Dealer Statistics of New York Fed. The empirical results reported largely support the narrative account of the idealized models.

Appendix

The two multiplier processes can be formalized in order to get an understanding of the economic processes at work. The mathematics may help instructors explain the principles involved.

7.1 Money multiplier

We can formalize the money multiplier in a system with multiple banks to illustrate the deposit creation process. The desired reserve ratio is $RE/D = 1/\mu$ so a bank's excess reserves will be $RE - (1/\mu)D$. Now let the central bank buy bonds from the household sector in an open market operation so the immediate effect is a payment from the central bank to the household that is deposited in a bank: $\Delta B^m = -\Delta B^h = \Delta D$. The deposit results in that bank receiving more reserves or $\Delta RE = \Delta D = \Delta B^m$. Now the bank has new excess reserves equal to $\Delta B^m(1 - 1/\mu)$ which it will want to use to buy a corresponding amount of bonds from the household sector. But this results in a deposit, perhaps in a second bank, of a corresponding amount. The second bank also receives new reserves when the transaction settles and now has excess reserves equal to $\Delta B^m(1 - 1/\mu)^2$. This second bank will use the excess reserves to buy a corresponding amount of bonds from households, resulting in yet another deposit and transfer of reserves to a third bank.

We can formalize this process by writing down the sequence of increases in deposits, starting with the initial open market purchase:

$$\Delta D = \Delta B^m + \Delta B^m(\frac{\mu - 1}{\mu}) + \Delta B^m(\frac{\mu - 1}{\mu})^2 + \dots .$$

This expression simplifies to

$$\Delta D = \mu \Delta B^m$$

which is the basic money multiplier equation. The math and economic intuition works for an open market sale just as well, in which case $\Delta B^m < 0$. In this case, the operation creates a reserve deficit that is resolved by selling bonds to the household sector. Starting with a central bank purchase (or sale) of bonds directly from a bank leads to the same result.

With multiple banks, each step in the process involves the redistribution of new reserves among the banks as each bond purchase results in a deposit and reserve transfer in another bank. If there were a single Wicksellian bank, it would be able to anticipate exactly how many bonds to buy from the households in order to restore its desired reserve ratio and achieve portfolio balance in one fell swoop since $\Delta B^b = (\mu - 1)\Delta RE$. In this case, the reserves injected by the open market operation stay on the books of the Wicksellian bank.

7.2 Collateral multiplier

In the case of the collateral multiplier, we can assume the central bank buys a bond (ΔB^m) from the dealer to simplify; considering the case of a purchase from the hedge fund or both leads to the same result. The dealer banks are assumed to keep the ratio of their trading book to their matched book constant as this is the accounting assumption underlying the collateral multiplier. The dealer who sells the bond to the central bank will thus buy a bond from the hedge fund to restore this ratio, $\Delta B^{hf} = -\Delta B^m$. It's net change in bondholdings is zero. But this will cause the the hedge fund to reduce its repo financing from perhaps another dealer by a corresponding amount. Then that dealer will make a correction to its balance sheet by selling some bonds back to another hedge fund. This dealer aims to keep matched book repo proportional to its bond holdings, $R_M = (c-1)B^d$. Thus, its sales in this step will be $-\Delta B^m/(c-1)$. Again this will not succeed in achieving portfolio balance since the hedge fund buying these securities now steps up its repo funding, leading to a subsequent purchase of bonds by another dealer equal to $\Delta B^m/(c-1)^2$. This process of alternating sales and purchases of bonds by the dealers and hedge funds will eventually resolve itself as the transactions become smaller and smaller.

The collateral multiplier process can be expressed as two convergent alternating series, one for the dealer bank and another for the hedge fund:

$$\Delta B^d = 0 - \Delta B^m(\frac{1}{c-1}) + \Delta B^m(\frac{1}{c-1})^2 \ldots.$$
$$\Delta B^{hf} = -\Delta B^m + \Delta B^m(\frac{1}{c-1}) - \Delta B^m(\frac{1}{c-1})^2 \ldots.$$

These expressions simplify to

$$\Delta B^d = \frac{-1}{c}\Delta B^m$$
$$\Delta B^{hf} = \frac{1-c}{c}\Delta B^m.$$

To check for consistency, notice that $\Delta B^d + \Delta B^{hf} = -\Delta B^m$. Also notice that $\Delta S = c\Delta B^d = -\Delta B^m = -\Delta D$. This illustrates that the money market mutual fund is redeeming shares for the household sector ("cash PM") and forcing it to use deposits at the narrow banking sector. A more sophisticated model might explore how changes in the price of deposits and mutual fund shares would facilitate this portfolio adjustment. Finally, if we considered a Wicksellian dealer bank (one monopoly dealer) we could get to the end of the collateral process in one motion.

7.3 Details of the Infante-Saravay model

As mentioned in the text, the Infante-Saravay model can be solved for a discrete number, k, of dealer banks. It is convenient to let dealer one's trading book equal unity, $B_1 = 1$, to reduce clutter. Since the kth bank has no one to lend to, its matched book repo is by definition zero, and it uses the repo borrowing from the $k-1$th bank to fund its bond holdings; it is essentially a hedge fund. Thus, another convenience is to define $j = k - 1$.

With these conventions, we can pin down the balance sheets of the dealer banks from 1 through j and the hedge fund, k. The ith dealer bank's bond position and trading book is

$$R_T = \left(\frac{c-1}{c}\right)^{i-1}$$

and its matched book is.

$$R_M = \left(\frac{(c-1)^i}{c^{i-1}}\right).$$

The kth bank thus holds bonds funded by its repo borrowing so we can call it a hedge fund. (Note that B_k is analogous to hedge fund bondholdings, B^{hf}.)

$$B_k = \left(\frac{(c-1)^j}{c^{j-1}}\right).$$

The total bonds in this system remain a constant multiple of dealer one's position: $B = cB_1$. The basic model in section 2 sets $k = 2$, so there is just one dealer and one hedge fund. As the number of layers, k, increases, bonds are shifted out of the hedge fund and onto the dealers' balance sheet but the total stays constant. We can see this by evaluating (recall that $B_1 = 1$)

$$B^d + B_k = \sum_1^k \left(\frac{c-1}{c}\right)^{i-1} + \left(\frac{(c-1)^j}{c^{j-1}}\right) = c.$$

This generalizes to $B^d + B_k = cB_1$. Note that as $k \to \infty$, the hedge fund vanishes and all the bonds have moved to the balance sheet of the dealer banks, funded by money fund repo, as all the interdealer repo remains within the dealer system. Thus we can see that as k increases the total amount of shadow money created outside the dealer network remains constant, $S = B^d + B_k = cB_1$.

References

Adrian T. and Shin H.S., 2010. Financial intermediaries and monetary economics, in Friedman B.M. and Woodford M., eds., *Handbook of Monetary Economics*, volume 3, pp. 601–650, Amsterdam: North Holland

Carpenter S. and Demiralp S., 2012. Money, reserves, and the transmission of monetary policy: Does the money multiplier exist?, *Journal of Macroeconomics*, volume 34, no. 1, pp. 59–75

Carpenter S., Demiralp S., Ihrig J., and Klee E., 2015. Analyzing Federal Reserve asset purchases: From whom does the Fed buy?, *Journal of Banking and Finance*, volume 52, no. 15, pp. 230–244

Infante S., Press C., and Saravay Z., 2020. Understanding collateral re-use in the U.S. financial system, *American Economic Review*, volume 110, no. 3, pp. 482–86

Infante S., Press C., and Strauss J., 2018. *The Ins and Outs of Collateral Re-use*, Board of Governors of the Federal Reserve System, Washington, fEDS Notes

Infante S. and Saravay Z., 2020a. *Treasury Market Functioning During the COVID-19 Outbreak: Evidence from Collateral Re-use*, Board of Governors of the Federal Reserve System, Washington, fEDS Notes

Infante S. and Saravay Z., 2020b. *What Drives U.S. Treasury Re-use?*, Board of Governors of the Federal Reserve System, Washington, finance and Economics Discussion Series 2020-103

Kirk A., McAndrews J., Sastry P., and Weed P., 2014. Matching collateral supply and financing demands in dealer banks, *Federal Reserve Bank of New York Economic Policy Review*, volume 20, no. 2, pp. 1–25

Mehrling P., 2010. *The New Lombard Street: How the Fed Became the Dealer of Last Resort*, Princeton: Princeton University Press

Mehrling P., 2012. The inherent hierarchy of money, in Taylor L., Rezai A., and Michl T., eds., *Social Fairness and Economics: Economic Essays in the Spirit of Duncan Foley*, Abingdon: Routledge

Mehrling P., Pozsar Z., Sweeney J., and Neilson D.H., 2013. *Bagehot Was A Shadow Banker: Shadow Banking, Central Banking, and the Future of Global Finance*, Institute for New Economic Thinking, New York

Pozsar Z., 2011. *Institutional Cash Pools and the Triffin Dilemma of the U.S. Banking System*, International Monetary Fund, Washington, D.C., iMF Working Paper 11-190

Pozsar Z., 2014. *Shadow Banking: The Money View*, Office of Financial Research, Washington, D.C., oFR Working Paper 14-04

Singh M., 2011. *Velocity of Pledged Collateral: Analysis and Implications*, International Monetary Fund, Washington, D.C., iMF Working Paper 11-256

Singh M., 2017. *Collateral Reuse and Balance Sheet Space*, International Monetary Fund, Washington, D.C., iMF Working Paper 17-113

Stigum M. and Crescenzi A., 2007. *Stigum's Money Market, Fourth Edition*, New York: McGraw-Hill