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Margins, debt capacity, and systemic risk*

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Abstract

Debt capacity depends on margins. When set in a financial system context with collateralized borrowing, two additional features emerge. The first is the recursive property of leverage whereby higher leverage by one player begets higher leverage overall, reflecting the nature of debt as collateral for others. The second feature is that the "dash for cash" is the mirror image of deleveraging. In any setting where market participants engage in margin budgeting, a generalized increase in margins entails a shift of the overall portfolio away from riskier to safer assets. These findings have important implications for the design of non-bank financial intermediary (NBFI) regulations and of central bank backstops.

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The interplay between margins and debt capacity is well-understood in the context of an individual investor. Lower margins enable greater borrowing, and hence higher leverage relative to the own funds of an investor.[1] In a financial system context where market participants borrow in wholesale funding markets by pledging collateral, debt has the dual property of being an asset of the creditor.

The purpose of this paper is to lay out a stylized accounting framework for system-wide debt capacity when debt serves the dual role of being both an obligation of the borrower, but also the collateral that the lender can pledge to secure additional funding.[2] Two features emerge from the analysis which shed light on systemic risk propagation.

The first is the recursive nature of debt capacity in which the debt capacity of one investor is increasing in the debt capacity of other investors. In this sense, leverage enables greater leverage. Conversely, deleveraging by one investor begets deleveraging by other investors, giving rise to a contraction in the leverage of the system as a whole. This recursive property of debt capacity is a reflection of the dual nature of debt as both an obligation of the borrower but also the collateral that the lender can pledge to secure further borrowing. The higher is borrowing, the more plentiful is collateral in the financial system. When leverage is high, there is an abundance of collateral that begets greater leverage. Conversely, deleveraging is associated with the scarcity of collateral, giving rise to diminished debt capacity in the system as a whole.

The second feature that emerges from our analysis is that deleveraging and the "dash for cash" are two sides of the same coin. In particular, when there is a generalized increase in margins across all assets in the financial system, there is a broad-based shift in the portfolio composition of investors from riskier assets with high margins toward cash-like assets with low margins. This feature turns out to be a remarkably robust feature of any setting and deleveraging does not depend on investor preferences or the nature of the underlying assets, but rather revolves around the margining budget constraint alone.

[1] When we use the term "margins" in this paper, we refer to both haircuts in collateralized borrowing (e.g., a repurchase agreement) or the capital posted to counterparty in order to maintain a partly unfunded exposure (e,g., a derivative contract).

[2] Our framework builds on the literature that studies how leverage fluctuations shape intermediation activity and systemic risk (see, for instance, Morris and Shin (2008); Geanakoplos (2009); Gorton and Metrick (2012); Adrian and Shin (2014)). Financial institutions typically manage risks to their solvency with a variety of tools, such as Value-at-Risk, that limit how much risk they can take. A decline in asset prices raises the leverage of financial institutions and their risk of insolvency, which is often countered by reducing debt and offloading some assets. As a result, balance-sheet capacity and intermediation activity shrink, further weighing on asset prices and potentially leading to additional deleveraging.

Our framework turns out to be particularly useful in studying the propagation of systemic risk with non-bank financial intermediaries (NBFIs) that rely on collateralized borrowing or synthetic leverage in derivatives markets. Traditionally, systemic risk narratives have relied on the "domino" model of cascading 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. 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)) – as evident during the Covid-19 crisis – in another core theme of our discussion.

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. An accounting framework for debt capacity

The key idea underpinning our work 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 summarized 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 generalized 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". The reason is that a generalized increase in margins across assets sets off a re-allocation of scarce economic capital, whereby investors rebalance their portfolios toward 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 channel emerge as two sides of the same coin, rather than being two separate and distinct channels.

1.1. Optimal portfolios with Value-at-Risk constraint

We now detail the portfolio choice problem that underlies our risk allocation framework. Consider an investor who is risk-neutral and maximises expected returns, while facing a

Value-at-Risk (VaR)[3] 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 returns 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 larger risks.

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 portfolio.

The Lagrangian for this problem is:

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

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

[3] 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.

expected return normalized 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 at the margin.

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 portfolio is proportional to the economic capital κ, so that a doubling a economic capital entails a doubling of the optimal holdings. Positions are also decreasing in the tightness of the imposed risk-constraint, α, and will be a function of the volatilities and covariances of asset returns, as captured by the Σ matrix.

1.2. 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 results 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 building blocks of this framework can be mapped into the balance sheets of key NBFIs. 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:

$$\left[\underbrace{\pi_{\mathrm{j1}}\mathrm{x}_1, \cdots, \pi_{\mathrm{jJ}} x_{\mathrm{J}}}_{\text{Inside debt claims}} ; \overbrace{\theta_{\mathrm{j1}} e_1, \cdots, \theta_{\mathrm{jJ}} e_{\mathrm{J}}}^{\text{Inside equity claims}} ; \underbrace{\phi_{\mathrm{j1}} y_1, \cdots, \phi_{\mathrm{jS}} y_{\mathrm{S}}}_{\text{Outside assets}} \right], \tag{6}$$

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 (6) 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 (2020)).

1.2. Balance sheet identity and margin constraint

The balance sheet identity for investor j is given by:

$$\textstyle\sum_{\mathrm{k}=1}^{\mathrm{J}} \pi_{\mathrm{jk}} x_{\mathrm{k}} + \sum_{\mathrm{k}=1}^{\mathrm{J}} \theta_{\mathrm{jk}} e_{\mathrm{k}} + \sum_{\mathrm{s}=1}^{\mathrm{S}} \phi_{\mathrm{js}} y_{\mathrm{s}} = x_{\mathrm{j}} + e_{\mathrm{j}}. \tag{7}$$

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:

$$\textstyle\sum_{\mathrm{k}=1}^{\mathrm{J}} \pi_{\mathrm{jk}} x_{\mathrm{k}} m_{\mathrm{k}}^{(x)} + \sum_{\mathrm{k}=1}^{\mathrm{J}} \theta_{\mathrm{jk}} e_{\mathrm{k}} m_{\mathrm{k}}^{(e)} + \sum_{\mathrm{s}=1}^{\mathrm{S}} \phi_{\mathrm{jk}} y_{\mathrm{s}} m_{\mathrm{s}}^{(y)} \leq \kappa_{\mathrm{j}} \leq e_{\mathrm{j}}, \tag{8}$$

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. As noted in the introduction, the margin can be interpreted both as the haircut required by the lender in a collateralized 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.

1.2. Debt capacity

Substituting (8) into (7) 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"

$$\begin{aligned} x_j \leq & \sum_{k=1}^{J} \pi_{jk} x_k \left(1 - m_k^{(x)}\right) + \sum_{k=1}^{J} \theta_{jk} e_k \left(1 - m_k^{(e)}\right) \\ & + \sum_{s=1}^{S} \phi_{jk} y_k \left(1 - m_k^{(y)}\right). \end{aligned}$$

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

$$\begin{aligned} x_j \leq & \begin{bmatrix} x_1 & \cdots & x_J \end{bmatrix} diag\left(\delta_1^{(x)}, ..., \delta_J^{(x)}\right) \begin{bmatrix} \pi_{j1} & \cdots & \pi_{jJ} \end{bmatrix}' \\ & + \begin{bmatrix} e_1 & \cdots & e_J \end{bmatrix} diag\left(\delta_1^{(e)}, ..., \delta_J^{(e)}\right) \begin{bmatrix} \theta_{j1} & \cdots & \theta_{jJ} \end{bmatrix}' \\ & + \begin{bmatrix} y_1 & \cdots & y_J \end{bmatrix} diag\left(\delta_1^{(y)}, ..., \delta_J^{(y)}\right) \begin{bmatrix} \phi_{j1} & \cdots & \phi_{jJ} \end{bmatrix}', \end{aligned}$$

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 $x = \begin{bmatrix} x_1 & \cdots & x_J \end{bmatrix}$ and express the financial system's debt capacity as:

$$x \leq x\Delta_x\Pi + e\Delta_e\Theta + y\Delta_y\Phi, \tag{9}$$

where

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

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 (9), we can express system-wide debt capacity as follows:

$$\begin{aligned} x &\leq x\Delta_x\Pi + e\Delta_e\Theta + y\Delta_y\Phi \\ &= (I - \Delta_x\Pi)^{-1}(e\Delta_e\Theta + y\Delta_y\Phi) \\ &= \sum_{\text{v}=0}^{\infty}(\Delta_x\Pi)^v(e\Delta_e\Theta + y\Delta_y\Phi). \end{aligned} \tag{10}$$

Equation (10) 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.[4] This last link emerges from the matrix Δ_x. As margins on debt claims compress and Δ_x approaches unity, debt capacity in the system can rise quickly, leading investors to increase risk-taking. By contrast, system-wide debt capacity can fall rapidly when margins spike, especially after a prolonged period of low margins.

1.2. 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

[4]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.

introduced as two separate and distinct channels.

Recall the margin constraint for investor j:

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

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 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 downward. The constraint (8) 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 increase as a share of the portfolio—the dash for cash emerges as a flip-side of the deleveraging induced by the spike in margins.

1.3. 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. 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:

$$\Sigma = \begin{bmatrix} z+c & c & \cdots & c \\ c & z+c & \cdots & c \\ \vdots & \vdots & \ddots & \vdots \\ c & c & \cdots & z+c \end{bmatrix}, \tag{11}$$

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:

$$\Sigma^{-1} = \frac{1}{z^2 + Ncz} \begin{bmatrix} z+(N-1)\,c & -c & \cdots & -c \\ -c & z+(N-1)\,c & \cdots & -c \\ \vdots & \vdots & \ddots & \vdots \\ -c & -c & \cdots & z+(N-1)\,c \end{bmatrix}, \tag{12}$$

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 comparative-static analysis 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 (12), the position for asset i becomes:

$$y_{\mathrm{i}} = \frac{\kappa}{\alpha\left(z^2 + Ncz\right)\sqrt{\mu'\Sigma^{-1}\mu}} \left(z\mu_i + c\sum_{k\neq i}\left(\mu_i - \mu_k\right)\right) \tag{13}$$

As Equation (13) shows, the optimal holding is driven by the difference between expected returns across the set of assets, scaled by a constant. Note that as $z \to 0$, $\rho \to 1$, 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 $\rho = \frac{1}{1+z}$.

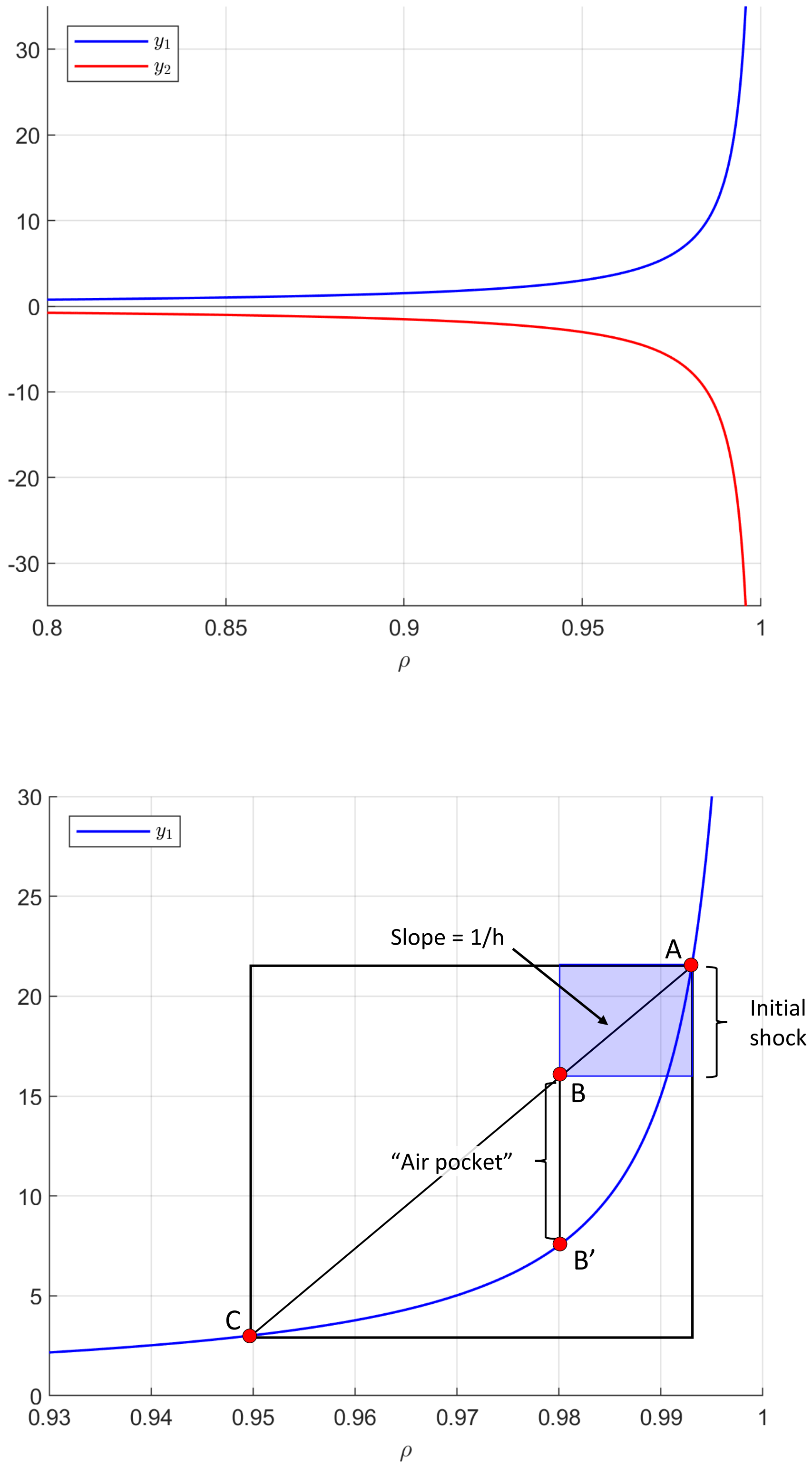
The top panel in Figure 1 shows the positions in the two bonds as z becomes small and the correlation in the bond returns ρ approaches one. As the economic capital κ is normalized to one, the change in the long-short position leads to a 1:1 change in leverage. As the graph shows, the position size of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

In the bottom panel of Figure 1, we illustrate the stress dynamics in the context of a backward-looking VaR rule often used by financial market participants (see Shin (2010)). Stress propagates because the interaction of asset sales and margin requirements leads to further deleveraging. 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 deleveraging by the investor and the decline in correlations. For instance, the use backward-looking updating rules for the covariance matrix, which is common in practice, implies that 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 observed during the initial period of stress in bond markets in March 2020.

Figure 1: 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.



2. Empirical illustration

In this section, we use the insights from our risk accounting framework to provide a unifying perspective on the liquidity imbalances that emerged as a result of the broad disruptions caused by the emergence of the Covid-19 pandemic in early 2020.

In an apparently counter-intuitive development, yields in US Treasury markets experienced a severe snap-back amid extreme turbulence in March 2020, at a time when safe-haven flows would have otherwise led to a sharp fall in yields (Duffie (2020)). While a variety of players were liquidating US Treasuries at the time (Ma, Xiao, and Zeng (2020), Vissing-Jorgensen (2021)), position unwinds by hedge funds were an important contributor to the market dysfunction during the episode (FSB (2022)). Crucially, in the run-up to the pandemic, hedge funds had become key providers of liquidity for US Treasuries. They did so through popular relative-value trades (Schrimpf, Shin, and Sushko (2020); Barth and Kahn (2021)). These transactions involved taking long positions in relatively cheap cash bonds and short positions in relatively expensive futures.[5] Starting in 2018, leveraged investors, a category that includes hedge funds, expanded their short futures positions rapidly (Figure 2, top left chart). Hedge funds used substantial leverage to make these trades profitable, typically relying on repo borrowing.

As a result, when the Covid-19 pandemic struck, a substantial amount of US Treasury positions were vulnerable to the deleveraging dynamics described by our risk accounting framework. Just as volatility in markets rose, margins for US Treasury futures spiked (Figure 2, top right chart). Investors were forced to scale down their positions rapidly, overwhelming dealers' capacity to intermediates and thus contributing to imbalances in market liquidity.

These dynamics clearly exemplify the first proposition that we derived in Section 1. The negative externalities from forced deleveraging onto prices were a consequence of a microprudential – as opposed to macroprudential – perspective toward margins.

Sharp rises in margins were not limited to the market for US Treasury futures, but were broad for positions opened by CCP clients (Figure 2, middle left chart) (see Huang and Takáts (2020); Mittendorf, Neumeier, O'Neill, and Rahimi (2021); Wong and Zhang (2021)).

[5] The profitability of relative-value trades was rooted in the slight discount embedded in Treasury prices relative to corresponding futures, mostly reflecting large issuance of federal debt and limited broker-dealer intermediation following the GFC.

Increases in initial margins, which are mostly driven by recent events (Cohen and Tracol (2023)), proved considerably more persistent than changes in variation margins (see Figure 2, middle right chart for an example related to interest rate swaps, courtesy of Cohen and Tracol (2023)). On balance, initial margins requested by CCPs in derivatives markets surged by as much as $300 billion between early February and mid-March (see BCBS, CPMI, and IOSCO (2021); see Figure 2, bottom left chart).[6]

Besides selling Treasuries due to forced deleveraging, hedge funds also ramped up their cash buffers, especially if they offered shorter redemption notices periods (Kruttli, Monin, Petrasek, and Watugala (2021)). Many market participants sought refuge in cash by selling unusually large amounts of sovereign debt and also drawing on prime money-market funds (MMFs), all the while government MMFs saw significant inflows (Figure 2, bottom right chart)) (Haddad, Moreira, and Muir (2020), Eren, Schrimpf, and Sushko (2020a,b) Avalos and Xia (2021)).

The shift towards low margin assets – notably cash, short-dated government paper and MMFs – illustrates the second proposition of our framework: deleveraging due to spikes in margins and dash for cash are two sides of the same coin, rather than being distinct channels of systemic risk propagation. Furthermore, a dash for cash can render liquidity provision by NBFIs fleeting and can add to the effect of disruptions in liquidity/maturity transformation on prices, feeding a spiral.

3. Conclusion

Systemic risk is born out of externalities that originate from the distress faced by a market participant and that adversely affect others, typically in the form of non-fundamental price movements. The propagation of systemic risk does not require insolvency, and can be routed through disruptions to liquidity/maturity transformation or through fluctuations in leverage that magnify changes in prices and intermediation activity.

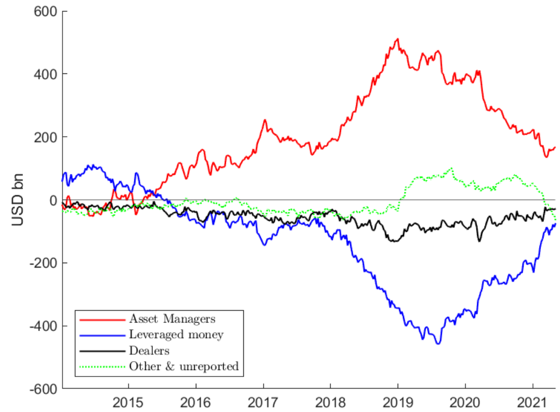
Over the past decades, non-bank financial intermedaries have become increasingly central in the supply of credit and liquidity. Collateralized borrowing, such as repurchase agreements,

[6] This figure also includes a generally unanticipated rise in "add-on" requirements related to liquidity and concentration risks.

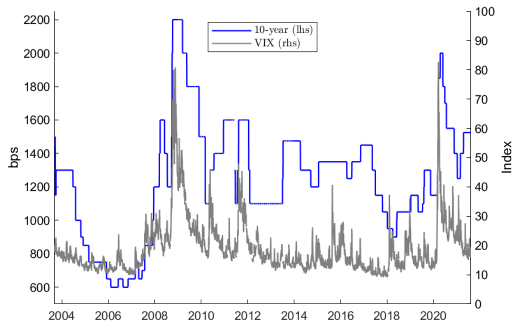
Figure 2: The Covid-10 pandemic led to broad delevergaing and to a dash for cash

In the top row, the left panel reports the net positions in US Treasury futures of various intermediaries (from the CFTC) and the right panel panel shows the implied volatility index VIX and initial margins set by CCPs for US 10-year (see Figure 12 in Barth and Kahn (2021)). In the middle row, the left panel panel displays futures margins (from the CFTC). The right panel reports initial and variation margins for hypothetical interest rate swap positions (see Cohen and Tracol (2023)). In the bottom row, the left panel the 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 derivatives, over-the-counter, interest rate swaps, foreign exchange, and initial margins). The latter chart is from BCBS, CPMI, and IOSCO (2021). The right panel shows flows into government MMFs and outflows from prime MMFs in early 2020 (from Avalos and Xia (2021)).

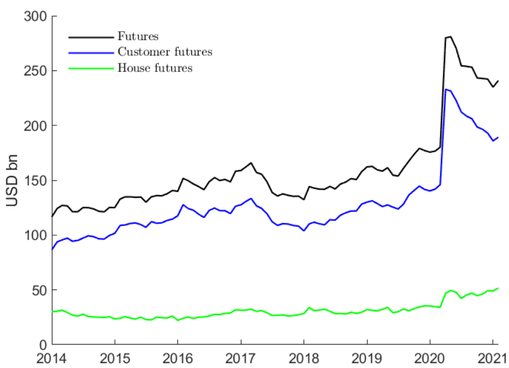
Positioning in US Treasury futures



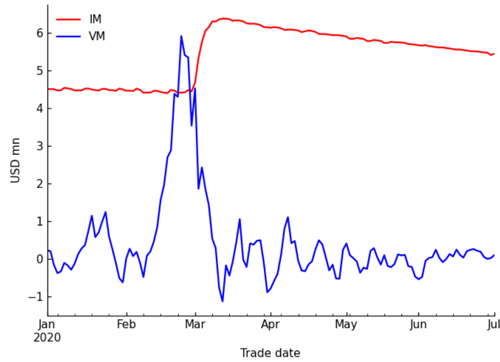
Margins on 10-year Treasury futures



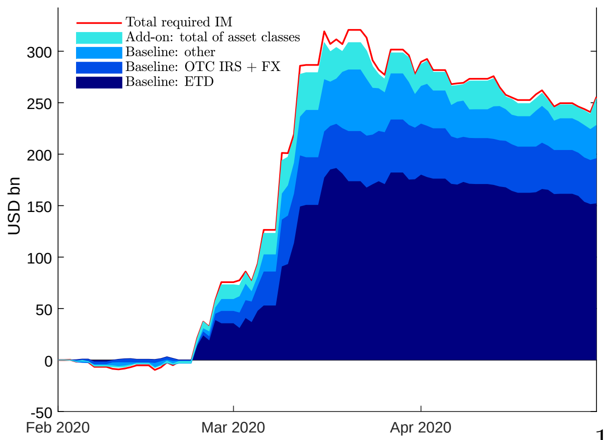
Futures margins



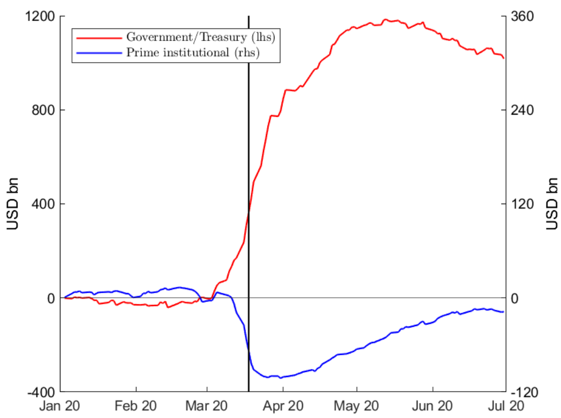
VM and IM surge in interest rate swaps



Cumulative changes in initial margins



Dash for cash and flows into government MMFs



and partially funded exposures, such as centralized or over-the-counter derivatives, are instrumental to the activity of NBFIs. In both instances, margins determine the debt capacity of intermediaries. For a given amount of capital available, margins are directly linked to the risk that market participants can take and the liquidity they can provide.

We develop a stylized risk accounting framework to explore how spikes in margins affect system-wide risk taking capacity and liquidity. We find that the recursive nature of debt capacity – namely, that higher leverage by one investor allows others to increase their leverage – magnifies fluctuations in financial activity and generates procyclicality. We also find that sudden reallocation from risky assets to safe havens (dash for cash) is a manifestation of deleveraging.

From a regulatory perspective, the presence of externalities highlights the importance of macroprudential policies. Leaning against procyclicalty generated by leverage fluctuations can potentially take the form of minimum initial margins, which would constrain leverage increases and dampen the ensuing declines.[7] Such provisions would complement appropriate self-insurance against adverse shocks, so to minimize the need for leverage adjustments in response to shocks. In the presence of very large shocks, the public sector – in particular central banks given their flexible balance sheet – may need to provide backstops (Markets Committee (2018)), thereby supporting debt capacity. Such prospect can alter behaviors and ex-ante incentives to self insure. Hence it is important to make sure that any public backstops be accompanied by an appropriate regulatory framework.

[7]For examples of regulatory work on this topic, see BCBS, CPMI, and IOSCO (2021).

References

Adrian, T., and HS. Shin, 2014, "Procyclicaly Leverage and Value-at-Risk," *Review of Financial Studies*, 27, 272–403.

Aldasoro, I., W. Huang, and E. Kemp, 2020, "Cross-border Links between Banks and Non-Bank Financial Institutions," *BIS Quarterly Review*, September, 61–74.

Avalos, F., and D. Xia, 2021, "Investor Size, Liquidity and Prime Money Market Fund Stress," *BIS Quarterly Review*, March.

Barth, D., and J. Kahn, 2021, "Hedge Funds and the Treasury Cash-Futures Disconnect," *Working paper.*

BCBS, CPMI, and IOSCO, 2021, "Review of margining practices," *Consultative report, Basel Committee on Banking Supervision, Committee on Payments and Market Infrastructures and Board of the International Organization of Securities Commissions.*

Cohen, B., and K. Tracol, 2023, "Market turbulence and soaring margins: lessons from two recent episodes," *BIS Quarterly Review*, February.

Duffie, D., 2020, "Still the World's Safe Haven?," *Hutchins Center Working Paper #62.*

Eren, E., A. Schrimpf, and V. Sushko, 2020a, "US Dollar Funding Markets during the Covid-19 Crisis - the International Dimension," *BIS Bulletin*, 15.

——— , 2020b, "US Dollar Funding Markets during the Covid-19 Crisis - the Money Market Fund Turmoil," *BIS Bulletin*, 14.

FSB, 2020, "Global Monitoring Report on Non-Bank Financial Intermediation," *Financial Stability Board Report, 16 December.*

——— , 2022, "Liquidity in core government bond markets," *Financial Stability Board Report, 20 October.*

Geanakoplos, J., 2009, "The Leverage Cycle," *NBER Macroeconomics Annual*, 24, 1–66.

Gorton, G., and A. Metrick, 2012, "Securitized Banking and the Run on Repo," *Journal of Financial Economics*, 104, 425–451.

Haddad, V., A. Moreira, and T. Muir, 2020, "When Selling Becomes Viral: Disruptions in Debt Markets in the COVID-19 Crisis and the Fed's Response," *NBER Working paper 27168.*

Huang, W., and E. Takáts, 2020, "The CCP-Bank Nexus in the Time of Covid-19," *BIS Bulletin*, 13.

Kruttli, M., P. Monin, L. Petrasek, and S. Watugala, 2021, "Hedge Fund Treasury Trading and Funding Fragility: Evidence from the COVID-19 Crisis," *Working paper.*

Ma, Y., K. Xiao, and Y. Zeng, 2020, "Mutual Fund Liquidity Transformation and Reverse Flight to Liquidity," *Jacobs Levy Equity Management Center for Quantitative Financial Research Paper.*

Markets Committee, 2018, "Monitoring of Fast-Paced Electronic Markets," *Markets Committee Papers*, 10.

Mittendorf, D., C. Neumeier, P. O'Neill, and K. Rahimi, 2021, "Capital Market Liquidity in the 2020 Coronavirus Crisis," *Research Note, Financial Conduct Authority.*

Morris, S., and HS. Shin, 2008, "Financial Regulation in a Systemic Context," *Brookings Papers on Economic Activity*, Fall, 229–261.

Schrimpf, A., HS. Shin, and V. Sushko, 2020, "Leverage and Margin Spirals in Fixed Income Markets during the COvid-19 Crisis," *BIS Bulletin*, 2.

Shin, HS., 2008, "Risk and Liquidity in a System Context," *Journal of Financial Intermediation*, 17, 315–329.

——— , 2010, *Risk and Liquidity.* Clarendon Lectures in Finance, Oxford University Press.

Vissing-Jorgensen, A., 2021, "The Treasury Market in Spring 2020 and the Response of the Federal Reserve," *Working paper.*

Wong, L., and Y. Zhang, 2021, "Procyclicality Control in Risk-based Margin Models," *Journal of Risk*, 23, 1–24.

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