Understanding the developments in derivative pricing with regards to xVA

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Abstract

Since the financial crisis of 2008, Credit Value Adjustment (CVA) and Debit Value Adjustment (DVA) have been widely implemented by banks. CVA is the reduction in the risk-free value of over-the-counter (OTC) derivative assets compensating for the probability of counterparty default. DVA is the adjustment made to the value of derivative liabilities to reflect an entity's own creditworthiness. Regulatory authorities, such as the IASB and Basel, have forced banks to include CVA and DVA when pricing derivatives and to ensure the correct reporting of transactions within their financial statements.

Due to evolving markets, increasing competition and growing pressure on business models, financial institutions now have to account for a series of xVAs in their financial reports. This acronym, xVA, refers to the list of valuation adjustments in general, where a letter referring to the specific adjustment can replace the "x". This list of adjustments includes CVA, DVA, Funding Value Adjustment (FVA), Collateral Value Adjustment (CollVA), Hedging Value Adjustment (HVA), Liquidity Value Adjustment (LVA), Marginal Value Adjustment (MVA) and Capital Value Adjustment (KVA).

This study will clarify concepts regarding the xVA framework, which provides an ideal platform for derivative trading. The description, calculation and relevance of each xVA will be given. In order to understand how to implement xVA within a financial institution, a look into the mechanics behind xVA pricing will be undertaken. After considering the opinions and approaches of the four largest professional services firms and well-known banks within South Africa, it has become clear that CVA and DVA are included when pricing derivatives. None of the other xVAs have been fully implemented. Hence, the importance of further research on the topic of xVA derivative pricing has become evident.

Key words:

CVA; DVA; FVA; CollVA; HVA; LVA; MVA; KVA; xVA; Fair Value; PD; Derivatives, IFRS, Basel.

Opsomming

Sedert die finansiële krisis van 2008, is kredietwaarde-aanpassing(CVA) en debietwaarde-aanpassing (DVA) deur banke geïmplementeer. CVA is die vermindering in die risiko-vrye waarde van oor-die-toonbank afgeleide instrumente, om vir die waarskynlikheid van wanbetaling deur die teenparty te vergoed. DVA is die aanpassing aan die waarde van die afgleide wat die kredietwaardigheid eie aan die party weerspieël. Banke is deur regulerende owerhede, soos die IASB en Basel, gedwing om kredietwaarde-aanpassing en debietwaarde-aanpassing in die pryse van hul afgeleides in te sluit en om die korrekte verslaggewing van transaksies in hul finansiële state te verseker.

As gevolg van veranderende markte, toenemende mededinging en verhoogte druk op besigheids-modelle, moet finansiële instansies nou in hul finansiële state vir ‘n reeks “xVAs” verantwoording doen. Hierdie akroniem, xVA, verwys na die lys van waarde-aanpassings, waar die “x” as plaasvervanger dien vir die letter wat verwys na die spesifieke aanpassing. Hierdie lys van aanpassings sluit befondsingswaarde-aanpassing (FVA), kollateralewaarde-aanpassing (CollVA), verskansingswaarde-aanpassing (HVA), likiditeitswaarde-aanpassing (LVA), marginale-waarde-aanpassing (MVA) en kapitaalwaarde-aanpassing (KVA) in.

Hierdie studie sal onsekerhede ten opsigte van die “xVA” raamwerk, wat ‘n ideale platform vir die handel van afgeleides bied, verduidelik. Die beskrywing, berekening en toepaslikheid van elke “xVA” word gegee. Om te verstaan hoe elke “xVA” in ‘n finansiële instelling geïmplementeer moet word, word daar in diepte gekyk na die meganika van hoe die “xVAs” geprys word. Na aanleiding van die menings en benaderings van die vier grootste professionele dienste maatskappye en bekende banke in Suid-Afrika, het dit duidelik geword dat CVA en DVA ingesluit word in die pryse van afgeleides. Nie een van die ander xVAs word ten volle geïmplementeer nie. Dus het die belangrikheid van verdere navorsing, rakende die onderwerp van “xVA” afgeleide pryse, duidelik geword.

Sleutelwoorde:

CVA; DVA; FVA; CollVA; HVA; LVA; MVA; KVA; xVA; billike waarde; blootstelling; afgeleides; IFRS; Basel.

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List of abbreviations and/or acronyms

BCBS	Basel Committee on Banking Supervision
BIS	Bank of International Settlements
Bps	Basis points
CAPM	Capital Asset Pricing Model
CCP	Central Counterparty
CCR	Central Counterparty Credit Risk
CDS	Credit Default Swap
CEM	Current Exposure Method
CollBA	Collateral Benefit Adjustment
CollCA	Collateral Cost Adjustment
CollVA	Collateral Value Adjustment
CRC	Cost of Regulatory Capital
CSA	Credit Support Annex
CVA	Credit Value Adjustment
DCF	Discounted Cash Flow
DVA	Debit Value Adjustment
EAD	Exposure At Default

EBA	European Banking Authority
EE	Expected Exposure
EFE	Expected Future Exposure
EFV	Expected Future Value
EL	Expected Loss
ENE	Expected Negative Exposure
EPE	Expected Positive Exposure
ES	Expected Shortfall
EY	Ernst & Young
FRTB	Fundamental Review of the Trading Book
FS	Funding Spread
FVA	Funding Value Adjustment
HSBC	Hongkong and Shanghai Banking Corporation
HVA	Hedging Value Adjustment
IASB	International Accounting Standards Board
IFRS	International Financial Reporting Standards
IM	Initial Margin
IMM	Internal Model Method

IOSCO	International Organization of Securities Commissions
IRB	Internal Ratings-Based
IRS	Interest Rate Swap
KPMG	Klynveld Peat Marwick Goerdeler (Accounting firm)
KVA	Capital Value Adjustment
LGD	Loss Given Default
LIBOR	London Interbank Offered Rate
LVA	Liquidity Value Adjustment
MTM	Market to Market
MVA	Margin Value Adjustment
OIS	Overnight Index Swap
OTC	Over-the-Counter
P&L	Profit and Loss
PD	Probability of Default
PDE	Partial Differential Equation
PFE	Potential Future Exposure
PwC	PriceWaterhouse Coopers (Accounting firm)
Repos	Repurchase Agreements

RR	Recovery Rate
RWA	Risk-weighted assets
SA-CCR	Standardised Approach for Counterparty Credit Risk
S&P	Standard and Poor’s
VaR	Value at Risk
WWFR	Wrong Way Funding Risk
WWR	Wrong Way Risk

CHAPTER 1
INTRODUCTION

The financial crisis of 2008 made it clear that no counterparty could ever be regarded as risk-free. Regulation regarding Credit Value Adjustment (CVA) has been implemented in both IFRS and Basel since the financial crisis, but for different purposes. IFRS (International Financial Reporting Standards) is an accounting framework developed by the IASB to ensure that particular types of transactions are reported correctly in financial statements. Basel is a committee that provides an opportunity for banking supervisory matters and their focus is on regulating capital and ensuring that banks do not take excessive amounts of risk given their capital at hand. In order to mitigate the impact of another financial crisis, the introduction of new regulatory and conservative rules, especially under Basel and IFRS, were needed and the old rules required improving. The new implemented regulations are mostly aimed at the over-the-counter (OTC) derivative market. The regulatory change was not the only change undertaken by banks. They have also dramatically reconsidered their assumptions on pricing, managing and valuing OTC derivatives. The acronym xVA has been introduced to refer to the list of valuation adjustments in general, where a letter referring to the specific adjustment can replace the “x”. OTC derivative valuation has subsequently become highly dependent on xVAs. The first risk adjustments incorporated were, notably, Credit Valuation Adjustment (CVA), Debt Value Adjustment (DVA), and Funding Value Adjustment (FVA). CVA is the adjustment made to the value of a derivative to include the counterparty’s credit quality. DVA is the adjustment made to fair value of a derivative in order to include the risk of a company’s own non-performance (Leuvennink, 2015:1). According to Crépey (2014), the profit and loss (P&L) centres of investment banks mainly use these two adjustments.

However, these two adjustments may not be sufficient as financial institutions are facing growing pressure on their current business models. This is due to the the increasing competition in the derivatives markets and the uncertainty of funding risks. These factors have led to a mass of adjustments to the risk-neutral price of over-the-counter (OTC) derivatives and the issue of correct addition without double counting. Banks have to account for what is now referred to as “the xVAs” (Kancharla *et al.*, 2014). According to Jon Gregory at the Quant Insights Conference in October 2015, the xVAs represent the correct pricing and valuation of credit, funding, collateral and capital costs. The xVAs discussed in this research include, but are not limited to, CVA, DVA, FVA, Capital Value Adjustment (KVA), Liquidity Value Adjustment (LVA), Hedging Value Adjustment (HVA), Collateral Valuation Adjustment (CollVA), and Marginal Value Adjustment (MVA).

In her research report, Leuvennink (2015) clarified the concepts concerning CVA and DVA as defined by Basel and IFRS individually. Although the 2007 financial crisis led to IFRS requiring financial institutions to include CVA and DVA when pricing derivatives, institutions now also have to include other xVAs in order to continue in this new era of derivatives trading. As the concept of xVA is still in its infancy, with very few academic references, the problem now is understanding exactly what each xVA entails, how to calculate it and how it should be included when determining derivative prices.

This research paper will seek to determine the importance of including the different xVA's into the post valuation adjustment when calculating the value of a derivative. The objective of this study is to simplify and explain each of the above-mentioned xVAs. This study provides a brief summary of the regulatory frameworks, i.e. Basel and IFRS that influence the implementation of these xVAs. The description, calculation and relevance of each xVA will also be discussed. The comprehensive literature review will clarify uncertainties regarding an xVA framework and related terms. This framework provides the ideal platform for derivative trading. xVA is an important, emerging concept and this study provides a high level concise summary of this topic. As certain xVAs are still vague, this study provides a basis for further research and development of this topic.

The study will start with a literature review on the different xVAs including CVA, DVA, FVA, CollVA, HVA, LVA, MVA, and KVA. Within the literature review, an elaboration on definitions, calculations and the relevance of each xVA will be provided. Within the third chapter, an in depth consideration into the mechanics behind xVA pricing is provided. This includes the setup and implementation of xVA desks, as well as the method underlying the construction of a technological xVA system. Within the fourth chapter summaries regarding the general opinions concerning each xVA, as well as the practical implementation by professional service firms and banks will be given. These four largest professional services firms include EY, KPMG, Deloitte, and PwC. The banks include Standard Bank, Nedbank, Barclays, First Rand, and Investec. The research will conclude with a concise comparison and conclusion concerning the relevance of each xVA.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The methods of calculating the fair value of fixed income derivatives with regards to the well-known principles of arbitrage-free pricing and the law of one price, have changed significantly since the major financial crisis of 2007 (Albanese & Iabichino, 2013). Hence, financial institutions were forced to make different adjustments in order to account for counterparty risk, because they realised there were other risks contributing to fair value (Morini, 2015).

Further, it also occurred that the spreads of banks, which refer to the difference in borrowing and lending rates, had increased rapidly and that these new funding costs are quantified together with CVA and DVA. The adjustment for funding cost was named FVA. However, hidden standards were found within FVA: firstly, in the collateral agreements, which should be examined by means of CollVA (Collateral Value Adjustment); secondly, in the cash flows of derivatives, which should be examined through HVA (Hedging Value Adjustment) and thirdly, through the credit liquidity premium which should be considered through LVA (Liquidity Value Adjustment). The dramatic increase in the requirements for capital also led to KVA (Capital Value Adjustment) and the requirements to post initial margins led to MVA (Margin Value Adjustment). The general concept of any xVA is to quantify the value of each component. This component could be counterparty risk, collateral, funding, or capital. Usually, the xVA terms are represented as costs, but they can also represent benefits.

In the literature review that follows, a brief history and description on regulatory frameworks will initially be given. Thereafter, each xVA term will be defined separately and a description on valuing and computing them will be given. The relationships between each of the terms will also be clarified, as well as how each term led to the other.

2.2 A BRIEF HISTORY OF REGULATORY FRAMEWORKS

The Basel Committee suggested the first method for capital computation for banks in 1988. The first version was known as Basel I, and ever since it has grown in form and complexity.

While this methodology can be used to foresee future problems, it can also be used retrospectively, due to problems having become crystallised. The IFRS is a set of accounting standards developed by the International Accounting Standards Board (IASB). IFRS 13, the standard on fair value measurement, was the result of a need for common practice in fair value measurement.

2.2.1 Basel I

Basel I is a capital measurement outline introduced in July 1988 and implemented in 1992. This Accord specified a minimum capital to Risk-Weighted Assets (RWA) ratio of 0.08 (Bank for International Settlements, 2014a:2-3). RWA is the requirement that a bank's assets and off-balance sheet exposures should be weighted according to risk. These risks are Market Risk, Credit Risk and Operational Risk (Ruiz, 2015:145). The calculation of RWA focuses on the credit risk of cash products that are found in the banking book. Securities that are not actively traded are included in the banking book. These securities are usually held until maturity. The RWA calculation, according to Basel I, was very simple:

$$RWA_{Cash} = (Principle)(Risk\ Weight)$$

The risk weight allocated to each of the debt products depends on the kind of counterparty. At the time of implementation, the derivatives market was still in its developing phase and this meant that calculations in the trading book were mostly driven by repurchase (repo) transactions. An asset was assigned to the trading book if a client wanted to sell debt securities to a bank instead of taking a loan. Repo RWA was given by

$$RWA_{Repo} = (C_{MV} - S_{MV})(Risk\ Weight)$$

where

C_{MV} - the value of cash proceedings

S_{MV} - the market value of the securities

Basel I had also set up a framework on how this capital should be allocated.

2.2.2 Basel II

In 1999, the Basel Committee published a proposal for a new framework to replace the first Basel version. This is known as the Revised Capital Framework or Basel II and was issued in June 2004. Basel II has three pillars: the first is an expanded version of the minimum capital requirements as in Basel I; the second pillar is a supervisory review process that evaluates a bank's internal systems and capital adequacy; and the third is a disclosure requirement that is implemented to enhance market discipline.

These pillars of Basel II are regarded as the pillars to financial stability (Bank for International Settlements, 2014a:3). This Accord attempted to address some of the weaknesses that had been identified with Basel I. The capital allocation remained the same. The capital calculation, however, changed. It became more complicated, since it was now grounded on a more advanced computation for credit risk capital (Ruiz, 2015:145).

2.2.3 Basel II to Basel III

It became clear even before the financial crisis of 2008 that it was necessary to revise the Basel II framework. At the time when Lehman Brothers collapsed, the Basel Committee on Banking Supervision (BCBS) announced principles for thorough liquidity risk management and supervision. These standards were issued in December of the same year and were titled *Basel III: International framework for liquidity risk measurement, standards and monitoring and Basel III: A global regulatory framework for more resilient banks and banking systems* (Bank for International Settlements, 2014a:4).

The first pillar consists of three subsections: the leverage ratio, capital requirements and the liquidity ratio. CVA forms part of the capital requirement under the risk-weighted assets section. There were no changes made from Basel II to III in the operational risk requirements, but major changes were made to the credit and market risk requirements. One of these, which is a combination of credit and market risk, is CVA. This is included under Central Counterparty Credit Risk (CCR). Another concept included in Basel III is the internal ratings-based (IRB) approach. IRB approach is a capital requirement method that may only be implemented by certain qualifying banks.

2.2.4 IFRS

As previously mentioned, IFRS is a set of accounting standards established by the IASB. IFRS 13, the standard on fair value measurement, was the result of a need for common practice in fair value measurement. Certain IFRSs either allow or require entities to report assets, liabilities or equity at fair value. As a result, discrepancies in the requirements have created some uncertainty regarding financial statements' comparability (International Accounting Standards Board, 2011b:A498). The IASB (2011b:B983) emphasises that IFRS 13 does not describe what is being measured but rather how it is measured, thereby providing a single basis for the determination of fair value. IFRS 13 regards fair value as a market-based instrument but in some cases market information might not be available and other valuation methods may be used.

There is no IFRS hierarchy when it comes to valuation techniques but IFRS 13 does specify that some techniques might be more appropriate than others in which case the most appropriate technique should be used. The components of the xVAs should be determined, if possible, by market observable inputs.

In determining the probability of default (PD), market implied PDs are preferred above estimates based on historical data. This can be extracted from Credit Default Swaps (CDSs) or proxy spreads, when the former is unavailable. Hull (2012:802) defines a CDS as an instrument in which the holder has the right to sell an asset at face value in the event of default of the issuer. Loss Given Default (LGD) is simple to calculate when the recovery rate (RR) is available. The preferred method to determine the RR would be to use market implied RRs as market observable inputs are preferred. The exposure profile will usually be created by initially considering current market data and thereafter simulating different scenarios which incorporate possible future market conditions (European Banking Authority, 2015:18-19). There are three types of valuation techniques specified in IFRS: the cost approach, income approach and market approach.

2.3 CVA (CREDIT VALUE ADJUSTMENT)

Credit Value Adjustment (CVA) is the reduction in the risk-free value of Over-the-Counter (OTC) derivative assets in order to compensate for the probability of counterparty default (European Banking Authority, 2015:32). As investors generally dislike volatility, this price has to be managed, since it creates undesired profit and loss (P&L) volatility.

The "risk-free" price of a derivative is usually referred to as its "credit-risk-free" price (Ruiz, 2015:126). This implies that when pricing a derivative, it is assumed that all the cash flows will take place as stipulated by the contract. It follows from this assumption that the possibility of one of the counterparties defaulting during the life of the trade is relatively small. According to Ruiz (2015:126), such an assumption can be relatively unrealistic and, hence, the risk-free price needs to be adjusted by an amount that incorporates the market price of the counterparty risk.

2.3.1 The CVA formula

CVA has become increasingly important for financial institutions. CVA losses accounted for nearly 66% of total losses due to counterparty credit risk during the crisis. With the definition of CVA known, the price (P) of a derivative can now be shown to be:

$$P = P_{CreditRiskFree} - CVA$$

where $P_{CreditRiskFree}$ is the price of the derivative without counterparty risk (Ruiz, 2015:128). In a risk-neutral valuation framework, the price of risk is assumed to be the amount it will cost to hedge it out. Therefore, CVA can be expressed as the price of hedging out counterparty credit risk. In a CDS, the risk of counterparty default is shifted from one entity to another. Hence, CVA should have a high correlation to the credit spread of the counterparties involved in the transaction.

The main components used to calculate CVA are: Probability of Default (PD), exposure and Loss Given Default (LGD). The LGD is the percentage that the entity will not be able to recover and is given by $LGD = 1 - Recovery\ Rate\ (RR)$. Exposure can be defined in different ways, depending on the type of calculation done. Expected Exposure (EE) can be divided into two parts: Expected Positive Exposure (EPE) and Expected Negative Exposure (ENE). In the calculation of the value of a derivative, an entity has to consider the Expected Positive Exposure (EPE) to calculate CVA (International Valuation Standards Council, 2013:8). A simplified calculation of CVA is generally accepted to be:

$$CVA = PD \times LGD \times EE$$

2.3.2 CVA and credit limits

A credit limit is assigned by an institution to each counterparty. This is done to ensure that the Potential Future Exposure (PFE) of that counterparty does not breach this limit.

As the PFE varies over the life of the transaction, credit limits will also be adjusted upwards or downwards. Gregory (2015:36) states that if a new trade breaches a credit limit at some time in the future, it will be rejected. Although, a credit limit takes into account variables such as the default probability of a counterparty, the expected recovery rate, the downgrade probability and the correlation between counterparties, it is done so in a qualitative fashion. As a result, decisions involving accepting or rejecting a new trade will be made on the basis of exposure alone, and not with regard to the actual profitability of the new trade. CVA evaluates counterparty risk at the trade level. On the other hand, credit limits evaluate risk at the portfolio level.

Hence, CVA and credit limits act complementary to each other (Gregory, 2015:37). Figure 1 below provides an illustration of the complementary use of CVA and credit limits to manage counterparty risk:

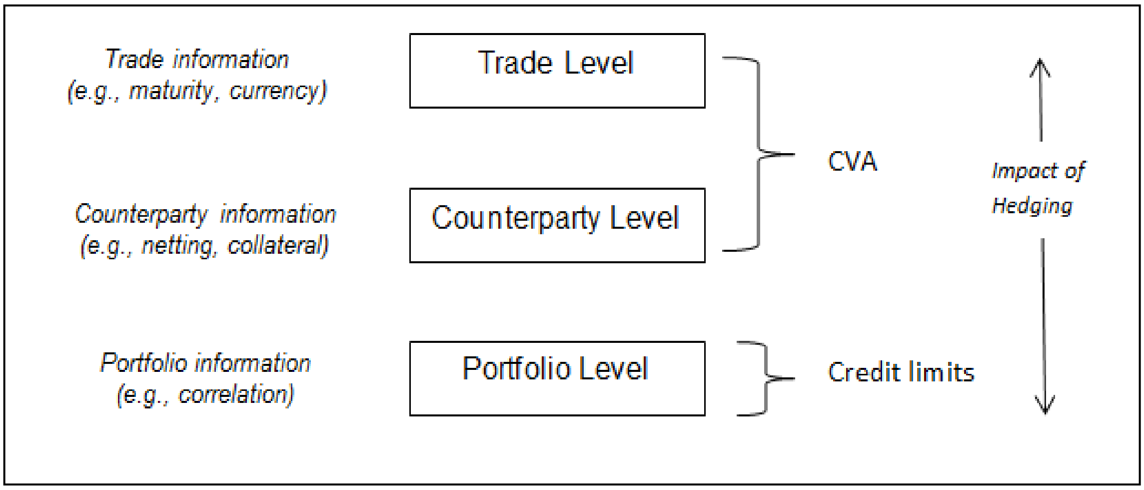


Figure 1: An illustration of the complementary use of CVA and credit limits to manage counterparty risk

Source: Gregory, 2015:39

2.3.3 The mechanics of a CVA desk

According to Ruiz (2015:193), the dealer can set up a specialised desk that makes it possible for financial institutions to manage the counterparty risk. This (CVA) desk will serve as a credit insurance against losses from counterparties defaulting to the standard desk.

These desks are necessary to facilitate the core activity of the financial institution, which is to trade as many derivatives as possible. The standard desk will have to pay a fee to the specialised desk for this service. This is the initial CVA. The CVA desk will then hedge out the market price of the counterparty credit risk of the standard desk. Hence, CVA can be viewed as a “credit insurance fee”.

2.3.4 Hedging CVA

Credit risk and CVA can also be used, in principle, when evaluating OTC derivatives, in order to assess the effectiveness of hedge relationships. Within the Black-Scholes-Merton framework, it is suitable to assume CVA as the market price of hedging the counterparty default risk. Basel and IFRS require that financial institutions include the asset and liability side of CVA in their balance sheet calculations (Ruiz, 2015:200). Changes in the CVA can lead to fluctuations in the balance sheet. Hence, financial institutions need to control P&L fluctuations resulting from the CVA in order to prevent instability.

2.4 DVA (DEBIT VALUE ADJUSTMENT)

Debit Value Adjustment is the adjustment made to the value of derivative liabilities to reflect an entity’s own creditworthiness (International Valuation Standards Council, 2013:3). It reduces the effects of losses due to increases in CVAs by taking the PD of the entity itself into account. Hence, DVA is CVA from the counterparty’s perspective. International accounting standards force a party to consider its own default probability when valuing its liabilities, even if the definition of CVA assumes that the party making the calculation has no possibility of default. There is a great deal of controversy regarding DVA, since an increase in a party’s DVA will increase the entity’s profits in their financial statements (Gregory, 2012a:7). In order to account for the increase in profits, DVA is added to the Market-to-Market (MTM) value of the entity. MTM is a measure of the fair value of accounts, such as time varying assets, and liabilities with respect to the most recent market price.

DVA can assist in understanding some of the theoretical limitations of CVA. Further, it assists in achieving price symmetry. In addition, the nature of DVA and its implications can lead to potential negative unintended consequences.

2.4.1 DVA and pricing

A study done by the European Banking Authority (EBA) confirms that DVA remains a controversial issue. Their studies found that while some banks do not include DVA for pricing and risk management purposes, they still include it for accounting purposes (Leuvennink, 2015:1). Theoretically, if two parties can agree on a price, DVA makes it possible to achieve price symmetry, even if price symmetry is not commonly a requirement for markets. The EBA also concluded that, at certain banks, calculation methods used for accounting purposes differed to that used for pricing and risk management purposes. The approximation of DVAs requires difficult modelling methodologies that estimate the development of exposures over time and that rely on a set of assumptions and parameters that are unique to each bank.

The following diagram illustrates the inclusion of DVA by banks:

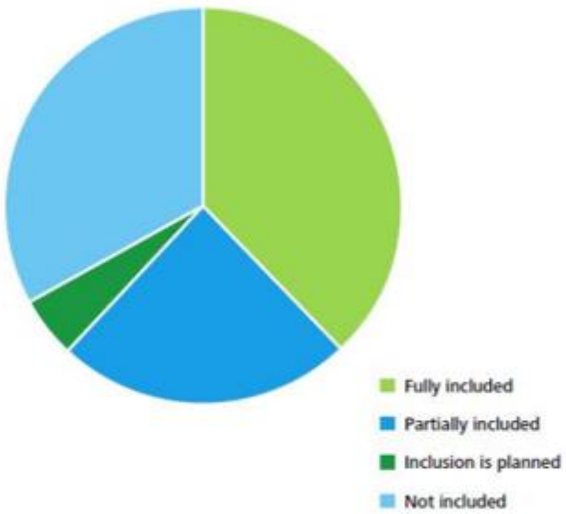


Figure 2: Inclusion of DVA in pricing

Source: Deloitte / Solum CVA survey (2013)

2.4.2 DVA and own-debt

In the years after the financial crisis, the "own credit risk" of banks went through periods of extraordinary volatility, with banks noting great fluctuations in their accounting results due to fluctuations in their credit spreads. This caused banks to question the significance of DVA. When using DVA, Gregory (2015:331) states that it is accepted that the fair value of the party's bond is calculated by using the price that the counterparties are willing to pay for the bonds. When a party wants to buy back their own bonds, it is questionable whether they would be able to do so without having to pay substantial funding costs. DVA is mostly viewed as a strange accounting effect, and equity analysts tend to remove DVA when assessing a company's performance.

2.4.3 DVA in derivatives

DVA in derivatives include difficult hedging arguments. For this reason, institutions have considered DVA in derivatives more than they have considered it in relation to own debt. Allen (2013:521) states that a firm cannot find any advantage in its own defaults, and that by including DVA in its calculations, it creates a one-sided picture. One of the main limitations associated with DVA is that it cannot easily be hedged against since it would result in Wrong Way Risk (WWR). WWR occurs when underlying market risk factors and the credit quality of the counterparty are unfavourably correlated, which may intensify exposure (Noh, 2013:347).

2.5 FVA (FUNDING VALUE ADJUSTMENT)

Traders need cash to be able to perform certain operations when managing a trading position. The cash needed can be attained from within the company or from the money market. Recently, banks have been pricing all the components of a trade, making it a necessity for them to understand trade profitability. These components include the CVA, the model value using the suitable discounting curve, the Cost of Regulatory Capital (CRC) and lastly the Funding Valuation Adjustment (FVA). FVA exists due to business operations and can be defined as the funding cost arising from borrowing or lending the shortfall in cash (Understanding FVA: A Risk Management approach, 2014). The occurrence of FVA is mainly due to the recent financial crisis. Financial institutions attained funding for posting collateral through a selection of low cost funding options, and as a result of this, they neglected collateral and funding costs. This approach can lead to arbitrage opportunities, which cause the theorists, i.e. Hull and White, to contest this approach (Gregory, 2015:339).

They insist that the FVA should not be included when pricing a derivative. They also argue that FVA accounting suffers from coherence problems, due to double counting between FVA and DVA. Funding cost is not always fully captured in the ideal assumptions of the bilateral CVA calculations. Some of the main reasons for the many conclusions are that FVA is not defined clearly and that, when calculating FVA, all of the relevant factors may not be taken into account.

2.5.1 Rationale underlying FVA

FVA is mostly considered for uncollateralised transactions, but in certain circumstances it can also be a component of collateralised transactions. The conclusions concerning FVA have not yet converged. The CVA's liability side can be seen as the price of funding (Ruiz, 2015:225). Under ideal circumstances, the CDS spread of institutions will be equal to their funding spread. The funding spread, which is given as the sum of the credit spread and the liquidity premium, is the spread over the risk-free rate at which an institution can borrow unreserved cash. This may cause confusion between CVA and FVA.

2.5.2 Valuation of FVA

The liability side of CVA can also be seen as the cost of guaranteeing that the institution does not default. This is seen as the valuation of FVA. Institutions that do not want to default can borrow an amount equal to their expected future cash liabilities and pay interest on this loan. The institution then reserves the money and this is referred to as the funding cost. Ruiz (2015:225) states that, under ideal circumstances, this cost will be the same as the amount it will cost the counterparty to hedge the credit risks it faces by entering into a transaction with the institution. This relates the liability side of CVA to the funding cost of the contract that is being priced.

When markets close at the end of the day, the price that is assigned to a stock is the price that the larger market of buyers and sellers decided it would be. This is the MTM. After the expected MTM over the lifetime of the portfolio has been considered, the FVA can be calculated. According to Gregory (2015:341), this is now the expected future value (EFV). The calculation of FVA involves integration over the EFV profile through time, taking into account the cost of funding at each point in time.

2.5.3 The FVA formula

$$FVA = -\sum EFV(t_i)\times FS(t_i)\times S(t_i)$$

$FS(t_i)$ - the Forward Funding Spread for the time t_i

$EFV(t_i)$ - the Expected Future Value, and this should be discounted

$S(t_i)$ - represents a survival probability for either or both of the two parties concerned.

The formula includes the cost of funding at each point in time. Internally, a bank's treasury quotes a funding spread for different maturities, which can be seen as a theoretical approximation of an additional margin on the reference rate for certain maturities.

This margin is the funding spread. The counterparty's survival probability can be used as the discounting factor. Gregory (2015:339) states that in a company's financial statements, FVA is usually reported together with CVA and DVA components. The funding risk of an institution is linked to its cash flows. An outflow of cash needs funding, while a cash inflow can either reduce these funding needs or be lent out.

2.5.4 Components of FVA

2.5.4.1 CollVA (Collateral Value Adjustment): FVA from Collateral Asymmetry:

After a derivatives dealer has entered into a OTC derivative contract with a counterparty, it will hedge the contract so that the profits and losses cancel each other out. This puts the dealer in a market-risk neutral position, allowing it to make a profit on an additional spread over the cost of the hedges. In other words, the derivatives dealer is synthetically reconstructing the contract with vanilla products. This is done on an exchange (Ruiz, 2015:225). As compensation for synthetically constructing the derivative, the dealer charges a fee. Here, the OTC derivative will not be fully collateralised. Figure 3 illustrates funding risk for an uncollateralised netting set and Figure 4 illustrates the situation where collateral CSA is agreed with the counterparty.

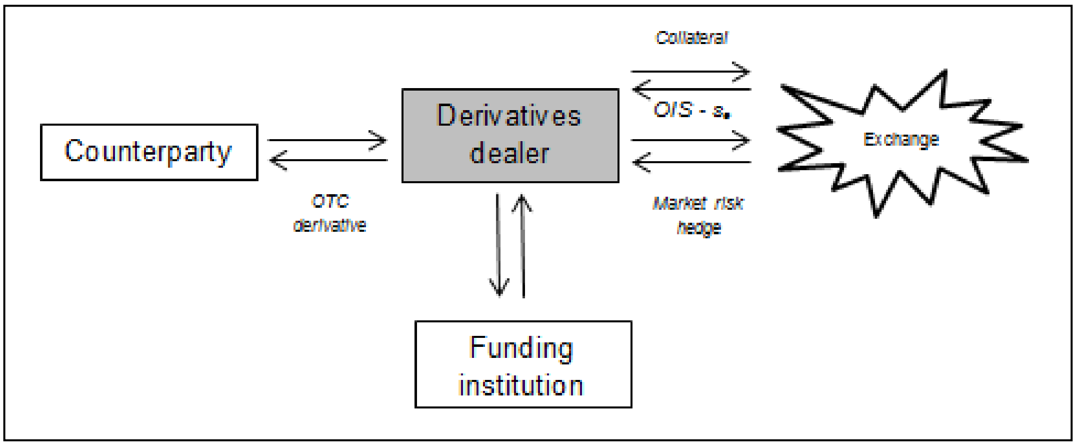


Figure 3: Illustration of the source of funding cost for an uncollateralised OTC derivative

Source: Ruiz, 2015:226

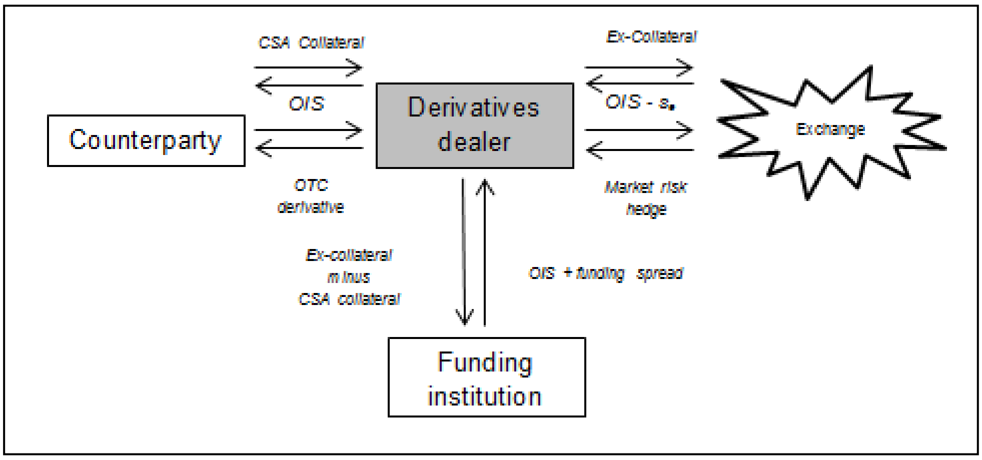


Figure 4: Illustration of the source of funding cost for a collateralised OTC derivative

Source: Ruiz, 2015:226

When collateral has to be posted to the exchange, the dealer will have to borrow this amount from a funding institution. Table 1 shows the dealer's payoff in this situation:

Receive	Risk-free rate (OIS) – a spread (s_e) for the collateral posted
Pay	OIS + dealer's own funding spread
Result	Exchange spread on the collateral borrowed – its own funding spread

Table 1: Dealer's payoff when collateral has to be posted to the exchange

2.5.4.1.1 The CollVA formula

Following the principles applied in the derivation of CVA, the Collateral Cost Adjustment ($CollCA$) and Collateral Benefit Adjustment ($CollBA$) are given by:

$$CollCA_0 = \int_0^T EPE_t^{collateral} \times DF_t^* \times (s_t^{borrow} + s_t^{post})\, dt$$

$$CollBA_0 = \int_0^T ENE_t^{collateral} \times DF_t^* \times s_t^{lend}\, dt$$

s_t^{borrow} - spread over the risk free rate at which a dealer can borrow unsecured cash

s_t^{lend} - spread over the risk free rate at which a dealer can lend unsecured cash

s_t^{post} - spread over the risk-free rate that dealers are charged on collateral posted

$EPE_t^{collateral}$ - expected positive exposure of the net collateral needs

$ENE_t^{collateral}$ - expected negative exposure of the net collateral needs

DF_t^* - discounting factor

The collateral requirements consist of an Initial Margin and a Variation Margin. These agreements also depend on Credit Support Annex (CSA) agreements and the margining requirements of clearing houses. In this situation,

$$CollVA = CollCA + CollBA$$

2.5.4.2 HVA (Hedging Value Adjustment): FVA from Derivative Cash flows:

The second source of funding risk comes from the perfect assumptions of the Black-Scholes model, which assumes that borrowing and lending can be done at the risk-free rate. Nevertheless, all the cash flows with regards to a derivative must first be funded at the risk-free rate before they can be used in netting agreements with counterparties. Unfortunately, risk-neutral valuation does not foresee any of these situations, and therefore this source of funding risk arises due to a perfect hedge not existing. This results in the Hedging Value Adjustment (HVA), which takes place regardless of any collateral arrangements (Ruiz, 2015:226). In an ideal world, when a trade with a counterparty takes place, an identical but opposite trade also takes place, allowing the overall position to be market neutral. However, in reality this is not the case.

Consider, for example, a 10-year swap with annual payments that could be hedged with a 10-year swap with monthly payments. A mismatch in the cash flows will occur and so an additional funding cost or benefit is incurred. This is where HVA comes in. Most financial institutions do not consider HVA, because it is usually very small. Ruiz (2015) gives two examples that contradict this statement:

1. A derivative, where it is promised to deliver power (physical or cash-equivalent compensation) over a specific time span and between specific hours of the day, is called a power derivative. If these specific regulations were, for example, Sunday to Thursday and between 1 am and 6 am, it is obvious that this cannot be perfectly hedged in the market. A trading desk may try to hedge against standard Base and Peak power contracts. These contracts deliver power for either 12 or 24 hours per day and therefore, the cash flow positions in the hedge are different.

2. When looking at the banking industry, HVA could be crucial in a highly exotic book of trades. This happens as the delta hedging position attempts to match the P&L changes, while actual cash flows could be mismatched.

2.5.4.2.1 Valuation of HVA and its formula

According to Kjolhede and Bech (2016:60), HVA depends on the expected cash flow exposure before margining occurs. It is clear that HVA could arise from a mismatch that ensures either a funding cost or a funding benefit.

Assume that in the previous example of a 10-year swap with annual payments hedged with a 10-year swap with monthly payments, $(x_t + h_t)d_t$ represents the cash flows. If x_t represents the perfect hedge's cash flows, then the extra h_t will need to be borrowed or lent out. For this reason, two new adjustments follow, namely, Hedging Cost Adjustment (HCA) and Hedging Benefit Adjustment (HBA) (Ruiz, 2015:372).

Therefore,

$$HVA = HCA + HBA$$

Where,

HCA – funding cost of the mismatch.

HBA – funding benefit of the mismatch.

The following approximations are used:

$$HCA_0 = \int_0^T EPE_t^h \times DF_t^* \times s_t^{borrow} dt$$

$$HBA_0 = \int_0^T ENE_t^h \times DF_t^* \times s_t^{lend} dt$$

Where,

EPE_t^h - expected positive exposure of extra hedging cash needed.

ENE_t^h - expected negative exposure of extra hedging cash needed.

DF_t^* - discounting factor

This means if at any time the uncollateralised net exposure of the hedge is positive it will contribute to EPE_t^h and if it were negative, it will contribute to ENE_t^h. It is important to note that HVA includes the net present value of funding costs or funding benefits from cash flow mismatches throughout the lifespan of a derivative contract.

2.5.4.3 LVA (Liquidity Value Adjustment): FVA from the Credit Liquidity Premium:

Liquidity Value Adjustment is the liquidity premium that the company's real debt products have over the CDSs. This is a present value adjustment due to the cost of carry of collateral on a collateralised transaction. If the collateral rate and the cost of funding do not equal each other, cost of carry arises. This means that the cost to ensure a party against the company's own default is different from the company's cost to survive.

The LVA term demonstrates the fact bond markets and liquidity environments have different liquidity settings. LVA is the adjustment made to the risk-neutral value of a portfolio of trades to take into account the real liquidity constraints that the institution faces in the funding and credit market (Ruiz, 2015:227). LVA is an indication of the difference between the counterparty's and the institution's cost of hedging out a certain risk. Hence, it represents the profit or loss formed by the liquidation of the Net Present Value (NPV) of the derivative contract due to the collateralisation agreement. If γ is the collateralisation percentage, where γ=0 corresponds to a non-collateralised contract and γ=100% corresponds to a fully collateralised contract, the formula for calculating LVA is

$$LVA = -(1 - e^{-\gamma(r_c - r)T})$$

where r_c is the collateral rate and r is the risk-free rate.

The three sources of funding risk, i.e. LVA, CollVA and HVA, can all be combined into a single equation:

$$FVA = CollVA + LVA + HVA$$

2.6 MVA (MARGINAL VALUE ADJUSTMENT)

Two extremely important features of regulatory rebuild after the global financial crisis relate to the initial margin (IM) and regulatory capital. In this section, initial margin and adjustments thereof will be discussed. In the next section, the focus will be on regulatory capital with regards to Capital Value Adjustment (KVA). According to the Financial Dictionary by Farlex, initial margin is the securities that an investor holds in a margin account to be able to borrow from a brokerage. It enables investors to make use of leverage and purchase more securities than their cash balance allows. Marginal Value Adjustment (MVA) quantifies the cost of posting IM.

MVA also quantifies the cost associated with any other over-collateralisation. An example of over-collateralisation is the requirement for liquidity buffers. Further, according to Kjolhede and Bech (2016:2), MVA covers the costs of funding the initial margin that can be posted alongside ordinary collateral. FVA, which was the topic of the previous chapter, deals with under collateralisation. This happens when the unsecured MTM of a derivative lead to a funding cost or a funding benefit. Although sometimes explained in the concept of collateral posting, FVA is not really driven by collateral posting. Rather, FVA mainly arises due to incomplete variation margin posting. Therefore, it is important to handle FVA and MVA exclusively.

2.6.1 Rational underlying MVA

According to Gregory (2015:360), MVA is made up of the following three factors:

1. *IM together with other funds required by a Central Counterparty (CCP):* When a clearing participant defaults, the CCPs desire IM to provide for a worst-case scenario if needed. Other financial commitments, such as rights of assessment and default fund contributions, are also required. These commitments become expensive, because third parties or CCPs hold IMs and default funds are thus not compensated above the risk-free rate. Therefore, it seems rational that the cost of default contribution should be included within MVA.

2. *Bilateral IM:* Bilateral derivatives require both parties to post IM. This IM cannot be hypothecated; meaning that the assets held by one client cannot be used as collateral in a transaction with another client. This IM needs to be segregated, resulting in high costs.

3. *Unforeseen IM:* Within some situations, IM posting is required through collateral agreements. This usually happens because of a downgrade in rating. The liquidity coverage ratio intends to guarantee that a bank maintains sufficient agile, high quality, liquid assets in order to meet all of its net outflows during a stress-period of 30-days. Regulatory rules force banks to hold a liquidity buffer to make provision for these outflows. These outflows need to be prefunded. It could be favourable for banks to post a reduced IM in order to remove these rating-based triggers. Seeing that IM are held in high-quality assets, this is possible.

Note that all of the abovementioned factors require the posting of high-quality IM. Therefore, these requirements are costly. A larger return could be achieved if the IM where allowed to be hypothecated, but this would then lead to added counterparty risk through CVA.

2.6.2 Valuation of MVA

The valuation of MVA requires pricing the cost over the life of the transactions that holds IM (Gregory, 2015:361). The valuation may include contingent or non-contingent components and the amount may be deterministic or uncertain, in which case it is based on a quantitative model. Most requirements for IM with regards to OTC derivatives use VaR (Value at Risk) and expected shortfall (ES). It has become common to include stress periods in the calculation to overcome this problem of an uncertain amount, because, if low volatility is repeated over periods it may result in very low IMs. Typically, historical simulation together with a VaR or ES at the 99% confidence level over a period of five or ten business days is used. Either bilateral markets or centrally cleared markets are used.

Bilateral markets recommend IM to use a ten-day period based on a 99% confidence interval. It also recommends calibration with a period that includes financial stress. Centrally cleared markets use historical simulation, where IM is the average of the six poorest moves over the selected period. The simulation is calculated over a five-day period and then calibrated to a ten-year period. It uses expected shortfall at the 99.76% confidence interval.

According to (Gregory, 2015:362), because IM requirements depend on the amount of factors used, it can be expanded in many different ways:

1. Excluding new transactions, changes may occur in the portfolio structure as transactions evolve.

2. When extreme events enter or leave the dataset being used, repeated changes in the lookback period may occur.

3. Finally, there may also be changes in the methodology, including the underlying assumptions, changes in stress periods and recalibration of the parameters.

If initial margin is posted when segregated, it requires funding of the entire margin and therefore cannot be kept from the pricing of derivatives. Thus the present value of these costs form the margin value adjustment (Kjolhede & Bech, 2016:52).

2.6.3 The MVA formula

$$MVA = -\sum_{i=1}^{m} EIM(t_i) \times (FC(t_i) - s_{IM}) \times (t_i - t_{i-1}) \times S(t_i)$$

With,

$EIM(t_i)$ – discounted expected IM

$FC(t_i)$ – funding cost of posting IM

s_{IM} – remuneration of the funding cost

$S(t_i)$ – joint survival probability (probability that not one of the parties default)

IM may be remunerated at a rate that is below OIS, the Overnight Indexed Swap, in which case the $FC(t_i) - s_{IM}$ term will be higher. This is particularly apparent on CCPs. As previously stated, IM can also bring forth a cost. This occurs due to the segregation of IM. Such a situation would require calculating the $EIM(t_i)$ on the reverse portfolio. Traditionally, Monte Carlo simulation is required, but with IM calculations at every point, the MVA as an integral over the $EIM(t_i)$ profile will result in calculation difficulties. These problems can be overcome by relying on traditional VaR simplifications and by using approximations such as gamma and delta.

Gregory (2015:365) also stated that it is important to understand that the IM used in the MVA formula above, can be calculated in two different manners. Firstly, for a bilateral counterparty the IM needs to be calculated over four asset classes. These assets classes are currency, equity, credit and commodities. Secondly, for CCPs, IMs are netted across transactions of the same asset class. Therefore, for all CCP netted transactions, a total IM will be required.

Finally, the capital charges of IMs and default fund contributions need to be incorporated independently and assessed in a more accurate manner. These charges will be examined through KVA.

2.7 KVA (CAPITAL VALUE ADJUSTMENT)

With the arrival of Basel III, capital requirements regarding counterparty risk are more disciplinary. In the past, capital had been priced completely into derivative transactions by the use of hurdle rates. A hurdle rate is the minimum required rate of return on an investment. Nowadays, regulatory capital is priced using KVA. This is due to the rising importance of capital requirements (Gregory, 2015:367).

KVA intends to estimate the cost of holding regulatory capital over the life span of the transactions involved. KVA is a very complex adjustment, as capital can take on several forms. Further, according to Sherif (2015), KVA measures the total expected capital requirements of a contract and not just the current capital requirements.

2.7.1 Rationale underlying KVA

Historically, banks set limits on the use of capital or they required specific hurdles to be met during transactions. There are two major problems with these actions. Firstly, capital-intensive transactions are discouraged and secondly, the costs associated with holding regulatory capital are not priced correctly.

Investors require return on their investments and therefore capital is a cost. There is an analogy with FVA and KVA, because capital costs may be identified as funding. Through Basel III, the leverage ratio requirement and the increased cost of raising new capital, the importance of estimating capital in the right manner has become crucial.

Gregory (2015:367) believes capital requirements can take on the following forms:

1. *Default risk capital charge:* Capitalisation takes place for the likeliness of a counterparty defaulting. However, this is usually a very small amount and may be ignored.

2. *CVA capital charge:* MTM volatility arises when credit spread movements drive changes in CVA, when an actual default event is not present. CVA capital charge tries to capitalise this volatility.

3. *Market risk capital charge:* CVA related hedges could cause additional capital charge in a market risk capital framework.

2.7.2 Valuation of KVA

According to Kjolhede & Bech (2016:54), the valuation of KVA is the most subjective of all the other xVAs, because estimating future regulatory capital requirements is severely difficult. The valuation of KVA involves generating different capital profiles for each of the respective methods used.

An uncollateralised at-the-market seven-year maturity interest rate swap can be used. With this swap, a single counterparty holding a 200 basis points (bps) credit spread and a 0.2% default probability, is assumed. Gregory (2015:368) suggests the three historical methods used to calculate exposure to default are the Current Exposure Method (CEM), the Internal Model Method (IMM) and the Standardised Approach for Counterparty Credit Risk (SA-CCR). The result of running the capital evaluation over time, will be looked at by using forward rates. These types of profiles are not hard to compute, however, they do not consider future capital requirements. As market factors move, capital requirements can be very volatile over time. It is extremely important to know the intended variability of the capital over time. This can be computed by using the standard exposure simulation and then calculating the new capital requirements at different future time points. The CEM and SA-CCR approaches involve simple calculations. However, for the IMM, simulating future capital requirements are extremely complex, since the approach is mainly based on Monte Carlo simulation. The following graph illustrates the progression of counterparty risk capital charge over time when using the methods mentioned above. It shows the projected values.

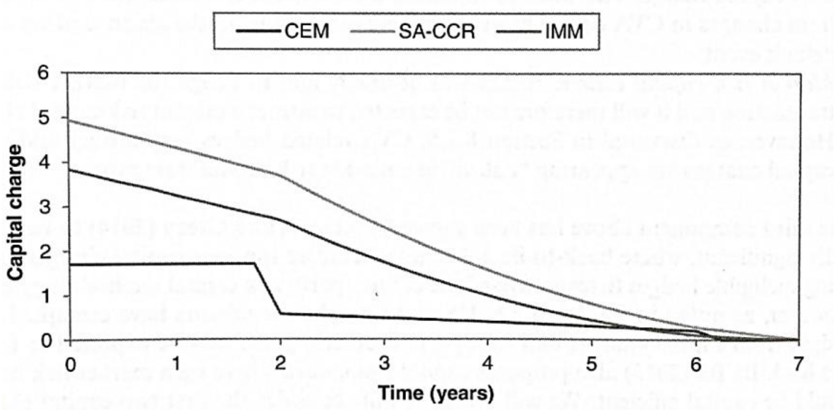


Figure 5: Illustration of the total projected counterparty risk capital for a seven-year interest rate swap

Source: Gregory, 2015:368

Under the CEM approach, exposure depends on positive MTM values and therefore the negative MTM values will not result in an offset. The capital requirement under the CEM can therefore not be any smaller. Further, it entails the expected capital to be much larger than the projected capital. Under the SA-CCR and IMM approaches, risk-reducing benefits of negative MTM's are recognised, and therefore their graphs are more symmetrical around the projected values. Finally, all of the preceding methods show a large inconsistency in the future capital requirements, leading to the need for a capital requirement in order to hedge counterparty risk.

2.7.3 The KVA formula

$$KVA = -\sum_{i=1}^{m} EC(t_i) \times CC(t_i) \times (t_i - t_{i-1}) \times S(t_i)$$

With,

$EC(t_i)$ – discounted expected capital profile.

$CC(t_i)$ – cost of capital.

$S(t_i)$ – joint survival probability.

$EC(t_i)$, which is the discounted expected capital profile is usually discounted using cost of capital. It depends on the bank's own dividend approach or on the Capital Asset Pricing Model (CAPM). The above formula should be calculated for the entire portfolio of the bank. The influence of the capital reducing hedges should also be contained within the $EC(t_i)$ figure. The $EC(t_i)$ figure will be defined by either CEM, SA-CCR or IMM.

2.7.4 Behavioural aspects

The hedging and reporting of CVA and FVA takes place within financial statements. Therefore, risk-neutral calibrations are applicable to them. KVA, however, is not usually charged using desks or reflected in the accounting statements. Therefore, the question on whether or not to use risk-neutral parameters to price KVA arises. It is important to consider the following issues regarding the capital costs of a transaction (Gregory, 2015:372):

1. *Regulatory capital approach:* A few banks are using the CEM, but most banks will have to prepare for using SA-CCR or IMM in the future.

2. *Regulatory changes:* In the regulatory view, there are many definite unknowns, but there are also further uncertainties. For example, The US considers a scale of 4%-6% for the leverage ratio while Europe uses a 3% leverage ratio. The agreed number will only be finalised in 2017.

3. *Exemptions:* Whether the existence of exemptions will have a powerful impact on prices and the true amount of capital is unknown.

4. *Capital assistance with hedges:* Index hedges can give partial capital relief, but the duration of the relief relies on the future behaviour of market variables.

As KVA is not typically hedged like CVA and FVA, the above assumptions and the actual real-world capital requirements are applicable. Furthermore, the calculation of KVA should be done using real-world parameters instead of risk-neutral parameters. Generally, KVA is not transfer-priced to an internal xVA desk and will therefore not be shown as a loss in the bank's book. Further, it is important to note that KVA is not treated as reserve capital, but that it contributes to economic capital, because it is treated as retained earnings (Albanese. et al, 2016)

2.7.5 KVA overlapping and reporting

Just as overlapping problems arise between DVA and FVA, KVA also leads to problems regarding overlapping with CVA. Theoretically, the cost associated with hedging counterparty risk is presented through CVA when using risk-neutral default probabilities. Further, CVA cannot be hedged perfectly so that KVA reflects the capital held. Adjustments can be made by banks to correct the problem of double counting, by charging the maximum between the two extremes that can occur concerning other components:

$$\max(CVA, EL + KVA)$$

According to Gregory (2015:374), KVA cost and an expected loss (EL) might occur due to the aggregation of counterparty risk. This is represented in the second term. Unfortunately, an xVA desk usually operates under a structure containing limits and can therefore not aggregate credit risk.

When charging the first term, the CVA will be lost at the xVA desk and therefore resulting in a zero expected return on capital. In comparison, if the second term where to be charged, no cash would be available for CVA hedging. Charging the standard CVA and only a portion of the capital charge, arising from hedging, would be a superior alternative. This cost should be revealed in the KVA formula, as previously discussed. The capital costs represented through KVA have similarities to the funding cost represented through FVA. These similarities lead to the following benefits (Gregory, 2015:275):

1. *Return on capital:* Required return on capital will be generated if KVA is taken as an accounting item. This occurs because profits are allowed to be discharged over the lifetime of the transaction under consideration.

2. *Incentives:* The right incentive can be created for front-office staff if KVA is again taken as an accounting item, because only then are profits allowed to be postponed and discharged over the lifetime of the transaction.

3. *Management:* Without transfer pricing KVA to a central xVA desk and managing it accordingly, a bank might experience rather volatile capital.

Compared to the FVA reported values, the once-off adjustment that is required to achieve the above-mentioned points will be very large. It is therefore difficult to see how a bank would make such a change, especially because most competitors are not yet applying this change. Furthermore, before considering using KVA within financial statements, the ongoing controversy of whether or not FVA should be used as an accounting adjustment should be resolved.

2.8 CONCLUSION

In this chapter a brief history and explanation regarding regulatory frameworks was given and each xVA term was theoretically defined. This serves as a basis for the subsequent chapters. In Chapter 3, a few mechanics behind the pricing of the xVA terms will be defined. A more in depth look of the practical implementation of the different xVAs will be performed in Chapter 4 and the opinions of auditing firms and banks will also be inspected. The final chapter is a summary of the research and states open questions on the topic of including xVAs when pricing derivatives.

CHAPTER 3 MECHANICS BEHIND XVA PRICING

3.1 INTRODUCTION

In order to implement xVAs within financial structures, many mechanics and optimal management techniques are required. In this chapter, a selection of these mechanics will be discussed. These include the setup of xVA desks, the implementation of xVA and the building of the technological structure required for the implementation. It concludes with a brief look at the components within the market and their place in the future. Chapter 4 entails the practical implementation of xVA. Within Chapter 5, a concise comparison and conclusion concerning the relevance of each xVA will be given.

3.2 XVA DESKS

The financial crisis of 2008 clearly showed that the Black Scholes risk neutral model has weak points. This problem led to the setup of xVA desks, which offers an optimal framework for the risk associated with derivatives. According to Ruiz (2015:274), xVA has changed the way in which risk is understood and has shaped a whole new world in which risk management and business development can work together.

3.2.1 Improving on Black Scholes

Hull (2012:307), explains the Black Scholes model as involving the setup of a riskless portfolio. The portfolio consists of a position in a derivative and a position in a stock. He states that when there are no arbitrage opportunities, the return on this portfolio should be equal to the risk-free rate.

A summary of the assumptions under the Black Scholes model is presented below:

1. A risk-free rate is used

2. Infinite liquidity of cash and assets

3. Frictionless markets

4. No arbitrage opportunities

5. Market prices follow geometric Brownian motion

When looking at the markets today, these assumptions are clearly an oversimplification of reality. Firstly, a derivative does not have one unique price, because the real price of a derivative depends on many factors, which are often arbitrary.

Different prices can be offered to different clients depending on factors such as the relationship between the client and the dealer, hedging and future strategies and- operational arrangements (Ruiz, 2015:275). It is clear that the above factors may lead to arbitrage opportunities, which will lead to the need for cash. Unfortunately, this cash is limited which again differs from Black Sholes assumptions. In addition, in the market, a non-risk-free cost will be charged.

Finally, as a result of the abovementioned limitations, adjustments need to be made to the Black Scholes pricing formula. The xVA framework and xVA desks will repair the detachment from reality of the risk neutral world.

3.2.2 Optimal xVA management

Kenyon and Green (2014) believe that banks should not only value their trading books, but also manage them. Management includes three sections, namely, pricing, hedging and allocation. Within the pricing section, different valuation adjustments are found. The hedging section requires evaluation of first-order sensitivities, which include delta and vega. Second-order sensitivities, such as gamma, can also be evaluated within the hedging section. Finally, the pricing costs and hedging costs are allocated to the xVA desks.

Through different xVA desks, different risks associated with the pricing of derivatives will be managed. The CVA desk will handle credit related P&L, the FVA desk handles funding related P&L, the KVA desk manages capital related P&L and the MVA desk will handle initial margin related P&L. In the end, the trading desks consider only the total xVA charge, which is the sum of all the different xVAs. Therefore, it seems rational to have only one xVA desk that can centralise all xVA related risk management and internal communication matters. Using this setup, whenever a new trading activity arises, the dealing desk will communicate with the xVA desk in order to determine the amount of the xVA charge. This single number will then be incorporated into the pricing of the trade to decide what the execution strategy will be.

If the trading activity is executed, the risk will be handled accordingly. Risk allocation will be distributed into the credit, funding, capital and margin sub-desks. Generally, according to Ruiz (2015:285), the following mandates can form part of an xVA desk:

1. *An Insurance Model:* The xVA charge is collected by the xVA desk and put aside as a risk backup for future losses. The hedging of risks is not included in this model and the balance sheet contains the full xVA P&L volatility.

2. *A Full Hedger:* The xVA desks strive to reach a flat zero P&L after every quarter and the desk is seen as a cost and volatility reduction desk. However, it is important that senior management interpret large P&L fluctuations accurately, because a massive profit in one quarter might be a fortuitous profit and not as a result of xVA being well-managed.

3. *A Profit Centre:* Credit and funding risk are handled in order to make profit from them. This desk runs like any other dealing desk, except that its clients are only internal.

All OTC deals are sent through the xVA desk. Therefore, the xVA desk has a very large responsibility and superior view of the organisation as a whole. It serves as the centre point of all deals. For these reasons, the xVA desk is perfectly positioned to manage a number of very important functions (Ruiz, 2015:286):

1. It can handle CSA collateral agreements and evaluate the influence of these arrangements.

2. The overall position of the firm can be shaped, because the desk sees all the different risks.

3. Economic and regulatory capital needs can be minimised because the desk faces capital computation at the front end of the business.

It is clear that accurate xVA calculations enlarge the competitive edge presented by a trading house. Unfortunately, accurate calculations will not be sufficient for the profitability and sustainability of a firm. The speed at which the calculation takes place is also very important. Because xVA calculations can become very complex, xVA desks can easily transform into an institution’s biggest technology burden.

Therefore, intelligent investment in efficient systems and methodology is crucial. Further, senior management should not underestimate their role in the xVA challenge, since interconnections are an important aspect of the xVA desk.

3.3 IMPLEMENTING XVA

A typical xVA calculation involves a number of computational requirements and therefore the implementation of xVA requires important computational and modelling decisions. The implementation of xVA mainly revolves around hybrid models that use Monte Carlo techniques.

3.3.1 Monte Carlo and xVA

In general, xVA calculations are performed through Monte Carlo models, where chance and random outcomes are the central focus, together with a range of models used to price trades in each Monte Carlo state.

Green (2016:353) strongly feels that Monte Carlo models should be used for the following reasons:

1. The calculation of xVA has many dimensions. In the event of default, closeout netting can be used. Closeout netting is a major credit relief procedure that can be used by counterparties in order to net all bilateral transactions with each other, before closing out, when a default might occur.

   Netting sets may include almost any derivative transaction on any underlying asset and therefore xVA calculations can become very difficult. Monte Carlo techniques seem to be the best practical solution.

2. There is a notable lack of realistic alternatives. Partial Differential Equation (PDE) models have been developed, but they do not represent a practical technique and are not viable due to their high dimensionality.

It is important to note that xVA is still an integral over a number of European options and therefore a series of Monte Carlo simulations is needed. It does make sense to incorporate these steps into one multi-step Monte Carlo simulation.

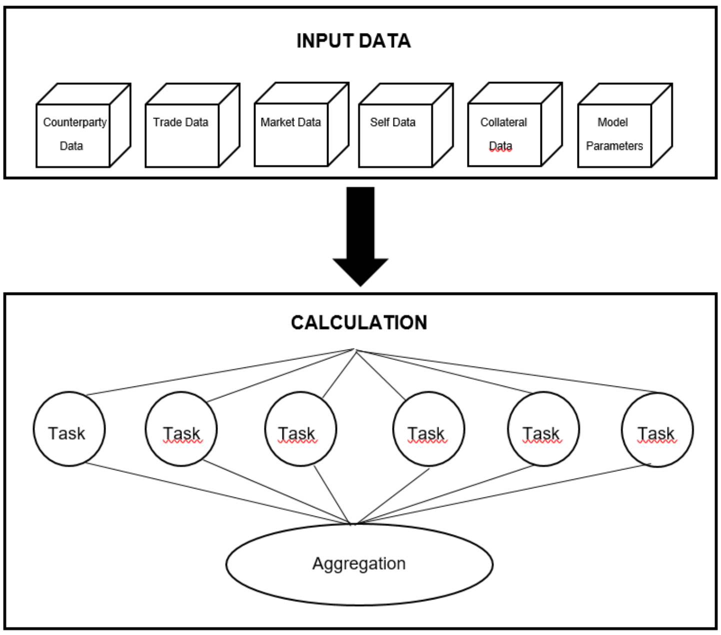
3.3.2 Hybrid-Modelling

The modelling of xVA is a far greater challenge than single asset class modelling, because it is a hybrid-modelling problem. This means, it runs across all asset classes. It is already extremely hard to develop a sophisticated single asset-class model. According to Rasmussen (2003:651), hybrid Monte Carlo modelling will not be successful without the use of a very large amount of model runs.

A refined hybrid Monte Carlo model would mean that multiple models would be combined, making the process extremely challenging. It is not a significant problem should a single trade undergo a model calibration failure. However, should an xVA model experience a model calibration failure, results could be detrimentally affected. A failure in xVA terms would mean that there would potentially be no results available for the whole portfolio.

3.4 BUILDING THE TECHNOLOGICAL INFRASTRUCTURE

Ultimately, the xVA model needs to be incorporated within the IT system of an organisation. For accounting purposes, a finance system will have to be implemented by entities that do not calculate xVA actively. Whenever new deals are made, xVA will have to be priced correctly. This requires incremental pricing capability. An explanation on how an xVA system can be constructed is given below in Figure 6. This xVA system will be able to accomplish batch processing and intraday trade pricing There are also a few groups of expertise, explained hereunder, who are needed to implement this system. The xVA system consists of three stages: input data, calculations and results. Green (2015:394) gives an in-depth description of these three stages.



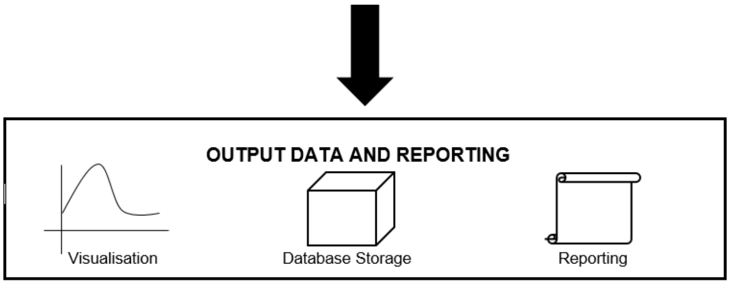


Figure 6: Illustration of the xVA logical system workflow

Source: Green, 2016:394

3.4.1 Input Data

In the financial markets, xVA's are some of the most data intensive calculations. The input data needed for xVA calculations consists of: counterparty data, trade data, market data, self-data, collateral data, and model parameters. This computation will only be as good as the quality of its input data and therefore it should be seen as a zero order risk.

3.4.2 Calculation

After the assembly and preparation of the input data, the next step will be the calculations. This phase consists of a few components:

1. *Calibration:* As a Monte Carlo model is used, some form of calibration will be needed. The different calibrations are dependent on one another and each asset class used in the simulation requires calibration. The interest rate calibrations are performed first because they are used in subsequent calibrations.

2. *Simulation and Valuation:* xVA calculations are difficult, because Monte Carlo simulation is used. A simplification is possible though, as the paths in the Monte Carlo simulation procedure are independent, making the trade valuations also independent. Therefore, the calculation would benefit from a large degree of parallelism.

3. *XVA Integrals:* XVA integrals will be calculated after the simulation has taken place and reductions, to obtain exposure profiles, are completed. An advantage of this component is that it is relatively inexpensive.

3.4.3 Reporting

The reporting of xVA values and sensitivities is the final step. Results will be reported at the counterparty level with risk aggregated over the entire portfolio. If an xVA business is divided within an organisation, it is important that the risk allocation will correctly report xVA risk to the xVA management functions. This will then allow the sub-businesses to hedge the xVA risk that is associated with their institution lines.

3.5 ROLES IN THE XVA SYSTEM

Implementing an xVA system within an institution is a moderately sized project. It will typically take one to two years to implement a full system. The following groups of people will be involved:

1. Accountable Executive and Steering Committee

2. Project Management

3. Business Analysis

4. Quantitative Analysts and Developers

5. Technology Development and Other IT Staff

6. Model Validation and Governance

3.6 THE MARKET IN THE FUTURE

Since the credit crisis of 2007, major changes have taken place in the banking and financial markets. According to Green (2015:465), the evolution of xVA has been part of these changes and is regarded as one of the biggest elements of market change, both now and in the future.

It is impossible to know exactly what the market will look like in the future, but possible future trajectories may incorporate some or all of the following changes:

1. *Products*: After the financial crisis, exotic derivatives have mainly vanished from the market.

   Vanilla products form the norm for derivative trading now and it seems unlikely that this will change, as the capital requirements and the risk of exotic derivatives make them uneconomic. If exotic derivatives do reappear, it is believed that they will be short-dated.

2. *CCP's, Clearing and MVA:* In 2009, the G20 leaders announced the introduction of mandatory clearing for standardised derivatives. Ever since, CCPs came forward in order to provide this clearing facility. Many derivatives can therefore be cleared but the period in doing so has definitely been slower than anticipated.

   Two questions arise. Firstly, given the shift towards clearing of standardised derivatives and because few non-standardised derivatives do trade, will all derivatives be cleared in due time? Second, could it be the end of CVA because of the large collateralisation associated with clearing? The answers were no.

   Corporate businesses will not be able to clear because they do not readily have access to eligible collateral and they do not have the operational capability to do so. Clearing is being used to replace bilateral relationships collateralised through CSAs. Therefore, the portion of CVA which counterparties, that are collateralised, have will determine the overall effect on CVA. In commercial banks, the impact of clearing on CVA might be very small, whereas for major international banks, CVA would decline substantially with clearing. This happens because large CVA reserves are associated with interbank counterparties and major corporates. CVA will never disappear because of clearing; it may just decline and be replaced by MVA.

   Collateral, margin and the costs related to them will be an increasing problem in the future. CCPs demand initial margin and so do bilateral relationships between financials. Since CCPs are becoming increasingly important, questions arise regarding consequences of one or more clearing members defaulting. Improved focus has also been placed on risk management standards regarding CCPs. Still, CCPs will definitely remain to play a major role in derivative markets in the future.

3. *Regulation, Capital and KVA:* A list of regulatory adjustments is under discussion and further changes will be made in the future. It is difficult to predict what their implications will be.

   A major concern within banks are regulatory capital and the management thereof, because it is such a scarce resource. Because resources are managed accurately, it is possible to de-risk the balance sheet and improve shareholders' returns. The importance of KVA arises as it provides ways in which banks can accurately calculate the return that shareholders make. KVA will motivate banks to use trades that perform well consistently, as opposed to trades that just perform well in their first year and fail to perform thereafter.

   A new discussion concerning the need of an accounting adjustment in respect of KVA is currently underway. This came forth because KVA forms part of the exit price. Presently, there are no firm conclusions.

3.7 CONCLUSION

The xVA framework has questioned the traditional way in which derivatives are priced. With the new framework, many mechanics are needed for implementation. Within this chapter, a few of these mechanics were discussed and future roles regarding market components were viewed. In the following chapter the practical implementation of the xVAs will be looked at and the final chapter will give a concise comparison and conclusion concerning the relevance of each xVA.

CHAPTER 4
PRACTICAL IMPLEMENTATION

4.1 INTRODUCTION

The revision to the fundamentals of fair value adjustment and pricing, through the gradual introduction of several valuation adjustments, is one of the more complicated changes that companies and banks face. These adjustments are having a genuine impact on earnings across the industry. The different methods of calculation of each xVA in practice will be discussed in the first subsection of this chapter. Secondly, the approaches in line with published guidance, by the four professional services firms in South Africa will be discussed. Finally, a short summary will be given on the implementation of xVA by banks in South Africa.

4.2 CVA IN PRACTICE

The events of the financial crisis lead to the increase in the importance of CVA trading. However, nowadays, those CVA desks are outdated. As seen previously, the CVA calculation has become very complex, due to the fact that it considers the MTM value of a derivative, which fluctuates through time. The MTM can fluctuate in either party's favour, and according to Pugachevsky (2011), this can lead to both counterparties being exposed to default risk. This calculation is further complicated by the fact that where the counterparty's default probability has previously been assumed to be constant, it may now also be correlated to other market risk factors. According to Dean Looney, head of the technology practice at NJF Search in London and a former CVA-specialist head-hunter, there had been a lot of hiring for positions at CVA desks in the recent past, but due to evolving markets, people who have been appointed in these CVA specialist positions are now struggling to find new jobs.

Most large banks, such as Barclays, have set up xVA desks to manage both valuation adjustments and regulatory capital, and to hedge CVA. Hedging CVA allows banks to lessen their default risk. Thu-Uyen Nguyen, a former Merrill Lynch derivatives trader, says that the extended definition of CVA considers all new accounting adjustments and also covers all issues with regards to derivative funding. Nguyen is of the opinion that even if banks have cut the amount of CVA traders at their desks, these traders have a broad skillset and will easily adapt to the new xVA desks.

4.3 DVA IN PRACTICE

Large financial institutions are more aware of the fact that they face CCR when entering into transactions with banks that have a risk of defaulting. This has led to counterparties charging unilateral CVA by taking DVA into account. Unilateral CVA is given by the risk-neutral expectation of the discounted loss. Paragraph 75 of Basel III specifies an adjustment that tries to neutralise the impacts of CCR on a bank's own credit risk. The process of isolating changes in the fair value of a bank's derivatives due to changes in its own creditworthiness, it involves several complications. These complications include the fact that DVA depends on the bank's own creditworthiness, the discounting rate used and other factors that affect expected exposure. This causes DVA to also be sensitive to changes in these factors (Bank for International Settlements, 2011:2).

Newly implemented regulations require the particular bank to calculate DVA according to IFRS 13. By hedging DVA, banks can reduce their earnings volatility. Due to corresponding losses incurred on their hedges, Goldman Sachs chose to not report a DVA gain. Even if Goldman were not able to sell protection on themselves, it was possible for them to sell protection on a basket that consisted of other big U.S. banks. These banks were highly correlated to Goldman Sachs, which is an effective hedging strategy. Banks can also hedge DVA by buying back negative MTM values, which is seen as loans that can be used by banks to buy back debt. The widening of a bank's credit spread can lead to the DVA gain on the derivative liability being offset by the loss on the bonds. According to Kelly, Pugachevsky (2011), this strategy makes DVA a more acceptable funding issue, clearing up any confusion that it has generally caused.

4.4 FVA IN PRACTICE

The inclusion of FVA by banks has been a controversial topic. By not considering FVA, the risky value only concerns the CVA and DVA and the price remains consistent. For banks that have beneficial funding costs, it would be an advantage to include FVA. On the other hand, for banks that are not in such a beneficial position, implementing FVA can wipe out their profits and could even cause them to default. Nowadays, banks assume that pricing and valuation are driven by CVA and FVA, while DVA is viewed as merely an accounting adjustment (Gregory, 2015:339). When a trade has a positive P&L and a high possible exposure, banks usually cannot ignore FVA. The pricing of FVA is done in such a way that it reflects the bank's own funding cost.

This has led to FVA being included in financial statements, even if it is not a condition of the accounting standards. Theoretically, FVA seems straightforward. The application of FVA is, however, more complex. The inclusion of funding costs can lead to a recursive pricing problem. Nevertheless, FVA is used to assign trading P&L and to lessen funding risk (Understanding FVA: A Risk Management approach, 2014). Inception pricing, accounting, hedging, if possible, and central management by the risk management team are critical strategies implemented by the firm.

4.5 MVA IN PRACTICE

Derivative practitioners are finding it very hard to achieve their end goal of profitability, because the xVA valuation framework evolves continuously. In March 2015, the Basel Committee and the International Organization of Securities Commissions (IOSCO) introduced a revision to the original margin requirements. These requirements were put in place for non-centrally cleared derivatives. The market is currently assessing future preparations, practical processes and reconsidering current practices (Kancharla, 2015).

Meanwhile, the Basel Committee and IOSCO also agreed to maintain a phase-in adjustment for exchange variation margins. This required adjustment was from December 2015 to September 2016. This move gives the OTC derivative market players more time to fully prepare (Kancharla, 2015). Once the bilateral margin requirements come into full play, it is argued that continuing to ignore MVA will be counter-intuitive and would have high cost consequences (Sherif, 2016). To uphold this statement, it is important to note that in the U.S. alone, the cost of funding margin is predicted by the Federal Reserve to be $2.5 billion (Sherif, 2016).

4.5.1 Calculating MVA

The problem of calculating MVA arises, because it is calculated as an expectation of initial margin and because it requires the use of Monte Carlo simulation. Most quantitative analysts dislike this approach, as it is time consuming and difficult. Sherif (2015), introduced a confining technique where the time that needed to complete portfolio revaluations is paired to each point in time significantly. Therefore, their technique reduces the time to evaluate MVA. Unfortunately, given the demanding requirements to calculate and price the adjustment, while also taking cognisance of other costs, it is argued that faster methods are still needed. Wujiang Lou, a director in global fixed income trading at HSBC in New York, proposed an approximation strategy.

He believes this technique will accelerate pricing through approximating initial margin requirements by means of delta sensitivity. This means using the change in the derivative's value relative to a change in the underlying value. This approximation can then be progressed into real margin payments. In Lou's method, the initial margin calculation and the derivative pricing techniques are kept separate.

A partial differential equation (PDE) is provided for the pricing part of the method, which speeds up the MVA pricing process. MVA is a relatively new concept, but a very important one nonetheless. If margin is evaluated, the effect of the evaluation should be included in the price, as with all the other xVA concepts. MVA fits perfectly into the xVA framework, because margin should not be accounted for unless MVA is also accounted for (Kancharla, 2015).

4.6 KVA IN PRACTICE

CVA and FVA are now widely recognised and calculated in major banks, and are accounted for in the financial reports, as well as in trading economics (Albanese & Andersen 2015). Capital is the amount of money that a financial institution has to put aside to protect itself from going bankrupt under stressed market conditions. KVA, or capital value adjustment, has emerged as being even a more difficult and seemingly more important topic than CVA and FVA (Sherif, 2015).

KVA has led international banks into a consensus regarding the need to recognise the impact that rising capital requirements have on their derivatives. Regulatory requirements regarding market risk, CVA, CCR and the leverage ratio for OTC derivative trades are present in most banks. The capital requirements of portfolios are usually very volatile, because most of these requirements are a function of the MTM value of the portfolio. Retrospectively, KVA should be equal to the capital held over the lifetime of the trade.

4.6.1 Accounting for KVA

Richard and Chris Kenyon (2016) explored the accounting view on KVA for derivatives and proposed an accounting treatment of the economic effects regarding KVA. The Risk magazine and EY provide direct evidence of KVA within the pricing of derivatives in two different surveys. In the first survey, ten respondents were used and nine of them stated they use KVA in derivative pricing. In the second survey, nine out of ten respondents said they noticed the existence of KVA in derivative pricing. For larger concerns, such as banks, accounting is regulated by international standards. IFRS, which is maintained by the IASB, is one of the main standards that is used.

The relevant standards for derivatives are IFRS 9, which relates to Financial Instruments, and IFRS 13 which relates to Fair Value Management. Through the use of modelling and under IFRS 9, KVA would be incorporated in the fair value of derivatives. The treatment of this cost is similar to the cost of processing in manufacturing. Traditionally, under accounting, crediting and debiting is used to describe the entries into accounts. A copy of the bank’s own account is received by the investor which reflects the opposite of what happens in the investor’s account. In other words, a debtor’s account will show an increase on the debit side.

4.6.2 Accounting Implications for KVA

Fair Value, that is defined under IFRS 13 and applied through IFRS 9, requires KVA to be included in accounts when pricing derivatives (Kenyon and Kenyon, 2016). In practice, KVA is treated as an increase to the value of a derivative and is considered to be a profit. This profit flows through the accounting system. The biggest issue regarding KVA is the actual present level thereof in a derivative. The effect of this level may be masked by other components, specifically when the initial fair value of the derivative is zero. Therefore, an internal hurdle rate might be useful so that it can be explicitly priced into the terms and conditions of the undergoing trade. Unfortunately, this internal hurdle does not work for historical trades where no explicit pricing took place. The actual built in level, applied currently, reflects the actual rate of return that can be expected by shareholders.

4.6.3 Challenges regarding pricing KVA

KVA pricing presents challenges for the following reasons:

1. It is becoming increasingly difficult to keep to all the diverse and lengthy regulations, especially those presented by Basel III.

2. Not only spot costs are needed. Lifetime capital costs, which is very hard to calculate, are also needed for the pricing of derivatives.

3. Calculations need to be done at different levels of granularity and thereafter they need to be combined.

4. The deadlines of new regulations are often uncertain, presenting challenges in terms of establishing compliance timeously.

To conclude, KVA is not a valuation adjustment in the sense of fair valuations. KVA is a characteristic profitability measurement of a firm, and is not meant to be combined with CVA, FVA and other valuation adjustments. It is arguably better termed “capital return measurement” as opposed to “capital valuation adjustment”.

4.7 PROFESSIONAL SERVICE FIRMS, BANKS AND XVA

4.7.1 ERNST & YOUNG (EY)

Since IFRS does not specify a valuation technique, there are quite a few that are applied in practice. EY (2014:5) considers a few approaches, of which they consider the EFE approach to be the most appropriate. This approach is the most fundamentally sound method for calculating CVA. This method simulates the market variables that drive a derivative’s fair value. These simulations are done by using different market scenarios, with each simulation giving a different value of the derivative. This is repeated many times after which EPE and ENE can be calculated.

The CVA and DVA is determined by using these exposure profiles and applying both party’s PD. While the EFE approach may be considered the most theoretically pure approach, it is quantitatively very demanding (EY, 2014:13). According to Shankar Mukherjee, a director at EY, the developing regulatory requirements and changing accounting standards force banks to continually improve their methodologies and operating processes with regards to the xVAs for derivatives. He continues by stating that the issues banks face when validating the valuations relate to the observability of inputs and secondary market prices for OTC derivatives. This can be particularly hard for valuation adjustments such as FVA, which are not yet widely reported. Given the capital and liquidity constraints banks face, they need to measure the returns on institutions they interact with, in order to determine which of them are producing the appropriate returns on the financial resources that banks need to support them.

EY UK hosted an IFRS banking conference on 1 July 2016, where they discussed the ongoing challenges arising from the changes to accounting and regulatory rules that affect the banking industry. At the conference, Rhys Taylor presented on some of the emerging xVA topics. According to Taylor, banks are increasingly pricing the funding cost of the initial margin into derivative valuations. Although market approaches are not all the same, initial margin funding costs are consistent with those used in FVA. The deferral of regulatory changes in Europe can possibly lead to MVAs being a fair value consideration for the majority of banks in 2017.

He continued by saying that KVA has not been a widely discussed topic in 2016, partly reflecting that the speed of exit by banks of capital-incentive trades has yet to become significant. The application of KVA is not applied consistently by all market participants, mostly due to differing regulatory regimes, measurement techniques and the degrees of sophistication in modelling technology. It appears more likely that KVA will form part of a prudent value before it becomes part of a fair value.

4.7.2 KPMG

According to KPMG International Standards Group (2012:15), the most common approach to value plain vanilla OTC interest rate swaps is to use discounted cash flow models. The present value of the discounted cash flow models can be adjusted by factors such as counterparty and own credit risk. KPMG emphasises the importance of valuation on a portfolio level. They do not elaborate much on the details of the calculation, however, two methods are described in a simplified manner. The first is the discounting method in which the credit spread is simply added to the discount rate. The second method is the generally accepted simulation in which CVA is the product of PD, LGD and exposure, summed over every point in time.

According to KPMG, FVA has an impact on the way some trades are priced and most market participants include FVA in the price set by the trader during negotiations. Banks are starting to increasingly interpret FVA as a significant factor contributing to fair value. By December 2013, more than six international banks have included FVA in their financial statements. While, in practice, institutions are not all including FVA in fair value, KMPG expects market standards to become more precise in the future. Therefore, they have established themselves as an expert when it comes to FVA. They have provided a basis for FVA management which is in line with liquidity risk management and internal funds transfer pricing. The following figure illustrates a potential target operating model for FVA management:

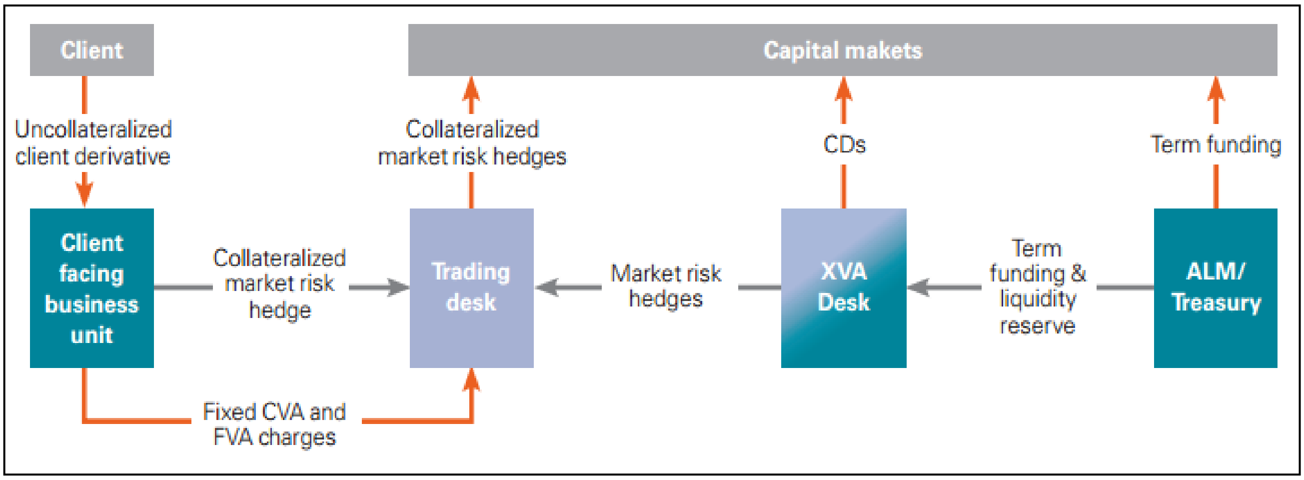


Figure 7: A potential target operating model for FVA management as suggested by KPMG

Source: KPMG International, 2014

4.7.3 DELOITTE

Deloitte and Quantifi's collective White Paper on IFRS 13 (Pugachevsky *et al.*, 2014a:2) describes the Quasi approach to calculate CVA or DVA. In the Quasi approach, they add the counterparty credit risk spread to the discount curve that is applied when discounting future cash flows. This method only provides an approximation of the CVA (DVA) for instruments with positive (negative) cash flows or trades deeply in-the-money (out-of-the-money).

Exposure for stand-alone instruments, such as swaps and forwards, can be calculated by using Black's formula. When taking netting and collateral into account, it usually requires the performance of numerous valuations under different scenarios. These scenarios can be generated under the real probability measure or under the risk-neutral measure. When created under the real probability measure, the drifts and volatilities are adjusted to the historical data the other hand, when generated under the risk-neutral measure, drifts have to be calibrated to ensure that there are no arbitrage opportunities within the price factors. In either case, the volatilities should be equal to market implied volatilities, when available.

In order to evaluate consistent CVA (DVA), a Monte Carlo simulation of the market dynamics that influence the valuation of each financial instrument or portfolio, has to be run (Pugachevsky *et al.*, 2014a:2).

At each point in time, one must simulate market factors and, for these market factors, one must evaluate exposures and potential future exposures. Requirements for the CCR calculation, according to Pugachevsky *et al.* (2014b):

1. The Monte Carlo model should be in agreement with the best market practices
2. It should easily adapt to market or historical data
3. It should capture the full effects of netting agreements and collateral
4. The calculation of wrong way risk should be included in the model
5. The model used should be consistent with front office pricing

Even though Deloitte does not specify methods in which they calculate their valuation adjustments, they emphasise that Monte Carlo simulation should be used when exposure to instruments other than bonds are calculated.

4.7.4 PRICEWATERHOUSE COOPERS (PwC)

In an attempt to simplify the calculation of CVA, PwC has established a Credit Risk Adjustment framework which is easy to apply. Before using the framework, it has to be determined whether or not non-performance risk has already been incorporated in the value of the asset or liability.

If it has not, PwC (2015b:8.10) describes a four-step framework that must be used to determine the necessary adjustment:

1. Determine the unit of measurement for credit risk
2. Apply a market participant perspective to available credit information
3. Calculate the credit risk adjustment
4. Allocate the credit risk adjustment to individual units of the account

For the company's financial statements to conform to IFRS requirements, estimates and assumptions that affect the revenue, expenses, assets and liabilities need to be made. PwC (2015b:8.27) argues that even though IFRS allows for flexibility in the valuation technique, once a technique is selected, the same method should be applied consistently across all calculations. Management's experience and expectations of future events are used to make the estimates. The valuation techniques mentioned are the cost approach, market approach and the income approach. The market approach is used when the inputs of valuation are observable in the market or when comparable inputs are available. The income approach applies the Discounted Cash Flow (DCF) method. In the DCF method, future cash flows are calculated and discounted at a rate which includes the appropriate risk. The cost approach is mainly applicable to property and equipment as opposed to financial assets and liabilities.

4.8 BANKS IMPLEMENTING XVA

Internationally, most banks have well-established xVA desks that manage CVA, DVA and FVA. These adjustments originate from their derivative positions. Locally, banks are at different stages in the transformation towards managing these additional factors.

This new development within the derivative market can cause uncertainty and frustration for clients, because most clients may believe it to be a way for the bank to make higher margins on trades. This is not the case. Derivative pricing is becoming mostly scientific and it is clear that the law of one price can no longer apply. Trades are not only priced into the bank's portfolio for incremental market risk anymore, but the incremental counterparty, funding and capital portfolio applications of trades are now also considered.

Portfolios differ significantly across different banks. It is therefore important for clients to understand that counterparty and funding risks can either decrease or increase with the marginal contribution of a new trade. It is interesting to note that the major banks in South Africa have only been fully implementing CVA as a value adjustment measure. Major banks have merely mentioned DVA in their financial statements and have, largely, not given attention to the other xVA's as yet. Barclays have, however, been implementing DVA and FVA as well. When taking a closer look at Barclays' regulatory framework, it is clear that comparatives for collateral, CVA and remuneration tables are being included. These were all first time disclosures in the 2014 financial year. In December 2015, Barclays reported two possible methods for the calculation of CVA:

1. *Standardised Approach:* The external credit rating of each counterparty is taken into account and the effective maturity and Exposure at Default (EAD) is incorporated from the CCR calculation.

2. *Advanced Approach:* The 10-day 99% VaR measure for the current one-year period and for a stressed period is calculated. The sum of these two measures is then tripled in order to calculate the capital charge.

Barclays' RWA decreased in 2015 by R39.7 billion, largely driven by a change in the calculation methodology of CVA included in updated regulatory guidance. CVA decreased by R1.4 billion to R5 billion, mainly due to the reduction in the average maturity date of the portfolio. DVA increased by R184 million to R2.9 billion, due to a deterioration of Barclays' credit spreads. FVA has decreased by R430 million to R1.1 billion primarily as a result of material trade unwinds and the reduction in the average maturity date of the portfolio (Barclay Annual Report, 2015). In the annual reports of Nedbank and Standard Bank in December 2015, mention is made of the implementation of CVA in order to holistically cover CCR and market value losses, which may occur due to a deterioration of the creditworthiness of the counterparty (Nedbank Annual Report & Standard Bank Annual Report, 2015). Both of these banks also included the CVA targets, which the Bank of International Settlements (BIS) released during July 2015. These targets include the following:

1. A complete re-examination of the current Basel III CVA regulatory framework to address shortcomings in the current standard.

2. The revising of the CVA framework so that it is aligned with the required changes and implemented under the Fundamental Review of the Trading Book (FRTB).

3. A closer alignment between CVA regulatory capitalisation and risk management frameworks.

4. The inclusion of exposure hedging into the capitalisation calculation, in order to incentivise prudent risk reduction strategies.

5. The alignment of governance framework standards for CVA with market and credit risk requirements.

In their annual report for the year ended 30 June 2015, FirstRand mentioned CVA in their RWA analysis (FirstRand Annual Report, 2015). They stated that counterparty credit risk arose due to the withdrawal of the CVA exemption for rand and local counterparty OTC derivatives. Investec reported using the standardised approach to calculate CVA capital requirement. They also stated, in their integrated annual report of 2015, that counterparty credit risk RWAs decreased by R276 million and CVA increased by R1.5 billion for the year of 2015 (Investec Annual Report, 2015). From the preceding discussion, it is clear that most South African banks are only implementing CVA. Only Barclays implement DVA and FVA, however, it does not use these measures when pricing derivatives. This shows that the market is still confronted with the new issues regarding derivative pricing and hedging and that a market-consistent framework is still far from complete.

4.9 CONCLUSION

xVA implementation at an operational level in banks faces a lot of challenges. It requires changes in banks' operating models by considering traditional front office trading operations. The implementation also requires a significant investment in IT infrastructure in order to assist finance, risk and operational functions. Within the final chapter, a summary of the results of this study and open questions for further research will be discussed.

CHAPTER 5
CONCLUSION

5.1 INTRODUCTION

The acronym xVA has been introduced to refer to the list of valuation adjustments in general. These valuation adjustments include CVA, DVA, FVA, CollVA, HVA, LVA, MVA and KVA. Even though CVA and DVA have been used for many years, the financial crisis of 2007 forced banks to consider other valuation adjustments as well.

5.2 SUMMARY OF MAIN FINDINGS

The aim of this research was to introduce the understanding of the developments in derivative pricing with regards to xVA. Chapter 2 is a literature review on all the xVA terms, defining them individually and describing their computation. After the financial crisis, the substantial increase in regulatory capital charges for counterparty risk has led to the creation of Basel III. Institutions have realised that funding costs for derivatives are significant. Hence, the FVA term has been developed. The cost associated with over-collateralisation arose in the form of MVA. The increasing amount of regulatory capital has led to KVA.

In the third chapter, the mechanics and optimal management strategies that are required to implement xVAs within financial structures were discussed. These include the setup of xVA desks and the building of the technological structure required for the implementation. The fourth chapter included the different methods of calculation and the approaches used, according to published guidance of the big four auditing companies in South Africa. A short summary of the implementation of xVA by banks in South Africa was also given. Interestingly, it has been found that most of the banks have only included CVA in their reports.

5.3 FUTHER RESEARCH

Derivative valuation is moving away from the Black-Scholes framework, as more realism needs to be incorporated. This is done through the xVA framework.

Some of the costs have always been present but were previously ignored, whereas others are entirely new costs, due to the changing market. The major focus on xVA might decline in the future, but a change in financial markets as a result of this changed focus is unlikely to occur.

Quants need to deal with the complexity on a new, enlarged scale. Unfortunately, the current partition between xVA and models within banks are synthetic and far from fundamental. Currently, xVA is only adjusting the price of models. A universal valuation model that values derivatives correctly over all sensitivities does not yet exist. While this study focused mainly on the abovementioned xVA terms, new terms, such as Tax Value Adjustment (TVA), have come forward. TVA is the adjustment that describes the effect that tax has on profit and losses (Kenyon & Green, 2015).

In conclusion, as some of the xVAs are still vague, there is room for further research on the topic of xVA.

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