CHAPTER 1

Introduction: The Valuation of Derivative Portfolios

Price is what you pay. Value is what you get.

—Warren Buffett

American business magnate, investor and philanthropist (1930–)

1.1 WHAT THIS BOOK IS ABOUT

This book is about *XVA* or *Valuation Adjustments*, the valuation of the credit, funding and regulatory capital requirements embedded in derivative contracts. It introduces *Credit Valuation Adjustment (CVA)* and *Debit Valuation Adjustment (DVA)* to account for credit risk, *Funding Valuation Adjustment (FVA)* for the impact of funding costs including *Margin Valuation Adjustment (MVA)* for the funding cost associated with initial margin, *Capital Valuation Adjustment (KVA)* for the impact of Regulatory Capital and *Tax Valuation Adjustment (TVA)* for the impact of taxation on profits and losses. The book provides detailed descriptions of models to calculate the valuation adjustments and the technical infrastructure required to calculate them efficiently. However, more fundamentally this book is about the valuation and pricing of derivative contracts. The reality is that credit, funding and capital concerns are very far from minor adjustments to the value of a single derivative contract or portfolio of derivatives. The treatment of CVA, DVA, FVA, MVA, KVA and TVA as adjustments reflects the historical development of derivative models and typical bank organisational design rather than the economic reality that places credit, funding and capital costs at the centre of accurate pricing and valuation of derivatives.

Since the seminal papers by Fischer Black and Myron Scholes and Robert C. Merton published in 1973, derivative pricing and valuation has been centred in the Black-Scholes-Merton framework complete with its simplifying assumptions:

- Arbitrage opportunities do not exist.
- Any amount of money can be borrowed or lent at the risk-free rate which is constant and accrues continuously in time.
- Any amount of stock can be bought or sold including short selling with no restrictions.

- There are no transaction taxes or margin requirements.
- The underlying asset pays no dividend.
- The asset price is a continuous function with no jumps.
- The underlying asset has a constant volatility.
- Neither counterparty to the transaction is at risk of default.
- The market is complete, that is there are no unhedgeable risks.

It could also be argued that there are additional implicit assumptions underlying the Black-Scholes-Merton framework:

- No capital requirement or costs associated with regulatory requirements such as liquidity buffers
- No price impact of trading
- The Modigliani-Millar theorem on the separation of funding and investment decisions applies to derivatives (Modigliani and Miller, 1958).

However, even in the mid-1970s it was clear that these assumptions were there to simplify the problem of option pricing and were not a reflection of reality. Subsequently, a number of authors sought to relax these assumptions:

- Constant interest rates – Merton (1973)
- No dividends – Merton (1973)
- No transaction costs – Ingersoll (1976)
- Jumps – Merton (1976), Cox and Ross (1976).

Subsequently, the original formulation of Black-Scholes in terms of partial differential equations has been replaced by measure-theoretic probability through the work of Harrison and Kreps (1979), Harrison and Pliska (1983) and Geman, Karoui and Rochet (1995). The Black-Scholes model itself has been steadily adapted to match market prices such as through the use of market implied volatilities that display a *skew* or *smile* relative to the single flat volatility assumption of Black-Scholes, implicitly indicating that the stock price distribution has fatter tails than those implied by the log-normal distribution. Nevertheless, the essential framework of risk-neutral valuation through replication has remained largely unchanged even though the mathematical machinery used by quantitative analysts has been enhanced significantly and the computational power available to derivatives businesses has grown exponentially.

The survival of the model is best illustrated through belief in the *law of one price*. The law of one price can be stated as follows:

> *The same asset must trade at the same price on all markets (or there is an arbitrage opportunity).*

This simple statement seems very persuasive at first glance. If an asset is quoted at price x on market X and at price y on market Y and $x < y$ then asset buyers acting rationally should

1. buy assets from market X if they need to consume the asset
2. buy assets from market X and sell on market Y to make a riskless profit of $(y - x)$,

that is, this market permits arbitrage.[1] However, in the context of derivatives it is not clear that the law of one price always applies:

- Over-the-counter (OTC) derivatives trade under bilateral agreements brokered under ISDA rules. The considerable variations in the terms of these legal rules mean that each ISDA (possibly coupled with a CSA) is effectively unique and hence so are the derivatives contracts traded between the two parties to the ISDA agreement.
- Counterparty risk is always present in practice because even under the strongest CSA terms there will still be delays between movements in portfolio mark-to-market valuations and calls/returns on collateral. Counterparty risk makes each derivative with a different counterparty unique with a distinct valuation. The traditional understanding of the law of one price no longer applies, as there are multiple derivatives with the same basic parameters with different prices. However, the law of one price could be preserved if we consider each pair of counterparties to be a different "market", although this reduces the "law" to irrelevance. If both counterparties to a trade use a unilateral model of CVA, where only the risk of the counterparty defaulting is considered, neither party will agree on the value of the transaction so the value is asymmetric between the two counterparties. The introduction of bilateral models for counterparty risk and DVA allows symmetry of valuation to be restored,[2] but FVA models have again broken the symmetry. The introduction of KVA and the realisation that different institutions have different capital regimes has broken the symmetry irrevocably.
- Counterparties clearly have asymmetric access to markets.
- Many derivatives, particularly for large corporates, are transacted on an auction basis. This means that there is one agreed price with the derivative provider that the corporate ultimately selects. However, individual derivative dealers will have different values for the same underlying transaction.
- Once transacted many corporate derivatives are essentially illiquid. Novations of trades to third parties do occur, but infrequently. If the derivative dealer were to instigate a novation this might threaten the banking relationship. Smaller counterparties will typically have a limited number of banking relationships or perhaps only one banking relationship. Novations would likely prove impossible to do in such cases as with no established banking relationship it is unlikely other derivative providers would have sufficient information on the small counterparty to be able to provide the required credit limits. The deal could only be torn up by agreement with the relationship bank.
- Counterparties will often transact a derivative under completely different accounting regimes. For example, a corporate may hold a derivative under IRS 39 hedge accounting rules, while the bank counterparty may include the derivative in a trading book under mark-to-market accounting rules.

The only case where the law of one price might be said to hold is in the case of very liquid exchange-traded derivatives such as futures or exchange-traded options (ETOs). In such cases, given the derivative is entirely commoditised and that margin arrangements are equal for

[1]Of course in reality there may be reasons why it is not possible to actually execute the trade, such as lack of access to both markets, regulatory prohibitions and so on.
[2]See section 3.3.3.

all market participants then the price can be said to be that of the last transaction that took place on the exchange. However, the law of one price has remained persistent in the world of quantitative finance.

The reality of the derivatives market in the aftermath of the default of Lehman brothers is very different from the idealised one encapsulated in the assumptions underlying the Black-Scholes model and risk-neutral valuation:

- Apparent arbitrage opportunities sometimes persist in the market. For example the *Repurchase Overnight Index Average Rate* (RONIA) is frequently higher than the *Sterling Overnight Index Average Rate* (SONIA) despite the fact RONIA relates to a secured lending market while SONIA relates to unsecured lending. In reality this reflects an inability to close the apparent arbitrage and market segmentation. The repo and OIS swap markets are separate, while constructing a trade which would close the apparent arbitrage is difficult because of the large notional of the offsetting positions that would be required.
- Banks cannot borrow money unsecured at a hypothetical "risk-free rate" and bank funding costs are significantly higher than any rate considered to be risk free such as an overnight index swap (OIS) rate.
- Banks cannot borrow money in any quantity. At various points following the collapse of Lehman Brothers, European banks found it difficult to fund themselves in US dollars, prompting central banks to set up large cross-currency swap positions (Lanman and Black, 2011).
- Short selling regulations (European Parliament and the Council of the European Union, 2012a) have made short selling more difficult to do in practice.
- The cost of trading derivatives is significant, particularly if KVA is considered.

The assumptions underlying risk neutral valuation are very clearly at variance with market conditions after the default of Lehman Brothers.[3]

This book, therefore, comprises two things. Firstly it is a practical guide to CVA, DVA, FVA and KVA, including both the mathematical models and the implementation of systems to perform the calculations. Secondly, it is a guide to the future of derivative valuation but one that is as yet incomplete as the transition away from risk-neutral valuation to a more realistic valuation framework is not yet complete. This chapter presents a picture of how derivative pricing and valuation has changed since the *credit crisis* and as such provides an introduction to the book as a whole but one that is naturally coupled with the last chapter on the future of derivatives.

1.2 PRICES AND VALUES

1.2.1 Before the Fall...

In 1996 when I first entered the derivatives market, the standard work on derivative pricing was John Hull's seminal *Options, Futures, and Other Derivatives*, then in its third edition (1997) and now in its eight edition (2011). For vanilla fixed income derivatives such as interest

[3]In my view it is precisely this break with the past that has led to such a vigorous debate around funding valuation adjustment, a subject that is discussed in section 1.4.1.

rate swaps the standard reference was Miron and Swanell's *Pricing and Hedging Swaps* (1991). The modelling approach for the valuation of interest rate swaps in 1996 involved the discounting of the future fixed cash flows using a discount function and the floating leg could be readily replicated with two notional cash flows at the start and end of the swap, if there was no margin on the floating leg, or equivalently by discounting the projected forward rate cash flows of the floating leg. There was a single discounting and projection curve for each currency. The yield curve (sometimes known as the swap curve to distinguish it from bond curves) was constructed using a simple bootstrap approach starting with cash deposits, followed by interest rate futures contracts and completed by interest rate swaps. Once the zero-coupon bond prices for different tenor points had been obtained the discount function was obtained on any date through log-linear interpolation.

Valuing interest rate swaps was straightforward and the discounting curve was driven by xIBOR rates. Cross-currency swaps were more involved and a spread or basis between currencies was required to revalue cross-currency swaps to par. Nevertheless single currency derivative books were typically valued using the single currency discount curve so that cross-currency and single currency books were valued inconsistently. Tenor basis existed in the sense that anyone who wanted to swap a 3M xIBOR rate for a 6M xIBOR rate was charged a spread but these spreads were small and reflected operational costs of the transaction. Tenor basis was essentially ignored for valuation purposes.

In 1996 CVA was not calculated and funding costs were not explicitly considered. Counterparty credit risk was managed through traditional credit limits set by the credit risk function within a bank. The Basel I framework had already been introduced but capital management was considered a back office function.

By the time the credit crisis began in 2007, many banks used a multi-currency discounting framework where USD was usually considered the primary curve with no currency basis and all other currencies had separate projection and discounting curves constructed in such a way as to reprice to par all of the single currency instruments used to construct the curve and the cross-currency swaps. CVA was commonly calculated and charged by tier one banks, with some institutions using unilateral models and some bilateral models. FAS 157 (2006) introduced a CVA(DVA) reporting requirement with wording that implies a bilateral model should be used.

1.2.2 The Post-Crisis World...

As the crisis hit, the market reacted rapidly and tenor basis spreads and the spread between three-month LIBOR and OIS widened rapidly. The USD three-month LIBOR and OIS reached a peak of 365bp just after the collapse of Lehman Brothers in 2008, having averaged 10bp prior to August 2007 (Sengupta and Tam, 2008). This prompted banks to switch to using multiple projection curves for rates with different tenors (see for example Kenyon and Stamm, 2012). It was also realised that the discount curve, normally believed to be based on three-month rates was not the appropriate choice for discounting trades transacted under CSA agreements. CSAs typically pay a rate of interest on posted collateral equal to the overnight rate in the collateral currency and hence it rapidly became market practice to use OIS-based curves to discount collateralised cash flows (Piterbarg, 2010; Piterbarg, 2012).

While CVA had been marked by many tier one banks prior to the crisis, a number of banks switched from the use of unilateral to bilateral models during the crisis. Bank CDS spreads widened significantly leading to dramatic increases in DVA accounting benefit where it was

TABLE 1.1 Components of derivative prices before and after the financial crisis of 2007–2009.

Pre-Crisis	Post-Crisis
Risk-neutral price (LIBOR discounting)	Risk-neutral price (OIS discounting)
Hedging costs	Hedging costs
CVA	CVA (DVA?)
Profit	Profit
	FVA (including cost of liquidity buffers)
	KVA (lifetime cost of capital)
	MVA/CCP costs
	TVA (tax on profits/losses)

marked. Competitive pressure on pricing also pushed banks to include DVA in derivative pricing as many corporate customers had CDS spreads that were significantly tighter than the bank counterparties they were trading with. Accounting standards moved to recommend bilateral CVA models because of the symmetrical valuation. Some banks chose to actively manage DVA, while others chose to warehouse some or all of the risk.

Unsecured funding costs became a focus as bank funding spreads widened significantly as their CDS spreads did and a number of models were produced (see for example Burgard and Kjaer, 2011b; Burgard and Kjaer, 2011a; Morini and Prampolini, 2011; Pallavicini, Perini and Brigo, 2012)). FVA remains controversial as will be discussed in detail in section 1.4; however, most practitioners accept that it must be included in pricing and accounting practice with most major banks now taking FVA reserves.

Post-Crisis, regulatory capital is a scarce and expensive resource that must be carefully managed by banks. Capital management is no longer a back office function and now resides firmly in the front office as a core activity for tier one banks. The cost of regulatory capital has to be priced into every new transaction to determine if a trade is expected to be profitable. Capital modelling is now based in the much more complex Basel II.5 and Basel III regimes (and their implementation by regional regulatory bodies).

In 2015 pricing a "vanilla" interest rate swap involves multiple projection and discount curves for the baseline valuation and a large-scale Monte Carlo simulation at counterparty level to calculate CVA, FVA and KVA; it is a long way from the single yield curve discount models of the mid-1990s (see Table 1.1). Indeed, as will become apparent in this book, single trades can no longer be valued in isolation and trade valuation is an exercise in allocation of portfolio level numbers down to individual trades.

1.3 TRADE ECONOMICS IN DERIVATIVE PRICING

1.3.1 The Components of a Price

Table 1.1 illustrates the components of pricing before and after the financial crisis of 2007–2009. Not all of these components apply to all trades and to understand the terms under which a derivative is transacted it is useful to divide counterparties into three types: unsecured, CSA and CCP. Of course, in reality the range of counterparty arrangements is a continuum between unsecured and an idealised CSA with full instantaneous transfer of collateral but it is useful to separate them for the purpose of this discussion. Each of these three cases will have different pricing components.

Unsecured Pricing

- Risk-neutral valuation
- Hedging/management costs
- CVA
- FVA
- KVA
- Profit (Tax/TVA).

For trades that are unsecured the components of the price begin with the baseline risk-neutral valuation, although there remains industry debate about the appropriate choice of discount curve for this, with both OIS and xIBOR-based discount curves used in the market. Hedging and trading desk management costs should be charged and this includes effects such as bid-offer, lifetime re-hedging costs and cost of supporting infrastructure such as system maintenance and staff. A profit margin will also typically be charged. Given there is no collateral to mitigate the exposure to the counterparty, CVA will be calculated based on the full expected exposure profile. If a bilateral CVA model is used there will also be a DVA benefit term. The same expected exposure will give rise to FVA. The lifetime cost of maintaining regulatory capital, KVA, will also be included, although this might be a *hurdle rate* or minimum return level rather than a cash amount.

CSA Pricing

- Risk-neutral valuation: CSA-based (OIS) discounting
- Hedging/Management costs
- Residual CVA (including impact of collateralisation)
- Residual FVA (including impact of collateralisation)
- COLVA/Collateral effects
- KVA
- Bilateral Initial Margin MVA
- Profit.

For trades covered by a CSA the baseline risk-neutral valuation will be discounted using a curve appropriate to the terms of the CSA. Given that the CSA is imperfect in the sense that the collateral transferred to support the mark-to-market of the trade is done on a discrete periodic basis rather than a continuous basis, a residual counterparty exposure will remain. This residual exposure leads to *residual CVA* and *residual FVA*. There may also be a COLVA adjustment to account for collateral effects in pricing that cannot be captured by a discounting approach such as collateral optionality. Capital must be held against collateralised portfolios and this gives rise to KVA, although the presence of collateral significantly reduces the amount of capital that must be held through the counterparty credit risk and CVA capital terms. The *leverage ratio* comes into importance here, however, as while collateral reduces the CCR and CVA terms, it has a restricted impact on the leverage ratio. Market risk capital will be held unless there are other market risk offsetting trades. Hedging and trading desk management costs should again be charged as should the profit margin. Under BCBS 226 (2012e) and BCBS 242 (2013e), trades supported by CSA agreements will also require bilateral initial margin to be held in a similar way to the way that CCP initial margin requirements operate.

CCP Pricing

- Risk-neutral valuation: CCP methodology including CCP discount curves
- Hedging/Management costs
- Residual CVA (including impact of variation margin)
- Residual FVA (including impact of variation margin)
- COLVA/Collateral effects
- KVA
- Initial margin
- Liquidity buffers
- Default fund
- Profit.

For trades cleared through a CCP the components of a price include similar components to those of a trade supported by a CSA agreement. Residual exposure above the collateral provided as variation margin gives rise to CVA and FVA as with CSA pricing. Hedging and trading management costs are the same as is the addition of a profit margin. The lifetime cost of capital is also present although the risk-weight applied to qualifying CCPs is the relatively low value of 2% (BCBS, 2012c). As with CSA pricing a COLVA adjustment may be needed. In addition to variation margin, three other payments are often made to CCPS: *initial margin*, *liquidity buffers* and *default fund* contributions. The initial margin is designed to cover exposure that might arise due to market movements during a close-out period and hence prevent loss should a counterparty subsequently default. Liquidity buffers can also be applied if the risk position of a CCP member is large. All CCP clearing members are required to post default fund contributions which are designed to be used in the event of the default of a CCP member.

1.3.2 Risk-Neutral Valuation

In all three of the cases studied in section 1.3.1 a baseline risk-neutral valuation model is still used. The risk-neutral valuation is the value as seen by the derivative trader and is the value this trader is tasked with hedging. Normally this trader will be an asset-class specialist with experience of hedging in the markets underlying the derivative and so this is where the majority of the market risk on the trade is managed. The risk-neutral trade level valuation makes the usual assumptions of no credit or funding risk so in effect this valuation assumes that a perfect CSA agreement is in place. However, in general the choice of discounting curve varies depending on the arrangements under which the derivative has been traded.

Unsecured The choice of discount curve is still a matter of debate in the industry and depends on internal factors. Many banks have left the baseline valuation of unsecured trades using xIBOR-based discounting models (Solum Financial Partners, 2014). In many cases this will be exactly the same multi-currency discounting model that was prevalent before the credit crisis, typically where all other currencies had cross-currency basis quoted against the US

TABLE 1.2 The possible choices of discounting for the baseline risk-neutral valuation of unsecured derivative trades.

Discounting	Motivation
xIBOR	■ Matches pre-crisis discounting (e.g. if this was USD based and included cross-currency basis) ■ Close-out reference value may be assumed to still be xIBOR based for unsecured trades
Single OIS curve	■ Central FVA management function ■ Single OIS curve discounting assumed to be reference close-out value (e.g. EONIA for European bank)
Multiple OIS curves	■ Central FVA management function ■ Single currency trading desks do not want cross-currency exposure ■ Multiple OIS curve discounting assumed to be reference close-out value
Funding discounting	■ Asset-class trading desks manage own funding costs ■ Discounting model of FVA adopted

dollar interest rates. Other choices are also possible including OIS discounting. The choice may be made to use a single currency discount curve for all unsecured trades, say for example Fed Funds. A further alternative might be to allow single currency derivatives to be discounted using the appropriate OIS curve for that currency and treat multi-currency trades differently. This has the advantage that single currency trading books would not be exposed to any cross-currency effects. If the bank elects to use funding discounting models for unsecured trades, then the discount rate will be the bank's internal cost of funds curve. The possible choices and motivating factors are listed in Table 1.2.

The choice of discounting depends on three key factors: organisational design, internal bank modelling of funding costs and the expected reference close-out in the event of default. Note that this reflects the practical reality of what happens in banks rather than theoretical correctness of any models used.

Organisation design Organisational design[4] determines which trading desks manage which risks. Broadly there are two main choices; either each individual trading desk manages their own funding (*distributed model*) or there is a central management desk for funding (*centralised model*). In the distributed model each trading desk will need to know the funding impact of all unsecured trades on their book. This would most likely be done using a funding discounting approach, although other models could be used. In the centralised model the asset-class trading desks will either wish to measure the funding risk and lay it off with the central desk or not be exposed to it at all. If the asset-class desks hedge out funding risks with the central desk then they will measure the funding cost and hedge it out through funding basis swaps, otherwise the asset-class desk would value all their unsecured trades either at xIBOR or OIS and be oblivious to funding considerations, with the central funding desk calculating and managing FVA directly.

[4]See Chapter 22 for a broader discussion of organisational design.

Bank models of funding costs The bank model of funding costs also plays a role in determining the choice of discounting for unsecured trades. As will be discussed at length in Chapter 9 there are broadly two types of model for FVA, discounting approaches and exposure-based approaches. Discounting approaches simply adjust the discount curve, while exposure-based approaches use models similar to those used for CVA. Discounting-based approaches simply adjust the risk-neutral valuation by using the cost of funds as the discount rate and hence the risk-neutral valuation. Exposure-based approaches apply FVA as an adjustment to the portfolio valuation in the same way as CVA so the underlying risk-neutral valuation remains unchanged.

Reference close-out The reference close-out value is the final factor in determining the choice of unsecured discounting model. To be consistent with the CVA model the unsecured reference valuation should match that used in the CVA model so that in the event of default the risk-neutral valuation matches the claim value made against the administrators of the defaulted counterparty and the CVA becomes the realised loss on the trade once the actual recovery rate is known. Note that the use of funding discounting models implies that the CVA model *has to be changed to be consistent with this choice of FVA model*.[5]

CSA CSA and OIS discounting will be discussed in detail in Chapter 8; however, it should be noted here that the implications of Piterbarg (2010) and Piterbarg (2012) are that the appropriate discount rate for fully collateralised counterparties is the rate of interest received on the posted collateral. Hence the discount curve depends on the terms of the CSA agreement. In the simplest case where collateral can only be posted in cash in a single currency then the rate of interest received on posted collateral is normally the overnight rate in that currency. Hence the appropriate discount curve is the OIS curve in the same currency as this curve represents the market expected overnight rate extended out to longer maturities. In the case where cash in multiple currencies can be posted the appropriate discount curve is a blended curve which represents the rate earned on the cheapest-to-deliver currency.[6] Many CSAs allow a variety of securities to be posted as collateral and in this case the choice of appropriate discount curve becomes more complex.

CCP The discount curve used by CCPs to determine the value for the purposes of margin calls is determined by the internal models of the CCP. For single currency interest rate swaps cleared through LCH.Clearnet SwapClear this is currently a single currency OIS discounting methodology, having switched over from a LIBOR methodology during 2010 (LCH, 2010a). This can be viewed as the risk-neutral valuation of the interest rate swap, but there is no guarantee that a clearing member's own risk-neutral valuation will match that of SwapClear and this could become problematic because of the privileged position held by CCPs (Kenyon and Green, 2013c).

[5]See Chapter 8.

[6]Chapter 8 discusses the construction of OIS discounting curves in more detail. It should be noted that collateral substitution where one piece of collateral is exchanged for another depends on the local legal framework and that collateral can be viewed as "sticky" in some jurisdictions. The pricing of the embedded cheapest-to-deliver option is not straightforward, therefore.

1.3.3 Hedging and Management Costs

The bid-offer spread quoted by trading desks has always been included in prices and reflects the trading desk cost of managing the trade. This is normally considered to include the cost of hedging the market risk on the trade at inception and any future re-hedging costs due to market movements and embedded nonlinear risk. There are however other elements that should be considered:

- *Staff costs* are a very significant fraction of the cost base of any bank. This includes trading and sales staff with primary responsibility for managing market risk and interacting with the customer. However, there are many other support functions involved including quantitative analysts, finance professionals and business controllers, risk managers, audit and operations staff.
- *Legal and other professional fees* are also a cost. Over-the-counter (OTC) derivatives are traded under the legal framework provided by ISDA (1992; 2002), which requires set-up and maintenance costs. Some transactions require external ratings, which means engagement with rating agencies and the payment of fees.
- *IT and other infrastructure costs* are also a significant part of the cost base of a bank. This covers everything from buildings, lighting and air conditioning through to the cost of IT system development, maintenance and hardware. For complex derivative products, even the cost of running the valuation and risk on a daily basis can be expensive due to hardware and the energy required to both power and cool it. Of course it is not just trading systems themselves, there are huge numbers of other risk systems for CVA, PFE, VaR etc that also consume resources.

1.3.4 Credit Risk: CVA/DVA

Part I of this book discusses CVA and DVA in detail, including models for unsecured and secured portfolios. Here I examine the CVA impact on pricing in each of the three cases.

Unsecured Unsecured portfolios represent the standard case for CVA as both counterparties are fully exposed to each other. In most cases, close-out netting will apply meaning that the exposure on default will be to the netted value of the portfolio. If unilateral models are used then the CVA is only calculated on the exposure to the counterparty. In theory this would give rise to asymmetry in the price obtained by both counterparties as each would only charge for the credit risk of the other and take no account of their own risk of default. It is this theoretical asymmetry that has been one of the key drivers behind the introduction of bilateral CVA models and DVA. If bilateral models are used then both counterparties can agree on the credit valuation adjustment as the two terms in the calculation, CVA and DVA, are mirror images of each other. Counterparty A calculates CVA_A and DVA_A, while B calculates CVA_B and DVA_B with the following symmetry holding:

$$\begin{aligned} \text{CVA}_A &= \text{DVA}_B \\ \text{DVA}_A &= \text{CVA}_B. \end{aligned}$$

Of course in practice this symmetry would certainly not hold as both counterparties would operate different CVA models and may be operating under different accounting regimes. For example, one could be a bank with the derivative held in its trading book using mark-to-market accounting while the other might be a corporate using IAS 39 hedge accounting rules (IASB, 2004). There are also a number of other issues to be addressed when pricing unsecured derivatives such as including the impact of right-way or wrong-way risk and dealing with illiquid counterparties. Counterparties that deal on an unsecured basis are more likely to be smaller names with no traded CDS contracts, although some will be larger corporates or governmental entities.

CSA In the case of perfect collateralisation, where any change in mark-to-market is instantaneously covered by a transfer of collateral to support it, there is no credit exposure and hence no CVA or DVA. In practice, of course, even the strongest of bilateral CSA agreements do not display this behaviour and have a daily collateral call. In general all CSAs have a minimum transfer amount (MTA) and many have non-zero thresholds. Many CSAs will also have asymmetric thresholds giving *one-way CSAs*. Some CSAs have credit-rating dependent features such as thresholds that reduce on downgrade, volatility buffers or a requirement to novate the trade if the derivative issuer falls below a certain rating. CSAs can have a much lower call frequency such as weekly or monthly and this is particularly true of non-bank counterparties who do not have the operational capacity to manage collateral on a daily basis. In general, a default is not recognised immediately and often there is a recognised *cure* or *grace* period where a counterparty that has failed to make a collateral payment is allowed time to make the payment. In general, a *margin period of risk* is included when modelling collateral to allow an estimate of the realistic expected exposure. In the Basel III regulatory framework this is set at ten days unless the counterparty is a significant financial institution in which case the margin period is increased to twenty days.[7] During the margin period of risk no collateral is assumed to be transferred by the counterparty but often it is assumed that the bank must continue to make collateral payments, even if the counterparty has previously failed to make a collateral payment. Collateral disputes can also give rise to exposure and to the regulatory margin period of risk if more than two disputes occur in the previous two quarters (European Parliament and the Council of the European Union, 2013a; European Parliament and the Council of the European Union, 2013b).

CSAs are imperfect and give rise to residual exposure and hence there is credit risk and so CVA can be calculated and charged. However, not all banks mark CVA on collateralised names, particularly those with low or zero thresholds and a daily call frequency.

CCP CCP *variation margin* arrangements are very similar to a strong CSA with a daily call frequency and in some circumstances collateral can be called intraday. Given the presence of initial margin the residual expected exposure to the derivative trades themselves will be very small or zero.[8] However, there remains the possibility of exposure to the CCP itself through the initial margin and the default fund. If the initial margin is bankruptcy remote then the exposure generated by posted initial margin can be excluded from CVA. However, this is not the case for the default fund contributions which are designed to be used in the event of the default of a member. The default fund certainly generates exposure and hence credit risk.

[7]Except for repo transactions where the margin period of risk is set at five days.

[8]Of course with sufficiently large market moves, almost any initial margin can be exceeded as is clear from the removal of the CHF-EUR peg by the Swiss National Bank on 15 January 2015.

1.3.5 FVA

FVA was initially controversial in the quantitative finance community as is clear from the series of papers by John Hull and Alan White (2012b; 2012c; 2014b) and the responses to them by Castagna (2012), Laughton and Vaisbrot (2012), Morini (2012) and Kenyon and Green (2014c). The debate around FVA is discussed in section 1.4.1 and FVA models are presented in Part II; however, it is clear that most market practitioners believe a pricing adjustment should be made for the cost of funding unsecured derivative transactions. In this context FVA represents the costs and benefits from managing the collateral on hedges used to eliminate market risk from the unsecured transactions. FVA and CVA together can be viewed as the cost of not trading under a perfect CSA agreement. The accounting status of FVA is now in transition with increasing numbers of banks taking reserves.

Unsecured As with CVA, unsecured trades are the standard case for FVA as both counterparties are fully exposed to each other. Symmetric models with both funding cost and benefits as well as asymmetric models with only funding costs have been proposed with a key determining factor being the potential overlap with DVA benefit. Broadly speaking, methodologies for FVA are either based on discounting, as noted earlier, or on exposure-based models that are extensions of CVA.

CSA The discussion on residual exposure from CVA also applies in the context of FVA so that deviations from a perfect CSA could give rise to *residual FVA*. If we view FVA as the cost of providing an effective loan or the benefit of an effective deposit through a derivative then the residual exposure just gives rise to a residual funding cost or benefit. However, as will be discussed later, if we view the FVA as the cost of maintaining collateral on a hedge trade then the argument for residual FVA on CSA trades is much weaker, although funding costs and benefits will still arise from mismatches in collateral requirements due to differing CSA terms. What is clear is that FVA does not apply to the secured portion of the exposure unless the assets provided as collateral cannot be rehypothecated. Lack of rehypothecation may be due to legal terms within the CSA or because the asset provided as collateral may be ineligible under other CSAs.

CCP – Variation Margin Given the degree of overcollateralisation for trades cleared through CCPs any residual exposure is likely to be small to zero. With this in mind the FVA component due to a mismatch between valuation and variation margin is likely to be close to zero.

Other Sources of FVA Central counterparties also require that initial margin be posted in addition to variation margin. Large net risk positions can give risk to volatility buffers and all members of the CCP are required to contribute to a default fund that will be used to cover any losses in the event of the default of a member. All of this additional collateral needs to be funded through unsecured borrowing and hence gives rise to *Margin Valuation Adjustment (MVA)*. Modelling the exposure at future times arising from these collateral buffers is complex. Initial margin is generally calculated using VaR models which means estimating expected future VaR. The volatility buffers use risk multipliers based on estimates of market depth so that large risk positions that cannot be quickly closed are penalised. The default fund, in the case of LCH, is based on all positions of all clearing members and so is very difficult to estimate as the positions of other members are unknown. In addition the methodology used by central counterparties is not always public, making models difficult to build.

The Basel Committee proposal on bilateral margin for financial counterparties BCBS 226 (2012h) and BCBS 242 (2013e) would similarly give rise to a funding requirement to maintain the initial margin collateral buffer.

Regulatory liquidity frameworks including FSA047/048 as applied in the UK (Financial Conduct Authority, 2014, section 12) and the liquidity framework under Basel III (BCBS, 2013b) also require the maintenance of an internal liquidity buffer to protect an institution from outflow in the event of a credit downgrade. This *liquidity buffer* has to be held in liquid assets by the bank against a two-notch downgrade of long-term rating by credit rating agencies. Many CSAs and ISDAs contain provisions for additional collateral in the event one or more rating agencies downgrade the counterparty below certain certain rating levels. In addition non-derivative products such as deposits may contain provisions to allow the counterparty to withdraw the deposit if the bank's credit rating falls below a certain level. The liquidity buffer must be funded through unsecured borrowing and hence is a type of FVA. Trades with counterparties that have embedded *downgrade triggers* in their documentation should include the cost of funding any additional liquidity buffer in the price of a new transaction.

1.3.6 Regulatory Capital and KVA

Under the Basel III framework (BCBS, 2011b) there are three key contributors to regulatory capital requirements:

- Market risk
- Counterparty Credit Risk (CCR)
- Regulatory CVA.

In addition some transactions will be subject to other capital provisions through *Specific Risk*, *Incremental Risk Charge (IRC)* and *Wrong-way Risk*. The incremental cost of capital due to a new trade is significant and has to be included in the price of a new derivative. This is not a funding cost, however, as there is no requirement to hold collateral or an asset return, rather there is a requirement to hold shareholders' capital against the risk of loss on the derivative portfolio. This capital is not free and shareholders require a return on this capital. Often bank management will state a target return on capital or direct staff within the bank to accept transactions that exceed a minimum return on capital. The Basel framework requires an amount of capital to be held based on the application of the capital rules to the current portfolio, giving a *spot capital requirement*.[9] However, the spot capital requirement is not necessarily a good measure of the expected capital requirement throughout the life of a transaction. An interest rate swap, for example, will be entered at close to zero value but will then diverge away from it, given additional CCR and CVA capital requirements during its lifetime. Hence the cost that

[9]Note that sometimes this spot capital requirement is referred to in terms of *RWA* or *Risk-Weighted Assets* as this is the regulatory asset value against which the capital must be held. In reality the Basel framework is written partially in terms of RWA and partly in terms of direct capital requirements but RWA is frequently used in finance as a shorthand way of describing all capital requirements.

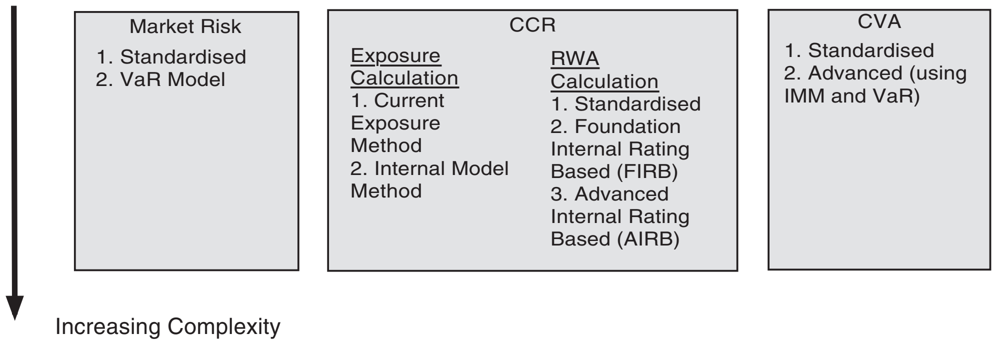

FIGURE 1.1 The different calculation methodologies available for market risk, counterparty credit risk and CVA under the Basel III framework. The more complex methodologies requiring regulatory approval are lower down the figure.

needs to be priced into to new derivatives is the *lifetime cost of capital* which measures the cost of all future capital requirements. Part III discusses approaches to how this lifetime cost of capital can be estimated.

Once we have a measure of the lifetime cost of capital, KVA, then new transactions can be priced in such a way as to achieve the desired minimum profit to achieve the desired return for shareholders. However, this will not remain constant as market moves can lead to higher or lower capital requirements. Both the CCR and CVA terms are driven by the portfolio mark-to-market and so the lifetime cost of capital will have market risk sensitivities in a similar way to CVA and FVA. This leads to the question as to whether or not capital can be managed in a manner similar to CVA and FVA. It certainly can be managed passively through managing the back book of trades through novation and trade cancellation. Counterparties with large trade portfolios between them may find that capital as well as operational costs and risks can be reduced through compression trades that seek to replace a large portfolio with a smaller number of trades with the same risk profile. Active management of the CVA and CCR terms is embedded into Basel III through the capital mitigation that is available from the use of single name and index CDS trades to hedge counterparty risk. In theory trades could be used to hedge the market risk sensitivities of the lifetime cost of capital. Such trades would be in place to generate retained profits at exactly the time additional capital would be needed. In reality, however, these transactions would likely attract additional capital themselves making hedging involve iteration/optimisation rather than simply constructing a trade to offset the risk directly.

One further point to note here is that the amount of capital required depends on the regulatory approvals that the institution has in place. For each of three main contributors to regulatory capital listed above, the calculation method depends on status, with more advanced institutions allowed to use internal modelling subject to appropriate approvals and oversight. The different approaches are illustrated in Figure 1.1.

It should be immediately clear that regulatory capital will not be the same for all market participants because the methodology in use in each institution is different. The cost of capital of each institution will also be different as each will set individual target returns. Even in the absence of book-specific effects, such as netting, the cost of capital embedded in the derivative price can be significantly different between different banks.

Regulatory uncertainty and regulatory divergence are also major issues. Further regulatory proposals have been made by the Basel Committee and more will be made in the future. For example, under the " review of the trading book" fundamental (2012g; 2013c) major changes will be made to the market risk capital framework, with the standardised approach revised and changes to IMM including a switch to *expected shortfall* from VaR. The two non-IMM approaches to counterparty credit risk will be replaced in 2017 with the *standardised approach* (BCBS, 2014b). The cost of future regulation is unknown but it will certainly apply to long-dated derivatives that are transacted today.

1.4 POST-CRISIS DERIVATIVE VALUATION OR HOW I LEARNED TO STOP WORRYING AND LOVE FVA

1.4.1 The FVA Debate and the Assault on Black-Scholes-Merton

As noted earlier, bank CDS spreads were very narrow prior to the start of the credit crisis in 2007. AA or better rated banks were able to fund themselves at the rate implied by the LIBOR discounting curve or in some cases below. FVA adjustments were not made as they were not needed. After the default of Lehman brothers as credit spreads widened sharply so did funding costs. The spread between overnight rates and rates of longer tenors widened significantly with the US Dollar OIS-3M LIBOR spread reaching 365bp just after the collapse of Lehman Brothers in September 2008 (Sengupta and Tam, 2008). Unsecured funding costs became very significant for the first time in the history of derivative markets.

Initially unsecured funding was seen in the context of multiple yield curve models. These models were introduced to account for *tenor basis* or the large discrepancies observed between instruments with different payment frequencies, observable through the prices of basis swaps. *Cross-currency basis* was already well established in yield curve frameworks and pre-crisis yield curve models were already contructed in such a fashion as to reprice both single currency and cross-currency swaps. These cross-currency models implicitly used 3M US Dollar LIBOR as the primary discount curve and all other currencies were marked with currency basis with respect to US Dollars. The main justification for the use of US Dollar discounting was its role as global reserve currency. A number of papers were published on multiple curve discount models including Henrard (2007); Henrard (2009), Ameritrano and Bianchetti (2009), Chibane and Sheldon (2009), Fujii, Shimada and Takahashi (2010b) and Bianchetti (2010). A number of authors then extended the multiple curve frameworks into models designed to value exotic interest rate derivative products while accounting for both tenor and cross-currency basis and models of this type were presented by Mercurio (2010b), Fujii, Shimada and Takahashi (2009) and by Kenyon (2010) in the short rate modelling framework.

A parallel development to this was the realisation that the use of 3M xIBOR curves as the primary discounting curve was incorrect for derivative portfolios secured by collateral under CSA agreements. Market practitioners realised that the correct discount curve was in fact the OIS curve, at least for CSAs which accepted collateral in a single currency and paid the overnight unsecured rate of interest on posted collateral on a daily basis. This was driven by a realisation that the OIS curve was considered risk free while the rapidly increased divergence between the OIS rate and 3M xIBOR rates clearly demonstrated that xIBOR was perceived as far from risk free by market participants (see for example Hull and White, 2013). Piterbarg clearly demonstrated that the interest rate paid on collateral was the correct discount rate under a perfect single currency CSA agreement (Piterbarg, 2010) and subsequently in the multi-currency case (Piterbarg, 2012).[10]

Unsecured derivatives were seen as just another discount curve, with valuations either remaining at 3M xIBOR discounted values or moved to a discount curve equivalent to the bank cost of funds if this was higher than 3M xIBOR. It quickly became apparent that such models led to *double counting* of benefit from DVA and funding for those institutions that used bilateral CVA models. The primary driver for both funding and DVA was the market perception of credit worthiness; in the context of funding this was seen through the yield on bank funding instruments and their spread over instruments considered risk free such as high quality government bonds and through the bank CDS curve in the case of DVA. This led Burgard and Kjaer (2011b) and Burgard and Kjaer (2011a) to produce a self-consistent framework the included CVA, DVA and FVA through a similar PDE approach to that used by Piterbarg in the context of collateralisation. Morini and Prampolini (2011) also developed a model including both DVA and FVA from a probabilistic approach. Kenyon and Stamm (2012) developed a portfolio level model for FVA, while Pallavicini, Perini and Brigo (2012) produced a portfolio level model that incorporates cash flows from collateral as well as individual trades using a probabilistic approach.

In the 25th anniversary edition of *Risk Magazine*, John Hull and Alan White (2012b) wrote an article arguing that FVA should not be applied to derivatives. The response from market practioners was an immediate vigorous counterargument that funding costs should be priced into derivatives, beginning with Laughton and Vaisbrot (2012) in the next issue of *Risk Magazine* and followed by Castagna (2012) and Morini (2012). Hull and White published a further two papers as the debate continued (2012c; 2014b). Kenyon and Green (2014c) and Kenyon and Green (2014b) continued the debate with Hull and White (2014c) in the context of the implications of regulatory associated costs.

Hull and White (2012b) based their argument on eight key points:

1. Discounting at the risk-free rate is a consequence of risk-neutral valuation.
2. Hedging involves buying and selling zero cost instruments and so hedging does not affect valuations.
3. The *Fischer-Hirshleifer Separation Principle* (Hirshleifer, 1958)/*Modigliani-Millar Theorem* (Modigliani and Miller, 1958) imply that pricing and funding should be kept separate.
4. Banks invest in Treasury instruments and other low-yielding securities without charging funding costs.
5. FVA is equal to the change in DVA from the fair value option on the bank's own issued debt.
6. FVA is a form of anti-economic valuation adjustment.
7. Proponents of FVA do not require the derivatives desk to earn a bank's weighted average cost of capital.
8. The FVA adjusted price is a *Private Valuation*.

Laughton and Vaisbrot (2012) countered that Hull and White's arguments were based on complete markets where all risks can be hedged, while in practice markets are incomplete

[10] OIS discounting models are discussed in Chapter 9.

and this introduces subjectivity into valuations; hence the *law of one price* no longer holds. Furthermore, Laughton and Vaisbrot argue that the Black-Scholes-Merton model relies upon both no arbitrage and the ability to borrow and lend at the risk-free rate in unlimited size, while in reality there is no deep liquid two-way market in borrowing and lending cash and that apparent arbitrage opportunities are visible in the market because of the practical difficulties in conducting arbitrage. Furthermore Laughton and Vaisbrot suggest that models should be practically useful to traders and that as a result the cost of borrowing is an exogenous factor that is unaffected by a single trade and that no value should be attributed to profit or loss on own default through DVA as it is impossible to monetise.

Antonio Castagna (2012) argued against points 1, 2, 3, 4 and 5 in the list above. Discounting using the risk-free rate may not be appropriate, argues Castagna, as it does not cover the cost of the replication strategy. Hedging does not always involve buying and selling zero cost instruments as the funding rate has to be paid if money is borrowed to purchase an asset. Castagna argues that the Modigliani-Millar theorem does not apply to derivatives. The argument proposed by Hull and White (2012b) that banks invest in low yielding instruments is simply false as these assets are mostly funded through the repo market. Finally, Castagna suggests that FVA cannot be offset by gains or losses through DVA from the fair value of own debt option as any such gains cannot be realised in the event of default.

Massimo Morini (2012) argues that it makes sense for a lender to charge funding costs as it will be left with a carry loss in the event it does not default itself, even if it does not make sense for the borrower. Morini suggests that FVA might be a benefit for shareholders on the basis that the shareholders of a limited liability company are effectively holding a call option on the value of the company. Like Castagna, Morini argues against the use of the Modigliani-Millar theorem but on the basis that Hull and White assume that the market response to the choice of projects undertaken by the company is linear as expressed through funding costs. Morini demonstrates that even in the case of a simple Black-Cox model the market response is nonlinear. Finally, Morini agrees with Hull and White's assertion that risk-free discounting is appropriate in derivative pricing.

What does this debate actually mean in practice? The answer to at least some degree is that quants protest too much when theoretical arguments are challenged by the market. Ultimately mathematics is a tool used in finance to, for example, value products, risk manage them, produce economic models, etc. All models have assumptions and if the market changes and the assumption is no longer valid the models have to change to remain useful. This is not the first time that models have "failed" to some degree. Skew and smile on vanilla options have long been present showing deviations from the Black-Scholes model. This demonstrates that the market believes the distribution of the underlying asset is not log-normal as assumed by the Black-Scholes model. During the credit crisis the Gaussian Copula models used to value CDOs were unable to match market prices. However, it is clear that FVA presents a broader challenge to quantitative finance than previous issues such as volatility smile. The fundamental assumptions underlying much of quantitative finance theory since Black-Scholes are challenged by FVA. Valuation is undergoing a paradigm shift away from these standard assumptions towards models that encompass more realism and away from the simplifying assumptions of the Black-Scholes framework.

Kenyon and Green (2014c) and Kenyon and Green (2014b) demonstrated that in the presence of holding costs the assumptions underlying the Modigliani-Miller theorem are violated. Regulatory costs, through capital requirements, act as holding costs leading to the direct consequence that Modigliani-Miller does not apply to derivatives and hence to FVA.

Furthermore it is clear that there is no single risk-neutral measure that spans the market and that no two market participants will agree on price. Hull and White (2012b) maintain that FVA should not be charged; however, the market as a whole has reached the opposite conclusion with numerous banks taking reserves for FVA, including a headline-grabbing figure of $1.5bn by J.P. Morgan in January 2014 (Levine, 2014).

1.4.2 Different Values for Different Purposes

The so-called *law of one price* argues that the same asset must trade at the same price on all markets or there is an arbitrage opportunity. For example, if gold trades at $\$X$ on market A and at $\$Y$ on market B and $X < Y$, in the absence of transport and other cost differentials all trades will take place on market A. The question is whether or not this argument applies to OTC unsecured derivatives markets.

Superficially it would appear that the law of one price should apply to unsecured derivatives if the term sheet for the transaction is the same across multiple banks. However, the terms under which those trades actually take place, that is the ISDA agreement, are frequently different so even in legal terms the trades are different. Add in the counterparty risk of dealing with the banks on an unsecured basis and it should be clear that each deal done with a different bank is different. If two banks offer the same derivative an arbitrager will find it very difficult to arbitrage them by taking opposite positions because of counterparty risk and capital considerations. Most unsecured derivatives are actually traded with corporate customers who use them to hedge balance sheet risks. Often the corporate will use hedge accounting rules and be focused on cash flows while the bank will use mark-to-market accounting. Many of these derivatives will be transacted one way round as corporates use the derivatives as a hedge on a natural risk. For example, many corporate fixed rate loans are structured as a floating rate loan with an interest rate swap in which the corporate receives the floating rate and pays the fixed rate. Derivatives transacted with corporates will also be frequently difficult to novate to a third party, particularly for trades with smaller corporates as they may have few banking relationships or indeed may have only one banking relationship. Other banks, particularly those from outside of the geographical region, may be reluctant to perform the credit analysis and *know your client* checks necessary to establish a relationship. The law of one price simply does not apply in such circumstances.

A useful analogy to consider when thinking about derivatives is that of the manufacturing industry. Consider manufacturing cars; all cars are designed to carry passengers and luggage but we clearly do not expect them all to cost the same. Cars have different designs and features and these feed into the price. The value of the car will depreciate at different rates after the purchase. The cost of the car is driven by a wide variety of factors including the cost of components, labour costs, transport costs, etc. In general the price will be determined by

$$\text{Price} = \text{Production Cost} + \text{Profit Margin}.$$

Why should derivatives be any different?

What is a Derivative Price? The price of a derivative is just the price at which the transaction is dealt. For unsecured derivatives the price achieved is the end result of a negotiation process, which lies in sharp contrast to exchange traded derivatives where prices are determined by supply and demand in a very liquid market. As a negotiation both parties will try

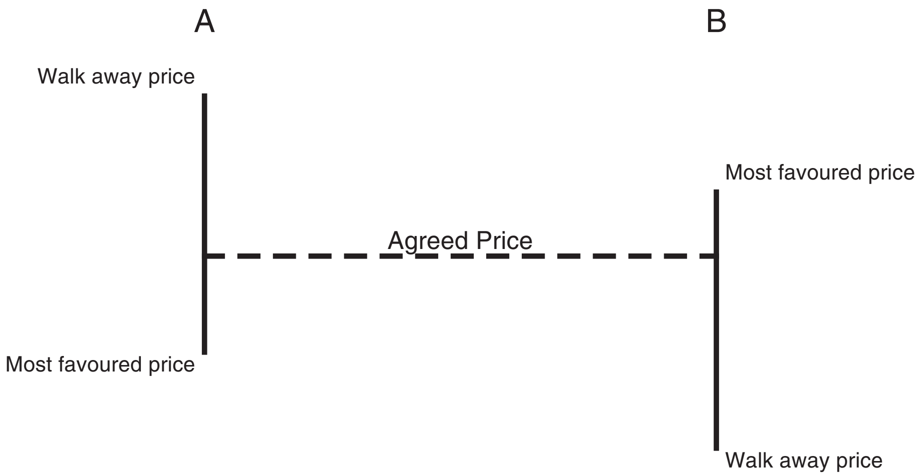

FIGURE 1.2 A diagram of a price negotiation between two parties A and B. Both parties have a *most favoured price* that they would ideally like to transact at and a *walk way price* below which they will not trade. The agreed price must lie between the most favoured price and walk away price of both parties. If these ranges do not overlap then no agreement is possible.

to reach an agreed price that satisfies the needs and expectations of both parties. Figure 1.2 illustrates the negotiation process.

It should be clear that:

$$Price \neq Value$$

What is a Derivative Valuation? A valuation is a numerical measure of the worth of a contract. The *law of one price* suggests that there is just one valuation for a derivative; in reality this is not the case and different agents have different measures of worth in different contexts. Here I consider three valuations, but the list is not exhaustive:

- Accounting valuation
- Trading valuation
- Regulatory valuation.

There is nothing new here and bond traders, for example, have used the concept of relative value for many years. Before the crisis these different valuations generally coincided for unsecured derivatives as bank credit spreads were narrow and funding costs were negligible. The credit crisis drove the valuations apart and it is unlikely they will ever coincide again for unsecured derivatives. Valuation, even of simple products, has become a challenge.

Accounting valuations Accounting valuations aim to provide an objective measure of the value of assets and liabilities on the balance sheet. Accounting valuation methodology is driven by

- Accounting standards (FSB, IFRS)
- Accounting principles (e.g. GAAP)
- Company law.

Sometimes these can be in conflict when market practice changes and it can take some time for these to be reflected back into accounting standards.

Trading valuations These provide a valuation measure that reflects all of the risk factors that the derivative is currently understood to be subject to. The valuation, and more importantly, the associated sensitivities, provide the means by which the trader can make appropriate risk management decisions in order to maintain the value of a book of derivative transactions exposed to market volatility. The trader is charged with risk management to fulfil a duty to shareholders and other stakeholders. There is no requirement for objectivity in valuation as the risk factors can be a function of the institution itself.

Regulatory valuations Regulatory valuations are those used by the regulator to define capital requirements. Regulatory valuations are increasingly becoming distinct from accounting valuations. For example, the regulator has disallowed DVA as a contributor to capital (BCBS, 2011a) and while this does not directly impact the valuation of individual trades it has affected the effective book valuation. The forthcoming *Prudent Valuation* regime (EBA, 2012; EBA, 2013a; EBA, 2014c) will require banks to calculate *Additional Valuation Adjustments (AVA)* to adjust the value of a trade down to that based on a the 90% confidence level, given market price uncertainty. The adjusted value will be that used for regulatory capital purposes.

1.4.3 Summary: The *Valuation Paradigm Shift*

Different agents have different perspectives and drivers and the valuations they use will reflect this. Derivative pricing reflects manufacturing costs and these costs include CVA, FVA, MVA, KVA and TVA. Representatives of companies, including banks, are required to operate on a going concern basis and to factor in the management of all visible risk factors into valuations. *Realism* is an important element of trading valuations that have to reflect the actual cost of manufacturing derivatives. Derivative valuation theory is not invalid but has been shown to be out of date and hence needs to be updated to reflect market reality. This book aims to provide the required update.

1.5 READING THIS BOOK

This book can be read in two ways. Firstly it can be read as a *manifesto* for the change in derivative valuation and the move away from the pure Black-Scholes-Merton framework. This is a controversial topic and will no doubt remain so for some time. The book can also be read as a practical guide to the calculation of valuation adjustments and it is therefore up to the reader what model elements are selected from those discussed.

The book is organised into five main parts. Part I discusses models for counterparty credit risk and CVA, while Part II discusses FVA models as an extension to CVA model. The regulatory capital framework and KVA model are introduced in Part III. The implementation of XVA models is discussed in part IV and this section of the book is aimed to be a practical guide for those who are building bespoke internal models as well as those who may be buying third-party systems. Finally Part V discusses the management of XVA principally through active hedging programmes.