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Bank Capital Structure, Valuation Adjustments and Financial Market Liquidity

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Abstract

Valuation adjustments (XVAs) to systemic US banks' derivatives portfolios - caused by swings in their own creditworthiness and that of their clients; for example, COVID-19 has had a significant impact on their revenues and, therefore, market intermediation. This paper studies the implications of funding value adjustments (FVA) on banks' equity holders. Indeed, it is important to understand this implication, as dealers work in the interests of their shareholders. Therefore, intermediation could result in impairment when that cannot be achieved due to friction. Our findings offer critical insights into how financial institutions navigate valuation adjustments and their impact on banks' balance sheets and discuss policy implications related to the main results.

Keywords: XVA, Banking, Financial Markets

Classification codes: G12, G21, G32, E44, F31

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1 Executive Summary

The aftermath of the 2008 global financial crisis has had Basel III at its core; the objective was to strengthen the resilience of the banking system. To reach this goal, the new regulatory framework asked shareholders to give up high leverage as a source of high returns on equity. At the same time, it asked bondholders, especially those of systemically important institutions, to take more of a hit at default. In this light, it is easy enough to imagine that investors would have little reason to hail the new framework. Therefore, banks had to rethink their business models and change market practices and the way they used to do business. One important change happened with the introduction of funding valuation adjustments.

Following the 2008 global financial crisis, for example, in 2016, but also during the COVID-19 pandemic and the Russia-Ukraine war, valuation adjustments have led to significant losses for banks. This policy paper studies the impact of Funding Value Adjustments (FVA) and Margin Value Adjustments (MVA) using a simple bank's balance sheet framework. It aims to better understand how these adjustments relate to banks' equity holders and provide an interpretation for these adjustments that is coherent with economic theory. In so doing, we shed further light and stress the policy implications of recent research in this area (Burgard & Kjaer 2013, Hull & White 2014, Albanese & Andersen 2014, Andersen et al. 2019).

The paper rests on two parts. In the first part, we discuss FVA. To be more precise, we discuss Funding Cost Adjustments (FCA) and Funding Benefit adjustments (FBA). As for FCA, these adjustments have been at the centre of academic and industry discussions since 2013 (Burgard & Kjaer 2013, Hull & White 2014, Albanese & Andersen 2014, Andersen et al. 2019).

Although accounting bodies and the industry have now accepted using these adjustments, there are still issues which, as we shall discuss, are unclear, and their impact on financial intermediation is largely unexplored. One of the contributions of this paper is to provide academics with an economic framework which could be useful in developing theoretical (empirical) models and testing the effects of these frictions on asset prices, liquidity, and financial intermediation in a general sense.

As discussed in Andersen et al. (2019) and also in this paper, FCAs introduce what is known as the debt overhang cost to banks' shareholders. Debt overhang cost was first noted in Myers (1977). Myres noted that shareholders might be reluctant to finance a new project with new debt, even in the case when its net present value is positive, as a large part of the benefit of the project will accrue to the new creditors. That reflects the fact that banks' shareholders receive no payoff if the dealer defaults, but they pay a funding cost to creditors if the dealer survives. Andersen et al. (2019) and our paper show that this cost is approximately equal to the dealer's credit spread.

We explain why this cost should not be part of the dealer's **P&L** but rather should be accounted for in the equity section of the balance sheet. That is, it is a cost that shareholders have to bear. An additional implication of this is that this cost is not part of the fair value of the security, but it should be recovered by the dealer via what we call "donations" (see also Andersen et al. (2019)). That implies the dealer will have to quote a bid and ask the price for a spread in a way that compensates shareholders.

We shall point out the implications of the results in this paper for the functioning of financial markets and financial stability. The post-2008 new regulatory framework has had significant implications, not only on the banks' business models but also on banks' capital structure, for example, higher funding costs; this has been particularly significant for large banks (Berndt et al. 2023).

Following recent shocks, banks have reported significant losses in 2020 (COVID-19 shock) due to funding costs. JP Morgan reported a $951 million loss in its corporate and investment bank in its first-quarter earnings call on April 14, stating that losses are related to the loss of "funding spread widening on derivatives", Risk, April 2020. Bank of America followed by reporting a $492 million loss on April 15 that it said was largely caused by "certain valuation adjustments", Risk, April 2020. Banks have also been hit by losses related to funding costs in 2014. For example, JP Morgan reported $1.5 billion in losses in that year. The same happened after the Russia-Ukraine war started.

The industry's explanation for the significant losses is that it is very challenging for XVAs desks to hedge this specific risk (i.e. funding risk). It was not so during the LIBOR era when funding costs across banks were very small, and banks were exposed to the same interest rate on both sides of the balance sheet. Our analysis provides further support to Albanese & Andersen (2014), Andersen et al. (2019) suggesting that funding costs should not be part of the dealer's P&L, as this is a cost (benefit) to be imputed to shareholders.

However, the devil is in the details. The industry, driven by accounting procedures, defines the fair price (or exit price) of derivatives as the price for which the derivatives' position can be novated to a counterparty, with a small impact on its liquidity. We show that the fair price does not include funding costs. Including funding costs in the P&L makes it more volatile. J.P. Morgan correctly imputed funding costs to shareholders by scrapping dividends.

As we explain, dealers should recover funding costs via donations, that is, quoting a bid and ask spread, which is aligned with shareholders' break-even. This implies a business decision. Dealers are generally reluctant to transfer the full (or part) of this cost to their clients. For example, Risk.Net (Risk.Net September 2015) suggests that the industry only transfers a small part of the cost (in many cases none) to their clients.

In sum, banks, to retain market shares, have not always been able to charge funding costs via donations. J.P. Morgan correctly imputed this cost to shareholders by scrapping dividends.

Funding costs are very pervasive for banks. We discuss two very simple examples arising in an important market: the cross-currency swap market. The first is related to the 2014-2016 period, following the FED quantitative easing. The second example is related to the

2022 September budget shock in the UK. In a cross-currency swap with a client, the dealer generally will not receive collateral, but she will have to post collateral when hedging the position with another dealer (the hedge dealer). This additional cost will need to be taken into account via Margin Value Adjustment in a similar way as the dealer does with FVA. Generally, the collateral to be posted to the hedge dealer is borrowed from the bank's treasury at a rate which is generally higher than the free rate.

Suppose the dealer is in the money with the client (i.e. she is receiving money). In this case, the dealer will be out of the money with the hedge dealer. She will need to post collateral. This introduces an FCA on the dealer's book position. Suppose instead that the dealer is out of money on the trade with the client. In this case, the dealer will be in the money with the hedge dealer, leading to FBA. This FBA will only be rewarded at the risk-free rate. In addition, the swap position with the client will, in general, be held in the dealer's book for the full duration (generally difficult to novate). This means that every time the dealer's position is in the money with the client, it will increase the risk exposure and lead to higher regulatory capital.

During 2014-2016, following the FED quantitative easing, dealers increased their swap portfolios with European clients. In such an economic environment, there might be funding (capital) cost incentives to dealers to enhance the swap portfolio. For example, if the dealer expects to be, most of the time, out of the money with the client, the trade will generate an FBA, and this could be large enough to offset regulatory costs. Therefore, funding and regulatory costs may create perverse incentives for dealers and price distortions, which could affect the liquidity in that market. This is not yet well understood empirically and theoretically.

However, it is correct to assume that the very tight competition among dealers may have also contributed to this market practice. This practice is perfectly aligned with shareholders' interests, especially in a context where banks are subject to higher regulatory capital. For example, Cerrato et al. (2024) show that the shadow cost of the capital to the dealer reflects not only debt overhang costs to equity holders today but also in future states of the world. This suggests that if regulatory capital is binding, the dealer may have an incentive to be in an out-of-the-money swap with a highly rated client in order to offset capital usage and expand her portfolio.

A similar result is in Giannetti et al. (2024). They find that mutual funds replace large dealers in providing liquidity in the bond's market, and dealers, in order to mitigate regulatory capital costs, sell bonds at a discount.

The second example is related to the budget shock in the UK in September 2022. In this case, dealers' swap position with their clients was in the money, given that the sterling interest rate coupon paid by the clients increased. As discussed earlier, this generated FCAs for the dealer. Furthermore, the tight correlation between the UK sterling and the credit quality of the clients (i.e. the dealer was also exposed to wrong-way risk) increased the dealer's exposure and capital costs. These are situations when the dealer is caught "between two fires". High capital consumption and higher funding costs. Clearly, current capital regulations do not help in this case; they can only exacerbate the problem.

The two examples discussed earlier suggest the importance of funding (regulatory) costs and, therefore, debt overhang costs. Could large swings in markets like US$ fx spot and derivatives also be related to funding (or regulatory capital) costs? Recent empirical evidence seems to suggest that this is also the case. For example, Burnside et al. (2023) discuss how funding costs and funding valuation adjustments affect fx derivatives markets and prevent dealers from supplying the necessary US$ liquidity to arbitrage covered interest rate parity, earning a (risk-free) profit. This happens not only if the dealer funds CIP arbitrage in the unsecured market but also in the REPO and IOER markets. This suggests that CIP deviations post-2008 are not only related to regulatory frictions, but debt overhang probably also plays a very significant role.

Cerrato et al. (2024), using granular fx spot order flow (volume) data from two of the largest fx dealers' banks, report evidence that, especially in periods of financial turmoil (COVID-19 and 2008 financial crisis), dealers are reluctant to provide sufficient liquidity to clear the spot US$ market. They discuss debt overhang related to funding and/or capital as a plausible explanation. Andersen et al. (2019) also discuss FVAs related to the swap market.

Recently, we have observed large swings in Treasury and Gilt yields. We show and discuss why purchasing Treasury securities is expensive for shareholders. The cost we refer to does not arise from funding or capital costs (which are also significant). This cost is related to creditors who will be entitled to a safe asset at default, while shareholders will not get anything. This does not contrast with the recent literature blaming leverage ratio requirement for the observed swings in the Treasury yields. However, our results suggest that removing the leverage ratio may not help to improve the liquidity in the Treasury market, especially in times of market turmoil and if debt overhang is high. Removing the leverage ratio may only lead to freeing up additional capital to the dealer, which is not guaranteed to be used to purchase Treasuries. One alternative for regulators would be retaining the leverage ratio requirement while reserving the option to relieve banks from it in cases of systemic market dysfunction. This has already happened in March 2020.

Following the introduction of the FVA adjustments round 2016, the industry has started an intense discussion on the so-called Margin Valuation Adjustments (i.e. initial margins or IM). This new valuation adjustment was introduced following the new rules where interdealer market trading was subject to collateral. IM soon became standard practice in derivatives pricing. While implicitly priced for cleared trades, MVA is still struggling to gain acceptance in the non-cleared world. For example, it is, in general, only applied to trades whose exposure is less than $50 million. On the client side, IM is applied, in general, only to large hedge funds and asset management firms. Therefore, it seems that including IM in a trading price is more like a business decision.

We discuss margin value adjustments. These are additional costs to the dealer, which, unlike FVAs, affect more counterparties as IM applies to all clearing counterparties. For example, clearing the position of a client with a counterparty (clearinghouse) and posting initial margins. If the competition amongst clearing houses is sufficiently high, clearing margins will tend to be similar. Practically, instead, margins can be substantially different across clearinghouses. The difference in IMs then raises the (business) question of whether the dealer will have to pass this cost to the client or absorb it internally.

Unlike the FVA, initial margins (IMs) cannot be rehypothecated unless the margin poster is a client and the margin is being used to cover a call arising from a hedge of the client's trade. Therefore, unlike FVA, where we can have a funding cost but also a funding benefit, MVA is only an FBC to the dealer.

Furthermore, initial margins also have implications for the net stable funding ratio, as this indicates that 85% of the margins must be covered by long-term funds, which are generally more expensive. In sum, margin requirements can have significant implications for the dealer funding costs (and capital consumption), not only for bilateral uncleared trading that is hedged in the interdealer market but also for clearing trades. For example, consider the case of a dealer and a clearing house. Ideally, the dealer would have two-way flows, with the clearing house and client, that match. Therefore, by compressing the portfolio, the dealer will end up with no position facing the clearing house. However, if clients are sticky on their trades for the whole life of the transaction, the MVA cost to the dealer can be very large.

Initial margins are estimated by the clearing house using a value-at-risk or expected shortfall model and a period of 10 days at a 99% confidence level. In this way, margins are calculated by taking an expectation of the initial margin over the lifetime of the trade and applying a funding spread to it. To do this, one generally rests on a so-called nested simulation or a simulation within a simulation. There is very little transparency, in general, on how clearing houses calculate MV. This has important implications for the dealer and the client. Lower transparency will increase asymmetric information costs to the dealer, and this is likely to affect the trade, particularly in times of high volatility (which turns out to coincide with the time when the funding costs of the dealers are very high).

The discussion on MVA is timely and very important. In the US, a very large market like the Treasury and the REPO markets will be moved to clearing platforms from the end of 2025 and 2026. Our discussion suggests that the dealer's best option to clear a client's position is the one which grants the dealer the possibility to 1) minimise the usage of funding (initial margins) on behalf of the client; 2) net across clients the positions in a way that balance sheet costs can be reduced; or 3) minimise the asymmetric information with the clearing house. Our analysis and the discussion suggest that these are important issues that need to be sorted out before a clearing process can be efficient and effective for the industry and the market overall.

2 Valuation Adjustments after the Great Financial Crisis

In 2008, a financial crisis started; after that, regulators and banks started reviewing their approaches. Before the financial crisis, the LIBOR rate was the (risk-free) rate that banks used to fund and post collateral. Therefore, any change in the funding rate was offset by the rate received on posted collateral. Furthermore, funding costs for banks were very small or negligible. This is no longer the case (Duffie 2018, Burnside et al. 2023).

The regulatory framework following the 2008 financial crisis was rather complex. The Dodd-Frank Reform and Consumer Protection Act of 2010 (Dodd-Frank Act) represented a turning point in how regulators and banks started looking at financial markets and banking business. Thereafter, the new regulations within the framework of the Fundamental Review of the Trading Book led to a stricter separation of positions between the trading desk on the one side and the banking book on the other. The valuation adjustments discussed in this paper have been introduced following this new regulation, and today, accounting bodies recognise these adjustments and expect large banks to accomplish them.

These valuation adjustments related to derivative contracts take different forms. For example, Credit Valuation Adjustments (CVA) are related to counterparty credit risk. Capital Valuation Adjustments (KVA) are instead related to the cost of regulatory capital to maintain a trading position. Finally, Funding Value Adjustments (FVA) are related to the cost of funding a position via an uncollateralised credit market. Funding cost and funding risk, and the related funding value adjustment, are probably the risk that offers very significant challenges to dealers' banks (Albanese et al. 2015). In this paper, we review and critically discuss FVAs and their impact on banks' balance sheets and dealer's liquidity provisions.

We start by introducing some important concepts that we shall be using in the next sections. First, we introduce the bank's credit spread and its relation with the risk-neutral probability of default of the bank and its loss rate. Finally, we shall briefly discuss debit value adjustment (DVA). We show how this is related to the banks' equity holders and creditors and why banks use it.

Consider a risk-neutral bank funded by equity and debt. Assume for simplicity only two time periods, $t = 0, 1$, and a competitive capital market for debt and equity. The bank's assets are A_0 at time $t = 0$ and A_1 at time $t = 1$. The asset value at time $t = 1$ can be higher (lower) with a given probability. We use Af to denote the up-state scenario and Af the opposite.

Our bank issues a credit-risky debt with a face value of D_1 and a 1-year maturity. We assume $Af < D_1 < A_0 < Af$, such that the bank will either survive if the asset value increases to Af or default if the price drops to Af Let p define the risk-neutral default probability.

Our credit-risky debt is a one-year zero-coupon bond with a face value D_1, and its market value can be expressed as Di/(1 + r_1 + cp), where r_1 is the risk-free rate and cp is a credit spread.

Let's first focus on the credit spread. The discounted expected value of the bond is

$[(1 - p)D_1 + p(l - L)D_1]/(1 + r_1)$, where Lis the loss rate of the asset,

$$L = 1 - \frac{A_1^d}{D_1}. \tag{1}$$

We can define the recovery rate as

$$R = \frac{A_1^d}{D_1} = 1 - L.$$

Given the equations above, we have

$$\frac{D_1}{1 + r_f + \varphi} \qquad \frac{(1- p)D1 + p(l - L)D1}{1 + r_1}$$

Solving for *cp* gives an expression for the credit spread as

$$cp = (1 + r\ J)\ (l \text{———} L) \ \cdot \tag{2}$$

The credit spread is an increasing function with respect *top* or L. It follows that the larger the default probability (or loss rate), the larger the bank's credit spread[1].

Debit Value Adjustment (DVA). Consider first a risk-free bond with face value D_1. Its present value is

$$D_0^f = \frac{D_1}{1 + r_f}$$

The value of a credit-risky debt is instead

$$D_0^c = \frac{D_1}{1 + r_f + \varphi} \tag{3}$$

If we take the difference between the two bonds, we obtain the so-called debit valuation adjustment (DVA)

$$DVA = D_0^f - D_0^c = \frac{D_1}{1 + r_f} - \frac{D_1}{1 + r_f + \varphi}, \tag{4}$$

[1] Deriving the first difference of credit spread with respect to default probability is

$$\frac{8cp}{8p} \qquad \frac{(1 + r1)L}{(l\text{-}pL)^2}\cdot$$

One can easily find that both the numerator and denominator are positive since $r_1, L, p > 0$. Consequently, $8{<}p/ 8p > 0$. Similarly, the first difference of credit spread with respect to the loss rate

$$\frac{8{<}p}{8L} \qquad \frac{(l+r1)P}{(1 - pL)^2}$$

is also positive.

where DVA denotes debit value adjustment (DVA).

The interpretation of DVA is quite counterintuitive as it involves, in the surviving state, reporting a gain if the bank's own credit risk increases. This suggests that the bank recognises a gain as its credit quality deteriorates. This is due to the decrease in the value of its liability because of the higher DVA. The Basel Committee of Banking Supervision has now made clear that higher DVAs cannot be used to increase Tier 1 equity for capital adequacy. Barth et al. (2008) argue that DVAs are consistent with debtors partially absorbing negative shocks on the bank (see, for example, Merton (1974)). What is the economic intuition of the DVA? The DVA resembles a credit put option. Investors buy these cheap out-of-the-money options in good times to boost returns.

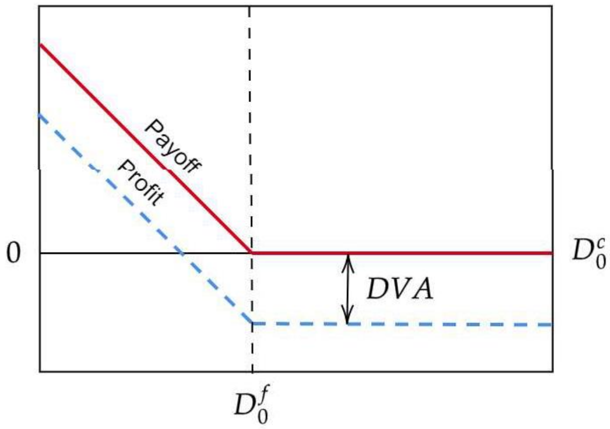

Figure 1. Payoff and Profit of Credit Put Option. This figure plots the diagram of a credit put option's payoff. The x-axis represents the present value of the credit-risky debt. The y-axis represents the payoff. The solid red line represents the payoff of purchasing credit-risky debt, while the dashed blue line represents the profit of the debt compared to risk-free debt. The distance between the two lines is the debit value adjustment (DVA).

If we substitute Eq 2 and Eq 1 into the DVA formula in Eq 4, we obtain a reduced form for the DVA

$$DVA = \frac{LD_1p}{1+r_f} \qquad \frac{(A_1^d - D_1)p}{1+r_f} \tag{5}$$

The DVA is a function of loss rate (L), face value (D_1), and the probability of default (p). In the surviving state, shareholders will compensate creditors by paying a spread above the risk-free rate, but in default, they will obtain nothing.

There has been a vigorous discussion in the industry on whether DVA should be part of the derivatives valuation. Part of the industry has been largely opposed to this idea as DVA is difficult to monetise (see discussion above).

DVAs can change quickly in an environment of lower credit spreads, for example, in 2023. Banks' credit spreads have declined quickly since COVID-19, and this has increased liabilities of most US banks, \$4.9 billion across the top five largest US banks in 2023. As DVA's losses on liability are recorded in the equity section of the balance sheet (Other

Comprehensive Income), and DVAs cannot be considered for Equity Tier 1 capital, losses from DVA are likely to hit equity holders. This suggests that if the interests of dealers are aligned with those of shareholders, these losses should, in general, be recovered via bid and ask spread quotes (this is similar to the discussion about funding value adjustments in the next sections).

3 Funding Cost Adjustment (FCA)

Funding Cost Adjustments. These adjustments have been at the centre of the academic and industry discussion since 2013 (Burgard & Kjaer 2013, **Hull** & White 2014, Albanese & Andersen 2014, Andersen et al. 2019).

The discussion centred on whether FCA should be an adjustment to the fair market value of a dealer's derivatives book, which captures the cost of financing a derivatives position. A related issue was whether this cost should enter into the dealer's earnings. Andersen et al. (2019) discuss the economics related to these adjustments and, crucially, contribute to the industry discussion on whether these adjustments should be part of the P&L of the dealer. We review Funding cost adjustments in this section using the framework introduced earlier. Assume that the bank purchases an option contract from a riskless counterparty (we do not introduce credit valuation adjustment (CVA) or counterparty risk). Suppose the dealer raises new credit (say wholesale unsecured market or internally from the bank Treasury) to fund the new asset. The assumption of the riskless counterparty implies that there is no credit value adjustment (CVA) to account for counterparty risk. Meanwhile, the counterparty also bears no debit value adjustment to account for its own credit risk[2].

Should the option value be adjusted to account for funding costs? Should dealers report the cost on their **P&L?** Finally, does the new derivative position affect the value of the bank? We shall discuss and shed further light on these important questions.

[2] Suppose $CVAB$ and CVA^0 denote the credit value adjustments made by the bank and the counterparty, respectively. Besides, $DVAB$ and DVA^0 denote the debit value adjustments made by the bank and the counterparty separately. The market value of the option contract is V_0 at time $t = 0$ and $Vi = V_0(l + r1)$ at time $t = 1$, without considering the credit risk of the two counterparties. We define the fair value of the option between two credit-risky counterparties as VtD at $t = 0$ and VtD at $t = l$. Similarly, the fair value of the same option contract between two riskless counterparties is Vl at $t = 0$ and VF at $t = l$. They satisfy:

$$V_0^D = V_0^{ND} - CVA^B + DVA^B = V_0^{ND} + CVA^C - DVA^C = V_0^{ND} = V_0.$$

It implies that the option is free of credit risk adjustments as a derivative receivable to the bank and a derivative payable to the counterparty.

3.1 Funding Assets Via New Debt

Assume that the bank issues new debt to fund the option and that this new liability ranks *pari passu* with the existing debt (or legacy debt)[3]. Let ½{ define the fair value for the option, *Vo* its market value and *FCA* defines the funding cost adjustment

$$V\{ = Vo - FCA.$$

Assume the volume of the option trade is sufficiently small and, therefore, it has little impact on the bank's default probability p[4]. We assume that the new debt, with face valueF_1, is fairly priced (that is, the net present value (NPV) of this debt is equal to zero). To achieve this, the bank has to offer the new creditors a credit spread that reflects the new capital structure of the bank, including the option.

Let's introduce the bank's new loss function. The new creditors will either receive the full face valueF_1 if the bank survives or recover $R' = 1 - L'$ of the face value if the bank defaults, where the new loss rate L' satisfies:

$$L' = 1 - \frac{A_1^d + V_1}{D_1 + F_1} \tag{6}$$

The numerator, $Af + V1$, describes the asset value at default, while the denominator, D1+F1, is the full value of total debt refunded to the creditors if the bank survives[5]. Since the bond for the new creditors is a zero NPV, it implies that the discounted value of the bond Fi should be equal to the cash required by the dealer to fund the option at time $t = 0$. This implies that, the face valueF_1 should satisfy

$$\frac{F_1(1-p) + (1-L')F_1 p}{1+r_1} \quad \frac{F_1(1-pL')}{1+r_f} \quad \frac{V_1}{1+r_f} \tag{7}$$

Since it is a quadratic equation ofF_1, thestraightforward solution[6] is given by

$$\begin{aligned} Fi^* = \{ & -0.5(1-p)^{-1}[p(Af + V1) + (1-p)D1 - Vi + W] \\ & -0.5(1-p)^{-1}[p(Af + V1) + (1-p)D1 - Vi - W] \end{aligned} \tag{8}$$

where

$$\backslash Jr = \{ [p(Af + Vi) + (1-p)D1 - V1]^2 + 4(1-p)ViD1\}^{\frac{1}{2}}.$$

[3]Since the new debt ranks *pari passu* with the legacy debt, the new creditors can recover a fraction $p = Fi/(Fi + D_1)$ of the bank's assets when the bank defaults.

[4]A question may arise that the bank's probability of default p may change due to the newly issued debt. We shall relax this in the next sections.

[5]1n this case, $Vi = (1 + rJ)Vo$ has two meanings: 1) The payoff of the derivatives receivable at time $t = 1$, and 2) the book value of the new debt for funding these derivatives if the dealer is risk-free. As a comparison, F_1 is the fair value of the new debt as it considers the credit risk of the dealer.

[6]This solution is one of the equilibria for fair valueF_1, butithasnottobetheonly solution.

Appendix A contains the proof of Eq 8. Given that *{At,* Vi, Di} are positive and O < *p* < 1, the solution that satisfies the constraints is

$$F_1^* = -0.5(1-p)^{-1}\left[p(A_1^d + V_1) + (1-p)D_1 - V_1 - \Psi\right]. \tag{9}$$

It follows that the bond is fairly priced at *F{.*

Do legacy creditors benefit from the newly issued debt, particularly the bank's asset liquidation at the default state? When the asset is in the default state, *At,* the bank must pay both new and legacy creditors with its assets and derivative receivable, *At+* Vi- Given the equal rankings between new and legacy debts, these creditors are allowed to account for their corresponding fractions of the bank's total assets. The new creditors will receive the fraction of *p* = Fi/(F1 + D1), while legacy creditors will receive the remaining part 1 - *p* = Di/(F1 + D1). If we compare this case with that of no new debt issuance, the gain of legacy creditors is

$$\pi^D = (1-\rho)(A_1^d + V_1) - A_1^d.$$

Rearranging the above expression provides

$$\pi^D = (1-\rho)V_1 - \rho A_1^d.$$

The first term of the RHS, (1 - *p)V1,* shows the fraction of the derivative receivable that legacy creditors receive, while the second term, *pAt,* shows the fraction that new creditors receive[7].

3.1.1 Debt Overhang

In this section, we now focus on equity holders. Does the new debt issuance affect shareholders' equity value? To answer this question, we assume that at time *t* = 1, the dealer will receive the cash of the option (receivable) V1. Given the limited liability of shareholders, the equity value is non-zero only if there is no default. Let *E0* and E1 denote the equity value at time *t* = 0, 1, respectively, and assume that *iA* = .E0(1+ *r1*). We first assume that the bank survives and the asset value and the derivative receivable is *At+* Vi- Shareholders' equity value is

$$\widetilde{E}_0 = \frac{E_1}{1+r_f} \qquad \frac{(\text{At+ V1 - D1 - Fi})(\text{l} - p)}{1 + 7'j}$$

[7]It is interesting that whether legacy creditors welcome new ones depends on who can benefit more than the other. If legacy creditors can obtain higher profit from the derivative receivable than the profit of new creditors from the asset valuation (that is, (1 - *p)Vi* > *pAf),* then legacy creditors are fond of new debt issuance because they are more profitable than before (that is, *1rD* > 0). Otherwise, they would avoid the newly issued debt. Particularly, the face value Fi is not necessary to be the fair value Fi. If so, the benefit of new debt for legacy creditors may be different.

And the change in shareholders' wealth is

$$\Delta W_E = E - E_0 = \frac{(V_1 - F_1)(1-p)}{1+r_f} < 0, \tag{10}$$

where ΔW_E is the change of the shareholders' equity, and E_0 is the equity value before new debt issuance

$$E_0 = \frac{(A_1^u - D_1)(1-p)}{1+r_f}$$

Eq 10 can be viewed as a reduced form of Andersen et al. (2019) shareholders' debt financing[8]. Since the survival probability $1-p$ and the discount factor are positive, ΔW_E is negative due to the fair value of new debt F_1 to creditors, which must be greater than the value of the derivative receivable V_1, after considering the credit spread of the bank.

This problem was first highlighted in Myers (1977), "Issuing risky debt reduces the present market value of a firm holding real options by inducing a suboptimal investment strategy." He named it debt overhang.

As discussed in Andersen et al. (2019) and pointed out above, FCAs introduce debt overhang cost to the banks' shareholders. It is well understood now (and in line with market practice) that this cost is recovered by dealers via bid-ask spread (see also discussion in Andersen et al. (2019), and the next section).

Should this cost be part of the dealer's income statement? Should the dealer report V_0 or V_0^*? Funding costs are not part of the P&L but should be included in the equity section of the balance sheet, accumulated other comprehensive income (AOCI). Indeed, equation 10 suggests that debt overhang is a loss to shareholders and a gain to the bank's creditors.

To see it in greater detail, consider the new creditors. The expected payoff at time $t = 1$ 1s:

$$D_{NC} = \frac{F_1(1-p) + p(A_1^d + V_1)p}{1+r_f},$$

where the subscript NC of D_{NC} represent the new creditors. With respect to the original investment in the bank, the wealth change to new creditors is

$$\Delta W_{NC} = D_{NC} - V_0 = \frac{F_1(1-P) + p(A_1^d + V_1)p}{1+r_f} - \frac{V_1}{1+r_f} \tag{11}$$

[8]See page 176 in Andersen et al. (2019)'s paper: *"If the dealer finances the position by issuing new debt, the marginal value of the asset purchase to shareholders is defined by ... $G = \delta E^*[1_{D^c}(Y - u(R+S))]$."* δ is the discount factor equivalent to $(1+r_f)^{-1}$ in our case. E^* denotes a risk-neutral expectation. 1_{D^c} is an indicator that indicates a survival scenario, equivalent to an up-state scenario with probability $1-p$ in this paper. Y is equivalent to V_1, u is equivalent to V_0, R is equivalent to $1+r_f$, and S is equivalent to φ'. Assume the survival scenario is independent of the bank's investment, which is $\mathrm{cov}(1_{D^c}, Y - u(R+S)) = 0$. Then, $G = \delta E^*[1_{D^c}(Y - u(R+S))] = \delta E^*[1_{D^c}]E^*[Y - u(R+S)] = \delta(1-p)(Y - u(R+S))$. In the context of this paper, it becomes $G = (1+r_f)^{-1}(1-p)(V_1 - F_1)$, exactly the same as Eq 10. Hillian (2016) provides a numeric example to demonstrate the calculation.

Consider instead legacy creditors. The expected payoff for legacy creditors at time $t = 1$ is:

$$\widetilde{D}_{LC} = \frac{D_1(1-p) + (1-\rho)(A_1^d + V_1)p}{1+r_f},$$

where the subscript LC of $\widetilde{D}_{LC}$ represents the legacy creditors. With respect to their initial payoff with no new debt issuance, the wealth change for legacy creditors is

$$\Delta W_{LC} = \widetilde{D}_{LC} - D_0^c = \frac{D_1(1-p) + (1-\rho)(A_1^d + V_1)p}{1+r_f} - \frac{D_1(1-pL)}{1+r_f} \tag{12}$$

Taken ΔW_{NC} and ΔW_{LC} together, the overall wealth change for creditors is:

$$\Delta W_D = \Delta W_{NC} + \Delta W_{LC} = \frac{(F_1 - V_1)(1-p)}{1+r_f} > 0 \tag{13}$$

It follows that $\Delta W_E = -\Delta W_D$ is a benefit to the creditors. Therefore, there is no economic reason why funding costs should be included in the P&L of the dealer.

Appendix ?? makes the case of a higher-equity bank using debt financing and derives shareholders' debt overhang cost in that case.

3.1.2 Credit Spread and Debt Overhang

Andersen et al. (2019) show that debt overhang can be approximated by the bank's credit spread. In this section, we shed further light on this. Re-calling Eq 7, we can re-write it in a way to relate this to the face value F_1 of the new debt

$$\frac{F_1}{1+r_f+\varphi'} = \frac{V_1}{1+r_f},$$

where φ' denotes the credit spread of the bank. Rearranging the equation

$$F_1 - V_1 = \frac{V_1\varphi'}{1+r_f} \tag{14}$$

and after inserting it into Eq 10, we obtain an expression for shareholders' debt overhang:

$$\Delta W_E = -\frac{V_1\varphi'(1-p)}{(1+r_f)^2}. \tag{15}$$

After differentiating ΔW_D with respect to V_1

$$\frac{\partial \Delta W_E}{\partial V_1} \qquad \frac{\varphi'(1-p)}{(1+r_f)^2}, \tag{16}$$

where cp' can also be expressed as

$$cp' = (1 + r_1)\left(1 - \frac{pL'}{pL'}\right) .$$

It follows that $\partial W_E/\partial V_1 \approx -cp'$ if the default probability p and the risk-free rate r_1 are close to zero[9]. Therefore, the marginal wealth shift to shareholders (debt overhang) can be proxied by the bank's credit spread. This also suggests that highly capitalised banks (higher equity) with lower credit spreads have smaller debt overhang costs. Appendix C discusses this situation.

3.1.3 Donations

As discussed above, if the interests of the dealer and the equity holders are aligned, the dealer will recover funding costs via bid-ask spreads. Andersen et al. (2019) suggest that this is a form of donation that the investor is making to the bank. What is the economic implication of donation to creditors and shareholders of the bank? We discuss it in this section.

One way for the bank to minimise the wealth shift to shareholders is to offer the new creditors the new debt at a book price V_1 instead of a fair price F_1. In fact, Eq 14 shows that the book price is below the fair price. This would imply a "donation" from the new creditors (see also Andersen et al. (2019)).

Note that to hold shareholders' wealth unchanged (no debt overhang), the bank's equity should be:

$$E_0 = \frac{(A_1 + V_1 - D_1 - V_1)(1 - p)}{1 + r_1} = \frac{(A_1 - D_1)(1 - p)}{1 + r_1} \tag{17}$$

So, the wealth change is:

$$\Delta W_E = E_0 - E_0 = 0. \tag{18}$$

In the default case, the new creditors receive the fraction $p = V_1/(D_1 + V_1)$ of the bank's assets, while legacy creditors receive the fraction $1 - p = D_1/(D_1 + V_1)$. Thus, the debt value to the new creditors at time $t = 1$ is

$$\tilde{D}_{NC} = \frac{V_1(1 - p) + p(A_1 + V_1)p}{1 + r_1} . \tag{19}$$

Therefore, donations will hit the new creditors

$$\Delta W_{NC} = D_{NC} - V_0 = -\frac{V_1 p - p(A_1 + V_1)p}{1 + r_1} < 0 . \tag{20}$$

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[9]This assumption approximates the default probability of large dealers.

Meanwhile, the expected payoff to the legacy creditors is:

$$\widehat{W}_{LC} = \frac{D_1(1-p) + (1-\widehat{\rho})(A_1^d + V_1)p}{1+r_f}. \tag{21}$$

If we compare this with the case of no-derivatives purchase, legacy creditors' wealth is:

$$\Delta\widehat{W}_{LC} - \Delta W_{LC} = \frac{V_1 p - \widehat{\rho}(A_1^d + V_1)p}{1+r_f} \tag{22}$$

It follows that legacy creditors will be better off. What about shareholders? Shareholders will also gain from donations

$$\Delta\widehat{W}_E - \Delta W_E = \frac{(F_1 - V_1)(1-p)}{1+r_f} > 0 \tag{23}$$

This implies a benefit to shareholders from the donation. But, as we pointed out above, the new creditors will suffer a loss following the donation. Compared with the no-donation case, their wealth change is negative

$$\Delta\widehat{W}_{NC} - \Delta W_{NC} = -\frac{(F_1 - V_1)(1-p)}{1+r_f} - \frac{(\rho - \widehat{\rho})(A_1^d + V_1)p}{1+r_f} < 0 \tag{24}$$

On the other hand, the benefit to legacy creditors is larger now than in the no-donation case. In fact, the change in their wealth is

$$\Delta\widehat{W}_{LC} - \Delta W_{LC} = \frac{(\rho - \widehat{\rho})(A_1^d + V_1)p}{1+r_f} > 0. \tag{25}$$

Would the bank credit spread reflect the donation case? The new bank's loss rate is:

$$\widehat{L} = 1 - \frac{A_1^d + V_1}{D_1 + V_1} \tag{26}$$

and the bank's credit spread is

$$\widehat{\varphi}^{H} = (1+r_f)\left(\frac{p\widehat{L}}{1-p\widehat{L}}\right) \tag{27}$$

If we recall Eq 14, we can easily see that the loss rate in the donation case is lower than the one in the no donation case, $\widehat{L} < L'$. It follows that, overall, if the dealer can recover debt overhang via donation, this can also lead to a reduction of the bank's credit spread.

In sum, to recover debt overhang costs, shareholders need a "donation" from the new creditors. Legacy creditors will benefit from the donation. The issue is whether dealers, who act in the interest of the shareholders, recover this cost (or at least have the incentive to recover it) or follow alternative roots to preserve their market shares. We introduce this discussion in the next section.

3.1.4 Discussion and Policy Implications

The results discussed earlier have important implications for financial market functioning and also financial stability. We shall discuss some of the policy implications of debt overhang cost following higher funding costs post-2008 (see also Berndt et al. (2023)).

Banks have reported significant losses in 2020 (COVID-19 shock) due to funding costs. JP Morgan reported a $951 million loss in its corporate and investment bank in its first-quarter earnings call on April 14, stating that losses are related to the loss of "funding spread widening on derivatives", Risk, April 2020. Bank of America followed by reporting a $492 million loss on April 15 that it said was largely caused by "certain valuation adjustments", Risk, April 2020.

The financial industry had already been hit by losses related to funding costs in 2014. JP Morgan reported $1.5 billion in losses in that year. The same happened after the Russia-Ukraine war started. The industry's argument for the significant losses is that it is very challenging for XVAs to hedge funding risk. It was not so during the LIBOR era when funding costs across banks were very small, and banks were exposed to the same interest rate on both sides of the balance sheet. The analysis in this paper suggests that these losses should not have been part of the dealer's P&L as FVA is a cost (benefit) to be imputed to shareholders (see also Andersen et al. (2019)).

But, as it happens often, the devil is in the details. The industry (and accounting methods) defines the fair price (or exit price) as the price for which the derivatives' position can be novated to a counterparty, with a small impact on the liquidity. We discussed the fair price, and we concluded that it does not include funding costs. By including funding costs in the P&L, one would only increase its volatility. J.P. Morgan correctly imputed funding costs to shareholders by scrapping dividends.

Dealers should recover funding costs via donations. Of course, they are reluctant to transfer the full (or part of the) cost to their clients, as they wish to retain a significant share of the business. For example, a survey in Risk.net (Risk.Net September 2015), in relation to capital value adjustments (KVAs), suggests that the industry generally transfers only a small part of this cost (in many cases none) to their clients[10].

In sum, to retain market shares, banks have not always been able to charge funding costs via donations. J.P. Morgan correctly imputed these costs to shareholders by scrapping dividends. We do not discuss issues related to hedging funding risk here. However, it is clear from the discussion and the significant losses banks have incurred that funding costs are difficult to hedge in practice. They make the dealer's P&Ls very volatile, with possible significant implications for financial market stability.

[10]This is an additional adjustment that the industry consider to account for the regulatory cost of the trade.

To appreciate the importance and relevance of funding costs and FVAs, consider these two examples from the cross-currency swap market. The first is related to the 2014-2016 period, following the FED quantitative easing; the second example is related to the 2022 September budget shock in the UK.

In a cross-currency swap with a client, the dealer generally will not receive collateral, but she will have to post margins when hedging this position with another dealer. Therefore, the dealer will need to take this into account via FVAs. For example, if the dealer is in the money with the client, she will be out of the money with the hedging dealer, and this will lead to FCA on the dealer's book position. If the dealer is out of the money on the trade with the client, this will lead to FBA. In addition to this funding cost (benefit), the swap trades are long-dated trades, in general, and held on the book for a long time (generally difficult to novate). It turns out that every time the dealer position is in the money with the client, she will lead to larger risk exposure and higher regulatory capital.

During the period 2014-2016, following the FED quantitative easing, swap dealers were accommodating a large demand for swaps coming from European corporates. As is generally the case, if the dealer expects to be most of the time out of the money with (highly rated) the client (and in the money with the hedge dealer), she could have a significant incentive to expand her swap's book as the trades would, potentially, generate a large FBA. This benefit, in this case, can be large enough to offset regulatory costs. This practice had a significant impact on swap prices during that period, as dealers exploited funding benefits to offset capital costs and, at the same time, retain large shares of a profitable (and highly competitive) business.

This practice can be perfectly aligned with shareholders' interests. For example, as discussed in Cerrato et al. (2024), in a similar context, the shadow cost of capital (debt overhang) to the dealer reflects not only that cost today but also the cost in future states of the world. In sum, the dealer could have an incentive to hold an out-of-the-money swap on the book if the funding benefit is large enough to offset regulatory costs and if this helps to expand the business in the future.

The second example is related to the budget shock in the UK in September 2022. In this case, the dealers' position with the clients was the opposite of the one we discussed above. The dealer position was in the money, given that the sterling interest rate coupon made by clients increased, generating FCAs. Furthermore, the tight correlation between the UK sterling and the credit quality of the clients (i.e. the dealer was also exposed to wrong-way risk) increased the dealer's exposure and capital costs.

The two examples discussed earlier suggest that funding (regulatory) costs and related debt overhang have become important to the dealer and are likely to impact financial intermediation. For example, would large swings in markets like fx spot and derivatives markets be related to funding (regulatory) costs? Recent empirical evidence seems to suggest that this is the case. For example, Burnside et al. (2023) discusses how funding costs and funding valuation adjustments affect fx derivatives markets and prevent dealers from supplying the necessary US$ liquidity to arbitrage-covered interest rate parity and earning a (risk-free) profit.

Cerrato et al. (2024), using granular fx spot order flow (volume) data from two of the largest fx dealers' banks, report evidence that, especially in periods of financial turmoil (COVID-19 and 2008 financial crisis), debt overhang costs prevent dealers from clearing the high demand of US$ liquidity. Andersen et al. (2019) also discuss FVAs related to the swap market.

3.1.5 Purchasing Treasury Securities

In this section, we discuss the purchase of "safe assets", Treasury securities and its implications to banks' shareholders. The simple example we discuss does not reflect fully market practice, but it will help us to appreciate the economic cost to shareholders following the purchase of Treasuries. Note that we do not discuss regulatory costs, which are leverage ratio requirements (LLR). LLR's cost, although in our view, is much smaller than funding costs, see Andersen et al. (2019) and Burnside et al. (2023), will add up on top of funding costs. We provide evidence of the economic cost to shareholders for a bank to maintain a large share of Treasury securities on their balance sheet.

In recent market shocks (2020 COVID-19, following Liz Truss's fiscal announcement in September 2022), dealers have been reluctant to provide the necessary liquidity to support the bond market functioning (He et al. 2022, Duffie et al. 2023, Pinter 2023). The discussion, both in academia and central banks, has focused on either dealers' balance sheet capacity (scarce balance sheet space due to higher capital requirements post-2008) or Leverage Ratio requirements, preventing dealers from providing liquidity, particularly in times of market turmoil. Copeland et al. (2024) suggest that banks' reserve scarcity could also have been instrumental in amplifying the shock.

In this section, we discuss whether there is a benefit for shareholders from the intermediation of Treasury securities. After all, dealers should act in the interest of their shareholders, in the sense that the trade should be undertaken as long as it adds value to the equity position of the bank. As also discussed in Duffie (2018), there is a cost to shareholders from adding safe assets (Treasury or gilts) to the balance sheet. In this section, we show that this is the case and discuss the mechanism.

Suppose that the original bank's assets are A_0 at time $t = 0$. In this example, we assume that the bank sells part of the risky assets, say $T_0 \in (0, A_0]$, to purchase Treasury securities with payoff $T_1 = T_0(1 + r_1)$ at time $t = 1$. If the dealer survives, the value of the assets, $A_0 - T_0$, on the bank's balance sheet is $Af\,A_0 1$; if the dealer defaults, the bank's asset value falls $Af\,A_{o1}$. The equity value is

$$E_0^T = \frac{[(A_0 - T_0)Af\,A_0^1 + T_1 - D_1](1 - p)}{1 + r_1} \tag{28}$$

And, as before, the wealth change for the equity holders, if compared with the case of no purchase of Treasury, is:

$$E[-Eo$$
$$\frac{[(Ao - To)Af\, A0^{1} + T1 - D1](l - p)}{1 + 7'j} \quad \frac{(At - D1)(l - p)}{1 + r_f}$$
$$\frac{(1 - p)\,((Ao - To)At\, A0^{1} + T1 - At)}{1 + 7'j}$$
$$\frac{(1 - p)\,(T1 - ToAt\, Aa^{1})}{1 + 7'j} \tag{29}$$

$T1 - T_0At\, A0^{1}$ is the return on the Treasury notes (T1) less the risky assets if the dealer survives $(ToAt\, Aa^{1})$. Since $At\, Aa^{1}$ is assumed to be greater than $1 + rJ$, this implies debt overhang to shareholders.

What about legacy creditors? The value to the creditors is:

$$DT_{o-} = \frac{(1 - p)D1 + pD1(l - LT)}{l + r1}, \tag{30}$$

where now the loss rate LT has the following expression

$$L^T = 1 - \frac{(A_0 - T_0)A_1^d A_0^{-1} + T_1}{D_1}. \tag{31}$$

The numerator term LT, $(Ao - T_0)Af\, A0^{1} + T_1$, shows that creditors can count on a new (safe) asset at default. This also suggests that the wealth change to the creditors is

$$D[-D$$
$$\frac{(1 - p)D1 + pD1(l - LT)}{1 + 7'j} \quad \frac{(1 - p)D1 + pD1(l - L)}{1 + r_f}$$
$$\frac{pD1(L - LT)}{1 + 7'j}$$
$$\frac{p\,(T1 - ToAf\, Aa^{1})}{1 + 7'j} \tag{32}$$

$T1 - T_0Af\, A0^{1}$ is the creditors' gain on the Treasury security (T1), minus the risky assets (at default) $(T_0Af\, A0^{1})$. Given that, since $T_1 > T_0Af\, A_0 1$, $W.5$ is positive. This suggests a wealth gain to the creditors.

The inclusion of the (safe asset) Treasury securities on the bank's balance sheet will make available (to creditors) that asset at default, and this will be entirely financed by entirely financed by equity holders.

This result has important implications. Trading Treasury securities carry significant costs to shareholders, especially during shocks. Although the leverage ratio requirement adds up to the cost discussed in this section, its complete removal may not help to improve liquidity, especially in times of market turmoil, if debt overhang is high. The complete removal of the leverage ratio requirement may only free up additional capital, which is not guaranteed to be used to purchase Treasuries. Regulators should probably keep LLR in place and reserve the option to relieve banks of it in case of systemic market dysfunction. This happened in March 2020, for example.

4 Funding Benefit Adjustment (FBA)

4.1 Debt Buyback

In the previous sections, we have discussed cases of receivable cash flows in the sense that the dealer was purchasing an option (or derivatives). In that context, we discussed funding cost adjustments, which generally apply to the derivatives position. In this section, we discuss cases when the option position is instead a liability on the dealer's balance sheet; for example, the dealer sells the option. This position generates a funding benefit for the dealer. For example, a derivative payable is one where the dealer obtains cash from selling the option. In this case, the expectation would be that the dealer uses the funding benefit to repurchase its debt. We start with debt buyback. In fact, debt buyback does not impact shareholders' wealth, as total assets will not change. To see this, consider this example. Consider shareholders' equity value in this case

$$\widetilde{E}_0' = \frac{[A_1^u - (D_1 - V_1) - V_1](1-p)}{1+r_f} \quad \frac{(Af - D1)(l - p)}{1 + r_1} = Ea. \tag{33}$$

Consequently, there is no debt overhang cost for shareholders,

$$\Delta\widetilde{W}_E = \widetilde{E}_0' - E_0 = 0. \tag{34}$$

To understand why there is a funding benefit adjustment in this case, consider the creditors and the scenario where the dealer defaults. Creditors, in this case, receive the fraction of the bank's assets as $p = (D_1 - V_1)/D_1$, while tendering creditors receive the remaining share, $1 - p = Vi/D1$.

Let's consider tendering creditors. The expected payoff is

$$D_{TC} = \frac{Vi(l-p)+(l-p)Afp}{l+ 7'j}. \tag{35}$$

Compared to the face value of the derivative payable, the change is

$$"W_u \; re- D \; re- \; \psi o - \frac{[(1 - p)Af - Vi]p}{1 + 7'j} \tag{36}$$

which is the funding benefit adjustment (FBA) we introduced earlier.

Consider now the remaining creditors. Their payoff is

$$D_{RC} = \frac{(D_1 - V_1)(1-p) + \tilde{\rho} A_1^d p}{1 + r_f}. \tag{37}$$

Compared to the face value of the remaining debt, the change is

$$W_{RC} = D_{RC} - \frac{D_1 - V_1}{1 + r_f} = \frac{[\rho A_f - (D_1 - V_i)]p}{1 + r_f} = DVA_{new} \tag{38}$$

which is the new debit value adjustment (DVA).

One can see that $|W_{RC} + W_{RC}| = DVA$

$$W_{TC} + W_{RC} = W_{TC} + W_{RC} + \frac{[\rho A_f - (D_1 - V_1)]p}{1 + r_f} = \frac{(A_t - D_1)P}{1 + r_f} = -DVA. \tag{39}$$

Therefore, in the case of derivatives payable, shareholders will benefit as DVA will decline by the amount equal to $|W_{\text{rel}}$.

4.2 Asymmetric Funding

In the previous section, we implicitly assumed that the dealer could borrow and lend money arising from cash flow at the same cost of funding (the dealer's spread). The main issue, which has been raised and discussed in the industry, is that borrowing and lending rates are set by the bank's Treasury and generally different. The Treasury will finance the dealer at the bank's credit spread and pay the dealer for excess cash, the risk-free rate of interest (see also discussion in Albanese et al. (2017)).

The fair value of the derivative to the counterparty is:

$$\frac{V_1(1-p) + p(A_f + F_f)p}{1 + r_1} \quad \frac{P_1^C}{1 + r_f}, \tag{40}$$

where F_f is the fair value of the derivative at time $t = 1$ to the counterparty in the asymmetric funding case, and pis the same as in Section 2.1.3. If the dealer survives (with probability $1 - p$), the buyer receives the full value of the option as V_i. If the dealer defaults (with probability p), the buyer obtains a fraction of the bank's assets. Solving for F_f provides:

$$P_1^{C*} = \frac{V_i(1-p) + pA_f r}{1 - pp}, \tag{41}$$

in which $F($ denotes the solution.

Given that the derivative position is a liability to the dealer, the client counterparty will apply the credit value adjustment. The credit value adjustment (CVA) is the difference between the fair value and the face value of the derivative,

$$\Delta W^c = \frac{F_1^c}{1+r_f} - V_0 = \frac{[\widehat{\rho}(A_1^d + F_1^c) - V_1]p}{1+r_f} < 0 \qquad (42)$$

Therefore, the derivative buyer needs to adjust the option value by the CVA.

What is the implication of this for the bank's creditors? For existing creditors, the value of debt is

$$fY_{0} - \frac{D1(l - p) + (1- p)(Af + Ff)p}{1 + r1} \qquad (43)$$

If we compare it with the value of the debt in the case of no derivative payable, the wealth change for existing creditors is

$$\Delta\widehat{W}'_D = \widehat{D}'_0 - D_0^c = \frac{[F_1^c - \widehat{\rho}(A_1^d + F_1^c)]p}{1+r_f} > 0 \qquad (44)$$

This suggests that creditors will be better off

What about the bank's equity holders? They can receive the remaining value after the payment of existing debt and derivative payables, but only if the dealer survives. The value of equity is

$$E'_{0} - \frac{(At + Ff - D1 - V1)(l - p)}{1 + r1} \qquad (45)$$

It shows that shareholders' wealth change, if compared with no derivative payable, is

$$\widehat{W}'_E = \widehat{E}'_0 - E_0 = \frac{(F_1^c - V_1)(1-p)}{1+r_f} < 0 \qquad (46)$$

In this case, equity holders face debt overhang. Based on Eq 40, one can find that 6-$\overline{W}$ = -6.Wf/[11], which means the reduction in shareholders' wealth is exactly the increase in creditors' wealth (i.e. debt overhang).

5 Margin Value Adjustments (MVA)

Generally, dealers trade with clients unsecured derivatives (in our previous example, cross-currency swaps), but they hedge their market risk exposure in the interdealer market with other dealers but using collaterals. The hedge dealer will ask the counterparty to post an initial margin and (generally intraday) variation margins, reflecting the client's risk exposure on that trade. What is the effect of variation and initial margins on the dealer's position? Would the dealer be exposed to FVA costs (benefits) in this case? We start considering the

[11] Inserting $Ff = Ff(1 - p) + Ffp$ into Eq 40 and rearranging the equation show the equality between D-W'$_E$ and -D-W'$_D$

hypothesis of a dealer buying an option (this is a simplified example, but our option could be a long-term interest rate swap where the dealer pays floating and receives fixed) from a client and turning to the interdealer market to hedge the position.

We assume that the underlying security of the options has a current spot price S_0 at time $t = 0$ and the same volatility as the one of the bank's assets[12]. The price change in this security is independent of the change in the bank's asset valuation.

Assume that the option is purchased by a credit-risky bank from a risk-free counterparty. Soon after the purchase, the dealer enters an off-setting position with another dealer bank, called the "hedge dealer." It is common for the hedge dealer to demand the bank to provide both IM and VM. Therefore, the bank holds two derivatives: an unsecured derivative receivable from the client and a secured derivative payable to the hedge dealer. As the hedging position needs to be financed, generally with additional funding, this raises the question of whether the value of the derivative should account for this cost. The initial margin is known in the industry as Margin Value Adjustment (MVA). This is known in the industry as margin value adjustments (MVA).

5.1 The Economics of Variation Margins (VM)

Let's start considering variation margins first. Variation margin (VM) is a collateral payment required by clearinghouses or counterparties, as in our example above, to cover the current exposure resulting from changes in the market value of a derivative contract. VM is calculated and exchanged daily (or even intraday) based on the mark-to-market value of the positions held, thereby reducing the credit risk between the counterparties.

We first consider the case of no initial margins and focus on the variation margin, as this is the most controversial one. Section 5.1.2 explores a single option between the bank and the hedge dealer. Section 5.1.2 explores a portfolio of two options: One option is between the bank and the counterparty, and another one is an offsetting option between the bank and the hedge dealer.

5.1.1 The bank and The Hedge Dealer

In this example, we discuss the position of the dealer with the hedge dealer. Note that the hedge dealer, in case of default, has priority over all the creditors. We do not include the dealer's client in this first example. The bank sells options to the hedge dealer and raises C_0. We assume that this amount will soon be in the hedge dealer's account as margin collateral. This collateral will pay the risk-free rate, and its value will be revised and exchanged at $C_1 = C_0(1 + r_f)$ an instant before time $t = 1$ (the time when the option expires).

[12]If the volatility of the underlying security is, for example, higher than the one of the bank's assets, it would result in a wealth transfer from the creditors to the shareholders. It is due to the asset substitution problem in which shareholders benefit from riskier investments at the expense of the creditors.

At maturity, the options could be in-the-money (ITM) or out-of-the-money (OTM). In the ITM case, the expected payoff to shareholders is:

$$E_0^{ITM} = \frac{(1-p)\left[(1-p)(A_1^u + C_1 - C_1^u - D_1)\right]}{1+r_f}, \tag{47}$$

while in the OTM case, it is:

$$E_0^{OTM} = \frac{p\left[(1-p)(A_1^u + C_1 - D_1)\right]}{1+r_f} \tag{48}$$

Assuming that the probability of the ITM case is the same as the one of the bank's up-state scenario, we can combine ITM and OTM cases with respect to their own probabilities:

$$E_0^{Call} = E_0^{ITM} + E_0^{OTM} = \frac{(1-p)\left[A_1^u + C_1 - (1-p)C_1^u - D_1\right]}{1+r_f} \tag{49}$$

According to Eq ??, $C_1 = (1-p)C_1^u$. It follows

$$E_0^{Call} = \frac{(1-p)\left[A_1^u - D_1\right]}{1+r_f} = E_0, \tag{50}$$

which means that the option value will not affect the shareholders' equity value given the collateralization scheme. Therefore, the hedge removes the variability of the payoff of the option whose value is known at time zero.

5.1.2 The Hedge Dealer, the Dealer and The Client

Suppose the bank has an options contract (derivative receivable) with the client and, after hedging, has a derivative payable with the hedge dealer. Therefore, on the one hand, the dealer will not receive collateral, but on the other hand, collateral will be expected (by the hedge dealer).

Suppose that the bank deposits the cash raised from the derivative payable and keeps the derivative receivable unsecured. As we discussed earlier, a collateralized derivative payable has no effect on the equity holder's value. Thus, the loss rate to creditors is unchanged, L_{MVA}.

The expected payoff to shareholders is

$$E_0^{MVA} = \frac{(1-p)\left[A_1^u + C_1 + C_1 - F_1^u - D_1 - C_1\right]}{1+r_f} = \frac{(1-p)\left[A_1^u + C_1 - F_1^u - D_1\right]}{1+r_f} \tag{51}$$

As the bank does not retire any debt, legacy creditors will receive the full value of the debt if the bank survives. Given the loss rate L_{MVA} in the default scenario, the expected payoff for legacy creditors is:

$$D_{LC}^{MVA} = \frac{(1-p)D_1 + pD_1(1-L_{MVA})}{1+r_f} \tag{52}$$

Since the derivative receivable is unsecured, the bank still needs to issue new debt and borrow from new creditors. Based on the zero-NPV investment rule discussed earlier, the payoff to the new creditors should be equal to the value of the option premium:

$$D1jfJA = \frac{(1-p)F\{ + pF\{(l - LMvA)}{l+r_1} = \frac{C_1}{l+r_1} \tag{53}$$

The hedge dealer requires the bank to post collateral against the option. Thus, the hedge dealer can always obtain the full value of the option, yielding:

$$D1;f)? = \frac{(1-p)C1 + pC1}{l+r_1} = \frac{C1}{l+r1} \tag{54}$$

In this partial collateralization case, the only distinction from the previous situation (no collateralization case) is the absence of a CVA adjustment for the derivative payable. There are no funding value adjustments.

The above example is rather simplistic and does not fully reflect market practice, particularly for the interdealer market. Furthermore, we can replace the example of a simple option with a cross-currency swap, whose maturity can be, say, five years. There is a real possibility that the receiveable (payable) legs will not match all the time, increasing substantially the dealer's exposure to the hedge dealer. These elements will need to be accounted for as they imply higher funding costs (other things stay unchanged). Therefore, the dealer will be, in practice, exposed to funding risk and debt overhang costs, which need to be priced.

5.2 Initial Margin (IM)

In this section, we discuss the initial margin (IM). IM is the upfront collateral that must be posted by a dealer or counterparty when entering into a derivatives contract. This margin serves as a deposit to cover potential future losses and ensure the performance of the contract. The initial margin is determined based on the volatility of the underlying asset, and, in the case of a clearing house, it is set using an internal model. Its purpose is to provide a buffer against adverse price movement before any additional variation margin is collected.

As discussed in the previous section, variation margins do not lead to additional funding costs or benefits. At the initial time (time $t = 0$), the option premium paid or received is balanced by the collateral posted or received. This does not apply to initial margins, as they must be posted in cash or non-rehypothecable assets and, therefore, must be fully funded. Therefore, does the dealer need to adjust the funding costs due to the initial margin?

Consider the bank's default scenario. If the option is properly collateralized, the variation margin should cover the hedge dealer's loss when the option is in-the-money. If it is insufficient, the worst-case scenario could see the entire initial margin transferred to the hedge dealer without any benefit to the legacy creditors. If the option is out-of-the-money, the legacy creditors will receive a portion of the (future value of) the initial margin. The expected gain for the legacy creditors is positive if there is a non-zero probability that the bank defaults while the option is out of the money.

Raising new debt or equity to fund the initial margin is a zero NPV investment for the new creditors or shareholders. The proceeds are either kept as cash or invested in riskless securities (for example, Treasury notes) held by a third party. This arrangement benefits the legacy creditors since they can recover a fraction of the securities held by the custodian in the event of default. Consequently, shareholders are worse off as they incur the financing costs of the initial margin in the no-default state. Therefore, a derivative contract requiring an initial margin is a negative NPV investment to shareholders.

In the following sections, we will discuss how the initial margin works in partial collateralization, full collateralization cases, and full collateralization with donation.

5.2.1 Derivative Payable and Derivative Receivable

Suppose that the derivative payable is collateralized and the derivative receivable is unsecured. The bank needs to issue new debt to fund the derivatives receivable and the initial margin required by the new creditors.

Assume that both the derivatives receivable and payable are homogeneous, which means they have the same strike price, movement and payoff per unit. As discussed earlier, this is a simplistic assumption that generally does not reflect interdealer market practice. If the option is in the money state, the dealer obtains Cf from the (derivative receivable) counterparty and pays Cf - C_1 to the (derivative payable) hedge dealer. In the out-of-the-money state, the bank gains nothing from the counterparty and pays nothing to the hedge dealer. Meanwhile, it can earn from the collateral C_1 against the derivative payable. What the bank obtains from the derivative receivable Cf will offset the payoff of the derivative payable Cf, leaving the collateral value C_{1}. Consequently, the expected value is C_1 in in-the-money and out-of-the-money states.

Suppose that for a newly issued debt, the fair value is F_{FM}- The loss rate to the creditors

$$L_{CM} = 1 - \frac{A_1^d + C_1 + M_1}{D_1 + F_1^{CM}} \quad (55)$$

The fair value F_{fM} satisfies the equation

$$\frac{(1 - p)F_{fM} + pF_{fM}(1 - L_{cM})}{1 + r_1} = \frac{C_1 + M_1}{1 + r_f} \quad (56)$$

where M_1 denotes the initial margin. This shows that the newly issued debt is a zero-NPV investment to the new creditors. Following up on Eq 9, we can solve for *FfM*, providing

$$F_1^{IM*} = -0.5\,(1-p)^{-1}\left[p(A_1^d + C_1 + M_1) + (1-p)D_1 - C_1 - M_1 - \Theta\right] \tag{57}$$

where

$$8 = \{ [p(Af + C1 + M1) + (1- p)D1 - C1 - M1]^2 + 4(1- p)(C1 + M1)D1 \}^{\frac{1}{2}} \tag{58}$$

Consider the bank's shareholders. These can obtain the residual of the assets, the payoff from the options, and the initial margin after the payment of new and legacy debt if the bank survives. In the bank defaults, they receive nothing. Therefore, the expected payoff is

$$ECM_o = \frac{(l-p)(Af+C1+M1-FPM-D1)}{1+r1} \tag{59}$$

Compared with the pre-derivative case, the change to the shareholders' wealth is

$$\Delta W_E^{CM} \quad E(jM - E_0 \quad \frac{(1- p)(Af + C1 + M1 - FPM - Di)}{1 + r_1} \quad \frac{(1- p)(Af - D1)}{1 + rf} \quad \frac{(1- p)(C1 + M1 - FfM)}{1 + r_1} \tag{60}$$

Since $C_1 + M_1 < FPM$, '6..WjM < 0, there is a wealth loss for the bank's shareholders.

5.2.2 Discussion and Policy Implications

Following the introduction of FVA, the industry, starting in 2016, has been hit by the so-called Margin Valuation Adjustment. This new valuation adjustment was introduced following the new rules where interdealer market trading was subject to collateral. IM soon became standard practice in derivatives pricing. While implicitly priced for cleared trades, MVA is still struggling to gain acceptance in the non-cleared world. For example, it is, in general, only applied to trades whose exposure is less than $50 million. On the client side, IM is applied, in general, only to large hedge funds and asset management firms. Therefore, it seems that including IM in a trading price is more like a business decision.

There is evidence that MVA affects more counterparties than FVA, as it applies to all clearing counterparties. For example, consider the case of clearing trades with clearing houses. Assume that one wishes to clear a position of a client with a clearing house, say, A and B, and assume that they post different IMs. If there is competition amongst clearing houses, this should not happen, but in practice, the difference in IMs can arise practically. The difference in IMs then raises the (business) question of whether the dealer will have to pass this cost to the client or rather absorb it internally.

With IMs, dealers cannot rehypothecate them unless the margin poster is a client and the margin is being used to cover a call that arises from a hedge of the client's trade. Therefore, unlike FVA, which can be FBA or FBC, MVA is only an FBC to the dealer.

In addition to these problems related to IMs, there are also implications for the net stable funding ratio, as this indicates that 85% of the margins must be covered by long-term funds, which are generally more expensive.

In sum, margin requirements can have serious implications for dealer funding costs (and capital consumption). For example, re-calling our example above between the dealer and a clearing house. In an ideal world, the dealer would have two-way flows that match. Therefore, by compressing the portfolio, she will end up with no position facing the clearing house. However, if the clients are sticky for the whole life of the transaction, MVA costs can be very high.

In addition to the costs discussed above, there is also an additional cost. Initial margins are estimated by the clearing house using a value-at-risk or expected shortfall model, using a period of 10 days at a 99% confidence level. Therefore, MVA is calculated by taking an expectation of the initial margin over the lifetime of the trade and applying a funding spread to it. To do this, one generally rests on a so-called nested simulation or a simulation within a simulation. There is very little transparency, sometimes, in the way clearing houses calculate the margins, but this has important implications for the dealer and the client. In the case of insufficient transparency, costs due to asymmetric information increase. This is likely to impact the trade, particularly in times of high volatility (which turns out to coincide with the time when the funding costs of the dealers are very high).

The discussion on MVA is both timely and highly relevant. In the U.S., significant markets such as Treasury and REPO will transition to clearing platforms by late 2025 and 2026. Based on our analysis, the optimal approach for dealers to clear a client's position involves: 1) minimizing the client's funding requirements (initial margins), 2) offsetting positions across clients to reduce balance sheet costs, and 3) reducing information asymmetry with the clearing house. These factors are crucial to address in order to ensure that the clearing process operates efficiently and supports both industry functionality and market stability.

6 Funding Costs and Cross-Currency Swaps

For simplicity, we consider only $t = 0, 1$. The dealer's asset valuation is A_0 at time $t = 0$. The asset value at time $t = 1$ can be higher or lower than A_0. Let Af denote the up-state scenario and Af the opposite. Suppose the dealer has an existing debt with a face value of D_1. The legacy debt is a one-year zero-coupon bond, and its current market price is Di/ $(1 + rf + cp)$, where rf is the risk-free rate and cp is the credit spread of the dealer. Since the face value satisfies $Af < D_1 < A_0 < Af$, the dealer will either survive if the asset value goes up to Af or default if it goes down to Af Let p define the risk-neutral default probability.

Suppose that a dealer starts a USD-to-FCU cross-currency swap with a counterparty where she sells USD against foreign currency. For simplicity, we assume that the swap has a lifetime of one year, which means it begins at time $t = 0$ and ends at time $t = 1$. Let $y^D_{0,1}$ be the annual interest rate for borrowing USD for 1 year in the wholesale market and $y_{0,1}$ be the equivalent interest rate for borrowing FCUs. Assume that the spot exchange rate between USD and FCUs is S_0 at time $t = 0$ and the 1-year forward exchange rate is $F_{0,1}$ at the same period.

The dealer will owe $(1 + y^D_{0,1})$ USD to the wholesale market in 1 year after borrowing USD. The swap with FCU currency is $(1 + y_{0,1})F_{0,1}/S_0$ USD. Covered interest parity (CIP) condition suggests:

$$(1 + y^D_{0,1}) = (1 + y_{0,1}) \frac{F_{0,1}}{S_0} \tag{61}$$

In the swap above, the dealer swap's notional is assumed to be \$1. Suppose now that the dealer raises X_0 USD and swaps it with the counterparty against X_0/S_0 FCUs. At the maturity $(t = 1)$, the dealer will obtain the interest income on the FCU assets, worth $y_{0,1}X_0F_{0,1}/S_0$ USD, while paying the interest expenses on the USD assets, $y^D_{0,1}X_0$. The dealer's profit and loss (PnL) of the cross-currency swap is

$$\pi_1 = \underbrace{y^D_{0,1}X_0}_{\text{Profit of USD}} - \underbrace{y_{0,1}X_0F_{0,1}/S_0}_{\text{Cost of FCUs}} \tag{62}$$

Rearranging the above equation provides that

$$\pi_1 = \left(y^D_{0,1} - y_{0,1}F_{0,1}/S_0\right) X_0, \tag{63}$$

Thus, if the interest rate on the FCUs ($y_{0,1}$) is greater than the one on the USD ($y^D_{0,1}$), the dealer's shareholders will earn a profit from the cross-currency swap. Otherwise, she will face a loss. This provides a break-even swap price to shareholders, $\pi_1 = 0$. Since the dealer needs to raise USD from the new creditors via the wholesale market (say, commercial papers), the bank can issue new debt with fair value to creditors (zero-NPV).

Assume the volume of the new debt is sufficiently small, and therefore, it has little impact on the dealer's default probability p. Also, suppose that the value of the new debt is F_1^{cross} which is a fair price for the new creditors (that is, the one making the net present value (NPV) of the debt equal to zero). Assume the new debt has the same ranking as the legacy debt, which means both new and legacy creditors can receive their debt values simultaneously at maturity $(t = 1)$[13]. The new creditors will either receive the full face value F_1^{cross} if the dealer survives or recover $1 - L^{cross}$ of the face value at default, where the loss rate to the

[13]Consider both new and legacy debt are senior debt in the dealer's balance sheet.

creditors becomes:

$$L^{cross} = 1 - \frac{A_1^d + \pi_1}{D_1 + F_1^{cross}} \tag{64}$$

We simplify the payoff of the cross-currency swap at time $t = 1$ as π_1. The numerator of the second term in Eq 64, $A_1^d + \pi_1$, is the asset value of the bank at the default state. The denominator, $D_1 + F_1^{cross}$, shows the full value of total debt if the dealer survives. Given zero NPV, the discounted face value F_1^{cross} should be equal to the payoff of the cross-currency swap. Thus, the fair price F_1^{cross} should satisfy:

$$\frac{(1-p)F_1^{cross} + pF_1^{cross}(1-L^{cross})}{1+r_f} = \frac{\pi_1}{1+r_f} \tag{65}$$

Solving the equation, we find the solution of the fair value as

$$F^{*}_{cross} = -0.5(1-p)^{-1}\left[p(A_1^d+\pi_1) + (1-p)D_1 - \pi_1 - \Lambda\right] \tag{66}$$

where

$$\Lambda = \left\{\left[p(A_1^d+\pi_1) + (1-p)D_1 - \pi_1\right]^2 + 4(1-p)\pi_1 D_1\right\}^{\frac{1}{2}}.$$

In this way, the new debt should be fairly priced at F_1^{cross} due to the zero NPV investment.

Now, let's consider the equity value. Assume that the dealer's balance sheet is measured in USD. If the dealer survives, shareholders receive the residual asset valuation after the payment of the debt. They receive nothing at default. The present value of the shareholders' equity value is

$$E_0^{cross} = \frac{(1-p)(A_1^d + \pi_1 - D_1 - F_1^{cross})}{1+r_f} \tag{67}$$

Shareholders' equity value without the newly issued debt is

$$E_0 = \frac{(1-p)(A_1^d - D_1)}{1+r_f}. \tag{68}$$

It follows that the change in shareholders' wealth due to the cross-currency swap is

$$\Delta W^{cross} = E_0^{cross} - E_0 = \frac{(\pi_1 - F_1^{cross})(1-p)}{1+r_f}. \tag{69}$$

Given that $F_1^{cross} > \pi_1$, following our discussion in equation (66) and equation (67), shareholders' wealth is negative, that is, $\Delta W^{cross} < 0$. This suggests a wealth shift from the dealer's shareholders to creditors. ΔW^{cross} is shareholders' debt overhang cost.

To study the relationship between debt overhang and dealer's credit spread in the case of cross-currency swap, we rewrite Eq 65 as

$$\frac{F_1^{cross}}{1 + r_f + rp^{cross}} = \frac{\pi_1}{1+r_f}, \tag{70}$$

in which *rpcross* is the credit spread of the dealer. The LHS of the equation shows that the fair value of the new debt should include the credit risk, measured by the credit spread, of the dealer. Rearranging the equation

$$F^{cross} \cdot \; 7r1 = \frac{7r1 \; rp^{cross}}{1 + r_1} \tag{71}$$

If we replace this equation into Eq 69 and rearrange, we have

$$\varphi^{cross} = -\frac{(1 + r_f)^2 \Delta W_E^{cross}}{(1 - p)\pi_1} \tag{72}$$

Since *w.Eross* < 0 is debt overhang to shareholders, and it is negative, the credit spread will be positive (*rpcross* > 0). Assuming that the risk-free rate is close to zero, r_f 0, and the probability of default of the dealer is also close to zero, which is realistic for large banks, we can rewrite Eq 72 as:

$$\varphi^{cross} = -\frac{\Delta W_E^{cross}}{(1 - p)\pi_1}. \tag{73}$$

This shows that the (discounted) profit of a new (debt-financed) swap to shareholders (i.e. discounted using the credit spread) is debt overhang cost to shareholders.

7 Conclusion

This paper provides theoretical models of valuation adjustments (XVAs) and their multi-faceted impacts on systemic banks' balance sheets and market intermediation. By focusing on Funding Value Adjustments (FVAs), we highlight their implications for banks' share-holders, creditors, and financial stability. The evidence and examples presented, particularly those related to the COVID-19 pandemic and geopolitical shocks, underscore the widespread influence of funding and regulatory costs on market behaviour.

Key findings indicate that FVAs and debt overhang costs significantly affect sharehold-ers' equity, warranting thoughtful recovery strategies such as bid-ask spread adjustments or "donations" from creditors. However, these solutions often involve trade-offs between mar-ket competitiveness and financial stability. Furthermore, our discussion of cross-currency swaps, funding benefits, and margin valuation adjustments (MVAs) illustrates the intricate interplay between regulatory frameworks, funding practices, and market liquidity.

From a policy perspective, the results advocate for a complex approach to regulation. Al-though measures like leverage ratio requirements aim to enhance resilience, they may exacer-bate funding costs during periods of turmoil. Regulators could consider dynamic frameworks that balance systemic stability with the operational needs of financial intermediaries.

Future research should investigate in-depth the long-term consequences of valuation ad-justments on global financial markets, focusing on how evolving regulatory landscapes and market practices shape funding dynamics. Ultimately, this paper contributes to a broader understanding of the challenges and opportunities facing financial institutions as they navigate valuation adjustments in an increasingly complex environment.

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Appendices

A Fair Value of New Debt

Substituting L' in Eq 6 into Eq 7 provides

$$\frac{F_1\left(1-p\left(1-\frac{A_1^d+V_1}{D_1+F_1}\right)\right)}{1+r_f} = V_0. \tag{A1}$$

Rearranging the above equation, we obtain a quadratic equation of F_1 which is

$$(1-p)F_1^2 + \left[p(A_1^d + V_1) + (1-p)D_1 - V_0(1+r_f)\right] F_1 - V_0(1+r_f)D_1 = 0. \tag{A2}$$

Since $V_0(1 + r_f) = V_1$, we can rewrite the quadratic equation as:

$$(1-p)F_1^2 + \left[p(A_1^d + V_1) + (1-p)D_1 - V_1\right] F_1 - V_1 D_1 = 0. \tag{A3}$$

Solving this quadratic equation for F_1 in a straightforward way provides the expression in Eq 8.

B The Effect of Bank's Equity Level

Considering the expression of the debit value adjustment (DVA) in Eq 4, we can rewrite the initial formula of the present value in Eq 3 as

$$D = D_b - DVA. \tag{B1}$$

That is, the bank is facing a default (survival situation when the asset valuation is in the down (up)-state scenario ($A_1 = A_1^d$). This will depend on the level of shareholders' equity value. Banks with higher equity levels are more likely to be solvent in a credit event than banks with lower levels of equity. We study bank shareholders' equity value for these two types of banks.

We start considering low-equity banks. In banks with lower levels of equity, shareholders' wealth is either $A_1^u - D_1$ in the up-state scenario or 0 in the down-state scenario[14]. It means that the bank can only generate value for shareholders if it can survive at time $t = 1$. Given this, we can write the equity as

$$E_0^L = \frac{(A_1^u - D_1)(1-p)}{1+r_f}, \tag{B2}$$

in which E_0^L denotes the present equity value of the low-equity bank, and the superscript L

[14] This is the bank's default state

denotes low equity.

Let's now focus on the high-equity bank. Similarly, the shareholders' wealth of the high-equity bank will be *At* - D_1 in the up-state scenario. Therefore, in the case where the value of the assets declines, we assume that it stays solvent, with an equity value given by *Af+* - $D_1 > 0$. Thus, the equity value of the bank will be

$$E_0^H = \frac{(A_1^u - D_1)(1-p)}{1+r_f} + \frac{(A_1^{d+} - D_1)p}{1+r_f}, \tag{B3}$$

in which *Ef!* denotes the present equity value of the high-equity bank, and the superscript *H* denotes high equity. Since the bank is solvent, creditors will receive the full value of the debt. In this scenario, debt becomes a risk-free one, and the present value is *D{* The difference between a high-equity bank and a low-equity one is:

$$Ef! - Eo = \left[\frac{(At - Di)(l - p)+}{l+r_1} \frac{(Af+ - D1)P]}{l+r_1}\right. \quad \frac{(At - D_1)(1 - p)}{1+r_1}$$
$$\frac{(Af+ - D1)P}{1+r_1} \tag{B4}$$

Compared with a highly capitalised bank, a bank with a lower level of equity would be insolvent in a state where asset prices decline. This implies that while lower-equity banks face debt overhang costs, wealth shifts do not happen in higher-equity banks.

This result is important as it suggests that banks that are more strongly capitalised can weather the crisis better and achieve better (and more sustainable) returns for their shareholders. For example, Caruana (2012) discusses how in periods when there is no crisis, there is no relationship between Tier 1 capital and equity returns. Instead, this relationship becomes much stronger and significant in periods of crisis.

C Default Probability and Wealth Shift

Now, we relax the invariant assumption of default probability. Suppose that a highly capitalised bank has a lower default probability than a less capitalised one since it has more equity to buffer against a credit event. We start with the bank's credit spread denoted by <*pD* where the superscript *D* indicates the debt financing case. The credit spread is expressed in the form of Eq 2 as

$$\varphi^D = (1+r_f)\left(\frac{pL'}{1-pL'}\right),$$

in which L' is a constant with an expression in Eq 6 and <*pD* is a function of *p.*

Substituting *rp'* in Eq 15 with *rpD,* we can have a new wealth change expression with respect to default probability p as

$$\Delta W_E^* = -\frac{V_1 \varphi^D (1-p)}{(1+r_f)^2}. \tag{D1}$$

The first differentiation of ΔW_E^* against default probability p is

$$\frac{\partial \Delta W_E^*}{\partial p} = \frac{V_1 L'(p^2 L' - 2p + 1)}{(1+r_f)(1-pL')^2}. \tag{D2}$$

Given the constraint $0 < p, L' \leq 1$ and $V_1 > 0$, we can solve $\partial \Delta W_E^* / \partial p = 0$ for p and derive the solution $p^* = (1 - \sqrt{1 - L'})/L'$. $p^* > 0$ satisfies the fact that $\lim_{L' \to 0} p^* = 1/2$ and $\lim_{L' \to 1} p^* = 1$. Then, we can prove that if the default probability satisfies $0 < p \leq 1/2 \leq p^*$, the change of shareholders' value with respect to the default probability is non-positive, given $\partial \Delta W_E^* / \partial p \leq 0$. Therefore, we can conclude that a bank with a higher capitalisation level possesses a lower default probability, and therefore, the bank shareholders' wealth shift is closer to null (or, the smaller the reduction in shareholders' equity value).