ACCOUNTING FOR OTC DERIVATIVES:

Funding Adjustments and the Re-hypothecation Option

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ABSTRACT

Banks hold and routinely exercise the option of freely re-hypothecating variation margin across counterparties and trades. However, the emerging FCA/FBA standards for funding cost accounting are mostly formulated in terms of netting set specific metrics that fail to properly account for re-hypothecation benefits to Common Equity Tier 1 Equity Capital (CET1). Additionally, the FCA/FBA standard introduces a double-counting issue between funding benefits and DVA which ultimately leads to a violation of the fundamental accounting tenet of asset-liability symmetry.

In this paper, we propose an alternative accounting framework meant to rectify some of the problems in existing standards. The new accounting method, denoted FVA/FDA, explicitly incorporates the re-hypothecation option into its definition of funding costs, and maintains consistency with the Modigliani-Miller Theorem, with fair-value asset-liability symmetry and with Basel III rules for DVA and equity capital. We argue that derivative pricing necessitates an incremental assessment of the capital structure impact of new trades and propose that entry prices should be struck at the indifference level for CET1. Unlike the FCA/FBA method, FVA/FDA accounting does not result in outright net income write-offs due to funding costs.

FCA/FBA accounting and FVA/FDA accounting lead to very similar and quantitatively close conclusions in the particular case of a portfolio consisting of a single netting set and a single trade. However, material differences arise in the case of large portfolios. We discuss a case study with a representative portfolio whereby CET1 adjustments for funding are three times as large as the ones required in FVA/FDA accounting. In case portfolio effects are accounted for, incremental entry prices for individual trades differ materially between the FCA/FBA and the FVA/FDA methods, with FCA/FBA accounting often displaying sizable and risky pricing biases between derivative payables and receivables.

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- A: Asset Account.
- BCBS: Basel Committee on Banking Supervision.
- CA: Contra-Asset Account.
- CCP: Central Counterparty (i.e, a Clearing House).
- CDS: Credit Default Swap.
- CET1: Common Equity Tier I Capital.
- CL: Contra-Liability Account.
- CFD: Central Funding Desk.
- CSA: ISDA Credit Support Annex Agreement.
- CVA: Credit Valuation Adjustment, same as FTDCVA.
- CVA_{CL}: Contra-liability Entry for the Credit Valuation Adjustment.
- DVA: Debt Valuation Adjustment.
- DVA2: Funding Debt Adjustment (same as FDA).
- EE: Expected Exposure.
- ENE: Expected Negative Exposure.
- EPE: Expected Positive Exposure.
- FBA: Funding Benefit Adjustment.
- FCA: Funding Cost Adjustment.
- FDA: Funding Liability Adjustment (same as DVA2).
- FTDCVA: First-to-default CVA, same as CVA.
- FTP: Funding Transfer Pricing.
- FVA: Asymmetric Funding Valuation Adjustment.
- PFV: Portfolio Fair Valuation.
- KVA: Capital Valuation Adjustment.
- L: Liability Account.
- OIS rate: Overnight Index Swap rate.

- OTC: Over the Counter.
- RE: Retained Earnings.
- REPO: Repurchase Agreement.
- RHO: Re-hypothecation Benefit.
- SFVA: Symmetric Funding Valuation Adjustment.
- UCVA: Unilateral CVA.
- VM: Variation Margin.
- XVA: "X" Valuation Adjustment (short-hand for all valuation adjustments, such as CVA, DVA, FVA, etc.).

1 INTRODUCTION

One key indicator of trade liquidity is the existence of an efficient REPO market infrastructure in support of market-making activities. In a liquid market, such as that of government bonds, security acquisitions may be financed by reverse REPO trades. The OTC derivative market, on the other hand, is not directly supported by a REPO infrastructure and uncollateralized derivatives must instead be funded by other means. As derivative receivables are an inefficient form of collateral, the rates banks face when funding Variation Margin (VM) for their hedges to uncollateralized derivatives are typically close to those for unsecured funding.

According to the famous Modigliani-Miller Theorem (MMT), see [18], the indifference price of a new trade should not depend on the rate at which the bank funds the VM on hedges. However, inefficient funding strategies may still give rise to wealth transfer across the capital structure of the bank, directed from shareholders to senior creditors, see [2].

Without an efficient REPO market infrastructure, managers cannot prevent or hedge the wealth transfer associated with unsecured derivatives trading. Instead, they must seek to recoup the loss to shareholders by passing on the cost to clients. At a more granular level, this cost transfer commonly goes through a chain that starts when a bank treasury issues unsecured debt to raise funds needed for uncollateralized derivatives trading activities. In a standard bank setup, the running spread cost of the bond issuance is subsequently passed by the treasury to a Central Funding Desk (CFD) which consolidates the management of funding costs[1] on behalf of the bank's trading functions. The CFD, in turn, transfers costs of funding to business line desks on an upfront basis, by implementing a Funding Transfer Pricing (FTP) policy. Finally, business line desks charge costs to clients by embedding them into deal structures.

While estimates for funding costs have been used (and incorporated into prices) informally for decades, it is only post-crisis that banks have attempted to recognize these costs in official accounting statements, by adding funding-related valuation adjustments (FVA) to the existing CVA and DVA credit risk adjustments[2]. Despite unresolved controversies in the literature, in the last quarter of 2013 funding costs were reflected on accounts at various banks including JP Morgan, Deutsche Bank, Nomura and others. Not only did this give rise to very material adjustments to Common Equity Tier I Capital (CET1), but also, due to asymmetries in the fair-value adjustments, to asset write-downs that in at least one case exceeded $1BN (see [22]).

The question of how and whether to include funding costs in accounts is complicated by the recent decision by national regulators to accept the recommendation by the Basel Committee [4] and mandate the exclusion of DVA and other own-credit benefits from CET1. This decision is relevant in the context of funding strategies, as popular accounting methods for funding costs are intertwined with the definition (or sometimes re-definition) of the DVA. In a realistic case-study example, we show that the impact of DVA capital exclusion is to triple CET1 deductions for funding whenever FCA/FBA accounting is used. In this paper, we argue that such adverse impacts are to a large extent due to logical faults in FCA/FBA accounting and are not justified in a more rigorous framework for funding costs.

1 In many cases, the CFD desk is merged with the CVA desk in a unified trading operation.
2 The alphabet soup of FVA, CVA, DVA, etc. is often collectively referred to as "XVA".

The calculations of CET1 deductions and of FTP amounts within business units are essentially always model based and depend strongly on a variety of assumptions and approximations. Of particular relevance here is how the Re-hypothecation Option (RHO) for VM is treated. As banks are allowed to re-hypothecate VM across netting sets in the same business line portfolio, the RHO is valuable and routinely exercised through the shifting of cash collateral from receivable hedges to payable hedges. As a consequence, a rigorously computed funding cost adjustment is an aggregate portfolio-level amount that cannot be linearly decomposed across netting sets. Specifically, re-hypothecation dictates that funding costs are calculated through a portfolio level simulation with scenarios that are shared at the *funding set* level, whereby a funding set is defined as a portfolio of unsecured or partly collateralized trades and the corresponding hedges among which variation margin can be re-hypothecated.

Modelling challenges here get intertwined with technology implementation difficulties. Funding cost calculations that require aggregation of trade and collateral values across netting sets are rarely a good fit for traditional CVA systems optimized for individual netting sets. In particular, modelling of re-hypothecation using common distributed computing setups is often awkward compared to an in-memory architecture where all counterparty credits are simulated dynamically and all scenarios are shared. To bypass technical implementation difficulties and re-use grid-based CVA systems, many market participants have implemented an approximate accounting method for funding costs based on metrics which are additive over netting sets.

The popular FCA/FBA accounting method was designed with linear aggregation in mind. However, the netting set additivity inherent in FCA/FBA accounting typically results in overlaps between funding benefits (as captured by the FBA) and the DVA on derivative payables. The resulting double-counting is normally handled by an outright replacement of DVA with FBA, see [12], [10]. This replacement inextricably intertwines the DVA on payables (a CET1 deduction) with the RHO (which instead should *add* to CET1).

To address the shortcomings of FCA/FBA accounting, this paper examines an alternative accounting method, denoted FVA/FDA, in which the RHO is modelled rigorously and care is taken to make entries on financial statements as meaningful as possible. The latter is often a delicate task as the accrual principles and "going concern" viewpoint of financial accounting inevitably clashes with the notions of fair market value, DVA and balance sheet wealth transfers. Yet, unlike the FCA/FBA accounting method, the FVA/FDA accounting method is simultaneously consistent with the MMT, risk-neutral pricing and general accounting principles such as asset-liability symmetry. Also, in FVA/FDA accounting, there is no double counting of the DVA and the funding cost adjustment to CET1 have the correct directional dependence with respect to the bank's own credit spread. Consistently with the MMT, FVA/FDA funding valuation adjustments do not impact income, but do affect both CET1 and entry price levels. This should help provide sufficient incentives for traders to manage their funding costs properly, something that cannot be said for classical accounting principles that ignore funding costs entirely.

The organization of the remainder of the paper is slightly non-standard, as we start out with a few sections that together are meant to provide a qualitative summary of results that are developed in full technical detail only later in the paper. Organizing the paper this way allows us to focus on regulatory and accounting principles early on, without drowning key messages in tedious and lengthy XVA formulas. While we run some risk of repeating material as the paper progresses into a more detailed discussion, the layout of the paper should, we hope, make it accessible to a variety of audiences, including those that are mainly interested in the big picture or in accounting rules. For the same reasons, the model setup in the main paper is somewhat simplified, with a variety of cash flow complications pushed into an Appendix.

With regards to the detailed contents of the remainder of this paper, the areas of funding and credit adjustment are, as we suspect the reader has already realized, heavy with jargon and abbreviations. Section 0 in the foreword conveniently collects all needed terms in one place. Section 2 gives an informal summary of our main results, with an emphasis on our specific accounting recommendations. Section 3 elaborates on the relevant regulatory implications of the Basel III Accord and also presents a framework to categorize cash flow streams in ways that facilitate their recording on financial accounting statements. We elaborate on accounting rules in Section 4 where we identify the elementary units of account into which an OTC portfolio can be split. In Section 5, we discuss in more detail cash flows associated with derivatives trading, both before and after a bank default. As mentioned, certain details are moved to Appendix A which deals with topics such as close-out conditions, variation margin from CVA hedges, collateral thresholds and mismatches between payoffs and hedges. Section 6 then gives a precise definition of XVA metrics and explains how they arise. Incremental XVA metrics for a single trade and the concepts of entry and exit price are discussed in Subsection 7.3, as are various rules for Funding Transfer Pricing (FTP). Section 8 goes through numerical results for a representative case study and Section 9 concludes the paper. Appendix B contains further discussions about alternative re-hypothecation assumptions and also briefly considers the application of liquidity spread discounting.

2 SUMMARY OF RESULTS

In this paper, we consider an OTC book containing trades with multiple unsecured counterparties, along with back-to-back hedges with dealers or clearinghouses. The unsecured counterparties are not posting VM in full while hedge trades are fully collateralized. In case the unsecured book is a net receivable, the hedge book is a net payable and the bank needs to procure VM to post as collateral to hedge counterparties. In this situation, the bank receives a rate of OIS on the collateral posted as VM. The funding value adjustment (FVA) is defined as the present value of the carry cost of funding VM, net of the OIS receipts on posted collateral.

OTC books are decomposed into *funding sets*, defined as trade collections for which VM for hedges can be re-hypothecated across all trades. Funding sets may span a large number (possibly thousands) of netting sets. The FVA is additive over funding sets but not over netting sets, as is both intuitively clear from the discussion in the introduction and evident from the mathematical definition in equation (24) below. As indicated earlier, the valuation of this formula is difficult to carry out with standard CVA systems and the industry is currently focused on using simpler alternatives which are linear over netting sets. We note that funding costs would, in fact, be additive over netting sets if either one of the following two mutually exclusive hypothesis held:

HY1 Re-hypothecation is possible only between hedges to trades in individual netting sets.

HY2 The collateral received from hedges to each payable netting set can be fully re-hypothecated as VM for hedges against other receivable netting sets.

Hypothesis HY1 leads to the FCA metric which aggregates funding costs linearly over netting sets, see equations (32) and (34) for a precise definition. The alternate assumption HY2 leads to a Symmetric FVA (SFVA) metric which recognizes a re-hypothecation benefit to all VM received. The metric

$$\mathrm{FBA} = \mathrm{FCA} - \mathrm{SFVA}. \tag{1}$$

measures the difference between funding costs estimated under assumptions HY1 and HY2. Precise definitions of these amounts are given below in equations (31) and (33). Note that in (1), the FCA generally overstates funding costs because it neglects the RHO for hedges to unsecured trades in different netting sets. The SFVA, on the other hand, has errors of the opposite sign since it overvalues the RHO.

In the interpretation of FBA, it is often noted that FBA overlaps[3] with the DVA on payables, see equations (19) and (23). As a consequence, advocates of FCA/FBA accounting remove the regular DVA contra-liability (CL) entry on the financial accounting statement and effectively replaces it with the FBA number[4].

DVA on payables is always recognized as a gain on the income statement and until 2012 could theoretically be considered a contribution to CET1. Under FCA/FBA accounting, this would ultimately lead to a net funding-related CET1 deduction equal to the SFVA. However, in 2012 the DVA on payables was de-recognized as contributing to CET1, see [4]. As the FBA is basically re-classified as DVA (see above), this effectively prevents the FBA from contributing to CET1 and sets the overall CET1 deduction for funding equal to the FCA. As a consequence, re-hypothecation benefits across netting sets are ignored altogether in CET1. As we discuss later, this has a material impact on both accounts and management trading decisions.

The compromise solution in FCA/FBA accounting includes the following:

1. Enter FCA and unilateral CVA (UCVA) as CET1 deductions.

2. Eliminate DVA on payables from accounts, replace it with the FBA and enter this amount as a contra-liability (CL) adjustment not contributing to CET1.

3. Transfer UCVA and SFVA to clients.

As we explain later in the paper, the end result is that FTPs are struck at the indifference level to income.

Besides the issues that have already been mentioned, it is clear from the booking rules above that FCA/FBA accounting implies a loss of asset-liability symmetry since the DVA on payables is eliminated in favour of FBA, even though CVA is supplemented with (rather

3 We elaborate on this difference in Section 6.4. In our case study, the FBA is about 20% larger than the standard DVA on payables.

4 To better comply with accounting laws, the CL entry may be broken into two pieces, the DVA plus a new "funding" term equal to FBA-DVA. The net CL entry is, however, still FBA.

than eliminated in favour of) FCA. The lack of symmetry is problematic from an accounting standpoint and contradicts FASB 159 (adopted in 2007). A possible way around this asymmetry involves deducting SFVA (rather than FCA) from capital, as we discuss in Appendix B. In this case, the DVA double-counting issue manifests itself by the fact that the SFVA inherits from the DVA a wrong-way sensitivity with respect to the own credit of the bank, i.e. it may decrease (causing the CET1 to increase) whenever the bank credit deteriorates. See the discussion in Subsection 6.5 and in Appendix B.

As mentioned in item (3) above, funding-related FTP policies in FCA/FBA accounting normally pass through the amount SFVA, i.e., include FBA benefits. Prior to 2012 rules, this could be argued to be reasonable from a shareholder perspective (as proxied by CET1, at least). Yet, since the FBA has currently been demoted to the status of contra-liability that is not recognized in equity capital computations, the FCA/FBA FTP policy induces deal-flow volatility to CET1. One way to interpret this effect is that the FTP policies are based on indifference pricing to the overall firm (including senior creditors), rather than to shareholders as is normally desired. In addition to this undesirable side-effect, our numerical experiments show that net FTP amounts are often too large in absolute value, despite the inclusion of FBA benefits. This effect is due to large inaccuracies in modelling VM re-hypothecation and leads to incorrect firm-level hedge ratios for market risk.

To overcome the shortcomings of FCA/FBA accounting, in this article we propose an accounting methodology which simultaneously

(i) reflects and justifies Basel III regulatory requirements regarding Counterparty Credit Risk;

(ii) is consistent with generally accepted accounting principles; and

(iii) is consistent with the tenets of classical Finance theory, such as the MMT and risk neutral valuation.

Within this framework, we then consistently value cash flow streams for VM funding and re-hypothecation strategies.

Our proposal fundamentally uses CET1 as a proxy for shareholder value and defines FVA as the discounted expectation of future funding costs occurring whenever there is an overall deficit of VM at the book level. Future scenarios where there is a net excess of OTC collateral do *not* contribute to the FVA. A Corporate Finance interpretation of this FVA metric equates it to the present value of wealth transfer from bank shareholders to bank senior creditors as a result of the bank entering into OTC trades with unsecured funding. Importantly, the FVA definition is such that funding adjustments are entirely divorced from the DVA on payables, wherefore asset-liability symmetry still holds and the own-credit sensitivity of the FVA metric has the correct sign. Since the RHO is embedded in the valuation of the FVA, the FVA amount is typically much smaller than the FCA amount in the case of portfolios of realistic size – about one third as large in our case study portfolio (see Section 8).

In FVA/FDA accounting, the MMT is satisfied, as the FVA is accompanied by an offsetting CL adjustment which does not overlap with the DVA on payables. This contra-liability is named DVA2 in [15] and is here renamed FDA. (In the case of FCA/FBA accounting, the DVA2 term is not meaningful because the approximations involved break the MMT and compromise a rigorous capital structure interpretation).

Within the FVA/FDA framework, the fair valuation of CVA is most naturally a bilateral one (sometimes known as first-to-default CVA, FTDCVA). As this fair value contains a DVA-like element of self-default benefit, the guidelines in [4] suggest that FTDCVA cannot be directly deducted from CET1, see also Section 3. Instead, we split out a unilateral CVA (UCVA) component from the FTDCVA number and record this as a contra-asset (CA) adjustment which is deducted from CET1. The remaining "self-CVA" term is listed as a contra-liability (CL) and is to be excluded from CET1.

In summary, the FVA/FDA accounting solution with rigorous RHO modelling includes the following elements:

(1) The UCVA and FVA are both entered as CA adjustments and CET1 deductions, recognizing the full benefit of the RHO to CET1.

(2) The DVA and the FDA are both entered as CL adjustments, as is the part of FTDCVA that involves benefits from bank default. None of these CL adjustments are to be counted for CET1 purposes.

(3) The FTP is designed to immunize CET1 from deal-flow volatility and to transfer the incremental costs of FVA and UCVA capital deductions to clients.

Note that (1)-(2) preserve the standard CVA-DVA accounting at the net income level, as the FVA and FDA adjustments cancel against each other. CET1, however, is affected by funding costs.

The FTP rule in FVA/FDA accounting aims at preserving CET1 capital, a principle that is fundamentally more conservative than the one followed in FCA/FBA accounting where one only insists that new trades not have a negative impact on income. In FVA/FDA accounting, deal flow still engenders volatility of contra-liabilities (such as the DVA) and of the fair valuation of the bank itself. However, due to our alignment of CET1 and shareholder value, mitigating this volatility is irrelevant from the viewpoint of the shareholder. Notwithstanding the stronger FTP requirement, the fact that RHO is properly modelled means that FTP amounts obtained in FVA/FDA accounting are generally quite reasonable and often materially smaller in absolute value than those in the FCA/FBA methodology. Relative to FVA/FDA, FCA/FBA accounting is observed to systematically undervalue derivative payables and over-value derivative receivables, thus potentially giving rise to biased sub-optimal positioning of OTC books.

It should be emphasized that under FVA/FDA accounting, the notion of an individual unsecured trade price loses its meaning[5] because all trades within the same funding set contribute non-linearly to the RHO of that funding set. We conclude that in order to correctly account for funding adjustments one needs to value derivatives in the context of the *entire* funding sets. In FVA/FDA accounting, in order to account for collateral thresholds and model re-hypothecation benefits correctly, whenever a new possible trade is priced, one needs to evolve dynamically the full portfolio valuation along with all CDS curves for all counterparties and compute book-level incremental statistics. We find that the differences between the FTPs computed in the two methods and the corresponding variations to accounting entries are large and material.

5 This is, to a lesser degree, also true in FCA/FBA accounting. In FCA/FBA accounting, the smallest possible additive unit of account is a netting set.

3 CET1 CAPITAL DEDUCTIONS IN BASEL III AND CAPITAL STRUCTURE CONSIDERATIONS

3.1 CET1 Deductions

As mentioned earlier, the BCBS recommended in 2012 that the DVA be fully deducted from CET1. The relevant wording from [4] is:

> *Therefore, after considering various alternatives, the Basel Committee is of the view that all DVAs for derivatives should be fully deducted in the calculation of CET1. The deduction of DVAs is to occur at each reporting date and requires deducting the spread premium over the risk free rate for derivative liabilities. In effect, this would require banks to value their derivatives for CET1 purposes as if they (but not their counterparties) were risk free and to deduct the unrealized gains both at inception of the derivative and afterwards, when the creditworthiness of the bank deteriorates.*

The BCBS rule ensures that a bank cannot claim increases in CET1 solely due to a deterioration in its own credit quality, consistently with the spirit of the Basel III accord [5]. While [4] nominally deals only with derivative liabilities and DVA, it is generally understood that the disallowance of CET1 increases from deteriorating bank credit is a universal principle that extends to CVA and FVA as well. For instance, for CVA some relevant language is (from [21]):

> *CVA equals the credit valuation adjustment that the Bank has recognized in its balance sheet valuation of any OTC derivative contracts in the netting set. For purposes of this paragraph, CVA does not include any adjustments to CET1 attributable to changes in the fair value of the Bank's liabilities that are due to changes in its own credit risk since the inception of the transaction with the counterparty.*

From the modelling viewpoint, adherence to this particular language can be achieved by deducting from capital a unilateral UCVA metric as opposed to a (smaller) bilateral FTDCVA.

3.2 Going concern or defaultable banks?

The intent of the regulator regarding both the CVA and the DVA capital deductions is to exclude from CET1 the present value of cash flows that benefit the bank after default. Care must be taken, however, not to extend this exclusion to a fair value setting. For instance, the regulatory notion of valuation from the viewpoint of a "going concern", in which the bank is assumed to be unable to default, is clearly at odds with both reality and with the objective of consistent market pricing. If taken literally and applied out of the intended context, this no-default assumption has the unwanted and undesirable side-effect of increasing the prices of bank-issued debt and significantly lowering the bank's funding costs.

We note in particular that if one were to consistently assume that the bank cannot default, then the spread separating the bank funding rates from OIS rates would need to be interpreted as a liquidity spread. This is one of the possible financial intepretation behind the FCA/FBA accounting rules, along with an alternative approach based on modelling debt buy-back strategies. We find that the liquidity spread assumption is hardly defensible: typical funding spreads are in the range 50bp-400bp while typical liquidity spreads are below 5bp. It would be very difficult to construct a financial interpretation to funding spreads which does not involve the credit risk of the bank. The debt-buyback argument is more subtle and is discussed in Appendix B

Besides making fair value considerations awkward, the no-default bank view is not reasonable for funding considerations, either. Specifically, FVA is the fair valuation of a cash flow stream resulting from a funding strategy that the bank clearly cannot implement past its own default: once the bank is in a state of default, its funding spread is infinite and the bank is unable to borrow funds on an unsecured basis or to conduct most other trading activities. As such, any correct measure for funding costs must inescapably reference default by the bank (and its counterparties, for that matter).

From yet another angle, discussed in depth in Sections 5 and 6, the FVA admits the financial interpretation as an internal wealth transfer across the capital structure of the bank resulting from the implementation of a funding strategy and is not the price of an asset sold to a counterparty on which the bank can default. However, wealth transfers must stop once default occurs and equity holders are wiped out.

3.3 Categorization of cash flow streams.

Since a straight "going concern" assumption is inadequate for our purposes, we put forward an alternative framework which reproduces and justifies the regulator-mandated CET1 deductions for CVA and DVA, but which is also meaningful from the viewpoints of funding costs, classical Finance theory and generally accepted accounting principles. For this purpose, we propose that cash-flow streams fundamentally be classified in the following five types:

(CF1) Contractually promised cash flow streams excluding all bank and counterparty credit risk events.

(CF2) Trade related cash flows resulting from counterparty defaults, but excluding bank default events.

(CF3) Trade related cash flows resulting from a bank default.

(CF4) Cash flow streams derived from dynamic trading strategies (such as funding strategies) implemented by the bank and taking place prior to bank default.

(CF5) Cash flow streams deriving from dynamic trading strategies (such as funding strategies) implemented by the bank and taking place at or after default of the bank.

Any derivative contract can always be split into separate contractual agreements generating cash flows of types CF1, CF2 and CF3. Similarly, the cash flows arising from any dynamic trading strategy can be modelled as being split between types CF4 and CF5. We assume that the splits have been carried out so that each unit of account referring to either a counterparty contract or a trading strategy is matched to the relevant cash flow stream. We then designate units of account whose underlying cash flow streams are of type CF1, CF2 and CF4 as contributing to CET1, while units of account whose cash flow streams are of type CF3 and CF5 do not contribute to CET1.

The key difference between a counterparty contract and a dynamic trading strategy is that the former is settled with the counterparty at the time of bank default while the latter simply terminates at that point in time. The reason why the two cases are treated differently is that a contractually promised cash flow reflects an obligation by the bank that extends to the last maturity, independently of whether the bank defaults or remains a going concern until then. Cash flows deriving from trading strategies instead cannot be implemented past the time of default of the bank, at which time the bank goes into receivership and is unable to carry out normal trading activities. Nevertheless, the implementation of trading strategies prior to default has consequences on a post-default basis which have an impact on the default claim held by senior creditors. These are cash flows of type CF4.

Relevant examples of the five types of cash flow streams above are discussed in detail in the remainder of the paper. Examples include the following:

- **Collateralized transactions** involve cash flow streams of type CF1 which are immune from counterparty credit risk.
- **The UCVA** refers to a cash flow stream of type CF2 and is, effectively, the price of a CVA protection contract promised by the bank, excluding the effects of bank default.
- **The DVA** refers to cash flow streams of type CF3 as it represents the benefit the senior creditors of the bank obtain from the default of the bank on derivative liabilities.
- **The CVA contra-liability** is the DVA component of the CVA; like the ordinary DVA on liabilities, it is a cash flow of type CF3.
- **The FVA** can be interpreted as the price of the strategy of borrowing VM collateral up to the time when the bank defaults (after which it becomes impossible to borrow any further). This is a cash flow stream of type CF4.
- **The FDA** is the post-default benefit to senior creditors deriving from owning a title to the portfolio of derivative receivables whose hedges where funded on an unsecured basis. The FDA corresponds to a cash-flow stream of type CF5.

The cash flow rules above are designed to allow for a Corporate Finance interpretation of CET1[6] as a proxy for the value of bank assets to shareholders. In particular, since shareholders are indifferent to cash flows occurring at or after bank default, such cash flow streams should not contribute to CET1 [7]. Also note that, by ensuring that cash flow streams of type CF3 have no impact on CET1, we achieve the stated regulatory objective of deducting both DVA and UCVA from CET1. By the same token, funding costs are assessed at market level and the benefit resulting from the exercise of the RHO at times prior to the bank default contributes positively to CET1.

One particular rationale for the regulator mandate to deduct the full UCVA from CET1 was to avoid that an increase in the bank's own credit risk spreads would lead to a higher CET1. One may ask whether a similar principle applies to FVA, necessitating the definition of "unilateral" FVA. Such a remedy would be difficult to justify within a consistent modelling framework, since we would have to introduce a notion of continuation funding

6 Or at least the contributions to CET1 from derivatives trading activites.
7 We are excluding here feedback effects of the sort discussed in [7]

spread for the bank at and after its own default. While such a notion could potentially be based on average or minimum peer spreads (post bank default), satisfaction of Basel III principles does not depend on it as our definition of FVA normally increases as a function of the bank's own spread. This is a fairly subtle point, as the FVA is impacted by rising bank credit spreads in two opposite directions: rising spreads tend to decrease FVA because funding costs are cut short by a bank default, yet rising spreads also tend to increase FVA as the spread paid on unsecured lending increases. In Subection 6.5, we show that in normal circumstances the latter effect dominates. In Subsection 6.5 we also show that this is *not* the case for SFVA, the metric for funding costs which is transferred to clients in the form of FTP in FCA/FBA accounting. Since the SFVA can be shown to have own-credit sensitivities of the wrong sign when applied to portfolios containing mostly payables, its use as a CET1 deduction would be problematic from a regulatory standpoint, see Subsection 6.5. For this reason alone, the CET1 deduction in FCA/FBA accounting must be the full FCA.

4 ACCOUNTING PRINCIPLES, UNITS OF ACCOUNT AND VALUATION ADJUSTMENT METRICS

4.1 Accounting Rules

The key accounting principles for derivative portfolios are listed here below (see for instance [16] and [20] for a discussion):

AP0 **Trading Securities:** Derivative contracts are categorized as Trading Securities and must be listed on the balance sheet at their fair market value. Changes in the fair market value is registered as income or loss on the income statement.

AP1 **Units of account and linearity:** Financial portfolios are decomposed into elementary *units of account* satisfying a linearity property, in the sense that the fair valuation of a portfolio is the sum of the fair valuations of its units of accounts.

AP2 **Fair value as exit price:** The *fair value* of a unit of account is defined in IFRS 13 as the price that would be received if one were to sell the unit of account in an orderly trade between market participants at the measurement date. This is called the *exit price* of the unit of account. In the determination of exit prices, neither transaction costs (such as broker commissions) nor entity-specific production costs are considered part of fair valuation.

AP3 **Model based valuation:** When a unit of account is not tradable in an active market, its fair value may be determined using a model-based valuation technique. In this case, an income approach is allowed, where the cash flows of trades are present-valued. This includes cash flows associated with the default of one of the counterparties.

AP4 **Symmetry principle:** When (as is often the case) there is no active market for a liability transfer, IASB accounting standards require that the fair value of a liability is determined from the perspective of the (asset) investor.

AP5 **Non-performance risk:** According to FASB 157, the benefit to senior creditors of non-performance on liabilities should be captured. Non-performance risk includes the effect of credit risk, as well as any other factors that influence the likelihood of fulfilling contractual obligations.

To consider the application of these principles for derivative securities accounting, we here (and throughout the rest of the paper) consider a situation where a bank B transacts in partially collateralized OTC derivatives with a set of n credit-risky counterparties. Each counterparty holds a portfolio of derivatives under an overarching CSA agreement involving a netting clause and, possibly but not necessarily, collateral posting obligations for variation margin (VM). In the absence of full collateralization, close-out protocols in place to govern settlements whenever either a bank or a counterparty defaults need to be explicitly considered; standard protocols are the ISDA Market Quotation close-out convention of 1992 (most common) and the ISDA Closeout Amount Protocol of 2009. Note that close-out protocols are relevant for fair valuation because of the accounting principles AP3 and AP5 above.

Before discussing any valuation metrics, we need to clarify how a bank OTC portfolio is linearly decomposed into units of account. The question is not trivial as an unsecured derivative contract in isolation generally cannot be considered a proper unit of account for at least two reasons:

- Netting clauses cause valuations to depend on the netting set to which the trade belongs.
- The RHO for VM causes valuations to depend on funding sets defined as the largest set of trades among which re-hypothecation is possible[8].

Fully collateralized trades done with dealers or with CCPs generally have negligible credit risk and shall here be considered to be default free; fair valuation of such trades is additive at the trade level. The valuation of an unsecured derivative assumed to be fully collateralized in cash[9] is referred to as its *default-free valuation*. The impact of counterparty and bank credit risk on valuations is then captured by other units of accounts called *adjustments*. Adjustments make reference to sub-portfolios as opposed to individual trades and can be interpreted as the valuation of derivatives referring sub-portfolios as underlying.

In this paper, we make reference to a streamlined accounting framework for OTC derivatives based on the following balance sheet accounts:

1. The **Asset Account (A)** includes receivable units of account referring to cash-flow streams of type CF1.
2. The **Liabilities Account (L)** includes payable units of account referring to cash-flow streams of type CF1.
3. The **Contra-Asset Account (CA)** includes payable adjustments with underlying cash-flow streams of type CF2 and CF4; these are deducted from CET1.
4. The **Contra-Liabilities Account (CL)** includes receivable adjustments referring to cash flow-streams of type CF3 and CF5; these do not contribute to CET1.

8 Notice that funding sets can cut across netting sets as it is entirely possible that VM is re-hypothecated separately across distinct business lines contributing to the same netting sets.

9 We ignore the minor subtleties associated with CSA agreements that allow for non-domestic cash posting.

5. The **Retained Earnings Account (RE)** includes provisions that are set aside to meet future obbligations such as funding costs and credit default losses. These entries do contribute to CET1.

6. The **Equity Account (PFV)** is defined in such a way that the basic accounting equation
$$A + RE - CA = PFV + L - CL \tag{2}$$
is satisfied. The Equity Account has the meaning of Portfolio Fair Valuation of the bank's OTC Portfolio (PFV) and the variation of PFV over an accounting period is called *Income*.

The CET1 is a capital measure that requires the exclusion of the value of units of account referencing cash-flows of type CF3 and CF5 and taking place at or after the time of default of bank B. As those types of cash flows are captured in the CL account, we exclude this account from common equity and write:

$$\text{CET1} = PFV - CL = A - L - CA + RE.$$

Within our framework, we interpret CET1 as the value of the bank to shareholders, while the PFV is the combined value to shareholders and senior creditors[10].

Upon entering into a derivative transaction, CET1 is subject to an incremental deduction denoted by ΔCA and is augmented (through earnings) by the FTP amount received from clients over and above default-free fair valuation. Attributing the FTP to the Retained Earnings (RE) account, the CET1 variation is given by

$$\Delta\text{CET1} = -\Delta CA + \Delta RE. \tag{3}$$

A new trade also affects CL adjustments by an incremental amount ΔCL, an amount tied to benefits of bank default and therefore having an impact only on senior creditors' wealth. The ΔCL term is excluded from CET1, but affects Income and the fair valuation of the bank:

$$\Delta PFV = \Delta\text{Income} = \Delta\text{CET1} + \Delta CL = -\Delta CA + \Delta CL + \Delta RE. \tag{4}$$

4.2 Contra-Asset and Contra-Liability Accounting for Credit Risk

To examine the CA and CL accounts more closely, consider first the fair valuation of the credit risk for the i-th netting set, denoted by CVA_i. This quantity can be interpreted as the value of the default protection contract implicitly sold by the bank to counterparty i, with a notional linked to the netting set "valuation" at the time of counterparty default. The precise valuation methodology to be used depends on close-out rules, see Section 6. The total CVA is computed by summing CVA_i across the n netting sets and is commonly be split into two components:

$$CVA = FTDCVA = UCVA - CVA_{CL} \tag{5}$$

10 In this paper, the term "senior creditors" is used to refer to a class of creditors which is separate from collateral lenders and which either have priority or are at the same seniority level as collateral lenders.

- The UCVA component is booked as a CA adjustment and is a unilateral CVA metric independent of close-out rules, i.e. is the present value of all counterparty credit risk losses resulting from the default of the counterparty computed under the assumption that the bank does not default (see equation (16) below).

- The $\mathrm{CVA}_{\mathrm{CL}}$ is loosely speaking the DVA component of the CVA, i.e. is the benefit bank senior creditors receive at the time of bank default by, in effect, no longer accepting to sustain future counterparty credit losses. It is booked as a CL adjustment. The magnitude of $\mathrm{CVA}_{\mathrm{CL}}$ is closely linked to close-out specifications; for ISDA 1992 close-out rules, the relevant expression for $\mathrm{CVA}_{\mathrm{CL}}$ is in equation (18) below.

According to the accounting principle AP5 on non-performance risk, cash flows taking place at or after the default of the bank should be present-valued and accounted for. In virtue of the Symmetry Principle AP4, the value of the default protection contract sold implicitly by the unsecured counterparty to the bank should be valued as the CVA assessed by the counterparty against the bank. This amount is the DVA for payables, the reporting of which was mandated by FASB 159 in 2007. DVA enters accounts as a CL adjustment and, as it references cash flows ensuing a bank default, is excluded from CET1. A split such as the one in (5) is not meaningful for DVA, as this quantity only involves post-default cash flows (with no direct relevance to equity holders and capital).

It should be noted in passing that not all banks account for the $\mathrm{CVA}_{\mathrm{CL}}$ term, as they effectively equate CVA with the UCVA term. While this "going-concern" definition is convenient in a number of ways (e.g., regulatory and accounting definitions of CVA are better aligned), it is hard to argue that it is correct or consistent with DVA accounting. We return to a discussion of these practices later.

4.3 Contra-Assets and Contra-Liabilities Accounting for Funding

Accounting for credit risk through the UCVA (contra-asset entry) and the (DVA + $\mathrm{CVA}_{\mathrm{CL}}$) term (contra-liability entry), as in Subsection 4.2, is a fairly well-established practice, even if there sometimes are minor differences in the way banks define CVA and DVA. As discussed, recently the CVA and DVA risk metrics have been supplemented by quantities meant to account for the funding cash flows to which banks are subject through their postings of VM on hedges. VM is normally paid in cash or (to a lesser extent) in highly liquid short term government debt and may be re-hypothecated across trades within the same funding set. The bank posts VM on collateralized derivative liabilities and receives VM on collateralized derivative assets.

For funding costs, we work with a unit of account at the funding set level and define the FVA as the discounted value of book-level funding costs arising whenever the funding set has a net collateral deficit. Future states of the world whereby the funding set is a net receiver of VM are modelled as *not* contributing to funding costs. On the one hand, excess cash deposited as VM can earn a riskless rate of OIS. But on the other hand, derivative counterparties pledging VM are also entitled to interest rate payments at a matching OIS rate. In total, states of the world whereby the bank enjoys accumulation of excess VM collateral are modelled as having zero funding costs. As discussed in Appendix B, the zero-benefit assumption around excess collateral may be considered a conservative assumption and some researchers have considered strategies whereby the bank buys back long-term debt with excess VM, see [9], [8], [7], [6]. However, these strategies are not only difficult to enact in practice as VM is very volatile, they also have a zero impact on income if one insists on MMT consistency. As a consequence, if deleveraging transactions occur at fair valuation, wealth is not transferred between shareholders and senior creditors, i.e. the benefit is not truly there.

Neglecting basis spreads, funding costs for VM procurement are non-zero because collateral lenders only receive partial recovery upon bank default. If we denote the recovery rate to collateral lenders with R_B^C, then the case where there is a perfectly functioning REPO market for derivative receivables would have $R_B^C = 1$. In reality, $R_B^C < 1$, i.e. recovery is only partial because of market inefficiencies and the spreads for collateralized borrowing are very close to the spreads for unsecured borrowing. The FVA is defined as the discounted expectation of funding costs up until the time of bank default. Hence, the FVA is booked as a CA adjustment and a CET1 deduction.

When short term debt is issued to fund VM collateral, the lenders providing the funds are exposed to the bank default risk. The flip-side of this risk is a DVA-like benefit held by the bank. To account for it, we introduce an FDA entry as the present value of the depreciation of collateral debt at the default time of the bank, due to incomplete recovery. That is, the FDA is the present value of $(1 - R_B^C)$ times the notional borrowed for VM funding purposes, received at the time of bank default. Since the FDA makes reference to cash-flows happening at or after bank default, the FDA is booked as a CL adjustment and excluded from CET1.

For the MMT to hold, the FVA must equal the FDA. In this case, funding strategies and in particular the value of R_B^C, do not affect the fair valuation of the bank. However, if R_B^C is strictly less than 100%, then deal flow induces a wealth transfer from shareholders to senior creditors. In accounting terms, if we decrease R_B^C starting from the value of 1 and down to 0, a portion of CET1 is gradually demoted to the status of Contra Liability, reflecting a wealth transfer from shareholders to senior creditors. The FVA may therefore be considered the wealth-transfer amount lost to shareholders, while the FDA is the amount earned by senior creditors.

5 CASH FLOWS

Having so far limited ourselves to a largely qualitative accounting discussion, we now proceed to provide concrete valuation formulas for XVA metrics. For this, we first need to consider the precise funding and credit related cash flows taking place in OTC derivatives trading, both before and after default of the counterparties and the bank itself. Since details can obscure the main concepts, we here omit certain less essential minutiae, such as the flows associated with rating dependent CSA thresholds and credit-risk sensitive close-out conditions. In Appendix A, the interested reader can find a more complete cash flow representation, much of which is implemented in our case study calculation in Section 8.

Whenever the bank enters into an unsecured trade, XVA adjustments are accompanied by charges to clients which can be structured in various ways. For our purposes here, we assume that XVA-related FTP payments are simply upfront and due at the inception of the trade in question. As described earlier, the business line trading desks, in fact, typically pays FTP charges to the CVA/CFD desks on an upfront basis. However, assuming an upfront structure for client charges is a stylized approximation, since sometimes costs are paid in instalments embedded into the unsecured derivative structure itself.

Working within the modelling framework briefly introduced in Section 4.1, let us introduce the notation $V_i^U(t)$, $i = 1, ..., n$, for the default-free valuation at time t of the portfolio held with counterparty $i = 1, ...n$, computed by neglecting all funding costs and credit risks (including that of the bank itself). That is, $V_i^U(t)$ represents the value of netting set i in a world where all trades are collateralized in full. $V_i^U(t)$ is defined to be zero in case the i−th counterparty is in a state of default at time t. Assuming no close-out risk and no initial margin, the fair valuation of fully collateralized books is additive over individual trades and therefore also additive over netting sets, i.e. we can meaningfully define a total default-free portfolio value of

$$V^U(t) = \sum_i V_i^U(t). \tag{6}$$

For simplicity's sake, we assume in the main body of this article that unsecured trades are hedged on a precise back-to-back basis[11] with hedging trades having a valuation $V_i^H(t)$ equal to exactly $-V_i^U(t)$. (This hypothesis is relaxed in Appendix A). The common value of default-free unsecured trades and hedges is denoted as follows:

$$V_i(t) = -V_i^H(t) = V_i^U(t). \tag{7}$$

We also assume here that neither the bank nor the counterparty post any VM to each other; Appendix A discusses extensions, including partial VM posting with CSA collateral thresholds.

Banks typically have a separate funding set for each business line and jurisdiction. Within each such dedicated book, banks always[12] exercise the RHO for VM across hedges. The net VM posted at any given time[13] is given by the sum

$$C_{VM}(t) = \sum_i C_{VM,i}, \tag{8}$$

where

$$C_{VM,i}(t) = V_i(t) 1_{t<\tau_B} 1_{t<\tau_i}. \tag{9}$$

Notice the presence of the indicator functions $1_{t<\tau_B}$ and $1_{t<\tau_i}$ above, reflecting the fact that default of either the bank or the counterparty results in an immediate settlement of the collateralized hedges. Our sign convention is such that, if $C_{VM}(t)$ is positive (negative), then the bank is a net poster (receiver) of collateral on the hedges.

For simplicity's sake, we assume that the difference between the OIS rate and the REPO rate for general collateral is quantitatively immaterial and denote both rates with $r_{OIS}(t)$. We also assume that the bank has at least two classes of debt. One is unsecured senior debt with recovery rate R_B used for regulatory capital, initial margin and administrative costs. The other is debt used to finance VM collateral, imperfectly secured by derivative

11 Indeed, one way to interpret the role of the CFD and CVA desk(s) is that they, after appropriate compensation, allow the line of business desks to hedge risks as if there were no funding or credit risk.

12 Albeit not necessarily optimally – the collateral systems of many banks tend to be fairly rudimentary.

13 This is a simplification, as there typically is also a material VM from CVA hedges. We discuss this complication in Section 5.2 and Appendix A.

receivables. We model this second class as having a recovery rate R_B^C, a funding rate equal to $r_B(t)$ and a spread over OIS equal to

$$s_B(t) = r_B(t) - r_{OIS}(t) \geqslant 0. \tag{10}$$

If there existed an efficient REPO market for unsecured OTC derivatives, collateral lenders would be guaranteed a full recovery on VM, i.e. we would have $R_B^C = 1$ and the funding spread would be zero. In general $R_B^C \leqslant 1$ and the risk neutral valuation of the overnight funding spread is given by

$$s_B(t) = (1 - R_B^C)\lambda_B(t) \tag{11}$$

where $\lambda_B(t)$ is the probability rate of default of the bank at time t, see for instance [17]. In practice, an additional liquidity spread adjustment may apply, but we neglect this minor correction for the present discussion.

We stress that the assumption that debt is subdivided into two classes is only formal and does not restrict the generality of our argument. In the general case, one can still assume that traded debt securities are hybrids between theoretical bonds of the two types we consider.

5.1 Cash flows related to VM funding

We start by considering the funding flows on the interval $[t, t + dt)$. To simplify the exposistion, we neglect funding costs for any VM arising from default hedges the CVA desk might have entered into. Suppose first that net VM collateral $C_{VM}(t)$ posted by the bank is *positive*, whereby the bank needs to borrow to fund its overall VM position. In this scenario, the bank treasury is assumed to issue short-term unsecured debt into the market to raise the necessary funds. More specifically, if in the time interval $[t, t + dt)$, the bank has to finance a net collateral shortage $C_{VM}(t) > 0$, then the treasury issues $C_{VM}(t)$ worth of short-term debt for this purpose, either unsecured or backed by derivative receivables. The interest charge on unsecured debt in the time interval $[t, t + dt)$ at the CFD funding rate $r_B(t)$ is $C_{VM}(t)r_B(t)\,dt$.

The required VM collateral is then routed through the inter-dealer positions where an interest rate amount of $C_{VM}(t)r_{OIS}(t)dt$ is received back. We see from Figure 1 that when $C_{VM}(t) > 0$ the CFD experiences a net negative cash flow in the amount of $-C_{VM}(t)s_B(t)\,dt$. The present-valued cost of this negative "carry" over the lifetime of the funding set or until the time of bank default, whichever comes first, is our definition of FVA.

In case the total collateral requirement for VM is *negative*, i.e. $C_{VM}(t) < 0$, the treasury OTC funding program is not called upon. In this case, we assume that the bank treasury would invest excess collateral in short-term securities, yielding on average (nearly) OIS levels. As the bank is liable for paying OIS to hedge counterparties on the net collateral received, the bank is therefore assumed to receive no benefits and face no costs due to VM posting obligations when $C_{VM}(t) < 0$.

In principle, one can imagine that the excess collateral would be passed by the CFD to the Treasury which in turn would use the funds to retire outstanding long-term debt. If this were the case, one imagines that the CFD should receive from the treasury a benefit based on the interest savings on long-term debt, resulting in positive carry. This is an agressive assumption, as VM varies greatly on short time scales and generally constitutes

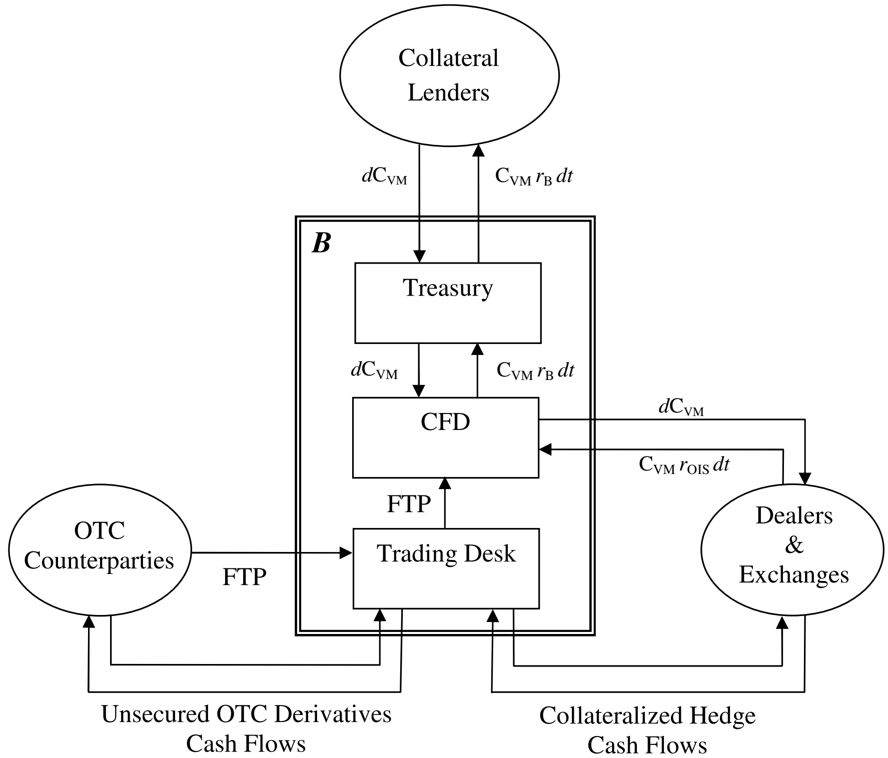

Figure 1: OTC derivative cash flows for Bank B in $[t, t + dt]$, assuming no defaults and $C_{VM} > 0$. The "FTP" here denotes the funding-related FTP charges associated with new trades executed on $[t, t + dt]$. To keep the figure simple, we have excluded the CVA desk and the cash flows (FTP, VM, CDS coupons) associated with the counterparty credit risk hedges.

an unstable base from which to retire debt. [14]. In practice, it is far easier to let debt mature than to retire long dated bonds on the secondary market.

Besides the above "neutral" assumptions about investment returns, our definition of FVA makes additional assertions about treasury funding strategies and funding rates. Specifically, we make the following assumptions:

(WC) We assume the worst-case scenario regarding funding rates, i.e. that derivative receivables cannot be passed as collateral and VM borrowing is entirely unsecured.

(BC) We assume the best-case scenario regarding over-provisioning, i.e. that the bank procures on an overnight basis the cash collateral which is strictly needed for VM borrowing, not more.

Both of these assumptions are reasonable for accounting purposes, although they admittedly represent idealizations of actual funding behavior (which no doubt varies from bank to bank). In this vein, it is important to note that FVA calculations are, in principle, non-unique and tied to the *actual* funding strategy to which a firm commits, a fundamental difference from the ideas underlying fair value pricing of derivatives. According to classical Finance theory, if there exists a replication strategy, then the cost of hedging equals

14 Normally collateral is over-provisioned allowing for buffers as the treasury needs to manage liquidity prudently. There are additional costs to collateral over-provisioning and the risk management of liquidity buffers, all of which are ignored here.

the fair value. Hence, if one replication strategy is theoretically possible, the cost of implementing it ought to equal fair value *whether or not* the strategy is actually implemented. If more than one replication strategies can potentially be implemented, absence of arbitrage dictates that the cost of implementing each one equals the fair value. For funding cost valuation, MMT tells us that the fair value of funding strategies for trades entered at fair value is zero, as FVA does not represent the fair valuation of an asset, but instead a wealth transfer amount from shareholders to senior creditors.

5.2 Cash flows at counterparty default

If τ_i is the default time of counterparty i, let $D_i(\tau_i)$ be the default cash flow received by the bank from counterparty i as part of the default-triggered close-out of the i-th portfolio. $D_i(\tau_i)$ is governed by the ISDA agreement between the bank and the i-th counterparty. For simplicity's sake, we assume here that the close-out procedure follows the ISDA Market Quotation close-out protocol of 1992 and refer to Appendix A for extensions and other protocols.

In the prevailing interpretation of the ISDA 1992 close-out protocol, if either the counterparty or the bank itself default prior to the maturity of their trade portfolio, then the portfolio is settled at default-free levels, i.e. XVA adjustments are excluded from the calculation of the settlement amount. In other words, the default cash flow at time τ_i received by the bank from counterparty i at the time of counterparty default is

$$D_i(\tau_i) = 1_{\tau_i<\tau_B}\left(1_{V_i(\tau_i)\geqslant 0}R_i V_i(\tau_i) + 1_{V_i(\tau_i)<0}V_i(\tau_i)\right) \tag{12}$$

where τ_B is the default time of the bank and $R_i \in [0,1]$ is the recovery rate received from counterparty i. Notice the presence of the default indicator function $1_{\tau_i<\tau_B}$ in this expression, a reflection of the fact that if the bank defaults prior to counterparty i, then no cash-flow takes place at time τ_i since the unsecured derivative portfolio held with counterparty i is assumed to have been unwound at τ_B. $D_i(\tau_i)$ might be positive or negative and can be considered an inherent part of the portfolio flows of counterparty portfolio i. Notice that, if $V_i(\tau_i) \geqslant 0$ (and $\tau_B > \tau_i$) then (12) represents a loss to bank B. The present value of this loss is the CVA_i for counterparty portfolio i.

As mentioned above, the cash flow formula above assumes that counterparty credit risk is left unhedged. In reality, the CVA desk seeks to lay off the counterparty credit risk through the purchase of credit hedges such as single name and index CDSs. This setup does not alter our conclusions about how to account for CVA, but it does mean that CVA hedges are typically entered with dealers/exchanges on a fully collateralized basis, which in itself produces VM postings that can be introduced into the overall VM "pool" generated by the client trades, see Appendix A.

5.3 Cash flows at bank default

At the bank default time τ_B, any posted collateral amount stays with the holder and all interdealer hedge positions are torn up, with no economic impact to any dealer counterparty[15].

15 Similarly, a default of a dealer used as a counterparty for hedging purposes has no economic impact as all credit risk is covered by collateral.

The positions with the n counterparties are typically settled at ISDA terms, leading to a loss for those counterparties that had positive exposure to the bank. Under standard ISDA 1992 terms, the effective default cash flow at time τ_B received by the bank from counterparty i may be written as follows:

$$D_i(\tau_B) = 1_{\tau_B<\tau_i}\left(1_{V_i(\tau_i)\geqslant 0}V_i(\tau_B) + 1_{V_i(\tau_i)<0}R_B V_i(\tau_B)\right), \tag{13}$$

where $R_B \in [0,1]$ is the recovery rate for bank B. Notice that the loss to counterparty i is therefore $-(1-R_B)V_i(\tau_B)^-$. Senior bank creditors, which in aggregate have a claim on derivative receivables of value $V_i(\tau_B)^+$ for the i−th counterparty, would similarly recover a fraction $R_B V_i(\tau_B)^+$ of their claim. Here we assume for simplicity's sake that the recovery rates on senior debt and on derivative portfolios are identical. Notice that if $V_i(\tau_B) < 0$ then equation (13) represents a gain for the bank relative to a fully collateralized payout of $V_i(\tau_B)$. The present value of this gain is the DVA_i associated with counterparty i.

Finally, note that if R_B^C is the recovery rate for VM collateral lenders, upon defaulting the bank does not return (i.e., effectively receives) the following amount in VM cash:

$$D_C(\tau_B) = (1-R_B^C)\left(\sum V_i(\tau_B)\right)^+. \tag{14}$$

Since the total amount of VM collateral borrowed is reduced by exercising the RHO, the amounts lent and recovered from collateral lenders cannot be represented as a linear sum over netting sets.

6 CREDIT AND FUNDING VALUATION ADJUSTMENTS

Having outlined all relevant cash flows above, we now discuss how these cash flows are valued and affect the capital structure of the OTC book. In particular, this section defines in detail the relevant XVA metrics needed for the accounting treatments outlined earlier, in Sections 2 and Subsection 4.1.

6.1 CVA and DVA

Under ISDA 1992, cash-flows triggered by counterparty defaults were discussed in Section 5. The loss in value due to the risk of counterparty i is measured by the present value of protection against the value loss inherent in (12):

$$\begin{aligned}
\mathrm{CVA}_i = \mathrm{FTDCVA}_i &= \mathbb{E}\left[e^{-\int_0^{\tau_i} r_{\mathrm{OIS}}(s)\,ds} 1_{\tau_i<\tau_B}\left(V_i(\tau_i) - D_i(\tau_i)\right)\right] \\
&= \int_0^\infty \mathbb{E}\left[e^{-\int_0^t r_{\mathrm{OIS}}(s)\,ds} 1_{t<\tau_B}(1-R_i)V_i(t)^+\right]\mathbb{Q}(\tau_i \in [t, t+dt]) \\
&= \int_0^\infty \mathbb{E}\left[e^{-\int_0^t (r_{\mathrm{OIS}}(s)+\lambda_i(s))\,ds} 1_{t<\tau_B}\lambda_i(t)(1-R_i)V_i(t)^+\right]\,dt \\
&= \int_0^\infty \mathbb{E}\left[e^{-\int_0^t (r_{\mathrm{OIS}}(s)+\lambda_i(s))+\lambda_B(s))\,ds}\lambda_i(t)(1-R_i)V_i(t)^+\right]\,dt,
\end{aligned} \tag{15}$$

Here $\mathbb{E}[\cdot]$ denotes expectation in the risk-neutral measure $\mathbb{Q}$ and $\lambda_i(t)$ is the (possibly stochastic) default intensity for counterparty i. The concept of default intensity was introduced by Lando in [17] in the context of reduced form credit risk models based on Cox processes but is meaningful (and quite useful) also for many structural models.

As we discussed in the previous section, the CVA entry to be booked as a contra-asset is the unilateral UCVA metric given by the formula

$$\mathrm{UCVA}_i = \int_0^\infty \mathbb{E}\left[e^{-\int_0^t (r_{\mathrm{OIS}}(s)+\lambda_i(s))\,ds}\lambda_i(t)(1-R_i)V_i(t)^+\right]\,dt, \tag{16}$$

without the indicator function $1_{t<\tau_B}$. This entry is accompanied by a CL adjustment defined as follows:

$$\mathrm{CVA}_{\mathrm{CL},i} = \mathrm{UCVA}_i - \mathrm{FTDCVA}_i \tag{17}$$

$$= \int_0^\infty \mathbb{E}\left[e^{-\int_0^t (r_{\mathrm{OIS}}(s)+\lambda_i(s))\,ds}1_{t\geqslant\tau_B}\lambda_i(t)(1-R_i)V_i(t)^+\right]\,dt. \tag{18}$$

The $\mathrm{CVA}_{\mathrm{CL},i}$ can be interpreted as the "DVA of the CVA", i.e. the benefit senior creditors have from the default of the bank on the default protection contract implicitly sold to counterparties. The more substantial benefit associated with the option of defaulting on the underlying derivatives themselves is instead captured by a DVA term defined as follows:

$$\mathrm{DVA}_i = \int_0^\infty \mathbb{E}\left[e^{-\int_0^t (r_{\mathrm{OIS}}(s)+\lambda_B(s))\,ds}1_{t<\tau_i}\lambda_B(t)(1-R_B)\,(V_i(t))^-\right]\,dt. \tag{19}$$

CVA and DVA numbers may be added across counterparties, giving rise to

$$\mathrm{FTDCVA} = \mathrm{CVA} = \sum_i \mathrm{CVA}_i, \tag{20}$$

$$\mathrm{UCVA} = \sum_i \mathrm{UCVA}_i, \tag{21}$$

$$\mathrm{CVA}_{\mathrm{CL}} = \sum_i \mathrm{CVA}_{\mathrm{CL},i}, \tag{22}$$

$$\mathrm{DVA} = \sum_i \mathrm{DVA}_i. \tag{23}$$

The booking of these quantities as CL and CA adjustments was covered earlier and is tabulated, for convenience, in Section 6.4.

6.2 FVA and FDA

As explained earlier, to find fair valuation formulas for the FVA, one needs to value a continuous cash flow stream for funding costs at the rate given by the spread in equation (10). We argued in Subsection 5.1 that the contribution to this cost in the time period $[t, t+dt)$ is $C_{\mathrm{VM}}(t)^+ s_B(t)\,dt$. The discounted present value of future funding costs is thus defined as follows:

$$\mathrm{FVA} = \mathbb{E}\left[\int_0^\infty e^{-\int_0^t r_{\mathrm{OIS}}(s)\,ds}s_B(t)C_{\mathrm{VM}}(t)^+\,dt\right]$$

$$= \mathbb{E}\left[\int_0^\infty e^{-\int_0^t (r_{\mathrm{OIS}}(s)+\lambda_B(s))\,ds}s_B(t)\left(\sum_i V_i(t)1_{t<\tau_i}\right)^+\,dt\right], \tag{24}$$

where the second equality follows from the definition of the net collateral $C_{VM}(t)$ in equation (8). As explained earlier, note that we include cash flows only up to the time of default of the bank[16].

Due to the lack of market infrastructure to guarantee water-tight collateralization mechanics with unsecured derivative receivables as underlying, funding spreads for VM collateral are observed to be near unsecured levels even in the rare cases where derivative receivables are nominally mentioned as collateral. The present value of the gain that senior creditors of bank B gain due to the inability of collateral lenders to recover in full on default is here called FDA. To compute this quantity, observe that at the time of a bank default, senior creditors will gain a benefit equal to the fraction $(1 - R_B^C)$ of the pool of derivative receivables, while a fraction R_B^C goes to the collateral lenders. Therefore, we have that

$$\mathrm{FDA} = \mathbb{E}\left[\int_0^{\tau_B} e^{-\int_0^t (r_{\mathrm{OIS}}(s))\,ds}(1 - R_B^C)\lambda_B(t)\left(\sum_i V_i(t)1_{t<\tau_i}\right)^+ dt\right] \tag{25}$$

$$= \mathbb{E}\left[\int_0^{\infty} e^{-\int_0^t (r_{\mathrm{OIS}}(s)+\lambda_B(s))\,ds}(1 - R_B^C)\lambda_B(t)\left(\sum_i V_i(t)1_{t<\tau_i}\right)^+ dt\right]. \tag{26}$$

Thanks to the risk neutral valuation formula (11) for bank credit spreads, we find

$$\mathrm{FVA} = \mathrm{FDA}, \tag{27}$$

consistent with the discussion in Section 6.2.

The FVA and FDA contribute with opposite signs to the bank fair valuation and cancel each other on the bank balance sheet, in agreement with MMT. In other words, the fair valuation of the bank assets is indifferent to the funding strategies employed and to the FDA and FVA. This relation was first noticed in Hull and White [14], where the FDA is called DVA2 and equation (27) is stated as a direct consequence of MMT.

6.3 FCA and FBA

FCA/FBA accounting is an approximation to funding valuation adjustment, motivated by a desire to base the methodology upon netting set specific, metrics which are computable by means of traditional CVA systems. This methodology is in a sense an extension to large OTC books of the research in [9] and [19] which focused on the case of individual trades treated in isolation and not in a portfolio context.

To better understand the logic of FCA/FBA accounting, we note that if, hypothetically, the bank was never a net receiver of VM collateral and there were no collateral thresholds, then the funding cost of a cash flow $X(T)$ would be represented as follows:

$$\mathrm{SFVA}_X = V_X(0) - V_X^*(0), \tag{28}$$

where

$$V_X(t) = \mathbb{E}_t\left[e^{-\int_t^T r_{\mathrm{OIS}}(s)\,ds}X(T)\right], \quad V_X^*(t) = \mathbb{E}_t\left[e^{-\int_t^T r_B(s)\,ds}X(T)\right],$$

16 There are a plethora of competing definitions of FVA (including those in Section 6.3 below), some of which deliberately avoid the complication of a default timing element. See [11] for more on the "dark art" of FVA definitions.

and $\mathbb{E}_t$ denotes time t expectation in the risk-neutral measure. One interpretation of this formula is that the CFD desk has access to borrowing and lending lines with a funding rate of $r_B(t)$ and are not subject to any credit risk.

By the Feynman-Kac Theorem, we have that

$$\mathbb{E}_0\left[e^{-\int_0^T r_B(s)\,ds}X(T)\right] = \mathbb{E}_0\left[e^{-\int_0^T r_{OIS}(s)\,ds}X(T) - \int_0^T e^{-\int_0^t r_{OIS}(s)\,ds}\left(r_B(t) - r_{OIS}(t)\right)V_X^*(t)\,dt\right],$$

and also, by symmetry,

$$\mathbb{E}_0\left[e^{-\int_0^T r_{OIS}(s)\,ds}X(T)\right] = \mathbb{E}_0\left[e^{-\int_0^T r_B(s)\,ds}X(T) - \int_0^T e^{-\int_0^t r_B(s)\,ds}\left(r_{OIS}(t) - r_B(t)\right)V_X(t)\,dt\right].$$

It follows that (28) may be written as

$$\mathrm{SFVA}_X = \mathbb{E}_0\left[\int_0^T e^{-\int_0^t r_{OIS}(s)\,ds}s_B(t)V_X^*(t)\,dt\right] = \mathbb{E}_0\left[\int_0^T e^{-\int_0^t r_B(s)\,ds}s_B(t)V_X(t)\,dt\right], \quad (29)$$

In practice, the dependence on $V_X^*(t)$ in the exposure integral is inconvenient, so the second equality in (29) is probably the most useful in applications.

Extending the result above to the more general portfolio case with collateralized hedges, we write the SFVA for counterparty i as

$$\mathrm{SFVA}_i = \mathbb{E}_0\left[\int_0^\infty e^{-\int_0^t r_B(s)\,ds}s_B(t)V_i(t)\,dt\right]. \quad (30)$$

Let us remark that, assuming there are no collateral thresholds, the SFVA_i decomposes further into a sum over the SFVA of trades contained in the i-th netting set. Collateral thresholds break this property and make the SFVA a netting set specific amount.

The netting set specific SFVA can be decomposed into cost and benefit components as follows:

$$\mathrm{SFVA}_i = \mathrm{FCA}_i - \mathrm{FBA}_i \quad (31)$$

where

$$\mathrm{FCA}_i = \mathbb{E}_0\left[\int_0^\infty e^{-\int_0^t r_B(s)\,ds}s_B(t)V_i(t)^+\,dt\right] \quad (32)$$

and

$$\mathrm{FBA}_i = \mathbb{E}_0\left[\int_0^\infty e^{-\int_0^t r_B(s)\,ds}s_B(t)(V_i(t))^-\,dt\right]. \quad (33)$$

We also introduce aggregate amounts:

$$\mathrm{SFVA} = \sum_i \mathrm{SFVA}_i, \quad \mathrm{FCA} = \sum_i \mathrm{FCA}_i, \quad \mathrm{FBA} = \sum_i \mathrm{FBA}_i. \quad (34)$$

6.4 CA and CL Adjustments

While, as described earlier, FVA/FDA accounting cleanly splits CA and CL adjustments, the lack of consistency in FCA/FBA accounting requires some effort to strike a reasonable compromise between conflicting assumptions. For this purpose, notice that the FBA in equation (33) is quite similar to the DVA in equation (19), yet differs from it in two ways. First, the FBA expression does not contain an indicator function $1_{t<\tau_i}$. Second, FBA losses are discounted at the rate

$$r_B(t) = r_{OIS} + (1 - R_B)\lambda_B(t),$$

rather than at (effectively) the rate $r_{OIS} + \lambda_B(t)$. Only in the unlikely case $R_B = 0$ the discounting rule in the two expressions match. In general, we have that FBA $>$ DVA.

The FBA partially accounts for the RHO, but always contains a large overlap with the standard DVA on payables. Since the two components in the FBA cannot be disentangled from each other, the full FBA entry is normally configured as a CL adjustment, similar to the way DVA is treated. On the other hand, the FCA is clearly a CA deduction from CET1 that adds to the usual CVA deduction.

In Section 4, we discussed the CA and CL adjustments for both FCA/FBA and FVA/FDA. Using the notation developed in this section, Table 1 summarizes the various adjustments.

	CA adjustment	**CL adjustment**
FVA/FDA	UCVA + FVA	CVA_{CL} + DVA + FDA
FCA/FBA	UCVA + FCA	CVA_{CL} + FBA

Table 1: CA and CL adjustments in FCA/FBA and FVA/FDA accounting.

To comment on the relative magnitudes of the CA and CL adjustments between the two methods, notice that since the FCA/FBA approximation effectively amounts to recognizing the re-hypothecation benefit only within individual netting sets but not across netting sets, one expects that FCA is much larger than FVA, i.e., that FCA/FBA accounting produces much larger CA deductions than FVA/FDA accounting. As for the CL adjustments, note that the CL adjustment under FCA/FBA discounting effectively (but see Footnote 4) drops the DVA term in order to avoid double-counting. Not surprisingly, our case study in Section 8 confirms these conclusions. In Section 8 we also quantify the RHO amount, the degree of symmetry breaking in FCA/FBA accounting and the difference between FBA and DVA.

6.5 Own-credit sensitivities

As discussed in Section 4, CET1 deductions should generally not decrease when bank spreads increase. To investigate the sensitivity of FVA to the bank spread, let us define the (discounted) Expected Positive Exposure (EPE) up to time t

$$\text{EPE}(t) = \mathbb{E}\left[\int_0^T e^{-\int_0^t r_{OIS}(s)\,ds}\left(\sum_{i=1}^{n} V_i(t)1_{\tau_i>t}\right)^+ dt\right] \geqslant 0,$$

where T (the upper integration limit) is longest maturity on any trade in the funding set in question. We have that:

Theorem 1. *Assume that* $s_B(t)$ *is independent of* $r_{OIS}(t)$ *and* $\sum_i V_i(t)1_{\tau_i>t}$ *and let* $s_B(t)$ *be subjected to a perturbation of the type*

$$s_B(t) \to s_B(t) + \epsilon h(t) \tag{35}$$

where ϵ *is a scalar and* $h(t) \geqslant 0$ *is a bounded deterministic function. Also define the corresponding Gateaux derivative*

$$D_h\text{FVA} = \left.\frac{\partial\text{FVA}}{\partial\epsilon}\right|_{\epsilon=0}.$$

Then $D_h\text{FVA} \geqslant 0$ *if and only if*

$$\int_0^T \text{EPE}(t)\mathbb{E}\left(e^{-\int_0^t \lambda_B(s)\,ds}\left(h(t) - \frac{1}{1-R_B^C}s_B(t)\int_0^t h(s)\,ds\right)\right)\,dt \geqslant 0. \tag{36}$$

Proof. Define $q_B = (1-R_B^C)^{-1}$. Written as a function of ϵ in (35), the FVA (24) becomes

$$\text{FVA}(\epsilon) = \mathbb{E}\left[\int_0^T e^{-\int_0^t (r_{OIS}(s)+q_B(s_B(s)+\epsilon h(s)))\,ds}\,(s_B(t)+\epsilon h(t))\left(\sum_{i=1}^n V_i(t)1_{t<\tau_i}\right)^+ dt\right],$$

where we have used (11). Straightforward calculus shows that

$$\begin{aligned} D_h\text{FVA} &= \left.\frac{\partial\text{FVA}}{\partial\epsilon}\right|_{\epsilon=0} \\ &= \mathbb{E}\left[\int_0^T e^{-\int_0^t (r_{OIS}(u)+\lambda_B(u))\,du}\left(h(t) - q_B s_B(t)\int_0^t h(s)\,ds\right)\left(\sum_{i=1}^n V_i(t)1_{t<\tau_i}\right)^+ dt\right] \\ &= \int_0^T \text{EPE}(t)\mathbb{E}\left(e^{-\int_0^t \lambda_B(s)\,ds}\left(h(t) - q_B s_B(t)\int_0^t h(s)\,ds\right)\right)\,dt, \end{aligned} \tag{37}$$

where the second equality follows from our independence assumption. Equation (36) then follows. □

A sufficient but conservative condition for $D_h\text{FVA} \geqslant 0$ is then

Corollary 2. In the setting of Theorem 1, if

$$h(t) \geqslant \frac{1}{1-R_B^C}\frac{\mathbb{E}\left(s_B(t)e^{-\int_0^t \lambda_B(s)\,ds}\right)}{\mathbb{E}\left(e^{-\int_0^t \lambda_B(s)\,ds}\right)}\int_0^t h(s)\,ds \geqslant 0, \quad \forall t \in [0,T], \tag{38}$$

then

$$D_h\text{FVA} \geqslant 0.$$

Proof. The corollary follows directly from (36) and the fact that $\text{EPE}(t) \geqslant 0$. □

Suppose, for instance, that h and s_B are positive constants; i.e., we have a flat credit curve that is being shifted up in parallel fashion. "Right-way" regulatory sensitivity is guarenteed, by (38), if

$$h \geqslant \frac{s_B h T}{1-R_B^C}$$

or

$$s_B \leqslant \frac{1 - R_B^C}{T}. \tag{39}$$

Some typical values for the constants on the right-hand side of (39) are $R_B^C = 40\%$ and $T = 10$ which yields $s_B \leqslant 6\%$, a condition that is rarely violated (common values for s_B are 1-2%).

Alternatively, if we assume that $\mathrm{EPE}(t) \approx \mathrm{EPE}$ is approximately constant in (36), then we may write (again, for constant h and s_B)

$$D_h\mathrm{FVA} \approx \mathrm{EPE} \cdot \int_0^T e^{-\lambda_B t} \left(h - \frac{1}{1 - R_B^C} s_B t \right) dt \approx \mathrm{EPE} \cdot hT \left[1 - \frac{1}{2} q_B s_B T \right]$$

which leads to a bound that is twice as loose as (39):

$$s_B \leqslant \frac{2(1 - R_B^C)}{T}.$$

In most situations the $\mathrm{EPE}(t)$ terms in (37) typically peak long before T, which would widen the bound even further. All in all, it is safe to say that in normal conditions FVA increases when s_B is decreased.

If we repeat the arguments in Theorem 1 for the SFVA defined in (30), the result is easily seen to be

$$D_h\mathrm{SFVA} = \mathbb{E}\left[\int_0^T e^{-\int_0^t (r_{\mathrm{OIS}}(u) + s_B(u))\,du} \left(h(t) - s_B(t) \int_0^t h(s)\,ds \right) \left(\sum_{i=1}^n V_i(t) \right) dt \right].$$

In case $h(t)$ satisfies the conditions above that ensure positivity of $D_h\mathrm{FVA}$ and in case funding sets are prevailingly net payables, both at valuation time and across time, then $D_h\mathrm{SFVA}$ becomes negative. In this situation, the SFVA has wrong sign sensitivities and is unsuitable as a CET1 deduction. Appendix B expands on this issue.

7 ENTRY PRICES, EXIT PRICES, AND TRADE FTP

We recall that an FTP policy defines the costs or benefits[17] that must, at a minimum, be passed through to clients in excess of default-free trade values. In other words, the FTP defines what constitutes a "break-even" transaction, and thereby determines the bank's *entry price*, i.e., the price that the bank would bid to acquire a trade or possibly a collection of trades. As mentioned earlier, any XVA-aware accounting system does not aggregate portfolio values linearly over trades, so FTP policies cannot operate only at the trade level but must take into consideration the effect that a new trade has on the risk profiles of existing trade aggregations (e.g., at the netting or funding set levels). For this reason, it is most reasonable to set out the FTP policy in terms of *marginal* increments to portfolio level metrics.

As the choice of accounting method has material implications on the magnitudes of various XVA quantities, FTP policies are necessarily different in the FCA/FBA and FVA/FDA accounting frameworks. We discuss this in detail in Sections 7.1 and 7.2 below. The topic of *exit prices* and fair value accounting is subsequently covered in Section 7.3[18].

17 FTP can be negative if a trade reduces credit risk or funding costs for the bank.
18 By convention, entry prices include transaction costs and exit prices exclude them. For the purpose of our discussion, we throughout assume that transaction costs are zero.

7.1 FTP for FCA/FBA Accounting

In the case of FCA/FBA accounting, the relevant units of account refer either to default-free trades or (for CVA, DVA, FCA and FBA) to netting sets. There are no funding set level units of account in the FCA/FBA method.

In FCA/FBA accounting, the standard FTP policy is to transfer to clients (at a minimum) the incremental amount

$$\mathrm{FTP} = \Delta\mathrm{UCVA} + \Delta\mathrm{SFVA}, \tag{40}$$

The ΔUCVA and ΔSFVA terms cover credit risk and funding charges, respectively, and are paid by the business line trading desk to the CVA and CFD desks. From (3), we see that the incremental impact of a new trade on equity capital is

$$\Delta\mathrm{CET1} = -\Delta\mathrm{CA} + \mathrm{FTP} = -\Delta\mathrm{UCVA} - \Delta\mathrm{FCA} + \Delta\mathrm{UCVA} + \Delta\mathrm{SFVA} = -\Delta\mathrm{FBA}, \tag{41}$$

while the change in contra-liabilities is

$$\Delta\mathrm{CL} = \Delta\mathrm{FBA}.$$

By design, the FTP policy in FCA/FBA accounting ensures that the impact on Income from adding a new trade is zero, i.e.

$$\Delta\mathrm{PFV} = \Delta\mathrm{CET1} + \Delta\mathrm{CL} = 0. \tag{42}$$

By tailoring the FTP in such a way that new trades have no impact on Income, deal flow induces volatility in CET1, as is evident from (41). As CET1 is a proxy for shareholders' wealth, it may be argued that (40) does not fully align executive incentives with shareholders' interests. An FTP policy designed for CET1 indifference would, however, not be viable for FCA/FBA accounting, due to the sheer size of the full FCA, as is also documented in the case study in Section 8.

7.2 FTP for FVA/FDA Accounting

In FVA/FDA accounting, FVA and UCVA are CET1 deductions and DVA, FDA, and $\mathrm{CVA}_{\mathrm{CL}}$ are CL adjustments. The upfront charge for a given trade that the business-line desk needs to pay to the CFD desk in order to ensure that CET1 stays constant is

$$\mathrm{FTP} = \Delta\mathrm{UCVA} + \Delta\mathrm{FVA} \tag{43}$$

With this choice, $\Delta\mathrm{CET1} = 0$.

We notice that the calculation of the FTP involves assessing the marginal impact of new trades on two separate units of account:

(1) the netting set associated with the counterparty to the trade in question (for UCVA); and

(2) the overall funding set under which VM may be re-hypothecated (for FVA). The latter calculation, in particular, is not always trivial; see Section 8 for further discussion.

By focusing on CET1, (43) effectively expresses a shareholder-centric view in the computation of FTP, where the proxy for "true" deal value in the FTP is only the shareholder part of the overall value that a trade brings to the firm. For trades that involve bondholder benefits post bank default, any such benefits are ignored when passing costs to the client. When it comes to Net Income, the FTP policy therefore has an impact given by

$$\Delta\mathrm{PFV} = \Delta\mathrm{CL} = \Delta\mathrm{DVA} + \Delta\mathrm{FDA} + \Delta\mathrm{CVA}_{\mathrm{CL}}. \tag{44}$$

Again, this is a marginal calculation at the level of both a netting set (DVA, $\mathrm{CVA}_{\mathrm{CL}}$) and a funding set (FDA).

We emphasize that while the FTP policy in FVA/FDA accounting is based on principles more conservative than those used for FCA/FBA, the inclusion of RHO into FVA causes the funding cost component of the CA account to be materially smaller in absolute value than in FCA/FBA accounting (by about a factor of two in our case study examples). As a consequence, CET1 immunization is practical in the FVA/FDA method, and results in a FTP principle which, we feel, aligns the interests of bank managers and shareholders well.

7.3 Exit Prices and Fair Valuation

Exit prices are important from an accounting viewpoint, as they provide a model-free method to assess fair valuations. The general idea is to go through the following steps:

(i) Decide what can be considered a unit of account.

(ii) If a unit of account can be transferred in a market trade with sufficient liquidity and without altering any expected cash flows, run an auction process for it and select the best bidder.

(iii) Failing (ii), use a model-based valuation method with a model calibrated consistently to all available market pricing information for the relevant risk factors.

According to accounting principles AP0 and AP1 in Section 4, the exit prices discovered through the steps (i)-(iii) above are what should be recorded as fair values for derivative assets and liabilities on the balance sheet.

Unless trades are fully collateralized, the notion that a single trade can ever be considered a unit of account is, as discussed before, an incorrect one. So, while it may be tempting to ask for the "market price" of a single trade, this question can only truly be asked about entire netting set portfolios – and sometimes even that may be too granular. To boot, when discussing portfolio prices, not only the netting set portfolio must be held fixed, but so must also the credit quality of the bank and its counterparty – otherwise cash flows induced by default are not the same. For instance, trying to assign a portfolio from a low-rated bank to a high-rated bank automatically changes the cash flow characteristics of the bilateral trade portfolio and violates the "apples-to-apples" provision in (ii) above. Due to this and to other effects[19], it is exceedingly rare that an auction of the type (ii) is ever practical; instead, the model-based pricing option in (iii) is virtually always called upon.

19 Even if a bidding bank has exactly the right credit spread, the bidding bank very likely already has trades with the counterparty in question. The bid is therefore not for the original portfolio in question, but for a combined portfolio of old and new trades.

7.3.1 *FVA/FDA Accounting*

As we have seen, exit pricing at the level of a netting set still operate at too narrow a unit of account, as funding costs (due to re-hypothecation) must generally be modeled at the funding set level. In the FVA/FDA method, this certainly is required for FTP and entry price calculations (as we just saw above), but is ultimately not needed for fair value. The reason for this is, of course, that cash flows associated with funding operations are modeled as having zero net value for the firm as a whole, consistently with the MMT. This manifests itself in the cancellation of CA and CL adjustments for funding, such that funding costs never make it to the level of Net Income and net fair asset/liability values on the balance sheet. DVA and CVA, however, generally do not cancel out and their difference shows up in net fair values. Specifically, for FVA/FDA accounting, the Portfolio Fair Value (PFV) of the derivatives portfolio is, according to Table 1:

$$\mathrm{PFV} = \mathrm{A} - \mathrm{L} - \mathrm{CA} + \mathrm{CL} = \mathrm{A} - \mathrm{L} - \mathrm{FTDCVA} + \mathrm{DVA}, \tag{45}$$

an expression that contains (in $\mathrm{A} - \mathrm{L}$), the present values of promised cash-flows and (in $-\mathrm{FTDCVA} + \mathrm{DVA}$) the present values of the lost cash flows due to defaults. The expression is focused on cash flows generated by the trades in isolation and does not reference how trades are funded. As a consequence, and as mentioned above, the right hand side of this expression is additive over netting sets. Again, we remind the reader that this is not the case for the FTP expressions in FVA/FDA accounting which are aligned around CET1 (a non-additive metric over netting sets).

7.3.2 *FCA/FBA Accounting*

In FCA/FBA accounting, funding costs are allowed to hit income as the PFV is given by

$$\mathrm{PFV} = \mathrm{A} - \mathrm{L} - \mathrm{UCVA} - \mathrm{FCA} + \mathrm{FBA} = \mathrm{A} - \mathrm{L} - \mathrm{UCVA} - \mathrm{SFVA}. \tag{46}$$

This expression is a mixture of partial, but incomplete[20], cash flow valuations, with a measure of funding costs thrown in. As in (45), this expression is additive over netting sets.

As we have mentioned earlier, it is clear that (46) violates both the MMT and the principle of asset-liability symmetry. One should also ask the question of whether the presence of SFVA in (46) amounts to an "entity-specific" cost adjustment decoupled from trade cash flows, something that violates the principles of exit pricing and is normally not allowed in fair value accounting (see AP2 in Section 4).

Proponents of FCA/FBA accounting often attempt to argue away the entity-specific nature of (46) by suggesting that their bank's credit spreads are "representative", wherefore the SFVA represents a market average that can be used for exit pricing purposes. This, however, is a questionable line of reasoning, for several reasons. First, even if a bank's spreads at some point is close to the market average, this may cease to be the case in the future, especially when the bank itself approaches default. And second, it is unclear that the market average spread is a metric that can be used for exit pricing and PFV computations – maybe the "best" spread (e.g., high spreads for receivables and low spreads for payables) could be argued to be more appropriate.

20 UCVA is generally not the fair-valuation of CVA, as it ignores self-default. Similarly, (46) does not contain the DVA and the approximation $\mathrm{FBA} \approx \mathrm{DVA}$ is a poor one.

A related line of thought suggests that the SFVA term in (46) is not to be computed at the bank's own spread, but at some separately marked "industry" spread. This removes the entity-specific nature of (46), but also decouples the FBA entirely from the DVA it normally is meant to approximate, whereby FCA/FBA accounting would violate AP5 in Section 4. One also wonders where exactly the industry spread curve is supposed to come from, especially since such curves are very hard to detect at the level of individual trades (since FTP entry prices operate on netting or funding set metrics only). Despite our skepticism, Appendix B investigates the idea of exogenous spread marking a bit further.

8 CASE STUDY FINDINGS

While market participants generally are aware of the fact that the FCA/FBA accounting method is approximate, little is known about the magnitude of the errors involved. Due to the computational challenges involves, this is especially true for the RHO, the proper accounting of which requires the simulation of exposures of entire funding sets with multiple netting sets.

In this Section, we attempt to shed some light on the materiality of errors, by using a realistic test-bed to compare FCA/FBA and FVA/DVA accounting results. Results were obtained by using Global Valuation Esther^{TM}, an in-memory risk analytics system designed for the simulation of massive OTC portfolios. Esther^{TM} uses a Mathematical framework based on operator algebras, as discussed in [1] and references therein. Model calibrations are taken from the Global Valuation Athena^{TM} data service and refer to the 7th of July, 2014.

As our test case, we use a realistic OTC portfolio of fixed income derivatives with about 100,000 trades, 1,600 counterparties and a variety of collateral agreements, some involving thresholds. The portfolio contains trades in 8 different currencies, including swaps, cross-currency swaps, swaptions, FX forwards and options. The simulation entails 100 time steps at each of which we find scenarios for the default-free valuation of all netting sets.

Most netting sets in our test are at least partially unsecured, with their collateral thresholds being either positive finite or infinite. Some large netting sets are of the unilateral "government" type, i.e. the threshold for the bank is zero and the threshold for the counterparty is infinity[21]. The portfolio contains also a few fully collateralized netting sets with both thresholds at 0, but they do not contribute to funding and contribute to CVA only mildly through close-out gap risk (which we do capture in the test, even though we did not discuss it in the paper).

Since funding metrics depend crucially on the bank funding rates, we carried out the calculation for the two different funding curves shown in Figure 2. One curve corresponds to a 5 year CDS spread of 106bp and the other to a 5 year CDS spread of 274 bp. Funding costs are simulated dynamically and consistently with the funding curve. CDS curves of all counterparties are also simulated dynamically, as needed for rating dependent collateral policies (of which our test portfolios had a few) and the analysis of credit-correlation effects related to loss distributions and stress-testing. We (obviously) also simulate all relevant market risk factors and derivative security prices. The various XVA metrics are

21 If all netting sets were of this type then FCA would equal FVA, as government type netting sets do not contribute to the RHO.

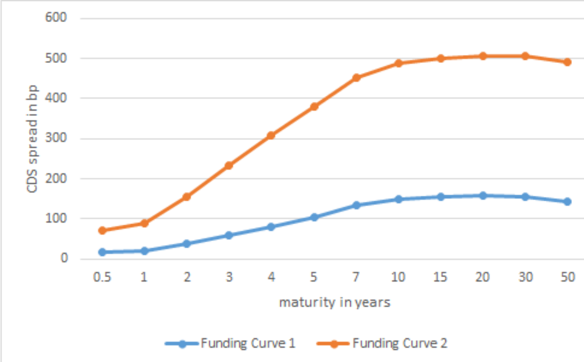

Figure 2: The two funding curves for the numerical example. The 5Y spreads are 106bp and 274bp, respectively.

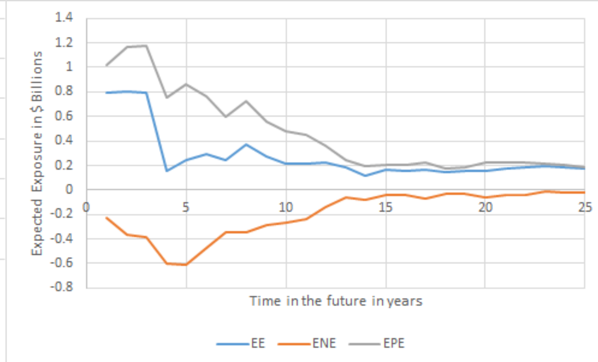

Figure 3: Term structures of the Expected (Positive/Negative) Exposure metrics EE, EPE and ENE.

computed by evaluating the expressions in Section 5, with the refinements in Appendix A.

In the simulation trials, funding set calculations are generally well-behaved. As one might expect, we find that the calculation of the incremental FVA is noisier than the calculation of book level FVA. In order to keep FVA errors below the 0.5% mark and incremental metrics within the 2% mark, it was necessary to run about 100,000 scenarios. We keep scenario information in memory aggregated with netting set granularity. By having the scenarios cached in memory, the calculation of incremental XVA metrics was quite efficient. Incremental metrics of interest include the FVA, the symmetric FVA (SFVA) as well as the UCVA, FTDCVA, and DVA.

Our hardware of choice is a compact Esther™ appliance consisting of one GPU accelerated dual-socket server and one large memory quad-socket server. On this hardware, a portfolio run takes approximately 10 minutes. Once the main calculation is carried out and scenarios are kept in memory, a complete set of incremental XVA metrics for an individual swap added to the portfolio takes less than 2 seconds to compute.

Table 2 shows the XVA portfolio metrics for the two funding curve scenarios. Accounting entries are computed using the rules of Section 4, see also Table 1. Accounting entries are computed separately for the three following cases:

- Only counterparty credit risk is accounted for
- Funding is accounted for using FCA/FBA accounting
- Funding is accounted for using FVA/FDA accounting

From Table 2 one can notice that there are material differences between FVA/FDA accounting and FCA/FBA accounting. In particular:

- The CET1 charge for funding is about triple in FCA/FBA with respect to FVA/FDA accounting
- Since FVA/FDA accounting is consistent with the Modigliani-Miller theorem, the write-off one faces by adding funding entries on top of credit adjustments is nil

- Contra-liabilities in FVA/FDA accounting are slightly larger than in FCA/FBA accounting. This happens because, although the FVA is substantially smaller than the FBA, the DVA is preserved as is required by asset-liability symmetry and since there is no overlap.

For FVA/FDA calculations, key statistic in measuring the RHO are the Expected Exposure (EE), the Expected Positive Exposure (EPE) of the portfolio as a whole and the Expected Negative Exposure (ENE). Using our 100,000 simulation trials, these metrics are reported as in Figure 3 for a range of time horizons. The book under consideration starts off as a net receivable and remains such on average (see the blue line indicating the EE). The impact of modelling re-hypothecation between hedges associated to different netting sets is sizable and receives contributions also from states of the world where the book is a net payable because, even in such situations, a fraction of the netting sets is a payable and the corresponding hedges receive collateral. Furthermore, the book valuation makes frequent swings to a net payable status, as one can see from the fairly substantial size of the ENE. A large ENE is an indication that the FVA is a materially non-linear metric which cannot be represented as a simple sum over netting sets. In other words, the incremental FVA for a netting set or a trade can be computed accurately only by knowing and accounting for the positions in the entire book.

Incremental XVA metrics are in Table 3. In our analysis, we add to the portfolio three swaps: one initially at par, one initially a payable and a third is initially a receivable. Incremental metrics are then computed under three different scenarios:

(i) The swaps are added to a netting set with finite collateral thresholds and which already contains other trades.

(ii) The swaps are added to a netting set with thresholds at infinity.

(iii) The swaps are added to a netting set which is initially empty, thus neglecting the benefits of netting.

The FTPs differ substantially between the three cases and are quite sensitive to both collateral thresholds and netting. Both collateral thresholds and netting materially decrease the FTP.

There are also material differences between the FTPs obtained under FCA/FBA accounting and those using the rules of FVA/FDA accounting. In the latter case, the FTPs are substantially smaller in absolute value by a factor of about 1.5-2. This is remarkable also in view of the fact that the FVA/FDA method does not recognize a DVA benefit to clients. This de-recognition is however more than compensated by a correct modelling of the RHO.

The incremental FTPs in the two methods achieve a different objective. In the case of the FCA/FBA method, the incremental fair valuation of the OTC portfolio dPFV is nil while Equity Capital is systematically depleted, especially in the case of payables. In FVA/FDA accounting instead, Equity Capital EC is stable while the Bank fair valuation appreciates systematically.

5Y funding rate	**curve 1 (106 bp)**	**curve 2 (274 bp)**
XVA metrics		
UCVA	210	210
FTDCVA	163	126
CVA_CL	47	84
DVA	163	324
FVA	87	178
SFVA	78	178
FCA	272	572
FBA	194	394
Capital charges and contra-liabilities for counterparty credit risk only, excluding funding.		
CA	210	210
CL	210	408
CET1 charge for credit	210	210
Capital charges and contra-liabilities including funding metrics according to FVA/FDA accounting.		
CA for funding	87	178
CL for funding	87	178
CET1 charge for funding	87	178
CA total	297	388
CL total	297	586
CET1	297	388
Write-off	0	0
Capital charges and contra-liabilities including funding metrics according to FCA/FBA accounting.		
CA for funding	272	572
CL for funding	30	70
CET1 charge for funding	272	572
CA total	482	782
CL total	241	478
CET1	482	782
Write-off	241	304
Comparison between FCA/FBA and FVA/FDA accounting.		
Funding CA ratio	3.13	3.21
Funding CL ratio	0.35	0.39
Funding CET1 charge ratio	3.13	3.21

Table 2: XVA metrics for the portfolio in the case-study example in million dollars.

	Incremental XVA statistics			Neglecting thresholds			Neglecting netting		
Incremental XVA metrics / funding curve 1 (106 bp)									
Δ UCVA	1.9	1.0	3.6	2.9	1.6	5.2	9.8	6.4	19.0
Δ FTDCVA	1.4	0.7	2.6	2.1	1.1	3.9	7.1	4.6	14.3
Δ DVA	−1.2	−0.3	−2.8	1.1	1.6	−9.8	2.5	4.9	0.4
Δ FVA	1.0	0.4	2.2	2.3	−1.1	8.5	2.1	−1.1	7.9
Δ SFVA	3.1	1.2	6.5	5.4	−0.4	15.7	4.8	−0.5	14.3
Δ FCA	1.7	0.9	3.1	2.5	1.4	4.4	7.8	5.1	14.8
Δ FBA	−1.5	−0.4	−3.4	−2.9	1.7	−11.3	2.9	5.6	0.4
FVA/FDA methodology / funding curve 1 (106 bp)									
Δ RE	2.9	1.4	5.8	5.2	0.5	13.7	11.9	5.3	26.9
Δ EC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ CL	−0.7	−0.2	−1.6	2.7	0.1	−2.7	1.9	1.9	3.6
Δ PFV	−0.7	−0.2	−1.6	2.7	0.1	−2.7	1.9	1.9	3.6
FCA/FBA methodology / funding curve 1 (106 bp)									
Δ RE	5.1	2.2	10.1	8.2	1.2	20.9	14.6	6.0	33.3
Δ EC	1.5	0.4	3.4	2.9	−1.7	11.3	−2.9	−5.6	−0.4
Δ CL	−1.5	−0.4	−3.4	−2.9	1.7	−11.3	2.9	5.6	0.4
Δ PFV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Incremental XVA metrics / funding curve 2 (274 bp)									
Δ UCVA	1.9	1.0	3.6	2.9	1.6	5.2	9.8	6.4	19.0
Δ FTDCVA	0.9	0.4	1.7	1.4	0.7	2.5	5.8	3.6	11.9
Δ DVA	−2.0	−0.4	−4.9	−4.3	4.3	−19.6	5.4	10.9	0.7
Δ FVA	1.8	0.5	4.0	4.1	−3.2	17.2	4.2	−3.4	17.8
Δ SFVA	5.2	1.8	11.3	9.3	−2.6	30.5	9.5	−2.7	31.4
Δ FCA	2.7	1.3	5.2	4.1	2.1	7.6	16.1	10.2	32.3
Δ FBA	−2.5	−0.5	−6.1	−5.2	4.7	−22.9	6.6	12.9	0.9
FVA/FDA methodology / funding curve 2 (274 bp)									
Δ RE	3.7	1.5	7.6	7.0	−1.6	22.4	14.0	3.1	36.8
Δ EC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ CL	−1.3	−0.4	−2.8	−1.6	0.3	−5.1	5.5	4.7	11.5
Δ PFV	−1.3	−0.4	−2.8	−1.6	0.3	−5.1	5.5	4.7	11.5
FCA/FBA methodology / funding curve 2 (274 bp)									
Δ RE	7.1	2.8	14.9	12.1	−1.0	35.7	19.3	3.7	50.4
Δ EC	2.5	0.5	6.1	5.2	−4.7	22.9	−6.6	−12.9	−0.9
Δ CL	−2.5	−0.5	−6.1	−5.2	4.7	−22.9	6.6	12.9	0.9
Δ PFV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3: Incremental XVA metrics for the case-study example. The increments are given in units of basis points per year.

XVA metrics / *5Y funding rate*	**106 bp (curve 1)**	**274 bp (curve 2)**
UCVA	0.30%	0.30%
FTDCVA	0.30%	0.30%
DVA	0.40%	0.20%
FVA	0.60%	0.40%
SFVA	0.80%	0.50%
FCA	0.40%	0.30%
FBA	0.40%	0.30%
dFTP (FVA/FDA method)	1.70%	1.21%
dFTP (FCA/FBA method)	0.63%	0.52%

Table 4: Standard errors with 100,000 scenarios

Standard errors of the simulation runs are in Table 4. Our simulation entails 100,000 scenarios and shows that the FTP for the FVA/FDA method is around 1.2-1.7%. An error of this size is perhaps acceptable in most circumstances. Using 10,000 scenarios would imply relative errors as large as 10% and of the order of one basis point per annum, which we would consider as being unacceptably large. Furthermore, 100,000 scenarios also allow to carry out reverse stress testing analysis by identifying extreme scenarios which either contribute to the tail of the loss distribution or invalidate a collateral procurement strategy.

The first pair of graphs in Figure 4 show incrementals after adding one trade of the forward FVA and SFVA defined as follows:

$$\mathrm{FVA}(t) = \mathbb{E}\left[e^{-\int_0^t (r_{OIS}(s)+\lambda_B(s))\,ds} s_B(t) \left(\sum_i V_i(t) 1_{t<\tau_i} \right)^+ \right]. \tag{47}$$

and

$$\mathrm{SFVA}(t) = \mathbb{E}\left[e^{-\int_0^t r_B(s)\,ds} s_B(t) \sum_i V_i(t) 1_{\tau_i > t} \right]. \tag{48}$$

The incrementals in Figure 4 are computed using the funding curve 2, i.e. the one with 5 year spread of 274 bp and refer to the case in which the additional trade is either an in-the-money swap (i.e. a swap receivable) or an out-of-the-money swap (i.e. a swap payable). The blue line shows the term structure of the incremental FVA, while the red line reports the incremental SFVA. Notice that the incremental SFVA is systematically above the incremental FVA in the case of receivables and systematically below the FVA in the case of payables. We conclude that the approximations which are intrinsic in FCA/FBA accounting over-estimates funding costs for receivables and also over-estimate funding benefits (discounts) for payables.

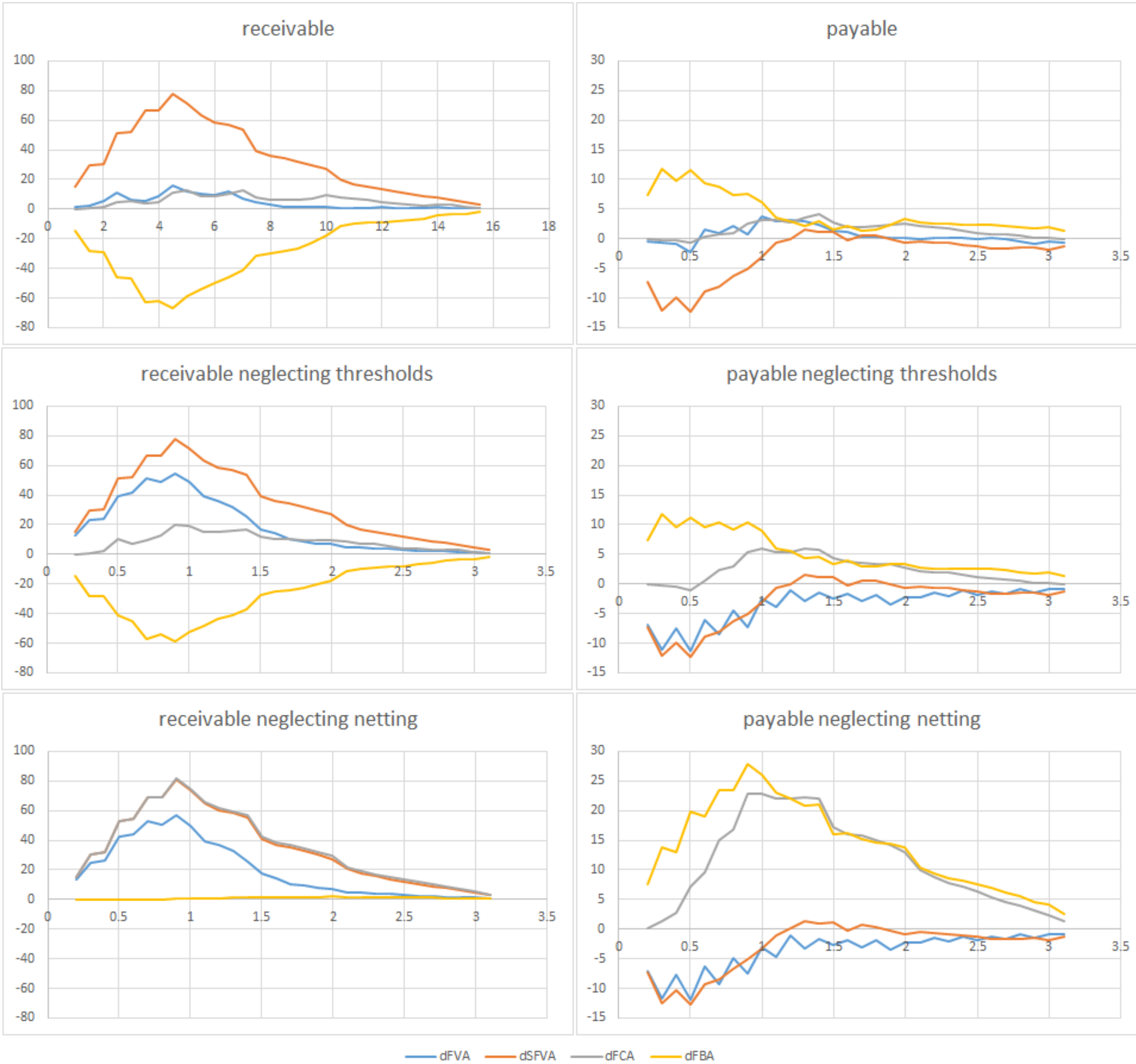

Figure 4: Incremental term structures for FVA, SFVA, FCA and FBA when adding a receivable and a payable swap and under the assumption of funding curve 2 with 274 bp at 5 years. Units are in basis points of nominal per year.

The bias in favour of payables in FCA/FBA accounting is a worrisome feature of this method as it induces banks to skew their exposure in favor of payables. If traders are incentivized with an FTP computed with this method, they are inclined to sell out-of-the money options for premium upfront, effectively raising collateral and substituting themselves to the treasury, thus incurring inefficiencies. This happens because the FCA/FBA method recognizes a benefit to a net excess variation margin at a rate equal to the funding spread of the bank (while the FVA/FDA method does not recognize any such benefit).

The SFVA is a transactional amount only in case there are no thresholds or thresholds are very remote and attained with negligible probability. For instance, in regards to Table 3, the two SFVAs for the case where a trade is added to an empty netting set and the case where the netting set is full but thresholds are neglected are very close. This happens although the FCA and FBA are very different. Compare also the second and third pairs of graphs in Figure 4 which share the same FVA and SFVA since thresholds are neglected but whose FCA and FBA are very different.

Within FCA/FBA accounting, a new trade does not cause volatility in the fair valuation of a bank as a whole, given by the PFV in the Tables. In this case however, each trade causes a transfer of wealth from CET1 to CL, i.e. from shareholders to senior creditors. On average, this transfer is a net loss to CET1. If MMT held, this would happen for a zero FTP. The fact that it happens for a non-zero FTP is yet again a signal of the internal inconsistency of FCA/FBA accounting.

In the case of FVA/FDA accounting instead, we propose to structure the FTP in seeking to keep CET1 constant. We could also have computed the FTP in such a way to keep income constant and this would have given rise to zero FTPs. Notice also that the FTPs in FVA/FDA accounting are already lower than those in FCA/FBA accounting for a net receivable book. This signals again the internal inconsistency of FCA/FBA accounting, as the FTP policy should ensure on average that CET1 is not depleted while instead it appears as it is.

It is also useful to consider the case of a portfolio with a single swap transaction and a single counterparty. In Table 5 we report the XVA metrics and accounting entries for such a case. Notice that the CET1 charge which measures the economic value to the transaction is very close in the two cases. In this sense, the FVA/FDA methodology can be regarded as an extension of the FCA/FBA method, as long as the latter is restricted to portfolios consisting of a single netting set.

A second interesting particular case is the one described in Table 6 whereby there is a portfolio with just two counterparties, each one with a single swap position. The swaps have identical terms except that one is a payable while the other is a receivable. What happens in this case is that collateral received from the hedge two one swap is nearly always the exact amount the bank is required to post on the hedge to the other swap. Discrepancies arise only in scenarios whereby one counterparty defaults while the other is still ongoing, in which case one of the hedge position is closed upon default. Assuming that the CDS spread curves of the counterparties are identical and that they reach about 200 basis points in 5 years, the resulting asymmetric FVA is small. Instead, the FCA for each of the two counterparties is large. As a consequence, in this limit case the FCA/FBA accounting method gives rise to capital deduction that are 9 times larger than the deductions resulting from the FVA/FDA method.

XVA metrics	value	stderr
UCVA	568.0	1.3%
FTDCVA	423.4	1.4%
CVA_CL	144.6	
DVA	244.6	1.4%
FVA	405.6	1.4%
SFVA	155.4	1.6%
FCA	453.6	1.6%
FBA	298.2	1.5%

Capital charges and contra-liabilities for counterparty credit risk only, excluding funding.

CA	568.0
CL	389.2
CET1 charge for credit	568.0

Capital charges and contra-liabilities including funding metrics according to FVA/FDA accounting.

CA for funding	405.6
CL for funding	405.6
CET1 charge for funding	405.6
CA total	973.6
CL total	794.8
CET1	973.6
Write-off	0.0

Capital charges and contra-liabilities including funding metrics according to FCA/FBA accounting.

CA for funding	453.6
CL for funding	53.6
CET1 charge for funding	453.6
CA total	1021.6
CL total	442.8
CET1	1021.6
Write-off	578.8

Comparison between FCA/FBA and FVA/FDA accounting.

Funding CA ratio	1.1
Funding CL ratio	0.1
Funding CET1 charge ratio	1.1

Table 5: XVA metrics for a particular case of a portfolio with one swap and one counterparty. Notice that the FCA/FBA accounting and FVA/FDA accounting give rise to very similar numbers for capital deductions.

	value	stderr
XVA metrics		
UCVA	72.2	2.0%
FTDCVA	48.3	2.0%
CVA_CL	23.8	
DVA	149.4	1.3%
FVA	16.3	2.5%
SFVA	0.0	0.0%
FCA	158.0	1.3%
FBA	158.0	1.3%

Capital charges and contra-liabilities for counterparty credit risk only, excluding funding.

CA	72.2
CL	173.3
CET1 charge for credit	72.2

Capital charges and contra-liabilities including funding metrics according to FVA/FDA accounting.

CA for funding	16.3
CL for funding	16.3
CET1 charge for funding	16.3
CA total	88.4
CL total	189.5
CET1	88.4
Write-off	0.0

Capital charges and contra-liabilities including funding metrics according to FCA/FBA accounting.

CA for funding	158.0
CL for funding	8.6
CET1 charge for funding	158.0
CA total	230.1
CL total	181.8
CET1	230.1
Write-off	48.3

Comparison between FCA/FBA and FVA/FDA accounting.

Funding CA ratio	9.7
Funding CL ratio	0.5
Funding CET1 charge ratio	9.7

Table 6: XVA metrics for a particular case of a portfolio with two counterparties only holding one swap each of equal terms and opposite sign. Notice that the FCA/FBA accounting and FVA/FDA accounting give rise to very different numbers for capital deductions.

9 CONCLUSIONS

Although funding costs may certainly feel all too real for the derivatives trader that sees his unsecured positions bleed negative carry, well-established Finance principles nevertheless insist that fair values of assets are independent of how they are funded. Reconciling these two opposing viewpoints within the confines of a financial accounting statements is not an easy exercise, especially since traditional going-concern accounting principles were not designed for credit-risky securities. Complicating matters further are also newly established regulatory principles for CET1 equity capital that require particular care in the accounting of DVA and DVA-like adjustments.

While some banks have put forward (and into action) the FCA/FBA method for funding cost accounting, our opinion is that this method is not satisfactory. First, FCA/FBA accounting does not properly reflect re-hypothecation options embedded in variation margin financing and as a result overestimates funding-related deductions from equity capital. Second, FCA/FBA accounting violates the asset-liability symmetry principle of generally accepted accounting standards, while soundly breaking the Modigliani-Miller Theorem dear to financial economists. Another popular variation of FCA/FBA accounting (which involves deducting SFVA from equity capital, rather than FCA) is not viable from a regulatory standpoint, as the deduction has wrong-way sensitivity respect to the bank credit spread for portfolios which are net payables.

Our proposal for funding cost accounting, the FVA/FDA method, aims to establish some coherence and to clear up a number of holes in FCA/FBA accounting. In our tests, this new framework differs significantly from the FCA/FBA method on key accounting numbers (such as CET1, Net Income and fair asset value), yet we think that FVA/FDA accounting should resonate with most relevant parties. Firstly, financial economists and the asset pricing quants should appreciate that the accounting rules satisfy the Modigliani-Miller Theorem and lean heavily on classic risk-neutral pricing principles. Secondly, regulators should appreciate that all self-credit benefits are collected cleanly in a contra-liability account that can easily be excluded from Common Equity for capital purposes. Thirdly, accountants should appreciate the careful adherence to accounting principles and, in particular, the asset-liability symmetry principle.

For trading staff, the picture is a little more complicated. On the one hand, FVA/FDA accounting does not trigger the funding-related adjustments to income and asset valuations that they might prefer to see. On the other hand, our paper describes why traders and the managers drafting incentive schemes, should care more about changes in CET1 than in Net Income. In particular, we highlight the link between shareholder value and CET1 and demonstrate how a rational FTP scheme can be designed around the principle of book-level CET1 indifference pricing.

On the topic of FTP calculations, there is no doubt that the FVA/FDA method requires a fairly sophisticated calculation engine to support the necessary incremental FVA calculation. Being a book-level quantity, the FVA (and therefore the FTP) computation involves simulating entire books through time, across a potentially large number of netting sets. This, in turn, requires modifications of standard CVA calculation engines that normally can only aggregate trades at the level of individual netting sets. Given the complexities involved in computing FTPs against the backdrop of an entire book position, there are challenging computational finance questions to be addressed.

While FVA/FDA accounting leans on a number of ideas from Corporate Finance, we should make it clear that the method is designed to be pragmatic and derivatives-focused. We have not attempted a rigorous full-blown analysis of the balance sheet that takes into account the many other assets and operations of a typical bank. Neither have we considered the effect of taxes, bond covenants, dividend policies and the subtle feedback effects from investment decisions on firm-wide recovery rates and default probabilities (which we instead assumed to be constant). In this sense, our analysis can be considered local or infinitesimal. It remains an interesting question for future research whether a more rigorous "large" (and necessarily complex) analysis can give any insights that can be turned into concrete accounting rules that improve on those we have proposed here.

While the FVA is the most prominent newcomer to the XVA alphabet soup, there are other adjustments waiting around the block. For instance, some have suggested that charges due to cost of capital should be reflected in deal pricing, through a "capital value adjustment" (KVA); see, e.g., [13]). Similarly, one may consider making valuation adjustments (MVA?) due to the funding cost of initial margin (IM), for netting sets that require IM posting[22]. The accounting for (and deeper meaning of) MVA and KVA and whatever additional metrics can be concocted, are topics for future research, as is their practical computation. We just note that both capital and initial margin are complex quantities that are more difficult to calculate dynamically on the path than just portfolio values (as needed in FVA); regression-based methods or nested simulations are likely needed here.

22 Initial margin is required when trading with CCPs and, due to regulatory requirements, also becomes far more prevalent in the future for non-cleared products. See [3].

APPENDICES

A A MORE DETAILED FRAMEWORK

In this Appendix, we give a more detailed and realistic analysis of cash flows and close-out protocols.

Let again $V_i^U(t)$, $i = 1, ..., n$, be the default-free valuation at time t of the portfolio held with counterparty i, i.e. the valuation computed by neglecting the upfront XVA payment and also neglecting credit risk and funding costs. The default-free value of the unsecured book is additive over the trades, in particular

$$V^U(t) = \sum_i V_i^U(t). \tag{A.49}$$

Hedges are typically struck at par and engender cash flows across time that super-replicate the cash flows of the unsecured trades. Strict super-replication is needed in order to ensure a positive return on equity.

In the case of swaps, adjustments are usually embedded as a fixed spread in addition to either the fixed or floating leg or both. This cash flows are such that typically the default-free valuation of the unsecured trade is positive at inception. A hedge would typically consist of one or a portfolio of collateralized swaps entered in the inter-dealer market, initially struck at par and whose cash flows super-replicate those of the unsecured trade. The excess cash flows are then routed to the CVA desk and the CFD desk at the time when they are received.

In the case of swaptions and FX options, premia are typically paid at maturity and struck at a level for which the present value of the option is zero. This structure lessens the amount of VM due to be exchanged. Unsecured trades instead often pay an upfront premium which is added to the book cash account. By transforming a portion of the upfront premium into a payment at the option maturity, one achieves super-replication also in this case. Excess cash flows are given by the XVA adjustments.

In general, hedges are not specific to individual netting sets. Even if hedges are entered initially on a deal specific basis, compression cycles of the collateralized swap portfolio reduce the number of hedge trades and obfuscates the attribution of hedges to individual netting sets.

Nevertheless, by means of a hedge attribution analysis, it is possible to arrive at the concept of value of the hedge book for one particular netting set i, let's call it $V_i^H(t)$. Super-replication is achieved when

$$V_i^H(t) \leqslant V_i^U(t). \tag{A.50}$$

The present value of the difference $V_i^U(t) - V_i^H(t)$ is the FTP.

We denote with

$$V^H(t) = \sum_i V_i^H(t). \tag{A.51}$$

the value of the hedge book.

As the interdealer market and exchanges require posting of VM collateral in full, the hedge trades are affected by credit risk only because of gap risk exposure. For simplicity's sake, we neglect gap risk on collateralized trades as our notations would become too heavy. However, a professional system implementation should account for it as the effect can be quite material.

Typically, CSA agreements include time dependent collateral trigger levels $\Gamma_i(t)$ dependent on the counterparty rating level and such that, if the exposure of the counterparty surpasses $\Gamma_i(t)$, then the counterparty is obliged to post collateral above that threshold. The bank has a similar trigger level $\Gamma_{B,i}(t)$ for each counterparty i. Initial margin on unsecured trade is not a common practice as they would be ineffective unless thresholds are struck at virtually zero level.

On this basis, the expression for the asymmetric FVA from the bank perspective in equation (24) needs to be amended as follows:

$$\mathrm{FVA} = \mathbb{E}\left[\int_0^{\tau_B} e^{-\int_0^t (r_{\mathrm{OIS}}(s)+\lambda_B(s))\,ds} s_B(t) \left(\sum_i -V_i^H(t)1_{t<\tau_i} - (V_i^U(t)1_{t<\tau_i} - \Gamma_i(t))^+ - (-V_i^U(t)1_{t<\tau_i} - \Gamma_{B,i}(t$$

This equation accounts for VM to be posted or received to unsecured derivative counterparties depending on thresholds. The FDA instead is

$$\mathrm{FDA} = \mathbb{E}\left[\int_0^{\tau_B} e^{-\int_0^t (r_{\mathrm{OIS}}(s)+\lambda_B(s))\,ds} (1-R_B^C)\lambda(t) \left(\sum_i \max\left(\min\left(V_i^U(t)1_{t<\tau_i}, \Gamma_i(t)\right), -\Gamma_{B,i}(t)\right)\right)^+ dt\right]. \tag{A.52}$$

Notice that, in this case, the FVA and the FDA do not coincide but they are very close. Because of inequality (A.50) we have that

$$\mathrm{FVA} \leqslant \mathrm{FDA}. \tag{A.53}$$

The discrepancy is due to the fact that FTP payments are embedded in the deal structure and at the time of bank default, the bank senior creditors still hold a claim to future FTP payments for funding without the obligation (or even capability) to continue hedging. This can be seen as a wealth transfer from derivative counterparties to senior creditors. The MMT theorem is not invalid as the game is still zero sum, as long as one includes in the analysis not only shareholders and senior creditors but also derivative counterparties.

The representation of cash-flows at the time of counterparty default under the ISDA 1992 close-out protocol in (12) are modified as follows to include collateral thresholds:

$$D_i(\tau_i) = 1_{\tau_i<\tau_B}\left(1_{V_i^U(\tau_i)\geqslant 0} R_i \min\left(V_i^U(\tau_i), \Gamma_i(\tau_i)\right) + 1_{V_i^U(\tau_i)<0} V_i^U(\tau_i)\right). \tag{A.54}$$

Similarly, equation (13) becomes

$$D_i(\tau_B) = 1_{\tau_B<\tau_i}\left(1_{V_i^U(\tau_i)\geqslant 0} V_i^U(\tau_B) + 1_{V_i^U(\tau_i)<0} R_B \max\left(V_i^U(\tau_B), -\Gamma_B(\tau_B)\right)\right), \tag{A.55}$$

Under the 2009 ISDA close-out rule, cash flows differ in that on the right hand side of equation (A.54), V^U is replaced by the exit price of the trade, including the residual DVA_i at the time of default. On the other hand, in case the bank defaults first, then the i-th counterparty has the right to recover its own DVA, which is CVA_i. This implies that, when valuing the CVA from the bank viewpoint, the default losses occurring after the time of default of the bank itself.

$$D_i(\tau_i) = 1_{\tau_i<\tau_B}\left(1_{V_i^{(+)}(\tau_i)\geqslant 0} R_i \min\left(V_i^{(+)}(\tau_i), \Gamma_i(\tau_i)\right) + 1_{V_i^{(+)}(\tau_i)<0} V_i^{(+)}(\tau_i)\right) \quad (A.56)$$

$$D_i(\tau_B) = 1_{\tau_B<\tau_i}\left(1_{V_i^{(-)}(\tau_i)\geqslant 0} V_i^{(-)}(\tau_B) + 1_{V_i^{(-)}(\tau_i)<0} R_B \max\left(V_i^{(-)}(\tau_B), -\Gamma_B(\tau_B)\right)\right), \quad (A.57)$$

where

$$V_i^{(+)}(\tau_i) = V_i^{U}(\tau_i) + DVA_i(\tau_i) \approx V_i^{U}(\tau_i)$$
$$V_i^{(-)}(\tau_B) = V_i^{U}(\tau_B) - CVA_i(\tau_B) \approx V_i^{U}(\tau_B).$$

The definition of the SFVA in equation (30) is extended as follows:

$$SFVA_i = \mathbb{E}_0\left[\int_0^\infty e^{-\int_0^t r_B(s)\,ds} s_B(t) \max\left(\min\left(V_i^H(t), \Gamma_i(t)\right), -\Gamma_B(t)\right) dt\right]. \quad (A.58)$$

The valuation formula for the UCVA under ISDA 2009 including CSA thresholds, is given by the following variation on formula (16):

$$UCVA_i = \int_0^\infty \mathbb{E}\left[e^{-\int_0^t (r_{OIS}(s)+\lambda_i(s))\,ds} \lambda_i(t)(1-R_i) \min\left((V_i^U(t))^+, \Gamma_i(t)\right)\right] dt. \quad (A.59)$$

The DVA instead is given by the following extension of equation (19):

$$DVA_i = \int_0^\infty \mathbb{E}\left[e^{-\int_0^t (r_{OIS}(s)+\lambda_B(s))\,ds} \lambda_B(t)(1-R_B)\left(-\min(V_i^U(t))^+, \Gamma_B(t)\right)\right] dt. \quad (A.60)$$

Under ISDA 2009, at the time of bank default, the bank needs to mark-to-market derivatives by including also the CVA discount. Symmetrically, whenever the counterparty defaults, a bank is also entitled to recover the DVA benefit. The latter, however, typically gives rise to a negligible correction that is neglected in our case study in order to avoid recourse to nested simulations for the calculation of the CVA itself. Hence, the fair valuation formula for the CVA is

$$\begin{aligned} FTDCVA_i &= \int_0^\infty \mathbb{E}\left[e^{-\int_0^t (r_{OIS}(s)+\lambda_i(s))\,ds} 1_{t<\tau_B} \lambda_i(t)(1-R_i) \min\left((V_i^U(t) + DVA_i(t))^+, \Gamma_i(t)\right)\right] dt \\ &\approx \int_0^\infty \mathbb{E}\left[e^{-\int_0^t (r_{OIS}(s)+\lambda_i(s))\,ds} 1_{t<\tau_B} \lambda_i(t)(1-R_i) \min\left((V_i^U(t))^+, \Gamma_i(t)\right)\right] dt. \end{aligned} \quad (A.61)$$

In this case, we also have a contra-liability contribution given by the present value of default losses occuring after the bank default, i.e.

$$CVA_{i,CL} = -\int_0^\infty \mathbb{E}\left[e^{-\int_0^t (r_{OIS}(s)+\lambda_i(s))\,ds} 1_{\tau_B\leqslant t} \lambda_i(t)(1-R_i) \min\left((V_i^U(t))^+, \Gamma_i(t)\right)\right] dt. \quad (A.62)$$

The sum

$$FTDCVA_{i,FV} = UCVA_i + CVA_{i,CL}$$

is the first-to-default unilateral CVA and represents the fair valuation of counterparty credit risk.

The equation for variation margin amounts in (A.63) can be refined to account for rating dependent collateral thresholds and for the fact that variation margin is also received on CVA hedges. The more general expression is

$$\begin{aligned} C_{VM,i}(t) &= 1_{\tau_B<t}1_{\tau_i<t}\left(-V_i^H(t) + (V_i^U(t) - \Gamma_i(t))^+ - (V_i^U(t) - \Gamma_{B,i}(t))^- - CVA_{i,CA}\right) \\ &\approx = 1_{\tau_B<t}1_{\tau_i<t}\left(-V_i^H(t) + (V_i^U(t) - \Gamma_i(t))^+ - (V_i^U(t) - \Gamma_{B,i}(t))^-\right), \end{aligned} \tag{A.63}$$

where again, the approximation is implemented in our case study.

Equation (10) for the spread $s_B(t)$ can also be extended. In general, $s_B(t)$ should be defined as the spread between the funding rate of the bank on the short term debt instruments used for the purpose of financing variation margin and the rate received on VM posted. In general, the interest rate received on VM posted may differ from OIS by a small spread.

Equation (A.63) can be used to extend equation (32) for the FCA as follows:

$$FCA_i = \mathbb{E}_0\left[\int_0^\infty e^{-\int_0^t r_B(s)\,ds} s_B(t)\,(C_{i,VM}(t))^+\,dt\right]. \tag{A.64}$$

while equation (33) for the FBA becomes

$$FBA_i = \mathbb{E}_0\left[\int_0^\infty e^{-\int_0^t r_B(s)\,ds} s_B(t)\,(C_{i,VM}(t))^-\,dt\right]. \tag{A.65}$$

The portfolio FVA is instead given by

$$FVA = \mathbb{E}\left[\int_0^{\tau_B} e^{-\int_0^t (r_{OIS}(s)+\lambda_B(s))\,ds} s_B(t)\left(\sum_i C_{i,VM}(t)\right)^+ dt\right].$$

The FDA is sensitive on the value of receivables at the time of bank default and is given by:

$$FDA = \mathbb{E}\left[\int_0^{\tau_B} e^{-\int_0^t (r_{OIS}(s)+\lambda_B(s))\,ds}(1-R_B^C)\lambda(t)\left(\sum_i \max\left(\min\left(V_i^U(t), \Gamma_i(t)\right), -\Gamma_{B,i}(t)\right)\right)^+ dt\right]. \tag{A.66}$$

Notice, that FVA and FDA are not precisely equal. Since banks typically enact slightly super-replicating strategies (as opposed to precise replication) in order to have a positive return on equity, the FDA tends to be slightly larger than the FVA.

In our case study, we model re-hypothecation by assuming that the VM received can be posted back to meet posting requirements by hedges in the same funding set. This is a simple assumption which may have to be refined in practical implementations. For instance, there may be restriction in the CSA preventing banks to re-hypothecate VM. Re-hypothecation bans are sometimes triggered by the degradation of the bank credit quality. Whenever this happens, cost of funding effectively is increased and the bank has a greater interest in "flattening out" its book. A careful simulation of funding costs should account for the resulting increase in funding costs that occur whenever such stress conditions manifest themselves. However, in our case study in the next section we neglect this sort of detail.

B LIQUIDITY SPREADS, ASSET-LIABILITY SYMMETRY AND ALTERNATIVE ALLOCATIONS FOR EXCESS COLLATERAL

In this Appendix we review the FCA/FBA accounting framework by examining a variety of assumptions that have been put forward to justify at least some elements of the FCA/FBA accounting ideas. These assumptions are quite strong and, we feel, not particularly realistic.

Derivatives are normally funded on a short-term basis, as the funding needs associated with derivatives trading typically exhibits considerable variation through time. This inherent variability, in turn, makes it unlikely that a bank's treasure department would commit to systematically use excess collateral from derivative trading to retire general term debt from the bank's liabilities. Yet, as we saw earlier, this assumption is essentially the one that is required to make sense of (some) of the FCA/FBA accounting ideas. In Section 4, we suggested a more reasonable and conservative assumption whereby excess collateral is simply invested in short-term risk-free investments, earning a rolling rate of $r_{OIS}(t)$. This way, no shareholder gain is generated out of variable excess collateral.

The sum of the value of the bank to shareholders and the value to senior creditors add up in income statements and define the PFV of the bank. The value of debt with collateral lenders is excluded from this calculation. Whenever the bank finds itself in a situation where it has excess cash, bank managers have an option to deleverage by buying back senior debt. According to MMT, neither of the decision of leveraging up with collateral lenders or de-leveraging by debt buy-back have a net impact on income. However, the two decisions differ in terms of wealth transfer between shareholders and senior creditors. The interest paid to collateral lenders triggers a wealth transfers between shareholders and senior creditors of the bank which is quantified by the FVA and FDA. Whenever bonds are bought back from senior creditors at their fair valuation, the wealth of both shareholders and senior creditors is not affected by the decision to de-leverage.

Notice that an alternative to the FVA/FDA assumption would be to assume that short-term collateral excesses can be invested in strategies that lead to time 0 shareholder and debt holder value increases of EG ("equity gain") and DG ("debt gain"), respectively. It would generally be a stretch to build into accounting statements any "sure thing" firm-wide profitability of investment strategies, so it seems that one should at least require

$$\mathrm{EG} + \mathrm{DG} = 0. \tag{B.1}$$

This is, of course, the condition required to satisfy MMT.

EG and DG are specific to whatever investment strategy the treasury commits to[23], but should one somehow be able to project the values of EG and DG, the FVA/FDA accounting method could be adapted as follows:

$$\textbf{CA Entries} := \mathrm{FVA} + \mathrm{UCVA} - \mathrm{EG} \tag{B.2}$$

$$\textbf{CL Entries} := \mathrm{CVA}_{CL} + \mathrm{FDA} + \mathrm{DVA} + \mathrm{DG} \tag{B.3}$$

23 This is a good time to once again point out that funding cost definitions are not immutable, but depend strongly on the assumptions that one makes about how funds are raised and invested. Baking any such assumptions into accounting numbers obliges the bank to actually follow the strategies on which it based its accounting numbers.

As equation (B.1) implies that EG=-DG, it is clear that introducing EG and DG into FVA/FDA accounting would preserve asset-liability symmetry and would not have any effects on Net Income. However, if EG$\neq 0$, new terms would arise at the balance sheet account level and would potentially affect CET1. As bank managers should not engage in trading strategies that have EG < 0, the introduction of EG and DG terms realistically would involve the case where EG > 0 (and therefore DG < 0); that is, we are considering only collateral investment strategies that prevent wealth transfer from shareholders to senior creditors. Such strategies are possible in principle, but are non-trivial to set up since bond covenants put serious restrictions on any activity that enriches shareholders solely at the expense of senior creditors. Transferring counterparty credit risk to third party investors may prevent wealth transfer from share-holders to senior creditors. However, unless such strategies are actually executed and properly quantified, theoretical equity gains should not be reflected in accounts just because they are possible. We thus feel that the FVA/FDA assumption of

$$\mathrm{EG} = \mathrm{DG} = 0 \tag{B.4}$$

is a more reasonable and rigorous one.

Should one nevertheless wish to pursue the extensions above a bit further, suppose that investment benefits are assumed to accrue to shareholders at a rate of $s_G(t)$, where we may interpret $s_G(t)$ as a spread above $r_{\mathrm{OIS}}(t)$ returns. In this case, we would write, along the same lines as equation (24),

$$\mathrm{EG} = \mathrm{EG}(s_G) = E_0\left[\int_0^\infty e^{-\int_0^t (r_{\mathrm{OIS}}(u)+\lambda_B(u))\,du} s_G(t)\left(\sum_i V_i(t)1_{\tau_i>t}\right)^- dt\right]. \tag{B.5}$$

For the special case where $s_G(t) = s_B(t)$, we can observe that

$$\mathrm{FVA} - \mathrm{EG}(s_B) = E_0\left[\int_0^\infty e^{-\int_0^t (r_{\mathrm{OIS}}(u)+\lambda_B(u))\,du} s_B(t)\sum_i V_i(t)1_{\tau_i>t}\,dt\right] \tag{B.6}$$

where now the max-operator has disappeared from the expectation. Approximating the recovery rate of the bank as zero, i.e. setting $R_B = 0$, we find that

$$\mathrm{FVA} - \mathrm{EG}(s_B) \approx \mathrm{FCA} - \mathrm{FBA} = \mathrm{SFVA}. \tag{B.7}$$

Of course, setting $s_G = s_B$ in (B.5) basically amounts to endorsing the debt retirement strategy we questioned above, so we cannot recommend this. Nevertheless, (B.7) does help us understand better the underpinning of the FCA, FBA and SFVA terms. We emphasize, however, that setting $s_G = s_B$ and following the CA and CL entries above does *not* reproduce the FCA/FBA accounting method, not even approximately. For instance, note that the FCA/FBA method sets the CA account to CVA+FCA, whereas (B.7) results in a CA account of CVA+SFVA. (B.2)-(B.3) constitutes an accounting method with asset-liability symmetry whereas FCA/FBA accounting does not.

Let us note that it is possible to preserve asset-liability symmetry without satisfying MMT. For instance, suppose that we (and the entire market) decides that a liquidity spread of s_L – unrelated to compensation for default risk – applies to all discounting operations on unsecured derivatives. Incorporation of this spread would, effectively, only mean a universal redefinition of the default-free security values V_i, something that would result in asset and earnings restatements across firms, but would not break asset-liability symmetry.

More concretely, let us define a liquidity value adjustment (LVA) as

$$
\begin{aligned}
\mathrm{LVA}(s_L) &= \mathbb{E}_0\left[\int_0^\infty e^{-\int_0^t (r_{OIS}(u)+s_L(u))\,du} s_L(t) \sum_i V_i(t)\,dt\right] \\
&= \mathbb{E}_0\left[\int_0^\infty e^{-\int_0^t (r_{OIS}(u)+s_L(u))\,du} s_L(t) \sum_i V_i(t)^+\,dt\right] \\
&\quad + \mathbb{E}_0\left[\int_0^\infty e^{-\int_0^t (r_{OIS}(u)+s_L(u))\,du} s_L(t) \sum_i V_i(t)^-\,dt\right] \\
&\triangleq \mathrm{LVA}_A(s_L) - \mathrm{LVA}_L(s_L).
\end{aligned}
$$

One obvious way of accounting for liquidity spreads would be to let $\mathrm{LVA}_A(s_L)$ and $\mathrm{LVA}_L(s_L)$ be entered as a contra-asset and contra-liability, respectively. It is here clear that $\mathrm{LVA}_L(s_L)$ – unlike all the other terms in (B.3) – is not associated with self-default or wealth-transfers and should therefore *not* be excluded from CET1. Note also that introducing LVA would result in an earnings impact equal to the LVA.

A radical idea is to assume that the funding spread s_B is unrelated to default and in actuality just a friction-type liquidity spread. In that case, one may interpret SFVA as a LVA, by noting the identity

$$\mathrm{SFVA} = \mathrm{LVA}(s_B),$$

as well as $\mathrm{FCA} = \mathrm{LVA}_A(s_L)$ and $\mathrm{FBA} = \mathrm{LVA}_L(s_L)$. In this interpretation, we would use the following accounting rule:

$$\textbf{CA Entries}: \mathrm{UCVA} + \mathrm{LVA}, \tag{B.8}$$

$$\textbf{CL Entries}: \mathrm{CVA}_{CL} + \mathrm{DVA} \tag{B.9}$$

where effective only $\mathrm{CVA}_{CL} + \mathrm{DVA}$ (but not FBA) would need exclusion from regulatory equity capital. Besides stretching the imagination by assuming that liquidity spreads are as large as credit spreads, this rule effectively double-counts DVA. Note that this does not preserve MMT (and results in a funding impact on earnings), but does preserve asset-liability symmetry. If, as in FCA/FBA accounting, DVA is removed from the CL entries to avoid double-counting, accounting symmetry is broken.

The approach above is problematic not only from an accounting angle but also from a regulatory viewpoint due to the wrong-way sensitivity of the SFVA on the bank own credit; see Section 6.5. In case there were generalized acceptance of the SFVA being interpreted as an LVA and qualified for a CET1 deduction, the FTPs computed using the SFVA would incentivize traders to buy payables and sell receivables, since they overstate both the funding benefits for the former and the funding costs for the latter. Hence portfolios of a bank with material credit spreads would drift toward being net payables. One can imagine that the SFVA for worst funders would become negative and develop a wrong-sign sensitivity with respect to the own credit. A vicious circle may ensue since a worsening of the credit of the bank would ipso facto increase equity capital. If a blow up occurs and accounting standards need to suddenly be changed for all market participants to enforce an FCA or an FVA deduction, the system-wide impact on regulatory capital would be pervasive.

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