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Non-bank Financial Intermediaries and Financial Stability*

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Abstract

The heft of non-bank financial intermediaries (NBFIs) has grown significantly after the Great Financial Crisis. This paper reviews structural shifts in intermediation and how NBFIs have shaped the demand and supply of liquidity in financial markets. We then lay out a framework for the key channels of systemic-risk propagation in the presence of NBFIs, emphasising the central role of leverage fluctuations through changes in margins. An investor's debt capacity is increasing in that of other investors in the system, so that leverage enables greater leverage, and spikes in margins can lead to system-wide deleveraging. In our framework, deleveraging and 'dash for cash' scenarios (as during the Covid-19 crisis) emerge as two sides of the same coin, rather than being two distinct stress propagation channels. These findings have implications for the design of NBFI regulations and of central bank backstops.

JEL Classification: G22, G23, G28.
Keywords: Financial Intermediation, Non-banks, Market-based Finance, Market Liquidity, Systemic Risk.

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The ecosystem that supports financial intermediation has evolved markedly over time. Banks and their affiliated broker-dealers remain a vital component, but they are now part of a larger mosaic of institutions that route the flow of funds and facilitate trading. Especially important, from a financial stability perspective, has been the greater involvement of non-bank financial intermediaries (NBFIs)[1].

The NBFI landscape is vast and varied, covering a diverse set of players with a number of business models and subject to different regulatory regimes. The boundaries of which activities are the purview of an NBFI as opposed to a bank's can at times be blurred, and so can be the delineations among NBFIs. Table 1 provides a brief overview of the main NBFIs and of their relevance for financial stability. NBFIs also differ in how they are interconnected with other players in the system, especially with banks. In contrast to banks, NBFIs have historically not been granted access to statuary public backstops, with either no (or only limited) access to the central bank balance sheet.

To keep our analysis focused, we restrict the coverage of this paper to NBFIs that matter the most for market liquidity (which refers to the ease with which a security can be traded (Brunnermeier and Pedersen (2009)). We mainly consider non-banks that – through business models involving liquidity mismatches and/or the use of leverage – are most likely to contribute to liquidity imbalances that can endanger financial stability. These institutions typically intermediate debt, which is generally less liquid than equity. Practically, this means that we focus on entities such as principal trading firms, hedge funds and asset managers of various types (notably money market funds and open-ended bond funds) as well as central counterparties (CCPs).[2]

The growing role of non-banks and market-based intermediation over the past decade has been driven by various factors. Key elements include regulatory reforms that constrained the activities of banks and their affiliated broker-dealers, demographic changes and a greater importance of capital markets in providing for retirement, as well as technological change and

[1] At the 2018 Plenary Meeting in Ottawa, the Financial Stability Board (FSB) decided to "[...] replace the term "shadow banking" with the term "non-bank financial intermediation" [...]" (FSB (2018)). Previously, the FSB "[...] defined shadow banking as "credit intermediation involving entities and activities (fully or partly) outside the regular banking system", or non-bank credit intermediation in short." (FSB (2015)).

[2] The intermediaries we do not cover could be subsumed under shadow banking (eg, securitisations) or market-based finance (eg, pension funds and other long-horizon investors). For these NBFIs, systemic risk may arise from regulatory arbitrage, in particular for shadow banking (Acharya, Schnabl, and Suarez (2013)), or the activities of some insurance companies (Foley-Fisher, Narajabad, and Verani (2016)). See, inter alia, Pozsar, Adrian, Ashcraft, and Boesky (2010) and Adrian and Ashcraft (2012) for a comprehensive review. See Adrian (2017) for a taxonomy of shadow banking and market-based finance.

the pursuit of operational efficiencies. In some cases, it was also active policy choices that strengthened the role of certain NBFIs. Notably, this includes the promotion of financial infrastructures such as electronic trading platforms and the strong push to move activity towards CCPs, which was aimed at reducing opaqueness and addressing vulnerabilities in over-the-counter (OTC) markets.

Figure 1: Overview of main NBFIs and related financial-stability risks.

The table shows key NBFIs, together with a short description of their characteristics relevant for financial stability, together with the attending financial stability risks.

Broad categories	Intermediaries	Key characteristics from a financial-stability perspective	Main systemic risks
Institutional investors and asset managers	Insurance companies	Premia collected from insured parties are invested in various assets, often long-lived and illiquid	Some leverage, some liquidity transformation
	Pension funds	Contributions by participants are invested in a mix of public-market and private-market assets	Some credit-risk transformation
	Sovereign wealth funds	Vehicles managed by state-affiliated entities, often focused on long-term illiquid assets	Possibly leverage
	Hedge funds*	Investors' capital is augmented with leverage and deployed through strategies that may involve arbitrage	Leverage, some liquidity transformation (limited by redemption notices)
	Exchange-traded funds*	Shares trade in secondary markets and are generally redeemed in-kind only by selected intermediaries	Some liquidity transformation (limited by the redemption mechanism)
	Mutual funds*†	Shares can be redeemed daily even if underlying assets are illiquid (if open-ended, incl. money-market funds)	Liquidity transformation (if open ended), possibly leverage
	Securitisations†	They invest in various assets, possibly risky, and issue notes with different seniority, including AAA-rated	Credit-risk transformation
Market intermediaries	Broker-dealers*	They use relationships or own inventory to facilitate client trades. They often enable leverage for their clients	Leverage, liquidity transformation
	Principal trading firms*	High-frequency buyers and sellers in electronic markets, holding minimal end-of-day inventories	Pro-cyclicality in liquidity provision, intra-day leverage
Financial market infrastructures	Exchanges & electronic trading platforms*	Marketplaces for trading securities and/or financial contracts like derivatives	Technical disruptions (eg, due to operational or cyber risks) could affect broader financial markets
	Central counterparties*	They act as counterparties to holders of certain financial contracts, netting and managing counterparty risk	Pro-cyclicality in market-wide leverage due to changes in initial margins, technical disruptions

(*) asterisks indicate intermediaries that can affect imbalances in the demand and supply of financial market liquidity more directly, and that we focus on in this paper
(†) entities engaged in elevated liquidity or credit-risk tranformation, such as most money-market funds or certain securitisations, are often considered shadow banks (eg, Adrian (2017))

These developments, which have turned NBFIs into indispensable building blocks of the financial system, have also had a profound impact on the demand and supply of liquidity. The management of liquidity risk has arguably gained in importance from a financial stability point of view. On the one hand, the NBFI sector itself has become a key source of spikes in liquidity demand, particularly from investment funds exposed to liquidity mismatches, such as money-market and bond funds. On the other hand, the supply of liquidity is no longer the exclusive domain of bank dealers alone, but it increasingly involves NBFIs as well. Cases in point are the activity of principal trading firms (PTFs) in electronic markets and the trading strategies of certain hedge funds. Yet, as several recent episodes have shown, liquidity provision by non-banks tends to be more opportunistic and more prone to evaporate at times of stress, with entities that generally provide liquidity suddenly turning into liquidity consumers. And, as broker-dealers have reassessed their business models and scaled back market-making activities, the supply of liquidity has become less responsive when the demand for it spikes.

These structural shifts mean that liquidity imbalances have the potential to greatly affect prices and, in extreme cases, endanger financial stability. The 'dash for cash' turmoil at the height of the Covid-19 crisis (when investors shifted away from risky assets to cash-like assets on a massive scale) painfully exposed such structural NBFI vulnerabilities and spillovers that affected other participants in the financial system. Ultimately, it was only central banks' flexible use of their balance sheets that arrested the adverse feedback loops and helped to restore market functioning.

Building on our analysis of the key changes in intermediation and their implications for liquidity imbalances, we lay out a stylised "accounting framework" for system-wide risk capacity. In this setting, an investor can take on a leveraged position through derivatives or by pledging the assets as collateral. However, the borrowing is subject to a margin that must be met by the investor's own funds—that is, equity. The total amount of posted margin is bounded by the economic capital of the investor, which in turn is limited by the investor's equity. In this way, the investor's portfolio choice entails the allocation of scarce economic capital across assets.

Within the framework, we derive two propositions. The first is that the debt capacity of an investor is increasing in the debt capacity of other investors. In this sense, debt capacity is recursive, and leverage enables greater leverage. Conversely, spikes in margins can lead to system-wide deleveraging. The second proposition is that deleveraging and the "dash for cash" go hand-in-hand, as a generalised increase in margins in the financial system leads both to deleveraging and to the re-allocation of economic capital away from assets with high margins toward cash-like assets with low margins.

The deleveraging channel and the associated pecuniary externalities – i.e. externalities that operate through prices and risk measures based on prices – can be important for stress propagation, adding to the effect of other sources of systemic risk such as liquidity transformation. Importantly, stress can propagate in the system even in the absence of defaults. We use this risk accounting framework to provide a unifying perspective on the liquidity imbalances that rocked financial markets in March 2020, amid the uncertainty shock of the Covid-19 pandemic.

1. NBFIs and the evolution of market-based intermediation

By some estimates, NBFIs currently account for about 50% of global financing activities (FSB, 2020a). To illustrate the underlying trends, Figure 2, top panel, shows the growing footprint of NBFIs in financing US corporate debt. Back in the 1980s, banks funded about 30% of non-mortgage debt through loans, but this figure has fallen now to a mere 10%.[3] In line with the greater presence of market-based finance, bonds and commercial paper currently make up the bulk of corporate debt, at roughly 65%. Non-banks have always been the main investors in these securities, but their role has further expanded after the Great Financial Crisis (GFC). Mutual funds, insurance companies, and pension funds hold nearly 80% of corporate and foreign bonds as of 2020, with a pronounced increase for mutual funds (Figure 2, top panel). Similar trends have emerged internationally. NBFIs, notably various types of asset managers, play an increasing role in financing the real economy (see Figure 2, lower panel, for the case of Europe).

As the activities of NBFIs often involve significant mismatches in the liquidity of assets and liabilities (especially in the case of money-market and corporate bond funds), the scope for *liquidity demand* pressures has grown as a consequence. At the same time, the *supply* of liquidity by traditional intermediaries, i.e. broker-dealers, has not kept up with rising demand. Broker-dealers are institutions that act as liquidity providers by facilitating trading by other investors. While they can be independent firms, they often form part of banking groups ("dealer banks") and are subject to applicable capital and prudential regulations on a consolidated basis.[4]

As shown in Figure 2, top panel, the bond holdings of broker-dealers have shrunk after the GFC, even as the overall market expanded. This trend stands in sharp contrast with pre-GFC dynamics, when broker-dealers played a crucial role in driving the shift from a bank-centric

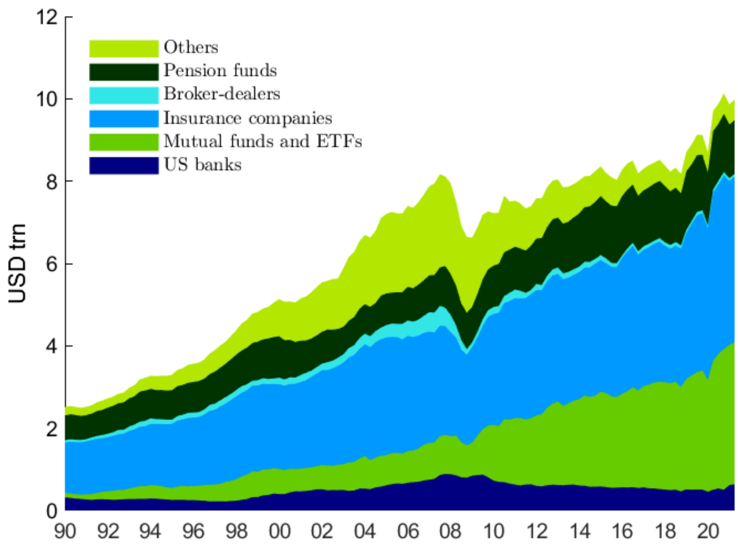
[3] Financial Accounts of the United States, Table L.103

[4] Typical services include market-making by facilitating the matching of transactions between clients wishing to trade the same asset in opposite directions; accommodating customer trades using an inventory of securities financed with the dealers' liabilities (which implies that dealers warehouse risk on their own balance sheets); providing clients such as hedge funds with leverage; and associated services like collateral management or facilitating the clearing of client trades.

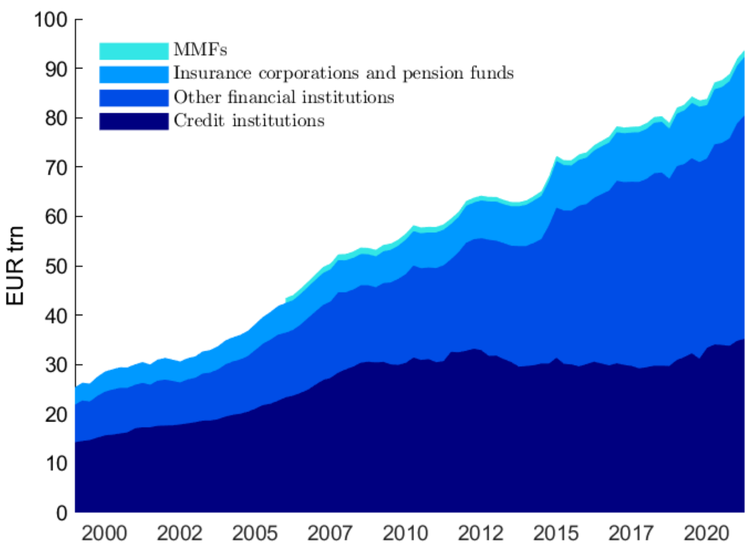
Figure 2: Trends in US and euro-area credit intermediation.

The top panel shows holdings of corporate and foreign bonds by US banks and a variety of NBFIs. The data are from Financial Accounts of the United States. The sample periods runs from 1990 to 2020. The lower panel reports the growth of the assets held by various types of financial intermediaries in the euro area. The category "Other financial institutions" includes, among others, mutual funds, ETFs, hedge funds and securitisations. The data are from the European Central Bank.

Holders of corporate and foreign bonds among US financial institutions



Growth in bank vs non-bank assets in the euro area



financial system towards a market-based one, as attested by the ten-fold expansion of their balance sheets between 1990 and 2008 and the corresponding increase in leverage (Figure 3). In general, higher leverage need not correspond to larger balance sheets (Figure 4, top panel), but broker-dealers clearly used debt to finance asset growth (Figure 4 bottom panel; see Adrian and Shin (2014)). As we highlight below, margins are a crucial source of fluctuations in the leverage of market intermediaries like broker-dealers: for a fixed amount of own funds or book equity, a compression in margin requirements allows the market participant to maintain a larger balance sheet. Margins tend to increase rapidly during periods of distress when volatility, their main driver, spikes. The rise in margins can, in turn, create knock-on effects impacting other players in the financial system and give rise to procyclicality (see in particular, BCBS, CPMI, and IOSCO (2021) as well as Section 4).

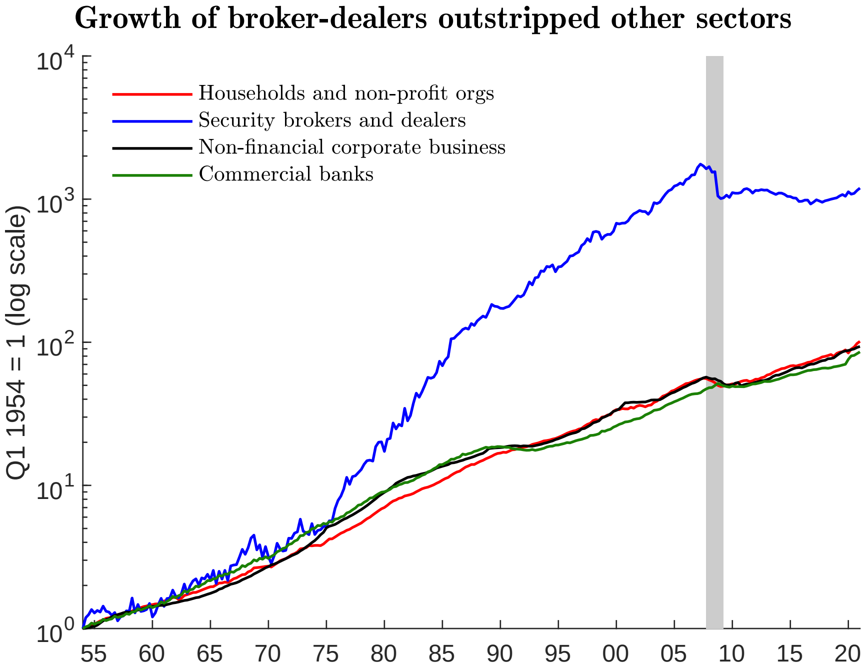
Due to regulatory tightening and a market-driven reassessment of business models, broker-dealer balance sheets now have a significantly smaller heft in the financial system than pre-GFC. Leverage supporting these balance sheets has also come down significantly. Important shifts in dealers' market-making business models have accompanied such trends (CGFS (2014, 2016)). The "principal" model, where dealer banks use balance sheet capacity to accommodate client trading demands, has given way to a model where they primarily match clients wishing to trade in opposite directions (see, e.g., Adrian, Boyarchenko, and Shachar (2017)).[5] One important consequence of this retrenchment of the principal model is that liquidity provision has moved increasingly outside of the broker-dealer sector, in favour of a broader set of players. Two types of entities stand out: principal trading firms (PTFs), who facilitate the redistribution of risk by buying and selling securities while keeping minimal inventories, and certain types of hedge funds, who effectively warehouse risks (Eren and Wooldridge (2021)). We briefly describe the salient characteristics of both intermediaries below.

PTFs, which are more lightly regulated than broker-dealers, are sometimes referred to as the "new electronic market makers" (Menkveld (2013)), since many of them pursue passive market-making strategies in electronic markets. They hold relatively limited capital and trade on their own account, typically using automated high-frequency strategies built on sophisticated data analytics (Markets Committee (2018)). PTFs and bank dealers com-

[5]This can be either pure agency trades where the dealer acts on behalf of clients or so-called risk-less principal trades where a dealer only absorbs a customer sale after having previously lined up a buyer, thereby involving minimal risk warehousing.

Figure 3: Evolution of assets and leverage of broker-dealers.

The size of the broker-dealer sector is illustrated using log-assets (top panel) and leverage (bottom panel). Shaded areas indicate the December 2007-June 2009 recession.



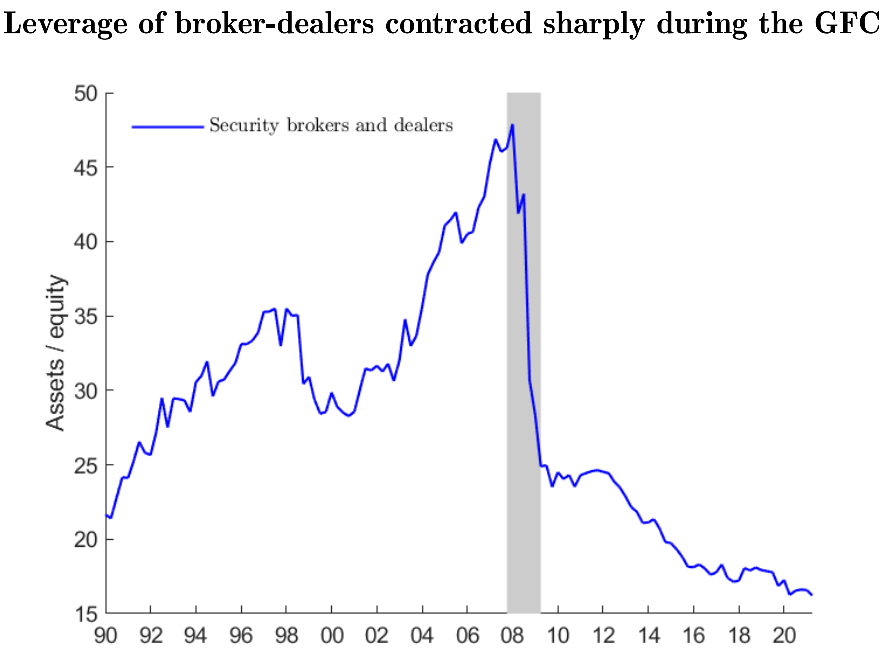
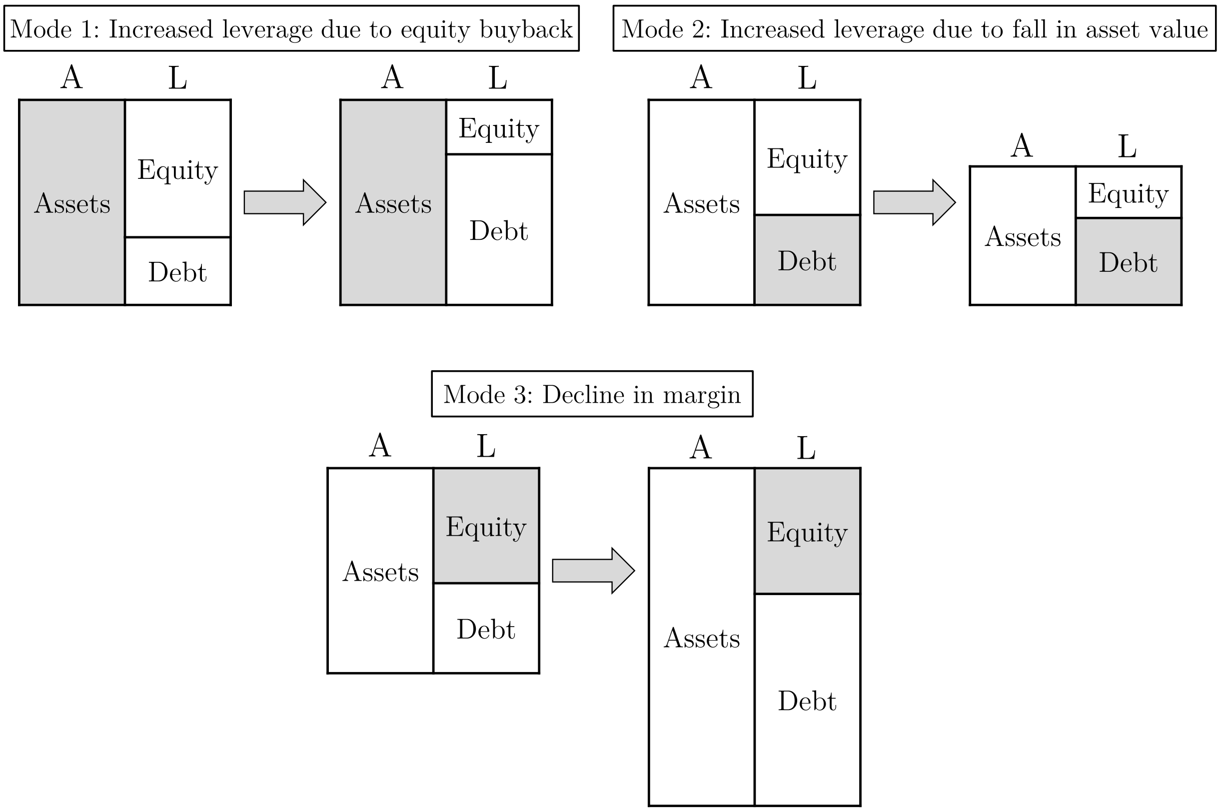


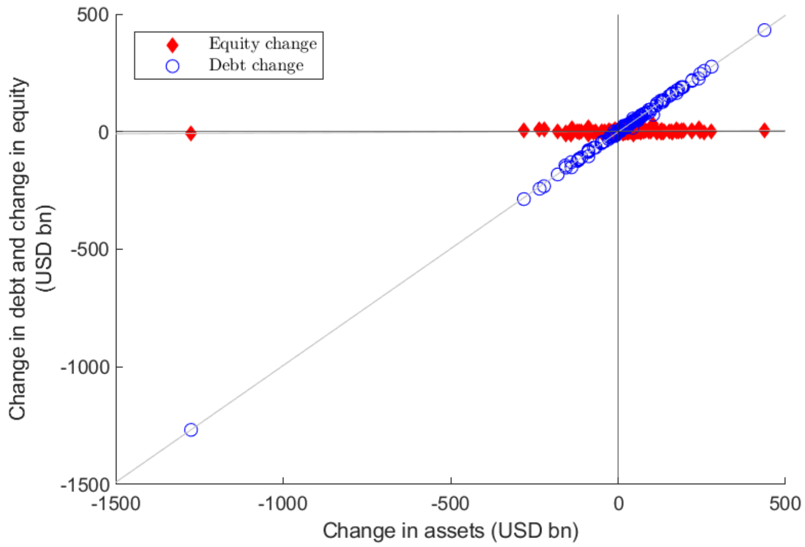
Figure 4: Leverage and changes to broker-dealers balance sheets.

The top panel illustrates alternative ways in which leverage can be increased and balance sheets expanded or contracted. The bottom panel plots quarterly changes in broker-dealer assets against changes in their debt and equity. Data are from the Financial Accounts of the United States.

Three ways of increasing leverage



Broker-dealers' balance sheet expansion driven one-to-one by increase in debt



pete when it comes to liquidity provision in financial markets, but there also tends to be a symbiotic relationship in that large broker-dealers usually act as a prime-broker for PTFs. Prime brokerage enables firms such as PTFs to conduct trades with a group of predetermined third-party wholesale counterparties in the prime broker's name and using the prime broker's credit (see, e.g., Schrimpf and Sushko (2019); Treasury Markets Practices Group (2019)).

PTFs first rose to prominence in exchange-traded equities and futures, but have made inroads into traditional OTC markets over the past decade. They currently account for the bulk of trading volumes on electronic trading platforms for on-the-run US Treasury securities, futures contracts, equities, spot FX, as well as certain classes of derivatives.[6] PTFs generate large amounts of short-lived orders and tend to close open positions quickly, with very tight inventory control (Adrian, Capponi, Fleming, Vogt, and Zhang (2020)). In normal times, PTFs help incorporate information into prices and distribute risk among market participants (Joint Staff Report (2015)). In periods of stress, however, questions remain about the true risk bearing capacity of PTFs as their business model based on tight inventory control typically involves minimal risk warehousing. Indeed, several recent episodes of market dysfunction indicate that, for instance, PTFs tend to scale down liquidity provision when volatility spikes (see, e.g., Dobrev and Meldrum (2020) and Aronovich, Dobrev, and Meldrum (2021) for an analysis of the evaporation of high-speed liquidity provision in the US Treasury market during periods of stress).

Hedge funds are the second set of players that have come to assume a more prominent role in liquidity supply, typically complementing the business activities of broker-dealers. Large hedge funds have global operations and usually rely on multiple prime brokers, highlighting the close interconnections with systemically important banks. Hedge funds' trading in fixed income markets often involves exploiting small mispricings between similar instruments, such as cash bonds and futures contracts, or between bonds whose prices deviate from those implied by a "smooth" yield curve.[7]. To profit from these "relative-value" opportunities, hedge funds take significant leverage, often through repo borrowing that is facilitated by bank-

[6]In other important market segments, such as non-US government bond markets or corporate bond markets, PTFs have not made significant inroads yet.

[7]Hedge funds are important liquidity providers for other asset classes as well, including equities, and their activity is sensitive to funding conditions (Cotelioglu, Franzoni, and Plazzi (2021)). Sudden retrenchment from trading partly reflects that investment strategies are exposed to sudden sharp losses (Agarwal and Naik (2004); Agarwal, Arisoy, and Naik (2017)).

affiliated broker-dealers. Under normal conditions, hedge funds' activity adds to liquidity, but sudden deleveraging forcing an unwind of positions can reverberate through financial markets (see, e.g., Kruttli, Monin, Petrasek, and Watugala (2021) for empirical evidence on these mechanisms).

One such case was the stress in US Treasury markets in March 2020, when the so-called Treasury cash-futures basis trade ground to a halt (see, e.g., Barth and Kahn (2020); Schrimpf, Shin, and Sushko (2020); Kruttli, Monin, Petrasek, and Watugala (2021)).[8] Typically, the futures-implied bond price is higher, reflecting that a futures contract is a zero-money-down bet and does not take up much balance sheet capacity at the time when it is entered into. In contrast, the equivalent cash bond entails balance-sheet usage and associated costs. In the run-up to the turmoil in March 2020, hedge funds would purchase relatively illiquid off-the-run Treasury securities (typically financed through short-term repo borrowing), while simultaneously selling Treasury futures, effectively warehousing liquidity risk embedded in off-the run cash bonds. Through this trade hedge funds essentially provided a risk sharing function vis-a-vis asset managers, by being "on the other side" of futures contracts and "storing" illiquid securities on behalf of those holding long futures positions (see, e.g. Barth and Kahn, 2021, for a discussion).[9] Barth and Kahn estimate that, at its height in 2019, the trade accounted for up to 25% of dealers' repo volumes.

It is important to note that, while PTFs and hedge funds give an extra boost to liquidity supply in normal times, their activity is opportunistic in nature. As such, doubts remain about the reliability of this type of liquidity supply during periods of stress. Unlike bank dealers, PTFs trade anonymously on electronic markets, hence they have no client relationships at stake when they withdraw liquidity.[10] Similarly, the risk warehousing provided by hedge funds largely stems from the exploitation of price discrepancies, rather than from pro-

[8]The cash-futures basis trade is just one example of many other relative-value trading strategies of hedge funds in fixed income markets. There are multiple other relative-value trades too, e.g. involving interest rate swaps rather than futures, or trades that benefit from mispricing of securities along the yield curve (see, e.g., Duarte, Longstaff, and Yu (2007)). LTCM is a primary example of a hedge fund simultaneously engaged in a large range of relative-value trades (see the coverage of the 1998 LTCM debacle in the popular book by Lowenstein, 2001).

[9]Asset managers are attracted to Treasury futures due to their high liquidity and the ability to use leverage, in turn allowing them to economise on capital. Futures allow asset managers to deposit only a fraction of the contract purchased in a margin account. In essence, asset managers can achieve exposures to their asset allocation targets through the use of futures, while still having capital available for other uses to generate alpha.

[10]In recent years, a few PTFs have made inroads into traditional OTC segments by building client relationships through trades in which they disclose their identities (Schrimpf and Sushko (2019)).

viding services to clients as in the case of broker-dealers. In addition, opportunistic liquidity provision and risk warehousing can suddenly turn into large liquidity demand and risk shedding in times of turmoil (see, e.g., Duffie (2020), Hauser (2020), Schrimpf, Shin, and Sushko (2020)).

Our overview of key changes in market-based intermediation over the past decade would not be complete without emphasising the essential role of financial market infrastructures such as central counterparties (CCPs), exchanges and other platforms. We illustrate this in the flow chart of Figure 5, where market infrastructures are placed at the centre of the stylised market-intermediation ecosystem. While the rise of NBFIs has generally occurred in a rather evolutionary manner, the growth of CCPs owes to an active policy push to reform the notoriously opaque OTC derivatives markets, whose vulnerabilities had been exposed during the GFC (see Borio, Farag, and Tarashev (2020)).

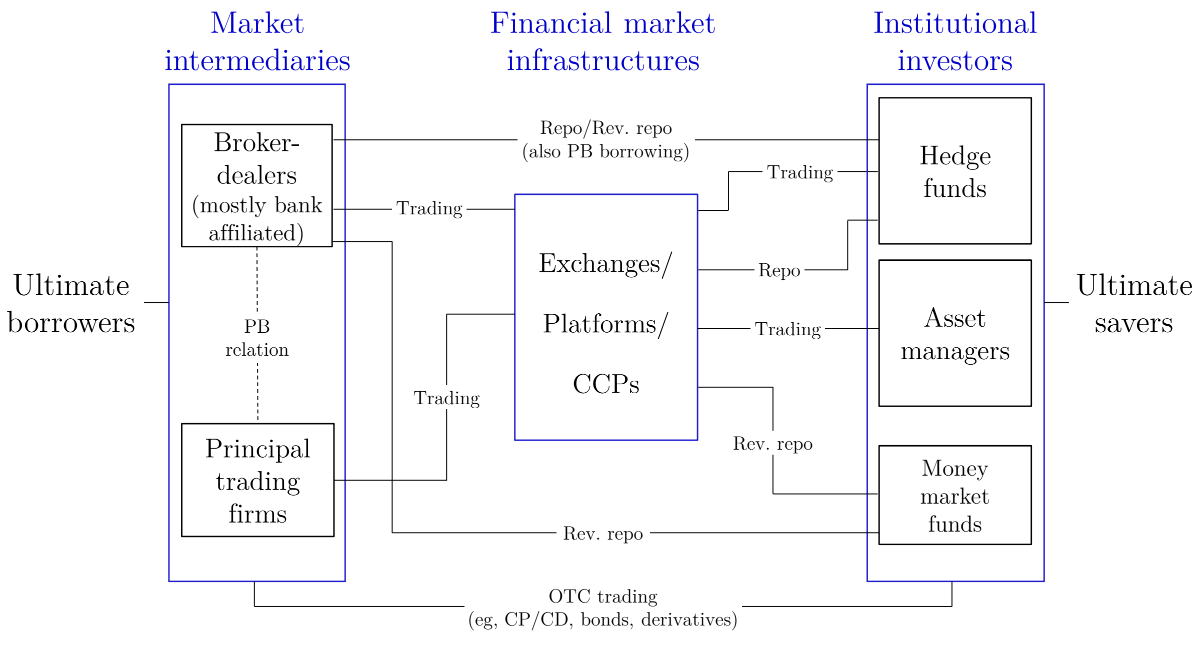
The crucial role of CCPs in many of today's markets is hard to overstate. CCPs act as intermediate agents that reduce overall counterparty risk between the two ultimate holders of a contract. As such, CCPs are central to risk management and capital efficiency, given that they net exposures and generally reduce posted margins compared to uncleared transactions.[11] In certain markets, including interest rate derivatives and, to a lesser extent, credit derivatives, CCPs currently support the majority of positions outstanding. As a result, CCPs' risk management practices of their exposures to clearing members take centre stage from a financial stability standpoint (Huang, Menkveld, and Yu (2021)). While CCPs are important for containing counterparty credit risk, they can sometimes exacerbate liquidity needs in the system. In particular, margin setting and collateral management have become first-order issues from a financial stability perspective. Margins are currently set in order to manage the counterparty risk faced by CCPs, but margin fluctuations have broad repercussions that can affect the risk-taking capacity of the financial system as a whole—a central theme we will come back to repeatedly in this paper (in particular, when discussing policy implications in Section 5).

All in all, the greater role of NBFIs means that risk exposures are increasingly intermediated and held outside of the banking system. The traditional model where banks warehouse liquidity and credit risks on their balance sheets has increasingly given way to a model where

[11] In practice, collateral efficiency depends on how many instruments are netted at the same time, and on how many CCPs are active (Duffie and Zhu (2011) and Duffie, Scheicher, and Vuillemey (2015)).

Figure 5: Stylized view of the market-intermediation ecosystem post-GFC.

The Figure depicts the structure of the market-intermediation ecosystem. It is organised as a flow chart, with the ultimate savers at the right and the ultimate borrowers at the left. Managing the households' savings are various types of institutional investors (hedge funds, asset managers and money-market funds). Market intermediaries include broker-dealers and principal trading firms (the latter typically trading in financial markets through a prime brokerage relation). At the centre of the diagram are financial market infrastructures, i.e. exchanges, electronic trading platforms and central counterparties (CCPs). The lines connecting the different boxes represent financial flows between the various entities (e.g. repos and reverse repos, securities or derivatives transactions).



such risks are outsourced to NBFIs.[12] A key theme in what follows is that such structural changes have alleviated counterparty credit risk, but have rendered the financial system more vulnerable to large swings in liquidity imbalances.[13] The reason is that the business models of NBFIs typically revolve around exploiting liquidity mismatches and, on net, provide liquidity in good times. During periods of financial turmoil, however, NBFIs often retrench and their liquidity supply can suddenly turn into substantial liquidity demand.

2. Systemic risk in NBFIs and liquidity demand

NBFIs undoubtedly bring a range of benefits to the financial system and the economy as a whole. They increase the diversity of the ecosystem, generally improving market functioning to the extent that their trading motives are less correlated with those of other players. In particular, some NBFIs may pick up the slack when banks retrench from certain intermediation activities. As such, NBFIs can assume a 'spare tire" function (Fischer (2015)). In financial markets, PTFs and hedge funds have indeed helped deepen market efficiency and liquidity in good times, complementing the role of bank dealers.

But, NBFIs can also contribute materially to systemic risk. Systemic risk refers to the possibility that disruptions to the activity of an intermediary could impose substantial costs, particularly in the form of externalities, on other financial institutions or non-financial firms (Acharya, Pedersen, Philippon, and Richardson (2017)). For instance, spikes in margins and haircuts reduce the risk-bearing capacity that NBFIs can sustain, potentially depressing prices and impairing market liquidity. Likewise, funds that need to meet large redemptions or are under pressure to delever might engage in fire sales, with knock-on effects on other players in the system.

Addressing systemic risk requires a macroprudential perspective. Focusing on investor

[12] This does not mean, of course, that banks and their affiliated broker-dealers have entirely withdrawn from such activities. Banks still remain integral nodes on the "liquidity risk" side—especially the management of mismatches in the timing of margin needs vs. clients' liquid resources. Banks are positioned to supply liquidity to large clients via margin lending or collateral transformation. This also has repercussions on the demand for central bank reserve balances that tends to spike in stress episodes when banks need to post margin on behalf of clients intraday.

[13] Liquidity crises and deleveraging episodes, even if defaults are avoided, are costly from a social welfare perspective. Financial activity will contract, sound real-economy borrowers may not be able to roll over their debt, or will only be able to do so at elevated funding costs. And, emergency interventions by central banks in such episodes are also no panacea but come with a host of costs and side-effects.

protection or on the safety and soundness of an individual institution, as regulations have done until recently, largely means issuing enough loss-absorbing liabilities to minimize default risk. From this microprudential vantage point, the main concern is managing the risks that stem from assets. An important feature of macroprudential policies is their focus on both the liability side as much as the asset side, because it is the interaction of the two that generates systemic risk (Morris and Shin (2008). This can be exemplified by the case of a corporate bond mutual fund that offers daily redemptions even if its illiquid holdings may take much longer to sell. If liabilities were not redeemable on short notice, as is the case with closed-end mutual funds, the systemic risk would be much reduced, irrespective of asset illiquidity.

NBFIs are mostly linked to two fundamental drivers of systemic risk that can lead to heightened demand for liquidity at times of stress. The first is liquidity/maturity transformation, and the second is leverage procyclicality.[14] Clearly, the two are closely related to the business model of banks, but they are also central to that of some NBFIs. The overlap between the systemic risks that characterise banks and NBFIs indicates a close correspondence between some of their economic functions, even as important differences remain, such as the more encompassing nature of bank intermediation. In the remainder of this section, we provide further details on the mapping between NBFI activities and sources of systemic risk, focusing in particular on those entities that can give rise to substantial liquidity demand during times of market turmoil.

Mutual funds

While some mutual funds also take on leverage (Boguth and Simutin (2018); Fricke (2021)), they do so less than other key players such as banks or hedge funds. The most relevant feature of mutual funds, from a systemic risk perspective, is that they offer daily redemptions even when their investments are illiquid. These liquidity mismatches are especially pronounced if the fund invests in illiquid assets such as corporate bonds or emerging market securities. Redemptions are generally honored at fair value, even when asset sales that are necessary to meet outflows incur a liquidity discount, which is thus borne by the remaining shareholders.

This setup gives rise to a first-mover advantage: expectations that a large number of

[14] Another source of systemic risk in NBFIs is credit risk transformation. This activity entails the issuance of liabilities with a substantially different risk profile than the underlying assets. In principle, investment vehicles can be designed so that, irrespective of asset quality, some investors bear little credit risk and others face high probability of loss. See Gorton and Metrick (2013) for a detailed discussion.

investors might sell create an incentive to be among the first to redeem. Such "strategic complementarities" are stronger when the underlying assets are more illiquid, and can lead to full-fledged runs and disorderly fire sales, which typically result in high demand for liquidity (Chen, Goldstein, and Jiang (2010); Goldstein, Jiang, and Ng (2017)).[15] Since the assets managed by funds holding illiquid securities, such as corporate bonds, increased markedly after the GFC, the contribution of mutual funds to possible liquidity disruptions has climbed sharply over time.

In principle, mutual fund managers can use various strategies to avoid incurring a liquidity discount. In particular, they often hold a buffer of easily tradeable securities that can be sold to meet outflows and are bought back over time as assets are disposed of. Many funds adopt this strategy (Chernenko and Sundaram (2016) and Aramonte, Scotti, and Zer (2020)), especially in tranquil times (Jiang, Li, and Wang (2020)). In volatile periods and when portfolios are very illiquid, however, managers tend to sell more assets than needed, so to increase buffers in the face of possibly prolonged outflows—a practice known as "cash hoarding" that we discuss in more detail in Section 4.

Money Market Funds

Among mutual funds, money market funds (MMFs) hold very short-term assets and issue shares that can be redeemed daily. We cover MMFs separately here due to their crucial role for the functioning of short-term funding markets (notably in the US dollar) and their heightened systemic importance.[16]

MMFs investing in non-public debt (so-called prime funds in the US and LVNAV and VNAV funds in Europe) use the proceeds to invest in certificates of deposit (CD) and commercial paper (CP), which lack a developed secondary market and are typically held to maturity. In contrast, government MMFs hold short-dated Treasury securities or reverse repos backed by Treasury-collateral. Because of the latter, they are crucial for the functioning of USD repo markets and an important source of funding for broker-dealers and hedge funds.

[15] Funds have the ability to suspend redemptions to protect shareholders (Section 22(e)(3) of the Investment Company Act of 1940) and can alter the redemption value based on flows - a tool known as 'Swing Pricing' (Lewrick and Schanz (2017); Jin, Kacperczyk, Kahraman, and Suntheim (2021)), but such actions carry significant stigma.

[16] MMFs are an important source of US dollar funding for non-US banks, and disruptions to the MMF sector can have significant spillover effects on FX swap markets and funding conditions for international banks (Eren, Schrimpf, and Sushko (2020a)).

Investors have come to expect that MMF liabilities are broadly equivalent to cash, meaning that they will maintain a stable value and can be redeemed at or around par. This perceived equivalence to money emerges from relatively low yields (Cipriani and La Spada (2021)), even if MMFs generally have an incentive to purchase comparatively risky securities in order to attract investor flows (Kacperczyk and Schnabl (2013); La Spada (2018)). Underscoring the strong aversion to 'breaking the buck', MMF sponsors have often supported their funds with own resources during stress episodes (Brady, Anadu, and Cooper (2012)).

Holding assets with variable prices and issuing liabilities with approximately stable value means that MMFs engage in liquidity transformation, leaving MMFs exposed to runs – which entail a spike in liquidity demand – when investors suspect that assets may not cover liabilities. Such was the case during the GFC (Schmidt, Timmermann, and Wermers (2016)), particularly for funds that had engaged in search for yield. To reduce the risk of runs, US regulatory reforms in 2016 posited that stable net asset values (NAVs) are only permissible for MMFs investing in government securities and those targeted to retail investors. MMFs investing in CPs and CDs (known as prime funds) and marketed to institutional investors are required to offer floating NAV. Additionally, funds can consider restricting redemptions with gates and imposing liquidity fees if certain asset-liquidity thresholds are breached. Nonetheless, some run-like dynamics were at play for MMFs in March 2020 (see e.g. Li, Li, Macchiavelli, and Zhou (2021), Anadu, Cipriani, Craver, and La Spada (2021)), as we discuss in Section 4, as regulatory liquidity thresholds may have led some investors to pre-emptively redeem to avoid the consequences of a fund crossing those thresholds.

Exchange traded funds

Similarly to mutual funds, exchange-traded funds (ETFs) allow investors to gain exposure to illiquid assets. The redemption mechanism, however, is fundamentally different (Ben-David, Franzoni, and Moussawi (2017); Lettau and Madhavan (2018); Todorov (2019)). ETFs hold portfolios of securities financed with the issuance of shares that can be traded continuously on centralised exchanges, but can only be redeemed by a set of specialised intermediaries known as Authorised Participants (APs). Trading pressure from ETF investors can open a wedge between the price of ETF shares and the value of the underlying portfolio. Unless this gap reflects fundamental differences in price informativeness (Aramonte and Avalos (2020)), APs engage in arbitrage that involves creating and selling ETF shares (if they are valued more than the assets) or redeeming previously purchased ETF shares (if they are valued less than the assets).

This mechanism implies that investors selling ETF shares bear any liquidity discount incurred when assets are disposed of, which in turn may mitigate incentives to redeem early (see Shim and Todorov, 2021, for an analysis of the mechanism). ETFs can still affect underlying prices through certain channels (Ben-David, Franzoni, and Moussawi (2018)), such as higher informational efficiency (Glosten, Nallareddy, and Zou (2021)), portfolio rebalancing (Todorov (2019)), liquidity (Saglam, Tuzun, and Wermers (2019)), and liquidity commonality (Agarwal, Hanouna, Moussawi, and Stahel (2018)). However, the nature of their liabilities is arguably less prone to systemic issues than that of open-end mutual funds holding illiquid assets. Still, large sales of ETFs can lead to spikes in liquidity demand as APs would transmit selling pressure from the ETF market to that for the underlying assets, even though APs can have a stabilising effect in some instances (Shim and Todorov (2021)).

Hedge funds

The liabilities of hedge funds have two key characteristics that are relevant for our discussion. The first is that, while liquidity risk is an important driver of returns (Sadka (2010)), investors are typically subject to relatively long notice periods before they can redeem their interest. For about half of hedge funds' assets, the notice must be submitted at least 90 days in advance, limiting issues arising from liquidity transformation.[17] The second is that hedge funds can be highly leveraged, often with credit provided by prime brokers through repos and/or synthetically through the use of derivatives. Hedge funds have grown from niche investment vehicles to a large sector that complements traditional intermediaries like mutual funds (Stulz (2007)). Systemic risks have increased correspondingly, particularly in relation to liquidity (Chan, Getmansky, Haas, and Lo (2005)).[18]

The ratio of total assets to net assets, a proxy for leverage, increased markedly between the mid-2010s and the early 2020s in the United States, with debt growth, driven to a substantial extent by higher repo funding, underpinning most of the rise in assets under management. That said, there is substantial cross-sectional heterogeneity in the use of

[17] Securities and Exchange Commission, Private Funds Statistics, Second Calendar Quarter 2019.

[18] Liquidity risk is an important driver of hedge fund returns (Sadka (2010)), inflows (Teo (2011)) and portfolio allocation (Aragon, Ergun, and Girardi (2021)). There is a close link between liquidity and contagion across asset markets in which hedge funds are marginal investors (Boyson, Stahel, and Stulz (2010)).

leverage depending on a fund's strategy, with those focused on relative-value trades in fixed income markets being the most leveraged (Barth and Kahn (2021)).

Leverage can amplify pro-cyclicality in risk taking and in asset prices. Raising funds by issuing debt implies that the value of assets can fall below the face value of obligations, making the firm insolvent. To keep the likelihood of default within an acceptable range, an increase in the riskiness of assets is often met with a reduction in debt. From the perspective of the individual firm, this behaviour is prudent, yet it can have important systemic consequences. As assets are sold to repay debt, prices fall further, and more sales are needed to keep leverage in check, potentially leading to a "liquidity black hole" (Morris and Shin (2004)). The effect is further amplified when key liquidity providers, like brokers-dealers, face funding constraints, since there is a close link between changes in intermediaries' balance sheet capacity and available liquidity (Morris and Shin (2008); Brunnermeier and Pedersen (2009); Adrian and Shin (2010)).

There are multiple ways of achieving leverage, all of which can give rise to excess pro-cyclicality. A common type of secured funding, heavily used by hedge funds, is repos. They are collateralised short-term loans in the form of asset sales with the agreement to buy back later at a pre-set price. To protect against borrower default, repos involve a haircut, so that the amount the debtor can borrow is less than the value of the pledged securities. In principle, haircuts can increase when default risk rises, leading to pro-cyclical changes in the leverage – even, potentially, when lending is backed by safe assets (Morris and Shin (2008)). Hedge funds can also achieve leverage through the use of derivatives, which allow to take exposures without fully funding positions. Margins are used to protect against the default of the derivative counterparty. However, margins can increase rapidly when volatility spikes, leading to a sharp decline in the amount of attainable leverage and hence in risk-taking capacity. From this vantage point, margins can impose externalities on other investors—that is, they can be a source of systemic risk.

Looking ahead: decentralised finance

The main sources of financial instability – such as leverage and liquidity transformation – tend to stay remarkably similar in the course of time, even if they take different guises as financial innovation advances. A relevant example is stablecoins, which are cryptoassets that tie their value to that of fiat currencies such as the US dollar. Stablecoins increasingly play a role as vehicle currencies within the decentralised finance (DeFi) ecosystem and act as a store of value especially in countries with a high history of inflation.

Normally, stablecoins strive to maintain a fixed value relative to fiat currencies by investing in short-term and sometimes illiquid financial assets. Certain stablecoins tied to the US dollar hold significant amounts of CPs and CDs and have characteristics reminiscent of MMFs. Not unlike open-end regulated investment funds, stablecoins investing in illiquid securities can be a source of vulnerability in the financial system, not least due to their fragile structure as near-money substitutes (Aramonte, Huang, and Schrimpf (2021); IMF (2021)).

3. NBFIs and the propagation of systemic risks

Some themes in the financial stability analysis of NBFIs discussed above, such as liquidity transformation and the role of leverage, share points in common with that of banks. But, there are also new dimensions arising from the importance of market prices and of balance-sheet management by NBFIs. These distinctive elements matter for liquidity imbalances and are especially important in the propagation of systemic risk. As a result, our model and discussion focus on a relatively less explored issue – the fluctuations in leverage and the liquidity risk propagation that they entail in amplifying shocks in the financial system. Concretely, the focus is on the fluctuations in margins on the procyclical variation of leverage.

Traditionally, the "domino" model of cascading defaults builds a narrative for systemic risk around interconnected defaults. According to the domino model, if Bank A has borrowed from Bank B, while Bank B has borrowed from Bank C, and so on, then a shock to Bank A's assets that leads to its default will hit Bank B as well. If the hit is big enough, Bank B's solvency will be impaired, in which case Bank C would be hit, and so on further down the line. Insolvency is seen as the driver of systemic risk in the domino model.

However, while insolvency often figures in systemic crises, it needs not do so. *Fluctuations in leverage* working through *shifts in risk-taking capacity* can also be a potent channel of propagation of stress, especially in settings with market-based intermediation. Margin is posted using own funds (equity) so that the ratio of total exposure to margin corresponds to overall leverage. Attainable leverage is therefore the reciprocal of the size of the margin investors post to open their positions. Changes in margin (and the corresponding fluctuations in leverage) are reflected in the fluctuations in the balance sheet size of market participants and in the broader risk-taking capacity of the financial system. In this context, a sharp increase in margins, especially after a protracted period of thin margins, will tighten financial conditions for the system as a whole. While insolvencies may exacerbate the stress, they are not a necessary ingredient.[19] Instead, pecuniary externalities – that is, spillovers that work through prices – can become potent channels through which stress can spread. In this sense, the cascading insolvencies of the "domino model" or the credit risk of the underlying assets are not a necessary condition for stress propagation. The fact that financial stress can emanate from safe assets such as government bonds (Morris and Shin (2008), and as evident during the Covid-19 crisis (see Section 4) is also an important theme of our discussion.

Framework for debt capacity. Our organising idea is that fluctuations in the risk capacity of market participants can be amplified by the actions of market participants themselves. The main building block is the risk budgeting decision of an investor who posts margins to acquire leveraged positions in assets. The investor chooses a portfolio $y = (y_1, \cdots, y_\mathrm{N})$ subject to:

$$m_1^{(y)} + \cdots + m_\mathrm{N}^{(y)} \leq \kappa \leq e,$$

where $m_\mathrm{i}^{(y)}$ is the margin posted for asset i and κ is *economic capital*, which is bounded by equity e. Allocating economic capital across different assets entails a risk budgeting decision akin to a consumer choice problem over goods with expenditures $m_\mathrm{i}^{(y)}$ and budget κ.

The main insights that come from our risk accounting framework (developed further below) can be summarised in *two main propositions.* The first proposition is that the debt capacity of an investor is increasing in the debt capacity of other investors. In this sense, debt capacity is recursive, and leverage thus enables greater leverage. Conversely, a spike in margins can set off a generalised deleveraging that leads to system-wide spillovers.

The second proposition is that the deleveraging channel of risk propagation can manifest itself as cash hoarding, or a "dash for cash". This is because a generalised increase in margins across assets sets off a re-allocation of scarce economic capital, whereby investors rebalance their portfolios towards less risky assets with low margin requirements such as cash or close substitutes. In this way, the deleveraging channel of risk propagation and the cash hoarding

[19]See Gârleanu and Pedersen (2011) for an asset-pricing perspective on the role of margins.

channel emerge as two sides of the same coin rather than being two separate and distinct channels of stress propagation.

3.1. Optimal portfolios with Value-at-Risk constraint

We now lay out the portfolio choice problem that underlies our risk allocation framework more formally.

Consider an investor who is risk-neutral and maximises expected returns, but is subject to a Value-at-Risk (VaR)[20] constraint of the form:

$$\alpha\sigma \leq \kappa, \tag{1}$$

where α is a positive constant that captures the stringency of the VaR constraint, σ denotes the standard deviation of return of the investor's portfolio and κ is the economic capital that determines the investor's risk capacity. The constraint limits the size of the investor's portfolio so that α times the standard deviation of returns is bounded by the economic capital κ. A high κ relaxes the VaR constraint, and allows the investor to take on larger risks in the portfolio decision.

Let μ_{i} denote the expected return on bond i $(i = 1, ..., N)$ and μ denote the N-dimensional column vector of expected returns $\{\mu_{\mathrm{i}}\}$. Notional bond holdings are collected in the column vector y, while Σ represents the covariance matrix of returns.

The investor's portfolio choice problem is to maximise expected returns subject to the VaR constraint, ie:

$$\underset{y}{\mathrm{Max}}\ \mu' y \qquad \text{subject to} \qquad \alpha\sqrt{y'\Sigma y} \leq \kappa, \tag{2}$$

where $\sqrt{y'\Sigma y}$ is the standard deviation of the return on the bond portfolio.

The Lagrangian for this problem is:

$$\mathcal{L} = \mu' y - \lambda\left(\alpha\sqrt{y'\Sigma y} - \kappa\right), \tag{3}$$

[20]Intuitively, VaR is a given percentile of the profit-and-loss (PnL) experienced by an institution so that, any loss larger than VaR happens with some given small probability. Formally, for $\alpha \in (0, 1)$, VaR at level α is the smallest number X such that the probability that PnL<X is 1-α.

with λ the Lagrange multiplier of the VaR constraint.

Rearranging of the first-order condition and substituting in the binding VaR constraint, we can solve for the Lagrange multiplier λ:

$$\lambda = 2\sqrt{\mu'\Sigma^{-1}\mu}. \tag{4}$$

The expression $\sqrt{\mu'\Sigma^{-1}\mu}$ is the N-dimensional analogue of the Sharpe ratio, i.e. the expected return normalised by the standard deviation of returns. Intuitively, the Sharpe ratio captures the additional return that, in expectation and expressed as a share of volatility, accrues to the investor when extra economic capital is freed by relaxing the budget constraint marginally.

Substituting the expression for λ in the first-order condition, we can solve for the optimal portfolio:

$$y = \frac{\kappa}{\alpha\sqrt{\mu'\Sigma^{-1}\mu}}\Sigma^{-1}\mu. \tag{5}$$

As Equation (5) shows, the optimal bond portfolio is proportional to the economic capital κ, so that a doubling a economic capital entails a doubling of the optimal holdings. Bond positions are also decreasing in the tightness of the imposed risk-constraint, α, and will be a function of the volatilities and covariances of the bond returns, as captured via the Σ matrix.

3.2. Example of long-short hedge fund

We now apply the portfolio choice problem to the example of a leveraged fixed income investor. The investor takes positions in N assets. These can include cash securities but also futures contracts on the bonds. Denote by y_{i} the notional holding of asset i. These holdings can also be negative—in other words, the investor can also enter into short positions in some of the assets. Fixed income instruments with different, but highly correlated, expected returns are attractive for long-short trades. In such relative value trades, the investor goes long one asset (say an illiquid bond with a higher yield), while selling short the futures contract (with a slightly lower implied yield).

For tractability, we posit a structure of the return covariance matrix that takes the following form:

$$
\Sigma = \begin{bmatrix} z+c & c & \cdots & c \\ c & z+c & \cdots & c \\ \vdots & \vdots & \ddots & \vdots \\ c & c & \cdots & z+c \end{bmatrix}, \tag{6}
$$

where both z and c are positive constants, but where z is small relative to c, so that the variances along the diagonal are just slightly larger than the covariances. Such a covariance structure for Σ reflects returns on closely correlated assets, such as government bonds of various maturities and benchmark status, futures contracts and other derivatives. As $z \to 0$, the correlation of returns approaches 1, and the asset returns become perfectly correlated.

It can be verified by multiplication that the inverse of the covariance matrix takes a simple form, given by:

$$
\Sigma^{-1} = \frac{1}{z^2 + Ncz} \begin{bmatrix} z+(N-1)\,c & -c & \cdots & -c \\ -c & z+(N-1)\,c & \cdots & -c \\ \vdots & \vdots & \ddots & \vdots \\ -c & -c & \cdots & z+(N-1)\,c \end{bmatrix}, \tag{7}
$$

where N is the number of assets. This simple expression for Σ^{-1} provides a tractable solution for the optimal portfolio of the leveraged investor. It also allows for some comparative statics analyses by varying the parameter z or, equivalently, the correlation coefficient $\rho = \frac{\sigma_{\mathrm{ij}}}{\sigma_{\mathrm{i}}\sigma_{\mathrm{j}}}$ which in this example simplifies to $\frac{c}{c+z}$.

Combining the expression for the optimal portfolio in (5) with the inverse covariance matrix in (7), the position for asset i becomes:

$$
y_{\mathrm{i}} = \frac{\kappa}{\alpha\left(z^2 + Ncz\right)\sqrt{\mu'\Sigma^{-1}\mu}} \left(z\mu_i + c\sum\nolimits_{k\neq i}\left(\mu_i - \mu_k\right)\right) \tag{8}
$$

As Equation (8) shows, the optimal holding is driven by the difference between expected returns across the asset set, magnified by a constant. Note that as $z \to 0$, $\rho \to 1$ and hence the absolute size of the optimal holding y_{i} becomes very large, reflecting highly leveraged long-short portfolios.

Numerical illustration. We illustrate the main mechanisms for a two asset example (N=2), choosing the following parameters: κ=1, $\alpha = 2$, μ_1=0.04, μ_2=0.01, and $c = 1$. The latter implies that the correlation between the two bonds becomes $\rho = \frac{1}{1+z}$.

Figure 6, top panel shows the positions in the two bonds as z becomes small and the correlation in the bond returns ρ approaches one. As the economic capital κ is normalised to one, the change in the long-short position leads to a 1:1 change in leverage. As the graph shows, the position size of the long-short portfolio grows rapidly, without bound, as the bonds become more correlated.

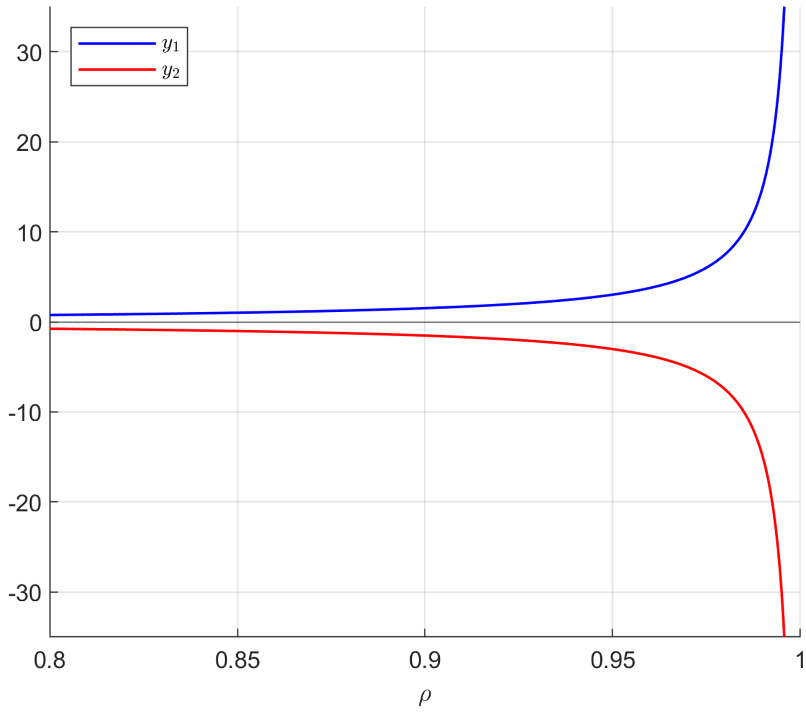
In the bottom panel of Figure 6 we illustrate the stress dynamics in the context of a backward-looking VaR rule typically used by financial market participants (see Shin (2010)). The stress dynamics feature a propagation due to the interaction between asset sales and margin requirements leading to further de-leveraging. The starting point A represents an initial, highly leveraged position before the arrival of a shock in the form of a sale of asset 1. For illustrative purposes, the parameter h gives the slope of the relationship between the deleveraging by the investor and the decline in correlations. For instance, if investors use a backward-looking updating rule for the covariance matrix, as typically is the case in practice, the unwinding of long-short positions will result in a decline in correlations.

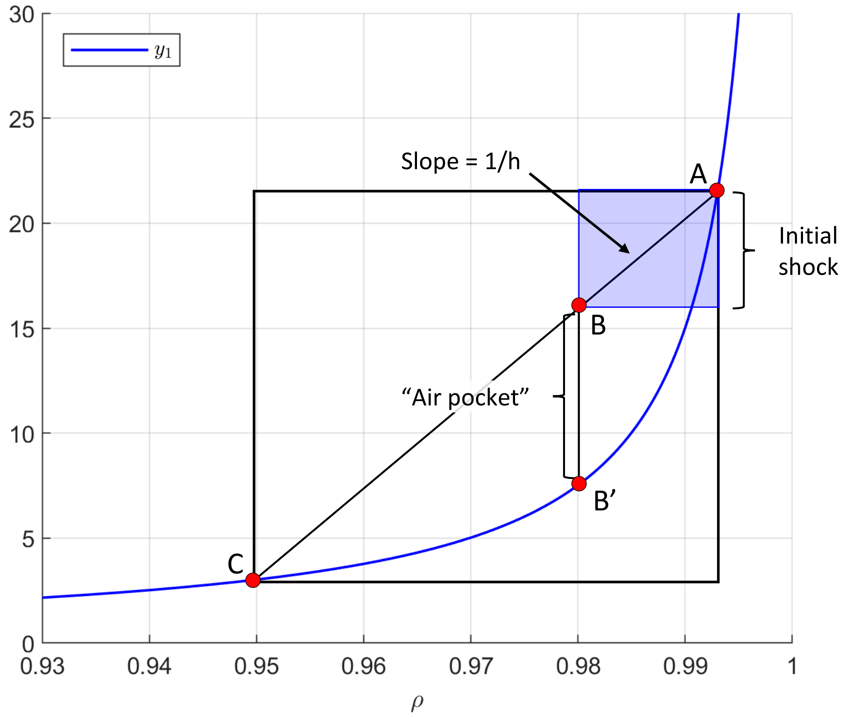
A decline in return correlation entails a tighter VaR constraint, resulting in a partial unwinding of the long-short position (that is, reducing the long position and covering part of the short position). The consequence of the initial shock is the shift from point A to point B in Figure 4. However, at the lower level of correlation associated with point B, the VaR constraint is not satisfied. The investor's position is too large. The investor hits an "airpocket" where additional position unwinds are necessary, i.e. a move in the positioning to point B'. However, this risk reduction sets in motion a further decline in correlation, entailing a further deleveraging. Hence an additional move along the curve down to point C is necessary for a new equilibrium to be reached. This type of feedback loop between leverage of long-short portfolios and a decline in correlations has figured from time to time in periods of market stress, such as during the turmoil in financial markets in 1998 associated with the hedge fund Long Term Capital Management. Similar declines in correlations were seen during the initial period of stress in bond markets in March 2020.

The flipside of this deleveraging mechanism is the increase in margins, which are just the

Figure 6: Illustration of relative-value trade dynamics.

The top panel depicts the optimal portfolio allocation between two bonds with different expected returns. As the correlation becomes progressively larger investors take very large positions in the bond with the highest expected return, funded by shorting the second bond. In the bottom panel, we illustrate how deleveraging affects positions and prices.





reciprocal of the asset positions. Indeed, the deleveraging dynamics sketched above entail a large shift from highly compressed margins to a situation with much higher margins and lower leverage. As Section 4 will show below, spikes in derivatives margins were an important element amid the dash for cash in March 2020.

3.3. Risk accounting

We now proceed to develop our risk accounting framework, building on the systemic accounting framework in Shin (2008). A key insight that emerges from our setup is that the "dash for cash" is the flipside of the fluctuations in margins. Intuitively, given fixed risk budgets for investors, an increase in margin requirements leads to a portfolio shift towards assets that have lower margins. Cash or cash equivalents (such as holdings of government MMF shares) have zero margins and therefore act as havens that attract large inflows. Even for non-leveraged investors, the imposition of economic capital constraints for assets result in similar shifts toward cash.

The main elements of our framework are as follows. There are J financial market participants (or "investors", for short) indexed by $j \in \{1, \cdots, J\}$. For investor j, we write x_{j} for the market value of j's debt, and denote by e_{j} the market value of its equity.

In addition to the liabilities of the investors, there are also S "outside" assets which are not the liabilities of any of the J financial market participants. We denote the market values of the outside assets as:

$$y_1, y_2, \cdots y_{\mathrm{S}}.$$

The asset portfolio of investor j is a $2J + S$ column vector consisting of the holdings of inside debt claims (J), inside equity claims (J) and the outside assets (S). The taxonomy of NBFIs can be built on these elements. For instance, a mutual fund issues only equity claims to investors, but could hold a wide range of assets. Hedge funds have both equity and debt claims outstanding, including short-term debt such as repos that may, in turn, be held by money market funds which issue equity claims to investors.

The asset portfolio of investor j is written as:

$$\left[\underbrace{\pi_{\mathrm{j1}}\mathrm{x}_1, \cdots, \pi_{\mathrm{jJ}}x_{\mathrm{J}}}_{\text{Inside debt claims}}\ ;\ \overbrace{\theta_{\mathrm{j1}}e_1, \cdots, \theta_{\mathrm{jJ}}e_{\mathrm{J}}}^{\text{Inside equity claims}}\ ;\ \underbrace{\phi_{\mathrm{j1}}y_1, \cdots, \phi_{\mathrm{jS}}y_{\mathrm{S}}}_{\text{Outside assets}}\right], \tag{9}$$

where π_{jk} is the proportion of x_{k} held by investor j, with $0 \leq \pi_{\mathrm{jk}} < 1$. θ_{jk} is the proportion of e_{k} held by investor j, and ϕ_{js} is the proportion of the outside asset y_{s} held by investor j (π_{jk} and θ_{jk} are equal to zero when $k = j$, that is own debt and equity do not contribute to net worth). The terms θ_{jk} and ϕ_{js} sum to 1, but they may take negative values indicating short-sales. Equation (9) captures the interconnectedness of NBFIs among each other and with other participants in the financial system that has been widely documented (see, e.g., Aldasoro, Huang, and Kemp (2020); FSB (2020a)).

3.3. Balance sheet identity and margin constraint

The balance sheet identity for investor j is given by:

$$\textstyle\sum_{\mathrm{k=1}}^{\mathrm{J}} \pi_{\mathrm{jk}}x_{\mathrm{k}} + \sum_{\mathrm{k=1}}^{\mathrm{J}} \theta_{\mathrm{jk}}e_{\mathrm{k}} + \sum_{\mathrm{s=1}}^{\mathrm{S}} \phi_{\mathrm{js}}y_{\mathrm{s}} = x_{\mathrm{j}} + e_{\mathrm{j}}. \tag{10}$$

Each asset has its own required margin in our accounting framework. In essence, this captures how much own economic capital the investor needs to put down for a position in the asset. For asset a, denote the margin required on a as $m^{(a)}$, where $0 \leq m^{(a)} < 1$. The total margin constraint for investor j can be written as:

$$\textstyle\sum_{\mathrm{k=1}}^{\mathrm{J}} \pi_{\mathrm{jk}}x_{\mathrm{k}}m_{\mathrm{k}}^{(x)} + \sum_{\mathrm{k=1}}^{\mathrm{J}} \theta_{\mathrm{jk}}e_{\mathrm{k}}m_{\mathrm{k}}^{(e)} + \sum_{\mathrm{s=1}}^{\mathrm{S}} \phi_{\mathrm{jk}}y_{\mathrm{s}}m_{\mathrm{s}}^{(y)} \leq \kappa_{\mathrm{j}} \leq e_{\mathrm{j}}, \tag{11}$$

where κ_{j} is the overall economic capital of investor j—the amount of equity capital allocated to the portfolio. The economic capital κ_j is bounded by the investor's equity e_{j}. The margin can be interpreted both as the margin required by the lender in a collateralised borrowing transaction, and also as the economic capital allocated to holding that asset even in the absence of any borrowing (say in a derivatives transaction). It is also instructive to consider the extreme case of cash holdings (commanding zero margin) or positions in near-money assets such as Treasury bills where haircuts also tend to be negligible. The difference between economic capital κ and equity e indicates the solvency buffer chosen by the institution, and is an additional dimension of the problem.

3.3. Debt capacity

Substituting (11) into (10) while setting κ_j equal to e_j, we can derive an upper bound on the debt of investor j, which we interpret as the investor's "debt capacity"

$$\begin{aligned} x_{\mathrm{j}} \quad \leq \quad & \sum_{\mathrm{k}=1}^{\mathrm{J}} \pi_{\mathrm{jk}} x_{\mathrm{k}} \left(1-m_{\mathrm{k}}^{(x)}\right) + \sum_{\mathrm{k}=1}^{\mathrm{J}} \theta_{\mathrm{jk}} e_{\mathrm{k}} \left(1-m_{\mathrm{k}}^{(e)}\right) \\ & + \sum_{\mathrm{s}=1}^{\mathrm{S}} \phi_{\mathrm{jk}} y_{\mathrm{k}} \left(1-m_{\mathrm{k}}^{(y)}\right). \end{aligned}$$

Using shorthand $\delta_{\cdot}^{(\cdot)} = 1 - m_{\cdot}^{(\cdot)}$ and writing this equation more compactly using matrix notation, we obtain:

$$\begin{aligned} x_{\mathrm{j}} \leq \quad & \begin{bmatrix} x_1 & \cdots & x_{\mathrm{J}} \end{bmatrix} diag\left(\delta_1^{(x)}, ..., \delta_{\mathrm{J}}^{(x)}\right) \begin{bmatrix} \pi_{\mathrm{j}1} & \cdots & \pi_{\mathrm{jJ}} \end{bmatrix}' \\ & + \begin{bmatrix} e_1 & \cdots & e_{\mathrm{J}} \end{bmatrix} diag\left(\delta_1^{(e)}, ..., \delta_{\mathrm{J}}^{(e)}\right) \begin{bmatrix} \theta_{\mathrm{j}1} & \cdots & \theta_{\mathrm{jJ}} \end{bmatrix}' \\ & + \begin{bmatrix} y_1 & \cdots & y_{\mathrm{J}} \end{bmatrix} diag\left(\delta_1^{(y)}, ..., \delta_{\mathrm{J}}^{(y)}\right) \begin{bmatrix} \phi_{\mathrm{j}1} & \cdots & \phi_{\mathrm{jJ}} \end{bmatrix}', \end{aligned}$$

where $diag(\cdot)$ is a diagonal matrix containing the indicated elements. This relation clearly indicates that the debt capacity of investor j is increasing in the debt capacity of all other investors, ie, leverage enables greater leverage.

Now, gather the x_{j} in the row vector $x = \begin{bmatrix} x_1 & \cdots & x_{\mathrm{J}} \end{bmatrix}$ and express the financial system's debt capacity as:

$$x \leq x\Delta_x \Pi + e\Delta_e \Theta + y\Delta_y \Phi, \tag{12}$$

where

$$\Delta_x = diag\left(\delta_1^{(x)}, ..., \delta_{\mathrm{J}}^{(x)}\right), \Delta_e = diag\left(\delta_1^{(e)}, ..., \delta_{\mathrm{J}}^{(e)}\right), \Delta_y = diag\left(\delta_1^{(y)}, ..., \delta_{\mathrm{J}}^{(y)}\right),$$

and Π, Θ, and Φ are matrices aggregating $[\pi_{j1}, \cdots, \pi_{jJ}]'$, $[\theta_{j1}, \cdots, \theta_{jJ}]'$, and $[\phi_{j1}, \cdots, \phi_{jS}]'$, respectively, across all js with each column representing an intermediary's holdings. By collecting the coefficients on x in equation (12), we can express system-wide debt capacity as follows:

$$
\begin{aligned}
x &\leq x\Delta_x\Pi + e\Delta_e\Theta + y\Delta_y\Phi \\
&= (I - \Delta_x\Pi)^{-1}(e\Delta_e\Theta + y\Delta_y\Phi) \\
&= \sum_{\mathrm{v}=0}^{\infty} (\Delta_x\Pi)^v (e\Delta_e\Theta + y\Delta_y\Phi)\,.
\end{aligned}
\tag{13}
$$

Equation (13) highlights that not only does debt capacity for a given intermediary depend on that of others, but that system-wide debt capacity also increases in the market price of assets. Quantitatively, a fall in margins has a larger impact on aggregate debt capacity due to the multiplicative effect of leverage through the system.[21] This last link emerges from the matrix Δ_x. As margins on the debt claims compress and Δ_x approaches unity, the debt capacity in the system can rise quickly, leading investors to increase risk-taking. By contrast, when margins spike (e.g. after a period of thin margins) debt capacity in the system can fall rapidly.

3.3. *Dash for cash as the flipside of deleveraging*

We now derive our second key result. As mentioned above, the portfolio choice of an investor can be seen as the choice of how to allocate scarce economic capital κ to each asset category. This risk budgeting problem is a useful way to frame the connection between deleveraging and the dash for cash. In many discussions, these two channels of stress propagation are introduced as two separate and distinct channels.

Recall the margin constraint for investor j:

$$
\textstyle\sum_{\mathrm{k}=1}^{\mathrm{J}} \pi_{\mathrm{jk}} x_k m_{\mathrm{k}}^{(x)} + \sum_{\mathrm{k}=1}^{\mathrm{J}} \theta_{\mathrm{jk}} e_k m_{\mathrm{k}}^{(e)} + \sum_{\mathrm{s}=1}^{S} \phi_{js} y_{\mathrm{s}} m_s^{(y)} \leq \kappa_j \leq e_j .
$$

Now, let y be the initial portfolio, $\widehat{y}$ be new portfolio, while margins increase from m to $\widehat{m}$ where $\widehat{m} \gneqq m$. The economic capital of the investor needs to be consistent with the new margins as well. Using $\kappa = \widehat{m}\widehat{y} = my$, and adding/subtracting $m\widehat{y}$ we obtain the following

[21]The inverse $(I - \Delta_x\Pi)^{-1}$ is well defined, as the rows of $\Delta_x\Pi$ sum to a number strictly less than 1, so that $\sum_{v=0}^{\infty} (\Delta_x\Pi)^v$ converges to a well-defined limit.

expression, where y_+ is the absolute value of y:

$$\underbrace{(\widehat{m} - m)}_{>0}\widehat{y}_+ + m\widehat{y}_+ = my_+ \;\Leftrightarrow$$

$$m\widehat{y}_+ < my_+.$$

When margins go up, investors' portfolios shift from high margin assets to low margin assets. The notional holdings of the fixed income assets $\widehat{y}$ will need to be adjusted downwards compared to previously. The margin constraint (11) makes it clear that a general increase in margins will force a shift of portfolio weights toward asset categories with low or zero margins, since previous positions cannot be sustained given a limited economic capital. Holdings of cash or cash equivalents with zero margin requirements take on great significance—the dash for cash emerges as a flip-side of the deleveraging induced by the spike in margins.

4. Liquidity imbalances during the March 2020 dash for cash

The disruptions caused by the Covid-19 pandemic greatly affected certain parts of the NBFI sector, leading to sudden and substantial liquidity imbalances (FSB (2020b)). In this section, we review selected events that occurred in early 2020, highlighting the links between our accounting framework and the dynamics that impinged on market liquidity. We start with the spike in margins (BCBS, CPMI, and IOSCO (2021)) that accompanied the substantial system-wide deleveraging. We then turn to cash hoarding by a broad variety of investment funds in the midst of a generalised "dash for cash".

CCPs rely on two types of margins to manage their exposures. The first are *initial* margins (IMs), which are posted when positions are established and are calculated based on potential future losses. IMs are particularly sensitive to changes in the risk backdrop, and when they spike liquid assets are shifted from investors to CCPs. The second are *variation* margins (VMs). Through VMs, the party that experienced losses in a derivatives transaction, transfers cash to the party that gained, resulting in a redistribution of liquid assets among investors.

As the pandemic shut down large swathes of the economy in early 2020, uncertainty in financial markets rose substantially. The VIX spiked to levels exceeding those at the height of the GFC. In this context, initial margins on many assets surged (Figure 7, top left panel; see Huang and Takáts (2020); Mittendorf, Neumeier, O'Neill, and Rahimi (2021); Wong and Zhang (2021)).

The rapid increase implied that, for a given amount of liquid assets available, investors were forced to scale down their positions rapidly, exacerbating liquidity imbalances. In order to meet rising liquidity demand, investors sold unusually large amounts of sovereign debt and also drew on money-market fund investments (Figure 7, top right panel). These dynamics clearly illustrated the mechanisms described in the first proposition derived in Section 3. The negative externalities from forced deleveraging onto prices were a consequence of a microprudential – as opposed to macroprudential – perspective towards margins.

Turning to the dash for cash in early 2020, the sudden flight to liquidity affected a broad set of securities and investment vehicles (Haddad, Moreira, and Muir (2020)). US prime MMFs, which hold short-term privately issued unsecured debt, saw substantial outflows, while those invested in government securities and reverse repo collateralised by sovereign bonds received large inflows (Figure 7, middle left panel). Such reallocation, which had important consequences for US and international borrowers (Eren, Schrimpf, and Sushko (2020a,b)), was partly driven by residual fragility even after post-GFC reforms improved the MMF resilience on many fronts (FSB (2021)). In particular, the presence of hard-wired liquidity thresholds that allow funds to impose gating can have undesired outcomes (Li, Li, Macchiavelli, and Zhou (2021)). Avoiding the mere possibility of gating can be so important that, as the thresholds get closer, managers engage in fire sales. While these factors reportedly did play a role, there is also evidence that MMFs that cater to large investors in particular experienced substantial withdrawals during March 2020, in a manner that was largely unrelated to funds' liquidity conditions.[22] These mechanisms are consistent with the second proposition of our framework, i.e. that assets with the lowest margins (in particular, cash) act as havens in episodes when the system-wide debt capacity shrinks.

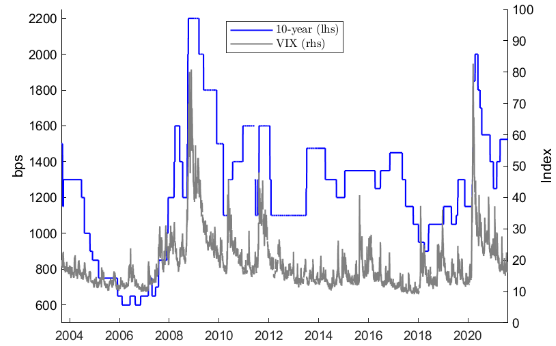
Such mechanisms were also present in corporate bond mutual funds that engaged in cash hoarding during the episode. These funds often reduce the risk of their portfolios at times of market distress (Cutura, Parise, and Schrimpf (2020)), and sales that increase cash holdings beyond the level needed to meet current redemptions are common (Morris, Shim, and Shin

[22]Indeed, there were only limited differences in outflows between funds with low and high asset liquidity (Figure 7, middle right panel; see Avalos and Xia (2021)).

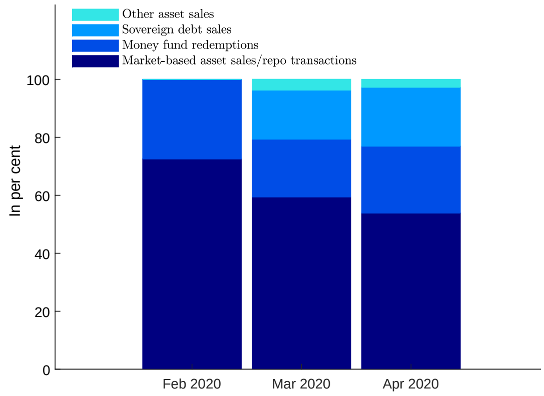
Figure 7: CCP margins and fund flows during the Covid-19 crisis.

The top left panel shows the implied volatility index VIX and the time series of initial margins set by CCPs for US 10-year (see Figure 12 in Barth and Kahn (2021)). The top right panel reports the relative shares of assets sold by investors to meet liquidity demands (from BCBS, CPMI, and IOSCO (2021). The middle left panel depicts flows into government MMFs and outflows from prime MMFs in early 2020. The middle right panel reports rescaled AUM for MMFs with different investor types and asset liquidity (from Avalos and Xia (2021)). The bottom panel show changes in cash holdings vs. investor flows for US (left) and emerging-market (right) mutual funds (from Schrimpf, Shim, and Shin (2021)).

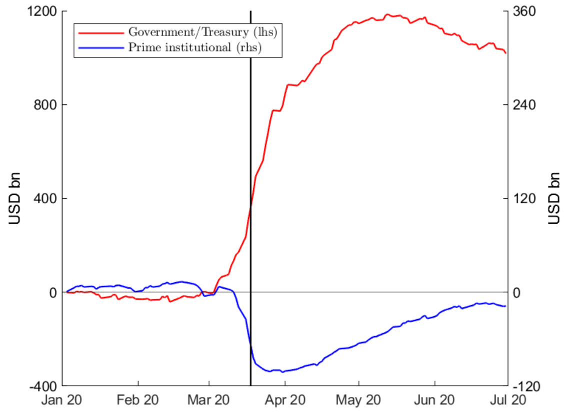
Margins on 10-year Treasury futures



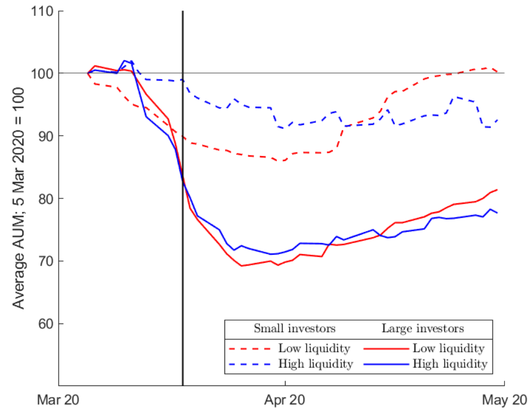
How investors met liquidity demands



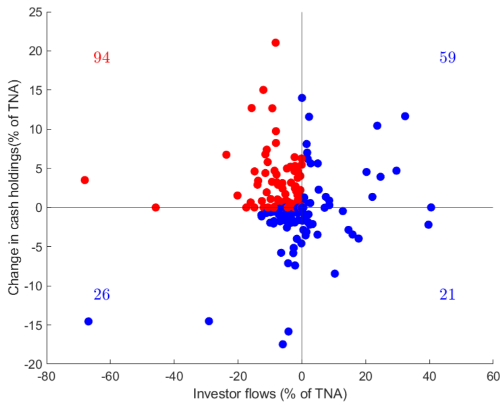
Flows into and out of US MMFs



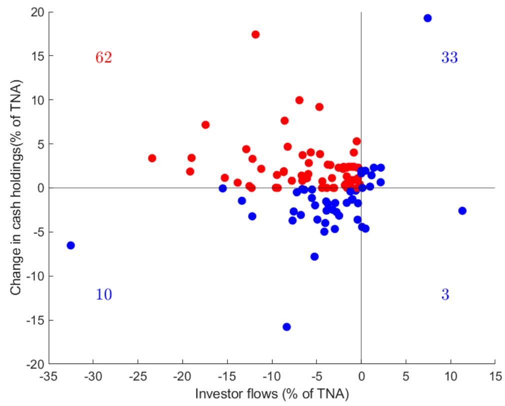
Limited effect of asset liquidity on flows



Cash changes and flows, US funds



Cash changes and flows, emerging-market funds



(2017)). During the Covid-19 crisis, corporate bond mutual funds experienced large and persistent outflows (Falato, Goldstein, and Hortaçsu (2021)) in early 2020, which led to price volatility in the underlying assets (Jiang, Li, Sun, and Wang (2020)). Cash holdings rose for many funds that saw net redemptions (Figure 7, bottom panels; see Schrimpf, Shim, and Shin (2021)), a pattern indicative of discretionary sales that likely exacerbated liquidity disruptions.

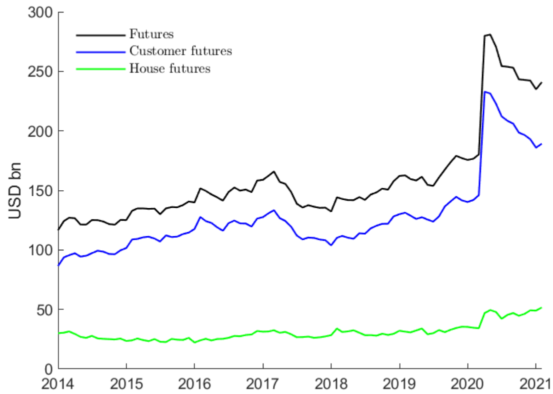
While they were by no means the only set of players that exerted liquidity demand pressure, position unwinds by hedge funds were an important contributor to one of the most notable episodes of market dysfunction during the early stages of the pandemic. In mid-March 2020, just as a number of intermediaries were shedding US Treasuries to raise cash (Ma, Xiao, and Zeng (2020), Vissing-Jorgensen (2021)), yields experienced a severe snap-back amid extreme turbulence, at a time when safe-haven flows would have normally led to a sharp fall in yields (Duffie (2020); Hauser (2020); Schrimpf, Shin, and Sushko (2020)). Treasury market illiquidity was exceptionally high, especially for less liquid off-the-run bonds in the dealer-to-customer segment, as broker dealers faced a 50% increase in daily customer transactions relative to February (Logan (2020)). Still, bank-affiliated broker-dealers increased their credit to hedge funds compared to other lenders. At the same time, futures margins surged (Figure 8, top left panel), in the context of a roughly \$300 billion increase in initial margins requested by CCPs between early February and mid-March (Figure 8, top right panel; see BCBS, CPMI, and IOSCO (2021)). This figure also included a generally unanticipated rise in "add-on" requirements related to liquidity and concentration risks. Besides experiencing large losses that required asset sales to reduce leverage, hedge funds that specialised in fixed-income arbitrage disposed of US Treasuries to ramp up cash buffers, especially if they faced shorter redemption notice periods (Kruttli, Monin, Petrasek, and Watugala (2021)). This precautionary behaviour led to a reduction in hedge funds' liquidity provision, contributing to unusual volatility in one of the deepest global markets.

As discussed above, hedge funds had become a linchpin of the ecosystem that supported US Treasury liquidity mostly thanks to the popularity of relative-value trades. These transactions involved buying relatively cheap cash bonds and selling relatively expensive futures. To render these trades profitable, substantial amounts of leverage are required. Indeed, leveraged investors expanded their short futures positions rapidly starting in 2018 (Figure 8, bottom left panel). From 2018, hedge funds became more active in funding their positions

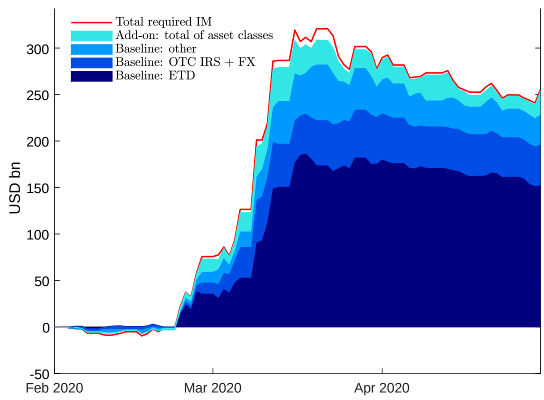
Figure 8: US Treasury market: 2020 disruptions and investors' positioning.

In the top row, the left panel shows futures margins and the right panel depicts the cumulated change in initial margins required by CCPs, starting from 1 February 2020 (ETD, OTC, IRS, FX and IM stand for, respectively, exchange-traded funds, over-the-counter, interest rate swaps, foreign exchange, and initial margins). The latter chart is from BCBS, CPMI, and IOSCO (2021). In the bottom row, the left panel reports the net positions in US Treasury futures of various intermediaries, while the right panel shows the amount of repo, including those cleared by the FICC, held by US MMF. The data are from the CFTC, the Office of Financial Research and IOSCO Financial Stability Engagement Group's Data Working Group survey of CCPs.

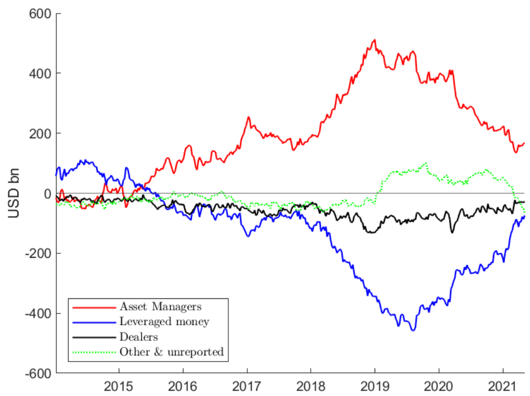
Futures margins spiked



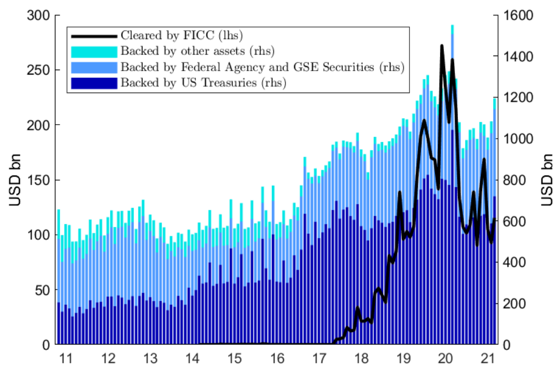
Cumulative initial-margins change from 1 February 2020



Net positioning of traders in US Treasury futures



MMF funded large amounts of sponsored repo



with capital-efficient “sponsored repo”, which is routed through a clearing platform and is often funded by MMFs (Figure 8, bottom right panel).[23]

The dislocations that occurred in the Treasury market in early 2020 are a stark illustration that a dash for cash – the flip-side of deleveraging, as discussed in Section 3 – can render liquidity provision by NBFIs fleeting. In turn, the impairment of liquidity/maturity transformation can put pressure on prices, feeding a spiral that only central banks with their flexible balance sheets could arrest, as was the case with massive interventions by the Federal Reserve in 2020.

5. Policy considerations and conclusions

The changes in market-based intermediation over the past decade, which we analysed through our conceptual framework, raise a number of policy and open research questions that we sketch in this section.

The greater footprint of NBFIs increases the importance of regulations that are consistent – or “congruent” (Metrick and Tarullo (2021)) – across activities rather than legal charters. Metrick and Tarullo’s proposal builds on the example of the US Treasury market, which underwent structural changes in recent years. These included the complementary risk warehousing function provided by hedge funds’ cash-futures basis trades, as discussed in Sections 1 and 4. Furthermore, they highlight the increased importance of central clearing of Treasury repos that has facilitated the establishment of leveraged positions by hedge funds that combine long positions in cash Treasuries with short futures positions. These more complex ways of taking exposure in a given market make it harder to track total exposures and the build-up of risk in the system, in particular as popular trades change over time. A key goal of congruent regulation is to formulate a more holistic approach that allows to gauge the risk-taking capacity of the system as a whole. In this context, the leverage ratio of the Basel

[23] Following 2017 regulatory changes, access to sponsored repo was extended to entities domiciled outside of the United States (Metrick and Tarullo (2021) and SEC (2017)). Hedge funds are often domiciled in the Caribbean region (Barth, Joenvaara, Kauppila, and Wermers (2020)), even though their main operations may be located elsewhere. The sponsored repo service was also attractive from the perspective of dealers due to the reduced balance sheet cost that comes from the ability of netting. As such, the introduction of cleared repo can be seen as freeing up extra debt capacity in the system that can be used for leverage. Indeed, soon after these changes, the use of sponsored repo grew rapidly, while positions in futures markets by levered investors grew strongly.

III bank capital rules assumes an organising conceptual role (also see the discussion in Borio, Farag, and Tarashev, 2020).

A important implication of taking a broad-based perspective is that containing solvency risk and addressing investor protection is not sufficient by itself to contain systemic risk. Systemic risk arises from externalities that the distress of a market participant imposes on others, be it in terms of non-fundamental price movements or declines in liquidity provision. As we show in Section 3, even if defaults are absent, price spillovers can be a potent source of systemic risk. A pure solvency-based perspective is hence of limited use, since it ignores the externalities and feedback effects that underpin system risk (Danielsson, Shin, and Zigrand (2004)). This calls for a macroprudential approach toward NBFI regulation (Carstens (2021)).

In the new market intermediation ecosystem, margin requirements take on a pivotal role for the propagation of financial conditions through fluctuations in leverage. Their evolution over time is especially important given the liquidity demand pressures that sudden spikes can generate in the system. When volatility surges, CCPs raise initial margin requirements to protect their own solvency, a mechanism that was an important element of the dash for cash during the Covid-19 crisis (see, e.g., Schrimpf, Shin, and Sushko (2020)). As shown in our framework in Section 3, such spikes in margins amount to a sudden reduction in risk-taking capacity, imposing externalities on other market participants. In leaning against excessive pro-cyclicality, minimum initial margins could limit the increase in leverage during good times and dampen the ensuing contraction in bad times.[24] Just as with bank leverage, reducing excessive pro-cyclicality would also limit the incidence of externalities – that is, it would lower systemic risk. Work is underway to address the identified vulnerabilities around margining practices (BCBS, CPMI, and IOSCO (2021)).

NBFI activities provide important benefits but are inherently fragile, since they often involve significant liquidity mismatches and leverage. Ex-ante polices that seek to reduce the likelihood and severity of liquidity crises, which often accompany rapid deleveraging, are hence a cornerstone in addressing the financial stability risks in NBFIs. Promoting appropriate levels of self-insurance by NBFIs is thus an important first line of defence. But, if it were not enough, improving regulation to contain the potential for liquidity imbalances

[24]There are several possible ways to assess and manage the effect of CCPs on liquidity at times of turmoil, including liquidity-focused stress testing (King, Nesmith, Paulson, and Prono (2019)) and augmenting margining models to explicitly consider and mitigate procyclicality (Murphy and Vause (2021)).

would be warranted. This may include implementing policies that seek to internalise the costs imposed on other market participants (e.g. when investors redeem funds at short notice) and, in some cases, measures to reduce liquidity mismatches and leverage in NBFIs.

Bolstering the resilience of liquidity also involves ensuring that the market infrastructure is robust and fit for purpose. In addition, it requires a strengthening of flexible nodes, such as banks, that are in a position to step in on the supply side in stress episodes.[25] It is hence important to ensure that constraints (either imposed by regulation or through internal risk management) do not bind for all players simultaneously and that buffers are usable at times of stress.

It is clear, however, that even though the policies sketched above will reduce the likelihood and severity of liquidity crises, it is highly unrealistic to expect them to eliminate such events altogether.[26] Hence, there remains a role for the central bank to step in as a "dealer of last resort", if the shock is very large and cannot be expected to be covered by private self-insurance mechanisms. Ex post interventions are indeed a powerful tool, especially as they – as seen through the prism of our framework – often effectively amount to propping up the debt capacity of the main participants in the system.[27]

But ex-post central bank actions are not a panacea. The difficulty of calibrating the size of the intervention is further compounded by implementation challenges and side effects. The operations themselves can be difficult to wind down, even if the source of market dysfunction is no longer present. To the extent that monetary policy is the only lever available to address market dysfunction, the monetary policy stance required by the macroeconomic backdrop may be less well aligned with the intervention needed to restore market functioning (see, e.g., the discussion in Hauser (2021)). Moreover, longer-lasting side effects cannot be ruled out. These could impinge on the market ecosystem through hysteresis, central banks' substitution for markets (Markets Committee (2019)), and weaker market discipline, with possible financial stability implications. There are also reputational issues for the central bank and political economy aspects to consider.

[25] See, e.g., Duffie (2020); Liang and Parkinson (2020) for recent reform proposals for improving the functioning of the US Treasury market.

[26] Fully eliminating the likelihood of such crises may not even be desirable as insurance also entails significant cost. See Adrian and Boyarchenko (2012) for a conceptual framework describing the trade-offs between systemic risk mitigation and costs of tighter risk constraints of financial intermediaries.

[27] During the euro debt crisis, the ECB implemented a range of collateral and haircut easing policies that – when seen through the prism of our framework – played an important stabilising role via the debt capacity channel. For further details on these policy innovations, see Bindseil, Corsi, Sahel, and Visser (2017).

Extending ex-ante backstop arrangements to NBFIs, e.g. by granting them access to standing facilities, would help ensure that liquidity percolates to the relevant parts of the financial system where it is needed (d'Avernas, Vandeweyer, and Pariès (2020)).[28] To limit the central bank's risk exposures, the facility could be restricted to loans secured by high-quality collateral (e.g., a standing repo facility that only accepts sovereign bonds, as advocated by Hubbard, Kohn, Goodman, Judge, Kashyap, Koijen, Masters, O'Connor, and Stein (2021).

However, when seen through the prism of our framework in Section 3, such backstop arrangements will also affect ex-ante system-wide risk capacity and leverage also in normal times. Any arrangements of this kind, even with carefully calibrated pricing, would therefore need to be complemented by a broader scope for regulations to keep moral hazard and risk-taking in check. And, as experience has repeatedly shown, in periods of turmoil the central bank may decide to accept low-rated securities as well, particularly if solvent systemically important institutions remained distressed after pledging all their top-rated collateral (Tucker (2009) makes this argument for banks). Knowing such likely outcome, market participants may decide to reduce self-insurance and hold poorer quality assets to begin with. Crucially, the reach of public backstops and the breadth of regulations are linked by an implicit *quid pro quo* between NBFIs and taxpayers, who ultimately are the providers of public backstops (Tucker (2014)). That is, any expanded access to the central bank balance sheet, and as such to the government purse, would need to come with the appropriate degree of regulation and supervision.

Open questions for policy and research. Finding the appropriate degree of public oversight on NBFIs, particularly from a macro-prudential perspective (Carstens (2021), involves balancing a number of trade-offs. Regulation fosters stability, but it is also costly and can weigh on intermediation capacity. Hence, an over-arching question is how to strike the optimal balance between the benefits (i.e. reduced likelihood of liquidity crises requiring ex-post interventions) and the costs of prudential regulation, including possible unintended consequences. When it comes to the role of central banks, a pressing issue relates to the extent, duration and design of central bank interventions. Since they potentially lead to a large

[28] Such expansion would increasingly blur the traditional two-tier structure of the financial system, where access to the central bank's credit facilities has typically been only granted to banks. Based on first principles, a case could be made also that NBFIs be granted more limited access to public backstops than banks. Such would be the case if the perceived societal benefits to the broader economy from the presence of NBFIs were deemed more limited than in the case of banks. For instance, NBFI's contribution to liquidity transformation and market-making could be considered more opportunistic and less reliable than those of banks.

intermediation footprint by the central bank, they may contribute to market distortions. A key point is therefore how best to balance market stability and some possible degree of inefficiency. Seeking answers to these questions constitute promising avenues for future research and policy work. Future research could also dig deeper into the specific mechanisms around feedback loops related to margins and their impact on system-wide deleveraging. Conceptually, such work could take our risk accounting framework a step further and cast it in a general equilibrium setting.

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