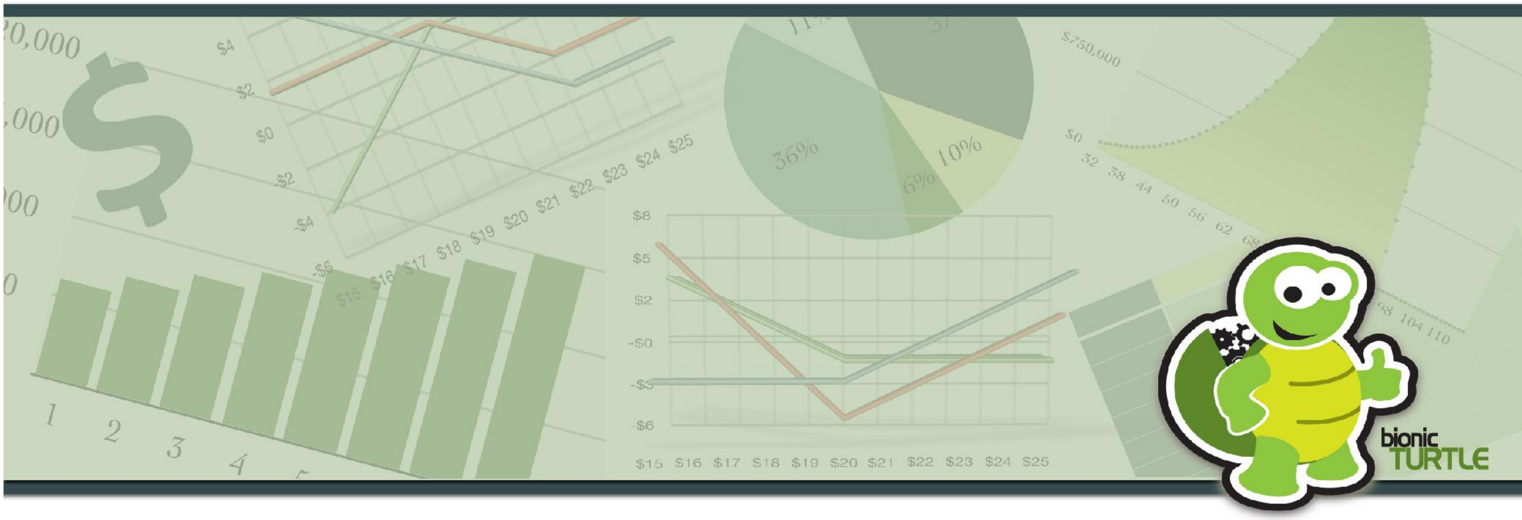

P2.T6. Credit Risk Measurement & Management

Jon Gregory, Counterparty Credit Risk and Credit Value Adjustment: A Continuing Challenge for Global Financial Markets, 2nd Edition

Bionic Turtle FRM Study Notes
Reading 45

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Gregory, Chapter 3: Defining Counterparty Credit Risk

Define counterparty risk and explain how it differs from lending risk.

Describe transactions that carry counterparty risk and explain how counterparty risk can arise in each transaction.

Identify and describe institutions that take on significant counterparty risk.

Describe credit exposure, credit migration, recovery, mark-to-market, replacement cost, default probability, loss given default and the recovery rate.

Identify and describe the different ways institutions can manage and mitigate counterparty risk.

Define counterparty risk and explain how it differs from lending risk.

Lending risk is the traditional credit risk: one party borrows and owes money to another party but may fail to pay some (or all) of the amount owed.

Lending risk has two features:

- **Principal at risk is easily quantified**: The principal amount at risk is known with some degree of certainty. For example, it is not difficult to estimate the exposure of a loan that has a principal balance outstanding. Market variables (e.g., interest rates) will typically contribute only moderate uncertainty to this known amount.
- **Unilateral**: Only one party takes lending risk. A bondholder takes considerable credit risk but an issuer of a bond does not face a loss if the buyer of the bond defaults. This point does not follow for most derivatives contracts.

Counterparty risk differs from lending risk in two ways:

- **The value of the derivatives contract in the future is uncertain**; in most cases, it is non-trivial to ascertain the value. This future value can be positive or negative and is typically highly uncertain (as seen from today).
- **Bilateral**: Since the value of a derivatives contract can be positive or negative, counterparty risk is typically bilateral. In other words, in a derivatives transaction, each counterparty has risk to the other. This bilateral nature of counterparty risk has been a particularly important feature of the recent credit crisis.

"The primary distinguishing feature of counterparty risk compared with other forms of credit risk is that the value of the underlying contract in the future is uncertain, both in magnitude and in sign!" – Jon Gregory

Describe transactions that carry counterparty risk and explain how counterparty risk can arise in each transaction.

Counterparty risk typically arises, not from exchange-traded derivatives, but rather from two classes of financial products: over the counter (OTC) derivatives and securities financing transactions (including repos). Specifically,

- **Exchange-traded derivatives:** When trading a futures contract (a typical exchange-traded derivative), the counterparty to the contract typically is the actual exchange. The exchange guarantees the contract performance and mitigates, if not eliminates, counterparty risk (a clearing role normally is attached to the exchange). Derivatives traded on an exchange are often considered to have no counterparty risk since the only aspect of concern is the solvency of the exchange itself.
- **OTC derivatives:** Due to the need for customization (lower basis risk), a much greater notional amount of derivatives are traded OTC. **OTC derivatives trade bilaterally** between two parties with each assuming counterparty risk to the other.
    - Interest rate products (e.g., interest rate swaps) constitute the majority of outstanding notional
    - The exposure of derivative products is substantially smaller than their gross notional. For example, the total market value of interest rate contracts is only 3.1% of the total notional outstanding (as of December 2010)
- **Repos**: Many institutions use standard sale and repurchase agreements ("repos") as a liquidity management tool to swap cash against collateral for a pre-defined period. The lender of cash is paid a "repo rate;" i.e., the interest rate on the transaction plus any counterparty risk charge. The collateral tends to be liquid securities, of stable value, with a haircut applied to mitigate the counterparty risk.

Settlement and pre-settlement risk

Counterparty risk is mainly associated with pre-settlement risk: the risk of counterparty default prior to expiration (settlement) of the contract**. However, we should also consider settlement risk; i.e., the risk of counterparty default during settlement process**.

- **Pre-settlement risk (a.k.a., counterparty risk)**: the risk that a counterparty will default prior to the final settlement of the transaction (at expiration). "Counterparty risk" usually refers to this risk.
- **Settlement risk**. This arises at final settlement if there are timing differences between when each party performs on its obligations under the contract.

Identify institutions that take on significant counterparty risk.

The range of institutions that take significant counterparty risk has changed dramatically over recent years. We can characterize these institutions generally:

Large derivatives player

- Typically a large bank, often known as a dealer
- Many OTC derivatives trades on books. Trades with many clients and large players
- Coverage of all or many different asset classes (interest rate, foreign exchange, equity, commodities, credit derivatives)
- Will post collateral against positions

Medium derivatives player

- Typically a smaller bank or other financial institution; e.g., hedge fund, pension fund
- Many OTC derivatives trades on books
- Trades with relatively large number of clients
- Will cover several asset classes although may not be active in all of them (may, for example, not trade credit derivatives or commodities and will probably not deal with the more exotic derivatives)
- Will probably post collateral against positions with some exceptions

Small derivatives player

- Typically a large corporate or sovereign with significant derivatives requirements; e.g., for hedging needs or investment) or a small financial institution
- Will have a few OTC derivatives trades on their books
- Will trade with potentially only a few different counterparties
- May specialize in a single asset class (e.g., , some corporates trade only foreign exchange products, a mining company may trade only commodity forwards, a pension fund may only be active in interest rate and inflation products);
- Typically unable to commit to posting collateral or will post illiquid collateral.

Third parties.

- For example, offer collateral management, software, trade compression and clearing services.
- They allow market participants to reduce counterparty risk, the risks associated with counterparty risk (such as legal) and improve overall operational efficiency with respect to these aspects

The Global Financial Crisis (GFC) exposed latent counterparty risk

Historically, large derivatives players had stronger credit quality than other market participants. However, even some small players (e.g., sovereigns, insurance companies) had AAA-rated credit quality and used this to obtain favorable terms such as one-way collateral agreements.

- Prior to 2007 (the onset of the global financial crisis), **much counterparty risk was essentially ignored** because large derivatives players or AAA-rated entities were assumed default free: the credit spreads of large, highly-rated financial institutions was just a few basis points per annum.
- However, the presumption of little counterparty risk was revealed to be a “myth” when the reality of unilateral and bilateral counterparty risk was recognized. Currently, all institutions facing counterparty risk must take it seriously and build their abilities in quantification, pricing and hedging aspects.

Describe credit exposure, credit migration, recovery, mark-to-market, replacement cost, default probability, loss given default and the recovery rate.

Credit exposure

Credit exposure is the loss in the event that the counterparty defaults.

- Credit exposure is characterized by the fact that a positive value of a financial instrument corresponds to a claim on a defaulted counterparty.
- If an institution is owed money and their counterparty defaults then they will incur a loss, but in the reverse situation they cannot gain from the default by being somehow released from their liability.

Credit exposure is a time-sensitive measure because the counterparty can default at any time in the future, including many years from today. **Derivatives do not put a full principal amount at risk, but rather only a replacement cost.**

A measure of exposure should encompass the risk arising from actual claims (current claims and those a financial institution is committed to provide), potential claims (possible future claims) as well as contingent liabilities. Therefore, to characterize exposure we need to answer two questions:

- What is the current exposure (the maximum loss if the counterparty defaults now)?
- What is the exposure in the future (what could be the loss if the counterparty defaults at some point in the future)? *This second question is far more complex to answer*

Key points about credit exposure:

- Exposure is the loss--as defined by the value or replacement cost—that would be incurred assuming zero recovery value.
- Exposure is conditional on counterparty default
- Exposure is relevant only if the counterparty defaults and hence the quantification of exposure should be ‘‘conditioned’’ upon this event

All exposure calculations, by convention, will ignore any recovery value in the event of a default; i.e., exposure is gross of (excludes) recovery.

Credit migration and default probability

To assess counterparty risk, we must consider a counterparty's credit quality over the lifetime of the transaction, which *can be an extremely long time horizon*. Two considerations:

- What is the probability of the counterparty **defaulting** in a certain time horizon?
- What is the probability of the counterparty **suffering a decline in credit quality** over a certain time horizon; e.g., a ratings downgrade?

Credit migrations or discrete changes in credit quality (e.g., due to ratings changes) are crucial because they influence the term structure of default probability. Suppose the probability of default of the counterparty between the current time and a future date of (say) 1 year is known. It is also important to consider what the same annual default rate might be in 4 years; i.e., the probability of default between 4 and 5 years in the future.

There are three important aspects of default probability:

- Future default probability *tends to decrease* due to the chance that the default may occur before the start of the period in question.
- For example, the probability of a counterparty defaulting between 20 and 21 years in the future is small, not because the counterparty is credit-worthy, but rather because survival over 20 years is remote.
- A counterparty with an expectation of ***deterioration*** (***improvement***) in credit quality will have an ***increasing*** (***decreasing***) probability of default over time

Recovery

In the event of a bankruptcy, the holders of OTC derivatives contracts with the counterparty in default would normally be *pari passu* with the senior bondholders. Therefore, recovery rates (a percentage of the outstanding claim recovered) can sometimes be reasonably high. Traditionally, **credit exposure is measured gross of any recovery** (worst case estimate).

- Related, loss given default (LGD) is linked to recovery rate on a unit amount by the simple formula: **loss given default (LGD) = 1 – recovery rate (R)**

Pari passu is a standard legal clause in public or private international unsecured debt obligations which, in Latin means "with equal step." In this way, ***pari passu*** refers to things that have the same rank or rank equally.

Mark-to-market

The mark-to-market (MtM) value, with respect to a particular counterparty, defines what could be potentially lost today.

- **Current MtM does not constitute an immediate liability by one party to the other but rather is the present value of all the payments an institution is expecting to receive less those it is obliged to make**. These payments may be scheduled to occur many years in the future and may have values that are strongly dependent on market variables. MtM may therefore be positive or negative
- Mark-to-market (MtM) is the sum of the MtM of all the contracts with the counterparty in question. But this depends on the ability to net the trades in the event of default.
- Risk-free MtM is closely related to replacement cost, which defines the entry point into an equivalent transaction(s) with another counterparty. For simplicity, models tend to assume the two are the same. However, the situation is more complicated.

Replacement cost

Replacement cost is closely related to the mark-to-market (MtM) value, but will not be the same. To replace a transaction, we must consider costs such as bid–offer spreads, which may be significant for highly illiquid securities. But such additional costs are better treated as liquidity risk. Hence, from a counterparty risk perspective, it is standard practice to base exposure on the current MtM value of a transaction or transactions.

Loss given default and Recovery rate

Recovery rates typically represent the percentage of the outstanding claim recovered when counterparty defaults. An associated variable to recovery is loss given default (LGD), which is linked to recovery rate on a unit amount by the simple relationship:

Loss given default (LGD) = 1 – recovery rate (RR)

Identify and describe the different ways institutions can manage and mitigate counterparty risk.

The ways an institution can mitigate (and manage) counterparty risk include:

- **Netting**. The ability to (legally) offset positive and negative contract values with the same counterparty, in the event of their default
  - However, netting creates legal risk in cases where a netting agreement cannot be legally enforced in a particular jurisdiction.
- **Collateral**. Holding cash or securities against an exposure can clearly reduce that exposure.
  - However, collateral leads to operational and liquidity risks through the necessity to run a complex collateral management function. Indeed, many counterparties cannot agree to collateral terms due to these risks and their inability to handle them effectively.
- **Central counterparties**. During crises, a centralized clearing house seems to offer an almost "magic bullet" solution to the problem of counterparty risk because **counterparties would simply trade with one another through the clearing house that would effectively act as guarantor to all trades**. All OTC derivatives traded through a clearing house would then be free of counterparty risk
  - But clearing houses create moral hazard problems that may lead to the creation of subtle long-term risks
  - They create operational and liquidity risks and systemic risk since the failure of a central counterparty could amount to a significant systemic disturbance
- **Hedging**. Hedging clearly has the aim of reducing counterparty risk but may lead to additional market risks through the mark-to-market volatility of the hedging instruments.
- Also, of course, the **traditional** methods:
  - Trade with **high-quality counterparties:** Traditionally the easiest way to mitigate counterparty risk was to trade only with entities of very strong credit quality. Larger dealers within the derivatives market have needed strong credit ratings and some institutions, such as monoline insurers, have made use of triple-A ratings to argue that they represent a negligible counterparty risk and furthermore avoid the need to post collateral. Institutions have set up bankruptcy-remote entities (swap subsidiaries) and special purpose vehicles (SPVs) that can attain triple-A ratings better than the institution itself
  - **Diversification**: By trading with a greater number of counterparties, an institution is not so exposed to the failure of any one of them. Diversification is not always practical due to the relationship benefits from trading with certain key clients. In such cases, credit exposures can become excessively large and must be mitigated by other means.

Chapter Summary

- Credit exposure (a.k.a., exposure) is the loss conditional on counterparty default
  - Exposure, with respect to a counterparty, exists for an institution when the position has positive value: if the position has positive value to the institution (i.e., the counterparty owes the institution), the institution incurs a loss upon the counterparty's default
  - Exposure calculations, by convention, ignore recovery; i.e., are gross of estimated recovery
- Counterparty risk includes the risk of credit deterioration, in addition to default probability
- Loss given default (LGD) = 1 – recovery rate
- Current mark-to-market (MtM) is the present value of all the (future) payments an institution is expecting to receive less those it is obliged to make
  - MtM does not constitute an immediate liability by one party to the other but rather defines what could be potentially lost (or gained) today, in present value term.
  - Unlike credit exposure which is positive, as credit exposure = MAX(MtM,0), MtM may be positive or negative:

Questions & Answers

1. Consider the following five assertions concerning the key difference(s) between lending risk and counterparty risk:

I. **Lending risk is a type of credit risk, but counterparty risk is a type of market risk**
II. **Lending exposure is somewhat predictable, but counterparty credit exposure is highly uncertain**
III. **Lending risk is unilateral, but counterparty risk is bilateral**
IV. **Lending risk arises due to an obligor's inability to meet a contractual obligation, but counterparty risk arises due to market variables**
V. **Lending risk cannot be easily quantified, but counterparty risk is amenable to a straightforward and conventional quantification**

According to Gregory, which of the above is (are) true in regard to difference(s) between lending and counterparty risk?

a) None are true
b) Only II. and III are true.
c) I., II. and V. are true.
d) All are true

2. Each of the following statements is true about credit exposure EXCEPT which is false?

a) Credit exposure defines the loss in the event of a counterparty default
b) Credit exposure does not assume counterparty default; i.e., is not conditional on default
c) Credit exposure includes the risk from current (actual) claims
d) Credit exposure includes the risk from possible future (potential) claims

3. A bank has a position in an over the counter (OTC) derivatives contract with a counterparty. The current mark-to-market (MtM) value of the bank's position is +$4.0 million, but the position is highly illiquid. There is no collateral or margin involved and the net counterparty risk happens to be zero: that is, the net CVA adjustment is zero. If the counterparty defaults, the bank expects a recovery rate of 35%. Which of the following most is the best estimate of the bank's position's replacement cost?

a) Replacement cost is about $1.4 million
b) Replacement cost is about $2.6 million
c) Replacement cost is less than $4.0 million
d) Replacement cost is more than $4.0 million

4. A Bank has multiple positions (transactions) in various bilateral derivatives contracts with the same Counterparty XYZ. Between them, they do have a legally binding bilateral netting agreement. From the Bank's perspective, the sum of transactions with positive values (i.e., Counterparty XYZ owes money to the Bank on a mark-to-market basis) is +$7.0 million. The sum of those with negative values (Counterparty XYZ is owed money by the Bank on a mark-to-market basis) is -$5.0 million. Compared to the Banks exposure without netting, what is the reduction in exposure due to netting; i.e., the exposure gain achieved due to the netting?

a) $1.0 million
b) $2.0 million
c) $5.0 million
d) $7.0 million

5. Traditional counterparty credit risk management depends on credit lines, but a more sophisticated approach employs a credit value adjustment (CVA). According to Gregory, which is the key advantage of CVA over a credit line?

a) CVA can include potential future exposure (PFE), but credit lines cannot incorporate PFE
b) CVA incorporates a portfolio perspective, but credit lines are not portfolio credit risk management
c) CVA enables transaction decisions based on profitability, not simply exposure
d) CVA includes default probability, recovery, and correlation between counterparties; but credit lines cannot

Answers:

1. B. Only II and III are true.

- In regard to I., both lending risk and counterparty risk are types of credit risk (although counterparty risk is far more susceptible to market variables)
- In regard to IV., as both are credit risks, both arise due to an obligor's inability to meet a contractual obligation.
- In regard to V., both can be quantified, but counterparty risk is more difficult due to its uncertain and bilateral nature.

Gregory: **"Lending risk is characterised by two key aspects:**

- The notional amount at risk at any time during the lending period is usually known with a degree of certainty. Market variables such as interest rates will typically create only moderate uncertainty in this amount. For example, in buying a fixed coupon bond with a par value of $1,000, the notional amount at risk for the life of the bond is close to $1,000. A repayment mortgage will amortise over time (the notional drops due to the repayments) but one can predict with good accuracy the outstanding balance at some future date. A loan or credit card may have a certain maximum usage facility, which may reasonably be assumed to be fully drawn for the purpose of credit risk.
- Only one party takes lending risk. A bondholder takes considerable credit risk but an issuer of a bond does not face a loss if the buyer of the bond defaults. This point does not follow for most derivatives contracts.

With counterparty risk, as with all credit risk, the cause of a loss is the obligor being unable or unwilling to meet contractual obligations. However, two aspects differentiate counterparty risk from traditional credit risk:

- The value of a derivatives contract in the future is uncertain, in most cases significantly so. The value of a derivative at a potential default date will be the net value of all future cash flows to be made under that contract. This future value can be positive or negative and is typically highly uncertain (as seen from today).
- Since the value of a derivatives contract can be positive or negative, counterparty risk is typically bilateral. In other words, in a derivatives transaction, each counterparty has risk to the other. This bilateral nature of counterparty risk has been a particularly important feature of the recent credit crisis.

The primary distinguishing feature of counterparty risk compared with other forms of credit risk is that the value of the underlying contract in the future is uncertain, both in magnitude and in sign!"

2. B. Credit exposure (aka, exposure) is the general term which encompasses current and potential future exposure and it necessarily conditional on counterparty default

Gregory: "Finally, a very important point: Exposure is conditional on counterparty default. Exposure is relevant only if the counterparty defaults and hence the quantification of exposure should be "conditioned" upon this event; i.e., What is the exposure in 1 year assuming the counterparty will default in 1 year? What is the exposure in 2 years assuming the counterparty will default in 2 years? And so on."

- In regard to (A), this is true: "Credit exposure (hereafter often simply known as exposure) defines the loss in the event of a counterparty defaulting. Exposure is characterized by the fact that a positive value of a financial instrument corresponds to a claim on a defaulted counterparty, whereas in the event of negative value, an institution is still obliged to honor their contractual payments (at least to the extent that they exceed those of the defaulted counterparty). This means that if an institution is owed money and their counterparty defaults then they will incur a loss, whilst in the reverse situation they cannot gain from the default by being somehow released from their liability."
- In regard to (C) and (D), this is true: "[Credit] Exposure is clearly a very time-sensitive measure since a counterparty can default at any time in the future and one must consider the impact of such an event many years from now. Exposure is needed in the analysis of counterparty risk since, for many financial instruments (notably derivatives), the creditor is not at risk for the full principal amount of the trade but only the replacement cost. A measure of exposure should encompass the risk arising from actual claims (current claims and those a financial institution is committed to provide), potential claims (possible future claims) as well as contingent liabilities. Essentially, characterizing exposure involves answering the following two questions: What is the current exposure (the maximum loss if the counterparty defaults today)? What is the exposure in the future (what could be the loss if the counterparty defaults at some point in the future)? The second point above is naturally far more complex to answer than the first, except in some simple cases. We emphasize that all exposure calculations, by convention, will ignore any recovery value in the event of a default. Hence, the exposure is the loss, as defined by the value or replacement cost that would be incurred assuming zero recovery value."

3. D. Replacement cost is more than $4.0 million
Replacement cost is approximated by the mark-to-market (MtM). Here, because the net CVA is zero, the adjusted MtM (after CVA adjustment) is $4.0 million. However, replacement cost in this case is likely to be higher than MtM due to the highly illiquid position.

Gregory: "The mark-to-market (MtM) with respect to a particular counterparty defines what could be potentially lost today. However, this is dependent on the ability to net the trades in the event the counterparty defaults. Furthermore, other aspects that will reduce the exposure in the event of default, such as collateral legally held against the contracts and possibly hedges, must be considered.

Current MtM does not constitute an immediate liability by one party to the other but rather is the present value of all the payments an institution is expecting to receive, less those it is obliged to make. These payments may be scheduled to occur many years in the future and may have values that are strongly dependent on market variables. MtM may therefore be positive or negative, depending on whether a transaction is in an institution's favor or not.

Contractual features of transactions, such as closeout netting and termination features, refer to replacement costs. Risk-free MtM is clearly closely related to replacement cost, which defines the entry point into an equivalent transaction(s) with another counterparty. Models tend to assume, for reasons of simplicity, that the two are the same. However, the actual situation is more complicated.

The replacement cost of a transaction, whilst closely coupled to the MtM value of a transaction, will not be the same. To replace a transaction, one must consider costs such as bid–offer spreads, which may be significant for highly illiquid securities. Note that even a standard and liquid contract might be non-standard and illiquid at the default time. In such a case, one must then decide whether to replace with an expensive non-standard derivative or with a more standard one that does not match precisely the original one. Documentation suggests that such cost can essentially be passed on via the replacement cost concept, therefore ignoring transaction costs when quantifying counterparty risk seems reasonable."

4. C. $5.0 million

- Without netting, the Bank's exposure is $7.0 million.
- With netting, the Bank's exposure is MAX(0, 7 - 5) = $2.0 million. The gain due to netting = $7.0 - 2.0 = $5.0 million.

5. C. CVA enables transaction decisions based on profitability, not simply exposure
Gregory: "By pricing counterparty risk, one can move beyond a binary decision-making process. The question of whether to do a transaction becomes simply whether or not it is profitable once the counterparty risk component has been ''priced in''. As we will show in Chapter 7, the risky price of a derivative can be thought of as the risk-free price (the price assuming no counterparty risk) less a component to correct for counterparty risk. The latter component is often called CVA (credit value adjustment). As long as one can make more profit than the CVA, then the transaction is a good one. This counterparty risk charge should be calculated in a sophisticated way to account for all the aspects that will define the CVA: the default probability of the counterparty; the default probability of the institution; the transaction in question; netting of existing transactions with the same counterparty; collateralization; hedging aspects."

In regard to (A), (B), and (D), each is FALSE

Gregory, Chapter 4: Netting, Compression, Resets, and Termination Features

Explain the purpose of an ISDA master agreement.

Summarize netting and close-out procedures (including multilateral netting), explain their advantages and disadvantages, and describe how they fit into the framework of the ISDA master agreement.

Describe the effectiveness of netting in reducing credit exposure under various scenarios.

Describe the mechanics of termination provisions and explain their advantages and disadvantages.

The primary methods to mitigate counterpart risk are:

- **Default-remote entities**: Although "laughable" recently, a simple method to mitigate risk is to trade with a vehicle that has a small probability of underlying default.
- **Termination events**: the opportunity to terminate a transaction at some point(s) between inception and the maturity date. It may exist as an option or be conditional on certain conditions being met (ratings downgrade, for example).
- **Netting**: the ability to offset all transactions (both in an institution's favor and against it) when a counterparty is in default.
- **Close-out**: this allows the termination of all contracts between the insolvent and a solvent counterparty without waiting for the bankruptcy to be finalized (which can take many years)
- **Collateralization**: An agreement that cash or securities will be ''posted'' as a guarantee against an exposure according to pre-defined parameters.

Two-way or one-way agreements

Each of the mitigants may be employed unilaterally or bilaterally (with the exception of default-remote entities).

- A bilateral arrangement can be useful in allowing both parties to mitigate current and potential future exposure.
- But "risk mitigation is not always a two-way street:" in the case of a large difference in credit quality of two parties, the better quality party may demand strong mitigants highly skewed in their favor such as one-way collateral agreements and independent amounts.
- For example, monoline insurers have based their entire business model on skewed risk mitigation in that their triple-A status supports the fact that they will not agree to post collateral.
- However, events such as the bankruptcy of Lehman Brothers and failure of monoline insurers are reminders that the justification for one-way risk mitigation may not be always valid.

Explain the purpose of an ISDA master agreement (MA).

The ISDA Master Agreement

The International Swaps and Derivatives Association (ISDA) is a trade organization for OTC derivatives practitioners. Central to the ISDA approach to netting is the concept of a Master Agreement that governs transactions between counterparties.

- The ISDA Master Agreement is a bilateral framework
- The Master Agreement (MA) is designed to eliminate legal uncertainties and to provide mechanisms for mitigating counterparty risk.
- The Master Agreement (MA) specifies the general terms of the agreement between counterparties with respect to general questions such as netting, collateral, definition of default and other termination events, documentation and so on.
- Multiple individual transactions can be subsumed under this general Master Agreement to form a single legal contract of indefinite term, under which the counterparties trade with one another. Individual transactions are incorporated by reference in the trade confirmation to the relevant Master Agreement. Placing individual transactions under a single Master Agreement that provides for netting is intended to avoid any problems netting agreements may encounter under differing treatments of bankruptcy.
- Netting legislation covering derivatives has been adopted in most countries with major financial markets. ISDA has obtained legal opinions supporting their Master Agreements in most relevant jurisdictions.

Describe netting and close-out procedures (including multilateral netting), explain their advantages and disadvantages, and describe how they fit into the framework of the ISDA master agreement.

The critical role of netting

Imagine a bank has two positions with the same counterparty. Further, the positions happen to have equal and opposite values: from the bank's perspective, Trade 1 has a market to market (MtM) value of +10 and Trade 2 has a MtM value of -10. In other words, Trade 1 is "in the money" with an MtM gain and Trade 2 is "out of the money" with an MtM loss. Now let's **assume the counterparty defaults**:

- **Without netting**, the bank's exposure is +10 because that is the sum of the value(s) of the transaction(s) that have positive MtM value. The position with a negative value (-10) will nevertheless need to be settled (paid to the defaulted counterparty) but the positive value (+10) will represent a claim in the bankruptcy process. If the two transactions are not netted, the bank's -10 loss does not "offset" its +10 gain.
- **With netting**, upon default by the counterparty, the bank can terminate both (all) contracts. Consequently, its exposure is the sum of MtM values, positive and negative. In this case, with netting, the exposure is +10 – 10 = 0.

Payment and close-out netting

There are two distinct types of netting used widely in the derivatives market:

- **Payment netting**. This covers a situation when an institution will have to make and receive more than one payment during a given day. Payment netting means that they agree to combine those cashflows into a single net payment. Payment netting reduces settlement risk and enhances operational efficiency.
- **Close-out netting**. This form of netting is most relevant to counterparty risk since it reduces pre-settlement risk. It covers the netting of the value of contracts in the event of a counterparty defaulting at some date in the future.

Close-out netting

In most business relations, netting (a.k.a.., set-off) is not a significant issue. Generally, an institution either buys from or sells to another firm, but rarely does both simultaneously. Therefore, in the event of bankruptcy, few if any contracts could be netted or set off. However, derivatives markets often generate large numbers of bidirectional transactions between counterparties.

Close-out and netting consist of two separate but related rights, often combined into a single contract:

- **Close-out**: The right of a counterparty to terminate contracts unilaterally under certain specified conditions (close-out).
- **Netting**: The right to offset amounts due at termination of individual contracts between the same counterparties when determining the final obligation.

Bankruptcy proceedings are by their nature long and unpredictable processes. During such proceedings, likely counterparty risk losses are compounded by the uncertainty regarding the termination of proceedings. A creditor who holds an insolvent firm's debt has a known exposure, and while the eventual recovery is uncertain, it can be estimated and capped. However, this is not the case for derivatives where constant rebalancing is typically required to maintain hedged positions. Once a counterparty is in default, cash flows will cease and an institution will be likely to want or need to execute new replacement contracts. Furthermore, netted positions are inherently more volatile than their underlying gross positions and require continuous monitoring and management

Netting agreement

A netting agreement is a legal agreement that comes into force in the event of a bankruptcy. It enables one to net the value of trades with a defaulted counterparty before settling the claims. As such, netting agreements are crucial in order to recognize the benefit of offsetting trades with a defaulted counterparty.

A ''netting set'' is a set of trades that can be legally netted together in the event of a default. A netting set may be a single trade and there may be more than one netting set for a given counterparty. Across netting sets, exposure will then always be additive, whereas within a netting set MtM values can be added.

Netting agreement: a simple example

Consider a counterparty with which there are many derivatives transactions. The sum of those with positive values (the counterparty owes money on a mark-to-market basis) is +$10. The sum of those with negative values (the counterparty is owed money on a mark-to market basis) is -$9m. The loss (without accounting for recovery) will then be $10m without netting and $1m with netting. Furthermore, consider the position from the counterparty's point of view. The sum of trades with positive values is +$9m and of those with negative values is $10m. The loss (without accounting for recovery) will then be $9 with no netting and zero with netting.

	Institution	Counterparty
Trades with positive MtM	+ 10	-10
Trades with negative MtM	- 9	+9
Exposure (no netting)	+10	+9
Exposure (netting)	+1	Zero

Netting allows counterparties to reduce the risk to each other via signing a legal agreement that becomes active if either of them defaults. Some institutions trade many financial products and the ability to apply netting to most or all of these products is desirable in order to reduce exposure.

However, netting gives preferential benefit to derivatives counterparties at the expense of other creditors (e.g., bondholders and shareholders). Shareholders and bondholders could argue that this adversely influences their position due to the increase in default probability and reduction of recovery potentially caused by sizeable derivatives exposure.

- Legal issues regarding the enforceability of netting arise due to trades being booked with various different legal entities across different regions. The legal and other operational risks introduced by netting should not be ignored.

Advantages and disadvantages of netting

	Advantage	Disadvantage
Exposure reduction	By combining two offsetting contracts under the same Master Agreement, parties only need to manage their net positions. Since positions may often offset one another to some degree (especially hedges), this **reduces risk and saves on operational aspects**.	Although exposure is dramatically reduced, resulting exposures may be **highly volatile** (on a relative basis) making the control of **exposure more complex.**
Unwinding positions	Unlike OTC derivatives (which are often illiquid and not readily tradable), an institution can easily execute an offsetting position with another market participant. Netting means that executing the reverse position with the original counterparty **offsets not only the market risk but also the counterparty risk**. Hence, any risk should be completely eradicated and collateral associated with the initial position is no longer required.	By offsetting, they will have **counterparty risk with respect to both the original and the new counterparty**. Collateral may need to be posted to one counterparty and, although it may be received from the other, mismatches and operation burden will be present. Further, a counterparty who knows that an institution is heavily incentivized to trade out of the position may offer unfavorable terms to extract maximum financial gain.
Multiple positions	When executing multiple, uncorrelated positions, an institution may obtain more favorable terms and reduced collateral requirements. Suppose an institution wants both interest rate and foreign exchange hedges. As these trades are imperfectly correlated, executing hedges with the same counterparty, the overall counterparty risk is reduced.	
Stability	How market participant react to perceptions of counterparty risk: If credit exposures were driven by *gross positions* then the troubled counterparty's trading partners are incented to terminate existing positions; such actions would exacerbate its financial distress But with netting, partners will be far less worried if there is no current exposure (MtM is negative).	

Close-out

Close-out involves the termination of all contracts between the solvent and insolvent counterparty. Termination cancels the contract and creates a claim for compensation based on the cost of replacing the contract on identical terms with another (solvent) counterparty.

- Upon default (or a contractually agreed event), the net value due is determined by marking-to-market (MtM) the contracts and calculating the total netted value.
- ***If the solvent party has a negative MtM***, they are in debt to their counterparty and the full payment is made to the insolvent counterparty or their trustee (assuming there is no walkaway-type agreement).
- ***If the solvent party has an overall exposure (positive MtM)***, then they become a creditor for this net amount. The calculations made by the surviving party may be later disputed via litigation. However, the prospect of a valuation dispute does not affect the ability of the surviving party to immediately terminate and replace the contracts with a different counterparty.

Close-out netting allows the surviving institution to immediately realize gains on transactions against losses on other transactions and effectively jump the bankruptcy queue for all but its net exposure. This offers strong protection to the institution at the expense of the defaulted counterparty and its other creditors.

Close-out protects surviving institutions

Close-out aims to protect the surviving institution rather than their distressed counterparty. As termination can exacerbate financial difficulties, some jurisdictions limit the rights of counterparties to enforce the termination clauses in their contracts. The court can impose a stay, which does not invalidate termination clauses in contracts but rather overrides them, perhaps temporarily, at the discretion of the court. Staying contracts establishes a ‘‘time-out’’ while keeping the contracts in force with normal payments being still due.

Close-out limits uncertainty of value of positions

Close-out also limits the uncertainty that an institution has with respect to the value of their positions with a defaulted counterparty. Suppose Big Bank has offsetting trades with different counterparties. Then one goes into default. Without close-out, Big Bank would not know to what extent the positions offset one another since it would not be clear what fraction of the exposure to the defaulted counterparty would be recovered. Hence, the percentage of the transaction that needs to be re-hedged is unclear. Close-out means that Big Bank can fully re-hedge the transaction with the defaulted counterparty and wait to receive a claim on their exposure at the default time. There is likely to be a counterparty risk loss (unless recovery is 100%), but there will not be additional market risk and trading uncertainty on top of this.

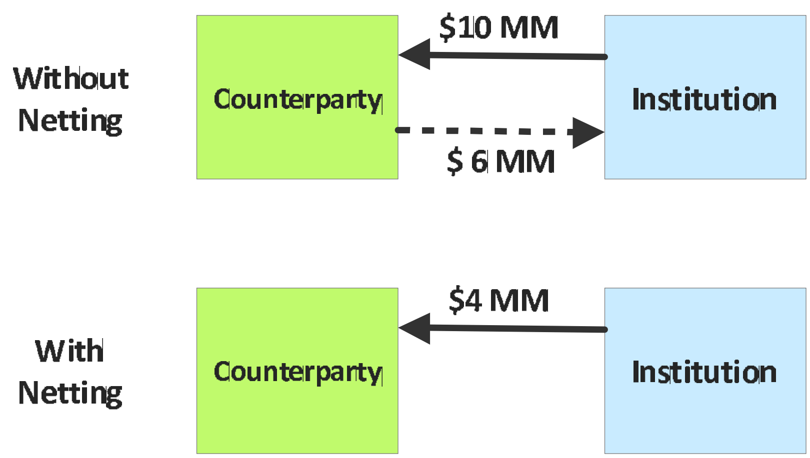
Close-out allows participants to freeze their exposures

Close-out permits derivatives market participants to freeze their exposures in the event of the failure of a counterparty or other event of default stipulated in their Master Agreement. Without the ability to close out their positions at the time a counterparty becomes insolvent, market participants would find themselves locked into contracts that fluctuate in value and are impossible to hedge (due to the uncertainty of future recovery).

Describe the effectiveness of netting in reducing credit exposure under various scenarios.

Illustration of the benefit of closeout netting.

- Without netting, the institution must pay $10.0 million to the defaulted counterparty whilst losing some or all of the owed $6.0m.
- With netting, the institution is allowed to pay only the net amount of $4.0 million, thereby gaining the $6.0 million owed in entirety.



For example (Gregory 4.2.3)

Consider five difference transactions with a particular counterparty with current MtM given by +7, -4, +5, +2, and -4.

- Without netting, total exposure = 7 + 0 + 5 + 2 + 0 = 14
- With netting, total exposure = 7 - 4 + 5 + 2 – 4 = 6

Impact of correlation (more detail in subsequent chapter)

When considering the netting benefit of two of more trades, the most important consideration is the correlation between the MtM values (and therefore exposures also).

- A **high positive correlation** means that mark-to-markets (MtMs) are likely to be of the same sign. This implies the netting benefit will be small or even zero.
- **Negative correlation implies a high benefit from netting**: Netting will only help in cases where the MtM values of the trades have opposite signs

Describe the mechanics of termination provisions and explain their advantages and disadvantages.

Long-dated derivatives might have relatively small current exposure but still have considerable long-term, potential (future) exposure. The role of reset agreement and break clauses (contractual features) is to mitigate this problem.

Reset agreements

A reset agreement avoids a trade becoming strongly in-the-money by means of readjusting product-specific parameters that reset the trade to be more at-the-money. Reset dates may coincide with payment dates or be triggered by the breach of some market value.

- For example, in a resettable cross-currency swap, the MtM on the swap (which is mainly driven by FX movements on the final exchange of notional) is exchanged at each reset time in cash. In addition, the FX rate is reset to (typically) the prevailing spot rate. The reset means that the notional on one leg of the swap will change. Such a reset is similar to the impact of closing out the transaction and executing a replacement transaction at market rates and consequently reduces the exposure. An example of the impact on exposure is shown in Figure 4.4.

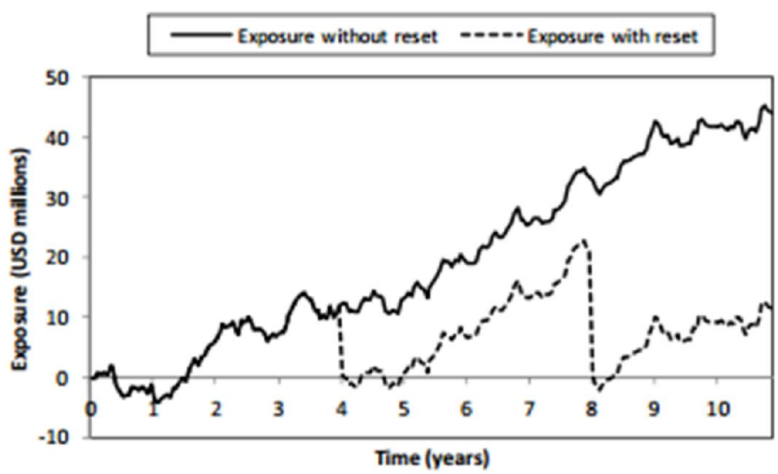


Figure 4.4 Illustration of the impact of reset features on the exposure of a long-dated cross-currency swap. Resets can be seen to occur at 4 and 8 years.

Additional termination events (ATE); a.k.a., break clauses

Additional termination events (ATEs) or so-called break clauses allow for the possibility of terminating a trade prior to their counterparty's creditworthiness deteriorating to the point of bankruptcy. **Under ISDA documentation, break clauses can be defined via "Additional Termination Events"**. Key points about break clauses:

- A break clause may occur at one or more pre-specified dates in the future and may be used by one or both counterparties to the transaction.
- If the break is exercised, then the exercising party can terminate the transaction at its current replacement value.
- A break clause may be especially useful when trading with a relatively good credit quality counterparty on a long-maturity transaction (for example, 10 years or greater). Over such a time horizon, there is ample time for both the MtM of the transaction to become significantly positive and for the credit quality of the counterparty to decline. A bilateral break clause will often be relevant since both parties to the transaction may be in the same situation.
- The break clause will typically or often only be possible after a certain period (for example, 3 years) and possibly at pre-specified dates (for example, annually) thereafter.
- **A break clause** specifies the termination of transactions. However, they are not always freely exercisable. Typically, such events can be defined to fall into three categories:
    - **Mandatory**: transaction will definitely terminate at date of the break clause
    - **Optional**. One (unilateral break clause) or both (bilateral break clause) counterparties have the option to terminate the transaction at the pre-specified date(s).
    - **Trigger-based**. A trigger (typically a ratings downgrade) must occur before the break clause(s) may be exercised. There is no ISDA standard ATE and events are therefore a result of negotiations between the parties concerned.

Each of the termination event types in a break clause has weaknesses

- A **mandatory termination** Is simple (and is a continuation of a reset) but there is complexity in terms of the definition of the replacement cost and whether it, for example, incorporates the credit quality of the replacement counterparty.
- **Optional and trigger-based break clauses** lead to more subtle problems in terms of defining their benefits. The problem with optional break clauses is that they need to be exercised early before the counterparty's credit quality declines significantly and/or exposure increases substantially. Exercising them at the "last minute" is unlikely to be useful due to systemic risk problems.
- **Trigger-based break clauses**, typically using credit ratings, create further problems.
    - Firstly, unlike default probability, rating transitions probabilities cannot be implied from market data. This means that historical data must be used which is, by its nature, scarce and limited to some broad classification.
    - Secondly, ratings have in many circumstances, especially during the financial crisis, been shown to be extremely slow in reacting to negative credit information. Indeed, under the Basel III rules for capital allocation, no positive benefit for ratings-based triggers is allowed

Prior to the financial crisis, break clauses were typically required by banks trading with some non-collateral-posting counterparties. **More recently, various counterparties (for example, asset managers and pension funds) have demanded break clauses linked to banks' own credit ratings due to the unprecedented credit quality problems within the banking sector**.

The dangers of credit rating triggers.

Certain debt contracts may contain an acceleration clause that permits the creditor to accelerate future payments (for example, repayment of principal) in the event of a rating agency downgrade, default or other adverse credit event. Acceleration features are clearly aimed at protecting creditors. However, the acceleration of required payments can precipitate financial difficulties and catalyze the insolvency of a firm. As such, these triggers can increase systemic risk.

Consider the case of American International Group Inc. (AIG), which failed in September 2008 due to liquidity problems. The liquidity problems stemmed from the requirement for AIG to post an additional $20 billion of collateral (relating to CDS trades) as a result of its bonds being downgraded. An institution trading with AIG may have thought the requirement for AIG to post collateral due to a downgrade would provide a safety net. However, since the downgrade was linked to the extremely poor performance of AIG's positions and collateral would be required to be posted to many institutions, in retrospect it is unlikely that a feature such as this would do anything more than catalyze a counterparty's demise. Luckily (for them and their counterparties if not the US taxpayer), AIG was bailed out but this story illustrates the limitation of any trigger linked to a credit rating change.

Walkaway features

Walkaway clauses (also called limited two-way payments and one-way payments) allow a surviving institution to avoid (walk away) from net liabilities to a counterparty in default whilst still claiming in the event of a positive MtM (exposure). A walkaway clause therefore allows an institution to benefit from the default of a counterparty.

- Walkaway features were common prior to the 1992 ISDA Master Agreement, but have been less common since and are not part of standardized ISDA documentation.
- However, they have sometimes been used in transactions since 1992. Whilst walkaway features do not mitigate counterparty risk per se, they do result in potential gains due to counterparty risk aspects.

Walkaway features seem to have been present in some Lehman Brothers transactions following their bankruptcy in 2008 but seem more limited and at risk from litigation and reputational aspects. There has been criticism of these features by market participants and bankruptcy litigants since they cause additional problems for a bankrupt party. Walkaway features are rather unpleasant and should be avoided (and possibly legislated against) for the following reasons:

- They create an additional cost for a counterparty in the event of default.
- They create moral hazard since an institution is given the incentive to contribute to their counterparty's default due to the financial gain they can make.
- A walkaway feature may be ‘‘priced in’’ to a transaction. The possible gains in counterparty default will then offset the negative component due to potential losses that may ultimately ‘‘hide’’ some of the risk

Chapter Summary (literal from Gregory's chapter)

In this chapter, we have described the primary ways of mitigating counterparty risk via exposure.

- Closeout netting is a crucial way to control credit exposure by being legally able to offset transactions with positive and negative mark-to-market values in the event a counterparty does default.
- Reset features allow the periodic resetting of an exposure.
- Early termination events allow the termination of a transaction to mitigate an exposure combined with a deterioration of the credit quality of a counterparty, possibly linked to some event such as a credit ratings downgrade.

Questions & Answers

1. In the category of so-called default-remote entities, Gregory includes: high-quality counterparties, special purpose vehicles, and central counterparties. He says, however, that "the overall lesson is that mitigating counterparty risk by trading with default-remote entities is highly suspect. The 'too big to fail' concept is a fundamentally flawed one. The centralization of counterparty risk is not obvious either. It is critical to have more sophisticated methods for mitigating counterparty risk." According to Gregory, each of the following is true as a vulnerability of these default-remote entities, EXCEPT which assertion is not true?

a) High-quality counterparties, including "too big to fail" or systemically important financial institutions (SIFIs), are not actually default-free
b) Special purpose vehicles (SPV) tend to transform counterparty risk into legal risk
c) Central counterparties (CCPs) may create moral hazard problems and tend to transform counterparty risk into operational risk and legal risk
d) Central counterparties (CCPs) are not naturally designed to transact standardized products; they prefer customized OTC products

2. According to Gregory, each of the following is true about termination and walkaway features in credit contracts, EXCEPT which is false?

a) Termination events give an institution the right (option) to terminate a trade prior to their counterparty's credit-worthiness deteriorating to the point of bankruptcy
b) A break clause--a.k.a. liquidity put or early termination option (ETO)--is an agreement to terminate (break) a transaction at pre-specified dates in the future at market rates
c) Break clauses are often linked to additional termination events (ATEs) which are not in the standardized ISDA documentation and therefore are a result of negotiations
d) Walkaway features are parts of the standardized ISDA documentation t and "should be utilized in almost all transactions" as they mitigate counterparty risk

3. Acme Bank has entered into two trades with its counterparty and wants to analyze the potential benefits of netting. To do this, it will model several scenarios to produce mark-to-market (MtM) values for each trade. Their model contains two key assumptions. The first is the initial mark-to-market (MtM) value of the trade (the derivative contract). The second is the correlation between each of the two trades. Under which of the following set of assumptions will the netting benefit be GREATEST; i.e., the netting benefit is the difference between expected exposure (as an average of scenarios) without netting and compares to the same but with netting?

a) Negative initial MtM and positive correlation (between trades)
b) Positive initial MtM and positive correlation
c) Negative initial MtM and zero correlation
d) Positive initial MtM and negative correlation

4. In regard to collateralization, each of the following is true except which is false?

a) The valuation agent is the party calling for delivery or return of collateral and thus must handle all calculations; i.e., calculation of credit exposure, market value of posted collateral, uncollateralized exposure, and the delivery or return amount.
b) A counterparty who posts a dividend-paying asset as collateral (i.e., the "giver" of collateral) forfeits all dividends as the receiver immediately becomes the economic owner of the collateral.
c) The threshold represents an amount of uncollateralized exposure: If an exposure is above the threshold, only the incremental exposure will be collateralized.
d) An independent is effectively a negative threshold and is typically held as a cushion against “gap risk;” i.e., the risk that a transaction's market value may gap substantially and quickly.

5. Gregory makes a key point that collateral does not eliminate risk so much as transform risk: "While collateral management is a very useful tool for mitigating counterparty risk, it has significant limitations that must be considered. Essentially, the counterparty risk is converted into other forms of financial risk." Collateral transforms into creation the following primary risks, except which should LEAST be created by the collateral itself?

a) Collateral creates CREDIT risks due to haircuts that are too low such that they do not cover the default risk of the collateral asset
b) Collateral creates MARKET risks due to minimum transfer amounts and the "margin period of risk; i.e., contractual period between collateral calls
c) Collateral creates OPERATIONAL risks due to the possibility of missed collateral calls, failed deliveries, computer error, human error, and fraud.
d) Collateral creates LIQUIDITY risks due to (i) price volatility over liquidation period; and (ii) risk that collateral value will not be realized in sale (endogenous liquidity risk)

Answers:

1. D. False: CCPs favor standardization of products
In regard to (A), (B), and (C), each is TRUE.

2. D. False. Walkway feature are not part of the standardized documentation; are not advised; and do not mitigate counterparty risk.

Gregory: "Walkaway features seem to have been present in some Lehman Brothers transactions following their bankruptcy in 2008 but seem more limited and at risk from litigation and reputational aspects. There has been criticism of these features by market participants and bankruptcy litigants since they cause additional problems for a bankrupt party. Walkaway features are rather unpleasant and should be avoided (and possibly legislated against) for the following reasons:

- They create an additional cost for a counterparty in the event of default.
- They create moral hazard since an institution is given the incentive to contribute to their counterparty's default due to the financial gain they can make.
- A walkaway feature may ‘‘priced in’’ to a transaction. The possible gains in counterparty default will then offset the negative component due to potential losses that may ultimately ‘‘hide’’ some of the risk."

In regard to (A), (B) and (C), each is TRUE.

3. D. Positive initial MtM and negative correlation
In regard to (C), this will produce negative initial MtM, but negative correlation will have the greatest impact

4. B. False. Economic ownership remains with the collateral giver.
Gregory: "As long as the giver of collateral is not in default then they remain the owner from an economic point of view. Hence, the receiver of collateral must pass on coupon payments, dividends and any other cashflows. The only exception to this rule is in the case where an immediate margin call would be triggered. In this case, the collateral receiver may typically keep the minimum component of the cashflow in order to remain appropriately collateralized."

In regard to (A), (C) and (D), each is TRUE.

5. A. Haircuts should cover market (price) risk, not credit risk
Gregory: "Haircuts are primarily used to account for the price volatility of collateral posted. Default relating to a security posted as collateral would clearly reduce the value of that collateral substantially and the haircut is very unlikely to cover such an event. For this reason, only high-quality debt securities are typically allowed to be used as collateral. Haircuts are designed to cover price volatility of assets only and it is therefore crucial that every effort is made to avoid collateral with significant default risk."

In regard to (B), (C), and (D), each is a key transformed-into risk.

Gregory, Chapter 5: Collateral

Describe features of a credit support annex (CSA) within the ISDA Master Agreement.

Describe the role of a valuation agent.

Describe types of collateral that are typically used.

Explain the process for the reconciliation of collateral disputes.

Explain the features of a collateralization agreement.

Differentiate between a two-way and one-way CSA agreement and describe how collateral parameters can be linked to credit quality.

Explain how market risk, operational risk, and liquidity risk (including funding liquidity risk) can arise through collateralization.

History of collateralization

Collateralization of derivatives exposures became widespread in the early 1990s, with collateral typically in the form of cash or government securities. Standardization began in 1994 via the first ISDA documentation. In the 1997/1998 period, collateral management had a greater focus with the default of Russia, the Asian crisis and the failure of the large hedge fund Long Term Capital Management (LTCM). These events resulted in tighter credit controls and a greater interest in mitigation techniques such as collateralization. **Collateral use has increased substantially since 2003 and at the current time around half of OTC derivatives exposures are collateralized.** This proportion increases for more counterparty risk-sensitive products such as CDSs (two-thirds of CDS exposures are collateralized).

Motivations

The fundamental idea of collateral management is simple: **cash or securities pass from one counterparty to another as security for a credit exposure**. The motivation for collateral management is to reduce counterparty risk but the detailed motivations include:

- Reduce credit exposure so as to be able to do more business. To maintain exposures within credit lines and overcome the bankers paradox.
- Enable one to trade with a particular counterparty. For example, ratings restrictions may not allow uncollateralized credit lines to certain counterparties.
- To reduce capital requirements; e.g., Basel II gives capital relief for collateralized exposures
- To give more competitive pricing of counterparty credit risk

Mechanics of collateralization

Collateral or margin agreements are normally negotiated prior to any trading activity between counterparties or may be agreed or updated prior to an increase in trading volume.

- They must define explicitly all the parameters of the collateralization and account for all possible scenarios. **The choice of parameters will often come down to a balance between the workload of calling and returning collateral versus the risk mitigation benefit of doing so**.
- Failure to define appropriately the collateral terms and cover possible future scenarios can strongly compromise the ability to mitigate counterparty risk and may create in some cases far greater risks.

In a swap transaction between parties A and B,

- Party A makes a mark-to-market (MtM) profit whilst party B makes a corresponding MtM loss.
- Party B then posts some form of collateral to party A to mitigate the credit exposure that arises due to the positive MtM.
- The collateral may be in cash or other securities, the characteristics of which have been agreed before initiation of the contract. **Collateral is an asset supporting a risk in a legally enforceable way.**
- Since collateral agreements are often bilateral, collateral must be returned or posted in the opposite direction when exposure decreases. Hence in the case of a positive MtM, an institution will call for collateral and in the case of a negative MtM they will have to post collateral

Setting up a collateral agreement

Here is a summary of the process by which two counterparties agree to collateralize their exposures:

- Parties negotiate and sign a collateral support document, containing the terms and conditions under which they will operate. The collateral agreement should cover all possible parameters defining the nature of the collateral agreement in all possible scenarios. Important points to be covered are:
    - Base currency
    - Type of agreement (one-way or two-way),
    - Quantification of parameters such as independent amounts, minimum transfer amounts and rounding
    - Eligible collateral that may be posted by each counterparty and the quantification of haircuts that act to discount the value of various forms of collateral with price volatility,
    - Timings regarding the delivery of collateral (margin call frequency, notification times and delivery periods),
    - Interest rates payable for cash collateral.
- Trades subject to collateral are regularly marked-to-market, and the overall valuation including netting is agreed (unless this amount is disputed as discussed later).
- The party with negative MtM delivers collateral (subject to minimum transfer amounts and thresholds as discussed later).
- The collateral position is updated to reflect the transfer of cash or securities (Periodic reconciliations should also be performed to reduce the risk of disputes.)
- (Periodic reconciliations should also be performed to reduce the risk of disputes.)

Describe features of a credit support annex (CSA) within the ISDA Master Agreement.

Within an ISDA Master Agreement, it is possible to append a **credit support annex (CSA) which permits the parties to mitigate their credit risk further by agreeing to various collateral posting**.

As with netting, ISDA has legal opinions throughout a large number of jurisdictions regarding the enforceability of the provisions within a CSA. The CSA is therefore at the center of any collateral agreement as it governs the mechanics of collateral with respect to issues such as:

- Method and timings of the underlying valuations.
- The calculation of the amount of collateral that will be posted.
- The mechanics and timing of collateral transfers.
- Eligible collateral.
- Collateral substitutions.
- Dispute resolution.
- Interest rate payments on collateral.
- Haircuts applied to collateral securities.
- Possible rehypothecation (reuse) of collateral securities.
- Triggers that may change the collateral conditions; e.g., ratings downgrades

A CSA is critically defined by the following important parameters:

- **Threshold.** Defines the level of MtM above which collateral is posted. If the exposure is below the threshold, it is not collateralized at all. When the exposure is above the threshold, the exposure is under-collateralized (by the amount of the threshold).
- **Minimum transfer amount.** This defines the minimum amount of collateral that can be called for at a time.
- **Independent amount.** This defines an amount of extra collateral that must be posted irrespective of the exposure. Hence, the exposure is over-collateralized. An independent amount is similar in concept to an initial margin required by an exchange or central counterparty. An independent amount is not common in CSAs, although it is used in some specific cases and will be required under new regulations in many cases (e.g., inter-bank trades).

As already discussed above, CSAs must explicitly define all the parameters of the collateralization and account for all possible scenarios. **The choice of parameters will often come down to a balance between the workload of calling and returning collateral versus the risk mitigation benefit of doing so**.

Threshold

A threshold is a level of exposure below which collateral will not be called.

- The threshold represents an amount of uncollateralized exposure.
- If the exposure is above the threshold, only the incremental exposure will be collateralized. In return for taking the risk of a moderate uncollateralized exposure, the operational burden of calling and returning collateral will be reduced.
- Put another way, many counterparties may only consider collateralization important when the exposure exceeds a certain level, the threshold.
- A threshold of zero implies that any exposure is collateralized while a threshold of infinity is used to specify that a counterparty will not post collateral under any circumstance.

Minimum transfer amount

A minimum transfer amount is the smallest amount of collateral that can be transferred. It is used to avoid the workload associated with a frequent transfer of insignificant amounts of collateral.

- The size of the minimum transfer amount again represents a balance between risk mitigation versus operational workload.
- The minimum transfer amount and threshold are additive in the sense that the exposure must exceed the sum of the two before any collateral can be called. We note this additively does not mean that the minimum transfer amount can be incorporated into the threshold – this would be correct in defining the point at which the collateral call can be made but not in terms of the collateral due.

Independent amount

An independent amount can be thought of (intuitively and mathematically) as a negative threshold. It is typically held as a cushion against “gap risk”, the risk that the market value of a transaction(s) may gap substantially in a short space of time. An independent amount can be significant and reduce exposure to practically zero. Independent amounts and gap risk are discussed further in Chapter 7 in the context of central counterparties. Sometimes the posting of an independent amount may be linked to a downgrade in a counterparty’s credit rating.

We can think of an independent amount as transforming counterparty risk into “gap risk”. A transaction with a risky counterparty might be collateralized with both frequent margin calls and additionally an independent amount. The aim is then that the transaction is always over collateralized by the independent amount so that even if the counterparty defaults, it is highly unlikely that any loss will be suffered. The residual risk is that, when the counterparty defaults, the value of the transactions will move dramatically or “gap” before it can be unwound. The independent amount is often considered large enough to make such a gap event in the relevant time horizon highly unlikely.

Independent amounts are often specific to a particular trade and are common for counterparties considered to be of relatively poor credit quality (such as hedge funds). However, future regulation seems likely to make them much more common.

Note: thresholds and independent amounts essentially work in opposite directions. Mathematically, an independent amount is a negative threshold and vice versa.

Impact of collateral

The impact of collateral on a typical exposure profile is shown in Figure 5.3. There are essentially two reasons why collateral cannot perfectly mitigate exposure.

- Firstly, the presence of a threshold means that a certain amount of exposure cannot be collateralized.
- Secondly, the delay in receiving collateral and parameters such as the minimum transfer amount create a discrete effect, as the movement of exposure cannot be tracked perfectly. This is illustrated by the grey blocks in Figure 5.3.

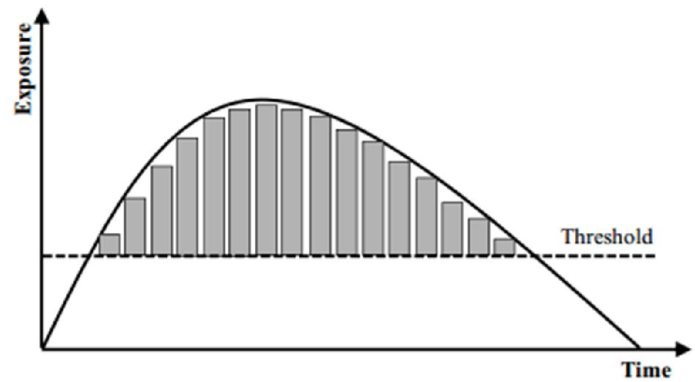


Figure 5.3 Illustration of the impact of collateral on exposure. The collateral amount is depicted by the grey areas.

Describe the role of a valuation agent.

The valuation agent is the party who calls for delivery (or return) of collateral and thus must handle all calculations. Large counterparties trading with smaller counterparties may insist on being valuation agents. In such a case, the “smaller” counterparty is not obligated to return or post collateral if they do not receive the expected notification, whilst the valuation agent is under obligation to make returns where relevant. Alternatively, both counterparties may be the valuation agent and each will call for collateral when they have an exposure.

The role of the valuation agent in a collateral calculation is as follows:

- To calculate credit exposure under the impact of netting.
- To calculate the market value of collateral previously posted.
- To calculate the uncollateralized exposure.
- To calculate the delivery or return amount (the amount of collateral to be posted by either counterparty). This is likely to differ from the uncollateralized exposure due to the discrete nature of collateral agreements, which means that collateral is transferred in blocks.

Third-party valuation agents provide operational efficiencies, and can also help prevent disputes that are common in bilateral collateral relationships.

Describe types of collateral that are typically used.

Types of collateral (see next AIM for further detail)

Traditional forms of collateral include (but are hardly limited to):

- Cash,
- Government securities,
- Government agency securities (e.g. Fannie Mae/Freddie Mac),
- Mortgage-backed securities (MBSs),
- Corporate bonds/commercial paper,
- Letters of credit (LOC) and guarantees,
- Equity.

Cash is common (> 80%) but so are government securities

- Cash collateral is the most common type of collateral: cash was 81.90% of collateral used for OTC derivatives according to a 2010 ISDA Margin Survey
- The ability to post other forms of collateral is often highly preferable for liquidity reasons but the credit crisis showed that even government agency securities (e.g., Fannie Mae and Freddie Mac) and triple-A MBS securities are not perfectly safe.
- Non-cash collateral also creates the problems of reuse of collateral or rehypothecation and additional volatility arising from the price uncertainty of collateral posted and its correlation to the original exposure.
- If the credit rating of an underlying security held as collateral declines below that specified in the collateral agreement, then normally it will be necessary to replace this security immediately. When two counterparties do not have the same local currency, one of them will have to take FX risk linked to the collateral posted, even when it is in the form of cash.
- Securities in various currencies may be specified as admissible collateral but may also attract larger haircuts due to the additional FX risk. FX risk from posted collateral can be hedged in the spot and forward FX markets but it must be done dynamically as the value of collateral changes.

Derivatives collateral is fundamentally different in both type and nature from the use of physical assets as security for debts.

- Secured creditors have a claim on particular assets but their ability to realize the value of the assets is subject to delays in the bankruptcy process. It is possible for secured creditors to petition the bankruptcy court to release their security but this is a complicated process.
- In contrast, collateral posted against derivatives positions is, in most cases, under the control of the counterparty and may be liquidated immediately upon an ''event of default''. This arises due to the laws governing derivatives contracts and the nature of the collateral (cash or liquid securities under the immediate control of the institution in question). Exposure, in theory, can be completely neutralized as long as a sufficient amount of collateral is held against it. However, there are legal obstacles to this and aspects such as rehypothecation. This was a significant issue in the Lehman Brothers' bankruptcy of 2008.

Explain the process for the reconciliation of collateral disputes.

Collateral management is one of the few areas of banking that has not fully embraced technological advances and still relies heavily on manual process and data standards. The use of spreadsheets is still quite common. Clearly, such practices can lead to significant disputes between counterparties.

A dispute over a collateral call is common and can arise due to one or more of a number of factors: trade population; trade valuation methodology; application of netting rules; market data and market close time; or valuation of previously posted collateral.

If the difference in valuation or disputed amount is within a certain tolerance specified in the collateral agreement, then the counterparties may "split the difference". Otherwise, it will be necessary to find the cause of the discrepancy. Obviously, such a situation is not ideal and will mean that one party will have a partially uncollateralized exposure at least until the origin of the disputed amount can be traced, agreed upon and corrected.

Typical steps in the case of a collateral dispute

The following steps are normally followed in the case of a dispute:

- The disputing party is required to notify its counterparty (or the third-party valuation agent) that it wishes to dispute the exposure or collateral calculation no later than the close of business on the day following the collateral call.
- The disputing party agrees to transfer the undisputed amount and the parties will attempt to resolve the dispute within a certain timeframe (the "resolution time"). The reason for the dispute will be identified (e.g., which transactions have material differences in valuation).
- If the parties fail to resolve the dispute within the resolution time, they will obtain MtM quotations from several market makers for the components of the disputed exposure (or value of existing collateral in case this is the component under dispute).

Rather than being reactive and focusing on dispute resolution, it is better to be proactive and aim to prevent disputes in the first place.

- Reconciliations aim to minimize the chance of a dispute by agreeing on valuation figures even though the resulting netted exposure may not lead to any collateral changing hands.
- They can even be performed using dummy trades before two counterparties transact with one another. It is good practice to perform reconciliations at periodic intervals (for example, weekly or monthly) so as to minimize differences in valuation between counterparties.
- Such reconciliations can pre-empt later problems that might arise during more sensitive periods.
- Reconciliations may be rather detailed and will therefore highlight differences that otherwise may be within the dispute tolerance or that by chance offset one another.

Explain the features of a collateralization agreement.

Features include:

- Margin call frequency
- Haircuts
- Coupons and interest payments
- Substitution, reuse of collateral and rehypothecation

Margin call frequency

Margin call frequency refers to the periodic timescale with which collateral may be called and returned.

- **Intra-day**: Intra-day margining is common for vanilla products such as repos but other instruments such as swaps may require at least a daily margin call frequency in order for the relevant valuations to be carried out.
- **Daily (becoming a standard)**: Daily margining is becoming a market standard. Some smaller institutions may struggle with the operational and funding requirements in relation to the daily margin calls required by larger counterparties.
- **Longer than daily:** A margin call frequency longer than daily might be practical for asset classes and markets that are not so volatile. A longer margin call frequency may be agreed upon, most likely to reduce operational workload.

Haircuts

A haircut is a discount applied to the value of collateral to account for the fact that its value may deteriorate over time. **Cash collateral will require no haircut** but other securities will have pre-specified haircuts depending on their individual characteristics.

A haircut of x% means that for every unit of that security posted as collateral, only (1-x)% of credit (or ''valuation percentage'') will be given. The collateral giver must account for the haircut when posting collateral. Important points to consider about the haircut are:

- Time taken to liquidate the collateral,
- Volatility of the underlying market variable(s) defining the value of the collateral,
- Default risk of the security,
- Maturity of the security,
- Liquidity of the security.
- Any relationship between the default of the counterparty and the value of the collateral (wrong-way risk).

Haircuts are primarily used to account for the price volatility of collateral posted. Default relating to a security posted as collateral would clearly reduce the value of that collateral substantially and the haircut is very unlikely to cover such an event. For this reason, only high-quality debt securities are typically allowed to be used as collateral. Haircuts are designed to cover price volatility of assets only and it is therefore crucial that every effort is made to avoid collateral with significant default risk.

It is also important to consider the potential correlation between the exposure and the valuation of collateral.

Example. Consider a security that attracts a haircut of 5% and is being posted to cover a collateral call of $100,000. Only 95% of the value of this security is credited for collateral purposes and so the actual amount of collateral posted must be

Market value of collateral	**= $105,263**
Haircut	**= $5,263 (5% of 105 263)**
Credit given	**= $100,000 (difference between the above)**

It is the collateral giver's responsibility to account for haircuts when posting collateral so that if a collateral call is made as above then (assuming they do not dispute the amount) the counterparty could post $100,000 in cash but $105,263 in terms of the market value of a security attracting a 5% haircut.

Rounding

A collateral call or return amount will always be rounded to a certain lot size to avoid unnecessarily small amounts. The rounding may be always up (or down) or might always be to the favor of one counterparty; i.e. up when they call and down when they return collateral.

Coupons and interest payments

Interest will be typically paid on cash collateral at an overnight rate (e.g., EONIA in Europe, Fed Funds in the US). A development seen in light of the credit crisis in 2007 has been for some institutions to offer to pay in excess of such a rate in order to incentivize the collateral giver to post cash rather than other more risky and volatile securities.

As long as the giver of collateral is not in default then they remain the owner from an economic point of view. Hence, the receiver of collateral must pass on coupon payments, dividends and any other cashflows. The only exception to this rule is in the case where an immediate margin call would be triggered. In this case, the collateral receiver may typically keep the minimum component of the cashflow in order to remain appropriately collateralized.

Substitution, reuse of collateral and rehypothecation

Sometimes a counterparty may require or want securities posted as collateral returned (for example, to meet delivery commitments). In this case, they can make a substitution request and post an alternative amount of eligible collateral with the relevant haircut applied. The requested collateral does not need to be released until the substitute collateral has been received. If substitution is optional (no consent required), then a substitution request cannot be refused (unless it is not valid). Alternatively, substitution may only be allowed if the holder of the collateral gives consent. Whether or not collateral can be substituted without consent is an important consideration in terms of the funding costs and benefits of collateral.

For collateral to provide benefit against funding costs, it must be usable (as economic ownership remains with the collateral giver) via rehypothecation; i.e., it can be posted as collateral or pledged via repo. To understand the importance of this, consider Figure 5.7.

Figure 5.7 Illustration of the importance of rehypothecation of non-cash collateral. An institution trades with counterparty A and typically hedges this transaction with counterparty B, both under CSA agreements. If counterparty B posts collateral then ideally it should be possible to pass this collateral on to counterparty A to minimise funding costs.

Collateral in securities that cannot be rehypothecated reduces counterparty risk but creates a funding problem. We will refer to this as funding liquidity risk.

Rehypothecation would seem to be obvious because it keeps the flow of collateral moving around the financial system without any blockage. The question arises as to whether rehypothecating a security in this way creates additional risk due to a loss of control of collateral.

An institution faces two possible risks in this respect:

- Collateral pledged in a collateral agreement against a negative MtM to another counterparty may be rehypothecated and consequently not be returned (in the event of a default of the counterparty coupled to an increase in the MtM).
- Collateral received from party A and then rehypothecated to party B. This may not be retrieved in the event that party B defaults, creating a liability to party A.

Prior to the credit crisis in 2007, the pledging, reuse and rehypothecation of collateral was strongly encouraged. This was viewed as being critical to the entire financial system. However, the practice of rehypothecation probably became too widespread, especially in the interbank market (presumably since there was little concern of actual bank defaults).

- The bankruptcy of Lehman Brothers has illustrated the potential problems with rehypothecation. One example is that customers of Lehman Brothers Inc. (US) were being treated more favorably than the UK customers of Lehman Brothers International (Europe) in terms of the return of rehypothecated assets (due to differences in customer protection between the UK and the US).

Singh and Aitken (2009) have reported a significant drop in rehypothecation, which is safer from a systemic risk perspective but leads to an increase in funding liquidity risk. Hedge funds are tending to be unwilling to allow rehypothecation, which will surely lead to an increase in prime broker fees. The problems with rehypothecation are another driving force behind cash collateralization becoming increasingly the standard and, in many cases, the only option that most institutions are willing to adopt.

When posting and receiving collateral, institutions are becoming increasingly aware of the need to optimize their collateral management as, during the financial crisis, funding efficiencies have emerged as an important driver of collateral usage. Collateral management is no longer a back-office cost center but can be an important asset optimization tool delivering the most cost-effective collateral. An institution must consider the “cheapest-to-deliver” cash collateral and account for the impact of haircuts and the ability to rehypothecate noncash collateral. For example, different currencies of cash will pay different OIS rates and non-cash collateral, if rehypothecated, will earn different rates on repo.

Differentiate between a two-way and one-way CSA agreement and describe how collateral parameters can be linked to credit quality.

Due to the very different nature of OTC derivatives counterparties, many different collateral arrangements exist. Broadly these can be categorized into the following.

- No CSA
- Two-way CSA
- One-way CSA

No CSA

There are two reasons why an institution may be unable or unwilling to post collateral.

- Because their credit quality is far superior to their counterparty.
- Because they cannot commit to the operational and liquidity requirements that arise from committing to a CSA.

One result of the above is that in some trading relationships, CSAs are not used because one or both parties cannot commit to collateral posting. A typical example of this is the relationship between a bank and a corporate where the latter's inability to post collateral means that a CSA is not usually in place (for example, a corporate treasurer may find it almost impossible to manage their liquidity needs if they transacted under a CSA).

Two-way CSA

For two similar counterparties, a two-way CSA is more typical. This is common, for example, in the interbank market. A two-way CSA is typically beneficial to both parties. Two-way CSAs may be skewed in some way. For example, one party may have a lower threshold than the other, which may be due to their inferior credit rating.

One-way CSA

In some situations, a one-way CSA is used which is beneficial to only the collateral receiver. Indeed, a one-way CSA represents additional risk for the collateral giver that puts them in a worse situation than if they were in a no-CSA relationship.

- One example of this would be a bank trading with a hedge fund and requiring collateral posting (possibly including an independent amount) to mitigate the significantly increased (and opaque) counterparty risk of the hedge fund.
- Another typical example is a high-quality entity such as a Triple-A sovereign or insurer trading with a bank.

Note that not all one-way CSAs are truly one-way. For example, one party may not post collateral immediately but may be required to do so if, for example, their credit rating deteriorates. Prior to the financial crisis, Triple-A entities such as monoline insurers traded through one-way CSAs but with triggers specifying that they must post collateral if their ratings were to decline. This seemed to put banks in a safe position but quite the reverse was true.

Linkage of collateral parameters to credit quality

It is very common to attempt to link the precise terms of a collateral agreement to the credit quality of one or both counterparties. The motivation for doing this is to minimize the operational workload whilst a counterparty has strong credit quality but have the ability to tighten up the terms of collateralization when their credit quality deteriorates.

The quantities to which collateral terms can obviously be linked are:

- Credit ratings;
- Traded credit spread;
- Market value of equity;
- Net asset value (sometimes used in the case of hedge funds).

The most commonly used of the above have been credit ratings. Linking a tightening of collateral terms to a credit rating (for example, a downgrade to sub-investment grade) might seem a rather easy and obvious method of mitigating an increase in counterparty risk. However, this type of agreement can lead to rather unpleasant discontinuities since a downgrade of a counterparty's credit rating can occur rather late and then cause further credit issues due to the requirement to post collateral.

An example of thresholds and their linkage to credit rating is shown in Table 5.3:

Table 5.3 Illustration of linkage of threshold to credit rating

Rating	Threshold
AAA	$100 million
AA	$50 million
A	$25 million
Lower	Zero

Explain how market risk, operational risk, and liquidity risk (including funding liquidity risk) can arise through collateralization.

Although collateral management is a useful tool for mitigating counterparty risk, it has significant limitations that must be considered. Essentially, the counterparty risk is converted into other forms of financial risk, such as legal risk (for example, if the terms defined in a CSA cannot be upheld within the relevant jurisdiction).

Correlation risk (where collateral is adversely correlated to the underlying exposure), credit risk (where the collateral may default or suffer an adverse credit effect) and FX risk (due to collateral being posted in a different currency) are also important. However, the three most important risks to consider are market, operational and liquidity risk.

Market risk and the margin period of risk

Collateral can never completely eradicate counterparty risk and we must consider the residual risk that remains under the collateral agreement. This is mainly due to contractual parameters such as thresholds and minimum transfer amounts that effectively delay the collateral process, in addition to the normal delay since collateral cannot be received immediately.

This can be considered a market risk as it is related to the extent of market movements after the counterparty last posted collateral. Whilst the residual risk may be only a fraction of the uncollateralized risk, it may be more difficult to quantify and indeed hedge.

Whilst there is a contractual period between collateral calls (often daily), one must consider what we shall call the "margin period of risk". This is the effective time assumed between a collateral call and receiving the appropriate collateral (or in a worst-case scenario putting the counterparty in default, liquidating existing collateral, closing out and re-hedging the trade). Under Basel II regulations, this should be a minimum of 10 days for OTC derivatives and the new Basel III regime defines a more conservative 20-day minimum in certain cases. The experience of most participants in the Lehman Brothers bankruptcy was that this period was approximately 5–10 business days.

Operational risk

The time-consuming and intensely dynamic nature of collateralization means that operational risk is a very important aspect.

The following are examples of specific operational risks:

- missed collateral calls
- failed deliveries
- computer error
- human error
- fraud

There is clearly no point in having a collateral management program that reduces significantly many credit exposures only to find that, in the event of an actual default, losses are not mitigated due to some lack of control or error.

The following is a list of points to consider in relation to operational risk:

- Legal agreements must be accurate and enforceable.
- IT systems must be capable of automating the many daily tasks and checks that are required.
- The regular process of calls and returns of collateral is complex and can be extremely time-consuming with a workload that increases in markets that are more volatile.
- Timely accurate valuation of all products is key.
- Information on independent amounts, minimum transfer amounts, rounding, collateral types and currencies must be maintained accurately for each counterparty.
- Failure to deliver collateral is a potentially dangerous signal and must be followed up swiftly.

Liquidity risk

Collateralization of counterparty risk leads to demanding liquidity requirements. Indeed, this is why some counterparties do not sign CSAs in the first place. One of the most obvious manifestations of this liquidity risk is in the event that collateral has to be liquidated following the default of a counterparty. Firstly, the surviving institution faces transaction costs (bid–offer) and market volatility over the liquidation period. Secondly, there is the risk that by liquidating an amount of a security that is large compared with the volume traded in that security, the price will be driven down and a potentially large loss incurred. If one chooses to liquidate the position more slowly in small blocks then there is exposure to market volatility for a longer period.

When agreeing to collateral that may be posted and when receiving securities as collateral, important considerations are:

- What is the total issue size or market capitalization posted as collateral?
- Is there a link between the collateral value and the credit quality of the counterparty? Such a link may not be obvious and predicted by looking at correlations between variables.
- How is the relative liquidity of the security in question likely to change if the counterparty concerned is in default?

Because of these liquidity impacts, a concentration limit of 5–10% may be imposed to prevent severe liquidation risk in the event of a counterparty defaulting.

Funding liquidity risk

The above considerations only come into play when a counterparty has actually defaulted. A more significant aspect of liquidity risk arises from the funding needs that arise due to CSAs. We refer to this as funding liquidity risk.

Despite the increased use of collateral, a significant portion of OTC derivatives remain uncollateralized. This arises mainly due to the nature of the counterparties involved, such as corporates and sovereigns, without the liquidity and operational capacity to adhere to daily collateral calls. In such cases, an institution must consider the funding implications that arise.

Since most banks aim to run mainly flat (hedged) OTC derivatives books, funding costs arise from the nature of hedging: a non-CSA trade being hedged via a trade done within a CSA arrangement. This relationship was illustrated in Figure 5.7, where the institution will incur a funding cost when the uncollateralized trade moves in their favor and experience a benefit when the reverse happens. In the recent financial crisis where funding has become costly, the need to assess this carefully has become paramount.

Figure 5.7 Illustration of the importance of rehypothecation of non-cash collateral. An institution trades with counterparty A and typically hedges this transaction with counterparty B, both under CSA agreements. If counterparty B posts collateral then ideally it should be possible to pass this collateral on to counterparty A to minimise funding costs.

The implications of funding liquidity risk arising from CSAs are even more important for non-banking organizations such as institutional investors, corporates and sovereigns that trade under CSAs with banks.

The conversion of counterparty risk into funding liquidity risk will be beneficial in normal, liquid markets where funding costs are low. However, in abnormal markets where liquidity is poor, funding costs can become significant and may put extreme pressure on an institution.

The BP Deepwater Horizon oil spill. In 2010, British Petroleum (BP) experienced the largest accidental marine oil spill in the history of the petroleum industry. This caused loss of life, severe environment problems and, of course, severe financial losses for BP themselves. In the immediate aftermath, some banks gave some flexibility to BP in terms of collateral posting. An obvious way to interpret this is that the banks believed that, whilst BP was certainly experiencing significant idiosyncratic credit problems, it was unlikely to default. Forcing the contractual posting of collateral (which may have been triggered by the resulting credit rating downgrades of the company) may have caused BP liquidity problems that would have made their default more likely.

The above is a good example of the dangers of funding liquidity risk. By not demanding collateral, a bank is essentially converting this risk back into counterparty risk, presumably with the view that long-term counterparty risk is better than short-term liquidity risk. The mitigation of counterparty risk via collateral is clearly useless in such a case.

Chapter Summary (literal from Gregory's reading)

In this chapter we have discussed in detail the use of collateral management in controlling credit exposure, which is a crucial method when trading involving large positions and/or relatively risky counterparties. We have described the mechanics of collateral management and the variables that determine how much collateral would be posted. The significant risks that arise from collateral use have also been considered.

Collateral management should be understood as a way to improve recovery in the event of a counterparty actually defaulting but it is certainly not a replacement for a proper ongoing assessment of credit quality and quantification of credit exposure. Furthermore, the use of collateral mitigates counterparty risk but can aggravate funding liquidity risk and create other financial risks.

In our description of risk mitigation we have now covered all the methods of reducing credit exposure. Collateralization is a very powerful mitigation tool against counterparty risk, but it does give rise to other risks such as market risk, operational risk and legal risk: collateralization needs to be implemented carefully and represents a significant workload for an institution. However, it is increasingly common that many counterparties will simply not trade on an uncollateralized basis.

Gregory, Chapter 8: Credit Exposure

Describe and calculate the following metrics for credit exposure: expected mark-to-market, expected exposure, potential future exposure, expected positive exposure and negative exposure, effective exposure, and maximum exposure.

Compare the characterization of credit exposure to VaR methods and describe additional considerations used in the determination of credit exposure.

Identify factors that affect the calculation of the credit exposure profile and summarize the impact of collateral on exposure.

Identify typical credit exposure profiles for various derivative contracts and combination profiles.

Explain how payment frequencies and exercise dates affect the exposure profile of various securities.

Explain the impact of netting on exposure, the benefit of correlation, and calculate the netting factor.

Explain the impact of collateralization on exposure, and assess the risk associated with the remargining period.

Explain the difference between risk-neutral and real-world parameters, and describe their use in assessing risk.

Exposure

A key feature of counterparty risk arises from the **asymmetry of potential losses with respect to MtM**. In the event that a counterparty has defaulted, an institution may close out the position and is not obliged to make future contractual payments (reasonably, since payments are unlikely to be received). However, the underlying contracts must be settled depending on the MtM value at the time of default.

Consider the impact of positive or negative MtM with a counterparty in default:

- **Positive MtM**. When a counterparty defaults, they will be unable to make future commitments and hence an institution will have a claim on the positive MtM at the time of the default. The amount of this MtM less any recovery value will represent the loss due to the default.
- **Negative MtM**. In this case, an institution owes its counterparty through negative MtM and is still legally obliged to settle this amount (they cannot walk away from the transaction or transactions except in specifically agreed cases). Hence, from a valuation perspective, the position is essentially unchanged. An institution does not gain or lose from their counterparty's default in this case.

This asymmetry (i.e., an institution loses if their MtM is positive but does not gain if their MtM is negative) is a defining characteristic of counterparty risk.

We can define exposure as:

Exposure = Max (MtM, 0) = MtM+

Counterparty risk creates an asymmetric risk profile that can be likened to a short option position:

- Since exposure is similar to an option payoff, a key aspect will be volatility of the MtM
- Options are relatively complex to price (compared with the underlying instruments at least). Hence, to quantify credit exposure even for a simple instrument may be quite complex.

Describe and calculate the following metrics for credit exposure: expected mark-to-market, expected exposure, potential future exposure, expected positive exposure and negative exposure, effective exposure, and maximum exposure.

We begin by defining exposure metrics for a given time horizon. Note that in discussing exposure below, we are referring to the total number of relevant trades, netted appropriately and including any relevant collateral amounts. We will refer to this as the netting set.

Expected future value (EFV); a.k.a., expected mark-to-market (expected MtM)

This component represents the forward or expected value of the netting set at some point in the future. As mentioned above, due to the relatively long time horizons involved in measuring counterparty risk, the expected value can be an important component, whereas for market risk VAR assessment (involving only a time horizon of 10 days), it is not.

Why does expected future value (EFV) will vary significantly from current value?

- **Cash flow differential.** Derivative cash flows are asymmetric such that an institution may expect a transaction in the future to have a value significantly above or below the current one. For example:
    - Early in the lifetime of an interest rate swap, the fixed cash flows will typically exceed the floating ones (assuming an upward sloping yield curve)
    - In a cross-currency swap the payments may differ by several percent annually due to a differential between the associated interest rates.
- **Forward rates.** Forward rates can differ significantly from current spot variables. This difference introduces an implied drift (trend) in the future evolution of the underlying variables in question (assuming one believes this is the correct drift to use). Drifts in market variables will lead to a higher or lower future value for a given netting set even before the impact of volatility..
- **Asymmetric collateral agreements.** If collateral agreements are asymmetric (such as a one-way CSA) then the future value may be expected to be higher or lower reflecting respectively unfavorable or favorable collateral terms.

Potential future exposure

PFE answers the question: *what is the worse exposure we could have at a certain time in the future, with some confidence level?* e.g., the PFE at 99.0% confidence defines an exposure that will be exceeded with a probability of no more than 1.0% (1 – confidence%).

PFE is therefore exactly the same as the traditional measure of value-at-risk (VAR) with two notable exceptions:

- PFE may be defined at a point far in the future (e.g. several years) whereas VAR typically refers to a short (e.g. 10-day) horizon.
- PFE refers to a number that will normally be associated with a gain (exposure) whereas traditional VAR refers to a loss. **VAR is trying to predict a worst-case loss whereas PFE is actually predicting a worst-case gain since this is the amount at risk if the counterparty defaults.**

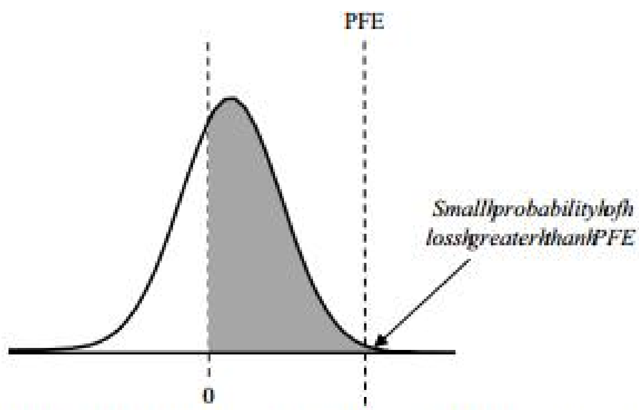


Figure 8.3 Illustration of potential future exposure. The grey area represents positive values which are exposures.

Expected exposure (EE)

Due to the asymmetry of losses, an institution typically cares only about positive MtM values since these represent the cases where they will make a loss if their counterparty defaults. Hence, it is natural to ask what the expected exposure (EE) is since this will represent the amount expected to be lost if the counterparty defaults. **By definition, the EE will be greater than the expected MtM since it concerns only the positive MtM values**

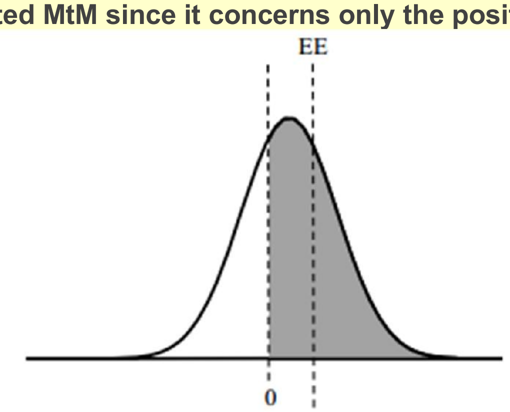


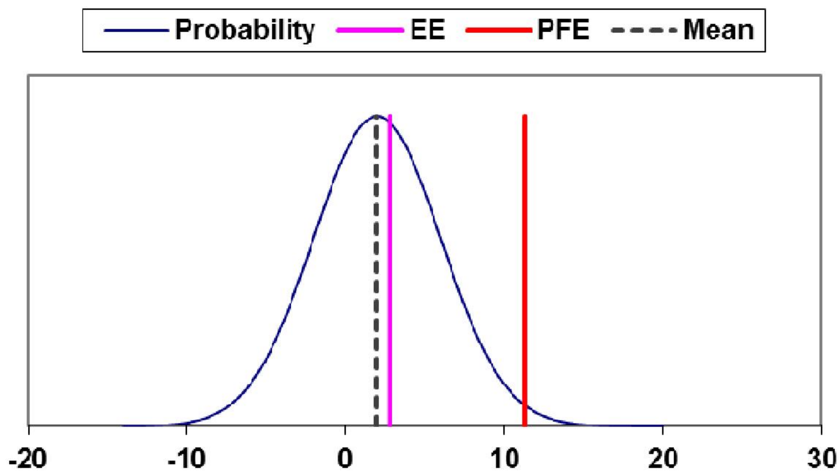
Figure 8.4 Illustration of expected exposure. The grey area represents positive values, which represent exposures.

EE and PFE for a normal distribution

The formulas for the EE and PFE of a normal distribution are reasonably simple to compute.

- The spreadsheet which calculates EE and PFE for a normal distribution is located here @ https://www.dropbox.com/s/4hihr4lj7gsry3u/T6.Gregory.2%20Definitions.xlsx

- The following chart plots the EE (2.79) and PFE (11.31) for a normal distribution with mean of 2.0 and standard deviation of 4.0:



Parameters		
Mu (mean)	**2.0**	**2.0**
Standard deviation (sigma)	**2.0**	**4.0**
Alpha (confidence level)	**99%**	**99%**
Calculations		
Expected exposure (EE)	**2.17**	**2.79**
Potential future exposure (PFE)	**6.65**	**11.31**

Maximum PFE

Maximum or peak PFE represents the highest PFE value over a given time interval, thus representing the worst-case exposure over the entire interval. This is illustrated in Figure 8.5.

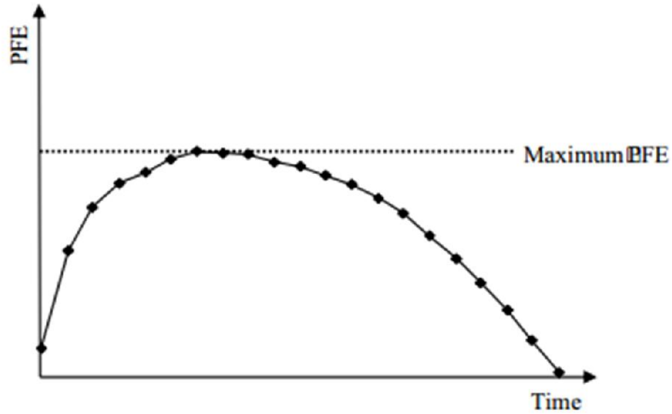


Figure 8.5 Illustration of maximum PFE.

Expected positive exposure (EPE)

Since EE is already an average over all exposures, it is perhaps natural to continue this averaging over time. Expected positive exposure (EPE) is defined as the average exposure across all time horizons. It can therefore be represented as the weighted average of the expected exposure across time, as illustrated in Figure 8.6.

This single EPE number is often called a "loan equivalent", as the average exposure is equivalent to the average amount lent (via an exposure) to the counterparty in question. It is probably obvious that expressing a highly uncertain exposure by a single EPE or loan-equivalent amount can represent a fairly crude approximation, as it averages out both the randomness of market variables and the impact of time.

- **EPE has a strong theoretical basis for pricing and assessing portfolio counterparty risk**

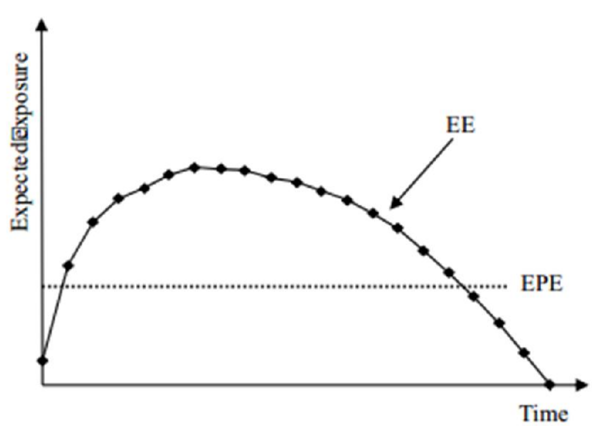


Figure 8.6 Illustration of expected positive exposure, which is the weighted average (the weights being the time intervals) of the EE profile.

Negative exposure

Exposure is represented by positive future values. Conversely, we may define negative exposure as being represented by negative future values. This will obviously represent the exposure from a counterparty's point of view. We can therefore define measures such as negative expected exposure (NEE) and expected negative exposure (ENE), which are the precise opposite of EE and EPE.

Effective expected positive exposure

Measures such as EE and EPE may underestimate exposure for short-dated transactions and not capture properly "rollover risk". This arises from current short-dated transactions that will be rolled over into new transactions at their maturity. For these reasons, the terms effective EE and effective EPE (EEPE) were introduced by the Basel Committee on Banking Supervision (2005).

- Effective EE is simply a non-decreasing EE.
- Effective EPE is the average of the effective EE. These terms are shown in comparison with EE and EPE in Figure 8.7. These measures approximately assume that any maturing transactions will be replaced.

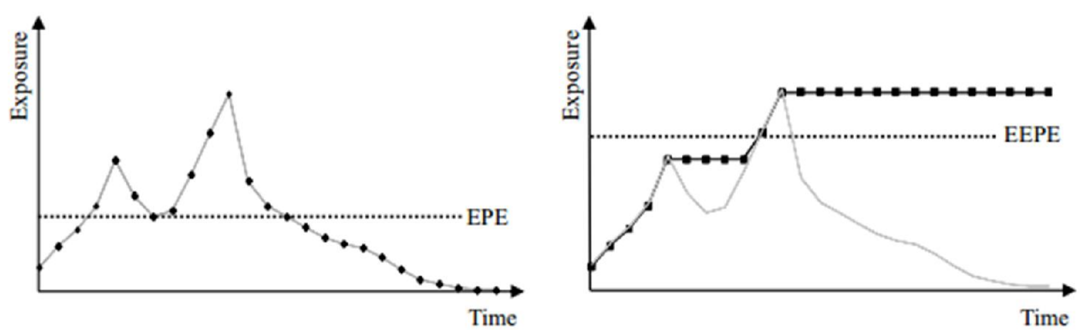


Figure 8.7 Illustration of effective EE and effective EPE.

- **Effective EPE is the average of the effective EE: Effective EE is simply a non-decreasing EE.**

Compare the characterization of credit exposure to VaR methods and describe additional considerations used in the determination of credit exposure.

The characterization of credit exposure shares similarities with the characterization of VaR, but credit exposure is "much more complex than VAR (which is itself a complex concept)." Further, credit exposure is only one component of counterparty risk

Although exposure is similar to VaR, characterizing exposure is faced with the following additional complexities:

- **Time horizon**. Unlike VaR, exposure needs to be defined over multiple time horizons (often far in the future) so as to understand fully the impact of time and specifics of the underlying contracts. There are two important implications of this.
    - The first is that "ageing" of transactions must be considered. This refers to understanding a transaction in terms of all future contractual payments and changes such as cash flows, exercise decisions, cancellations (e.g., callability) and more exotic aspects such as barrier crossings. Such effects may also create path dependency where the exposure at one date depends on an event defined at a previous date. In VaR models, due to the 10-day horizon used, such aspects can be neglected.
    - The second important point here is that, when looking at longer time horizons, the trend (also known as drift) of market variables (in addition to their underlying volatility and co-dependence structure) is relevant. In VAR the drift can be ignored, again since the period is so short.
- **Risk mitigants**. Exposure is typically reduced by risk mitigants such as netting and collateral and the impact of these mitigants must be considered in order to properly estimate future exposure. In some cases, such as applying the correct netting rules, this requires knowledge of the relevant legal agreements. However, in the case of future collateral amounts, another degree of subjectivity is created since there is no certainty over the type of collateral and precise time that it would be received. Other contractual features of transactions, such as termination agreements, may also create subjectivity and all such elements must be modelled, introducing another layer of complexity and uncertainty.
- **Application**. VaR is a risk management approach. Exposure must be defined for both risk management and pricing (i.e., CVA). This creates additional complexity in quantifying exposure and may lead to two completely different sets of calculations, one to define exposure for risk management purposes and another for pricing (or valuation) purposes.

Identify factors that affect the calculation of the credit exposure profile and summarize the impact of collateral on exposure.

Collateral typically reduces exposure but there are many (sometimes subtle) issues that must be considered in order to assess properly the true extent of any risk reduction. These issues include thresholds, minimum transfer amounts and the "margin period of risk" (to determine the true period of risk).

In addition to reducing counterparty risk, collateral transforms counterparty risk into other risks. Most notably, collateral leads to operational risk, legal risk and liquidity risk. Effective collateral management is counterproductive unless these risks are well understood and properly managed.

To the extent that collateral is not a perfect form of risk mitigation, there are three considerations, which are illustrated in Figure 8.25.

- Firstly, there is a granularity effect because it is not always possible to ask for all of the collateral required due to parameters such as thresholds and minimum transfer amounts (note that this can sometimes lead to a beneficial overcollateralization as seen in Figure 8.25 where the collateral amount is for a short period greater than the exposure). Note that this must also consider the impact of collateral that an institution must themselves post.
- Secondly, there is a delay in receiving collateral which involves many aspects such as the operational components of requesting and receiving collateral to the possibility of collateral disputes.
- Thirdly, we must consider a potential variation in the value of the collateral itself (if it is not cash). We also emphasize that the treatment of collateral is path-dependent since the amount of collateral called for at a given time depends on the amount of collateral called (or posted) in the past. This is especially important in the case of two-way collateral agreements.

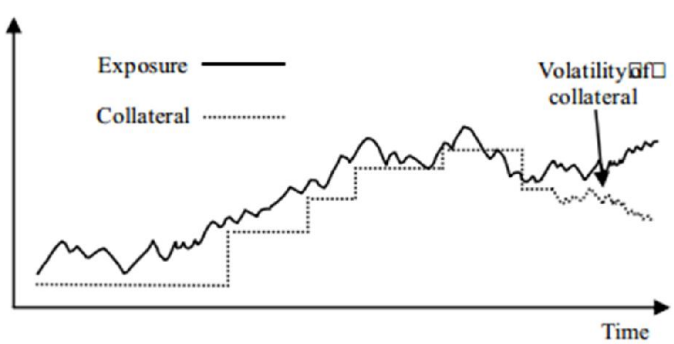


Figure 8.25 Illustration of the impact of collateral on credit exposure showing the delay in receiving collateral and the granularity receiving and posting collateral amounts discontinuously. Also shown is the impact of the volatility of collateral itself (for ease of illustration this is shown in the last period only).

How much collateral?

The first question to ask is how much collateral may be requested at a given point in time. The parameters in a typical collateral support annex (CSA) do not, by design, aim for a continuous posting of collateral. This is because the operational cost and liquidity requirements of collateral posting are significant and one or both parties may find it beneficial to reduce such requirements within reason. The threshold and minimum transfer amount (discussed in Chapter 5) serve this purpose. The threshold is an amount below which collateral may not be called and the minimum transfer amount is the smallest amount that can be requested at a particular time. Note that in the case of a two-way CSA, both parties are subjected to the impact of thresholds and minimum transfer amounts.

The following steps define the amount of collateral required at a given time:

1. Add or subtract any specified independent amount to the market value of the trades (V).
2. Calculate the required collateral amount, taking into account the threshold using the formula:

   $$\max\left(V - \text{threshold}_I, 0\right) - \max\left(-V - \text{threshold}_C, 0\right) - C$$

   Where (V) represents the current mark-to-market value of the relevant trades, threshold(I) and threshold(C) represent the thresholds for the institution and their counterparty, respectively and (C) represents the amount of collateral held already. If the above calculation results in a positive value then collateral can be requested, whilst a negative value indicates the requirement to post collateral (subject to the points below).
3. Determine whether the absolute value of the amount calculated above is above the minimum transfer amount. If not, then no call can be made.
4. If the amount is above the minimum transfer amount then round it to the relevant figure as specified in the CSA.

Identify typical credit exposure profiles for various derivative contracts and combination profiles.

The significant factors that drive the exposure profile include:

- Maturity
- Payment frequencies
- Option exercise
- Roll-off and default.

In all of the examples, **PFE is defined as a percentage of the notional of the transaction**.

Loans and bonds

The exposures of debt instruments such as loans and bonds can usually be considered almost deterministic and approximately equal to the notional value.

- Bonds typically pay a fixed rate and therefore will have some additional uncertainty since, if interest rates decline, the exposure may increase and vice versa
- Loans are typically floating-rate instruments but the exposure may decline over time due to the possibility of prepayments.

Future uncertainty

The most obvious driving factor in exposure is future uncertainty. Forward contracts such as forward rate agreements (FRAs) and FX forwards are usually characterized by an exchange of two cash flows or underlyings (often netted into a single payment) at a single date, which is the maturity of the contract. This implies the exposure is a simple increasing function. If we assume a normal distribution, the profile will follow a "square root of time" rule, meaning that it will be proportional to some constant times the square root of the time (t):

$$\text{Exposure} \propto \sqrt{t}$$

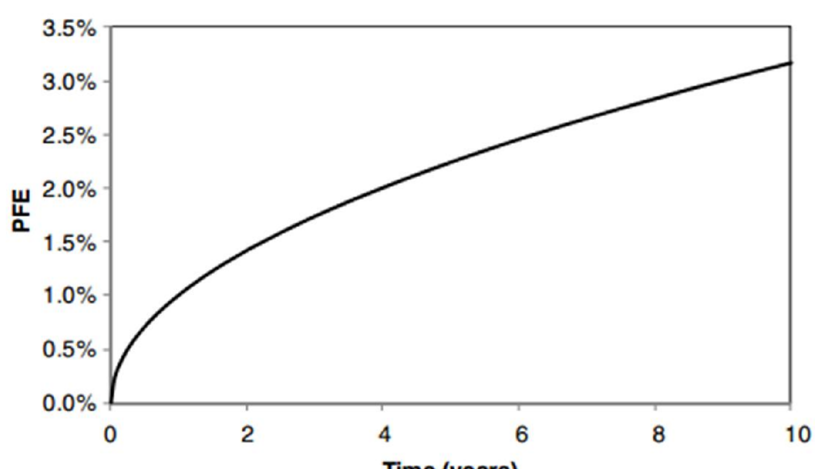


Figure 8.8 Illustration of a square root of time exposure profile that is seen, for example, in forward contracts and vanilla options positions.

Periodic cash flows

Many OTC derivatives include the periodic payment of cash flows, which has the impact of reversing the effect of future uncertainty. The most obvious example is a swap which is characterized by a peaked shape as shown in Figure 8.9. The shape arises from the balance between future uncertainties over payments, combined with the roll-off of swap payments over time. This can be represented approximately as

$$\text{Exposure} \propto (T - t)\sqrt{t}$$

Where T represents the maturity of the trade in question. The above function is initially increasing due to the √t term but then decreases to zero as a result of the (T – t) component, which is an approximate representation of the remaining maturity of the trade at a future time (t). **It can be shown that the maximum of the above function occurs at T/3, i.e., the maximum exposure occurs at one third of the lifetime**.

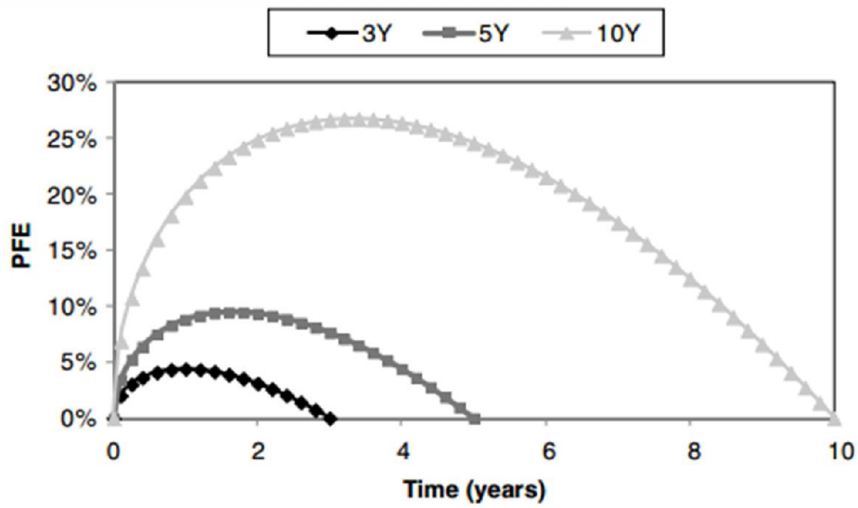


Figure 8.9 Illustration of the PFE of swaps of different maturities.

A swap with a longer maturity has much more risk due to both the increased lifetime and the greater number of payments due to be exchanged. An illustration of the swap cash flows is shown in Figure 8.10.

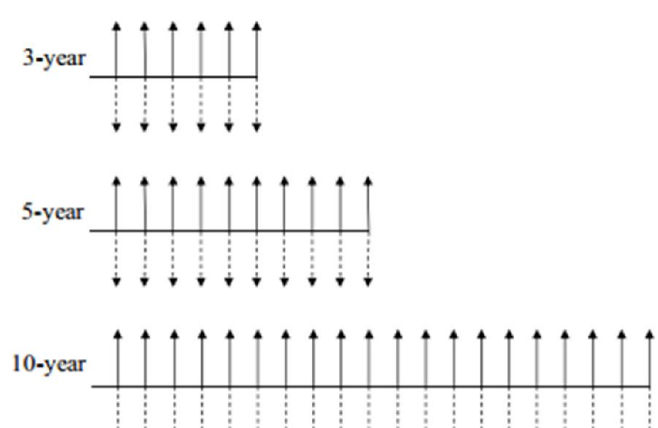


Figure 8.10 Illustration of a cash flows swap transaction of different maturities.

An exposure profile can be substantially altered due to the more specific nature of the cash flows in a transaction. A basis swap where the payments are made more frequently than they are received will then have more risk than the equivalent equal payment swap. This effect is illustrated in Figures 8.11 and 8.12.

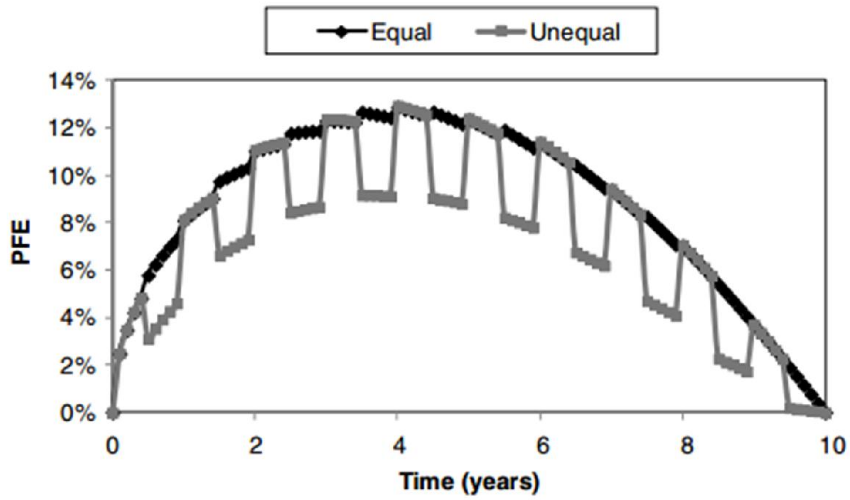


Figure 8.11 Illustration of PFE for swaps with equal and unequal payment frequencies. The latter corresponds to a swap where cash flows are received quarterly but paid only semi-annually.

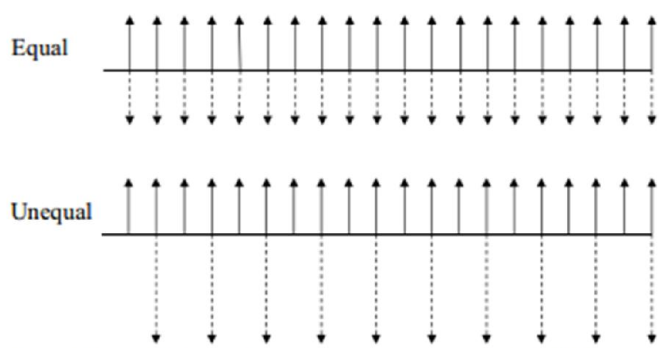


Figure 8.12 Illustration of the cash flows in swap transactions of with different payment frequencies.

Another impact the cash flows have on exposure is in creating an asymmetry between opposite trades. In the case of an interest rate swap, this occurs because of the different cash flows being exchanged. In a “payer swap”, fixed cash flows are paid periodically at a deterministic amount (the “swap rate”) whilst floating cash flows are received. The value of future floating cash flows is not known until the fixing date although, at inception, their risk-neutral value will be equal to that of the fixed cash flows. The value of the projected floating cash flows depends on the shape of the underlying yield curve. In the case of a typical upwards sloping yield curve, the initial floating cash flows will be expected to be smaller than the fixed rate paid whilst later in the swap the trend is expected to reverse. This is illustrated schematically in Figure 8.13.

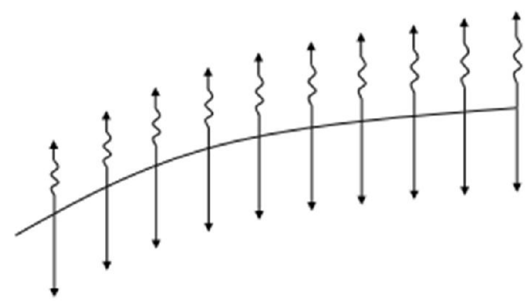


Figure 8.13 Illustration of the floating against fixed cash flows in a swap where the yield curve is upwards sloping. Whilst the risk-neutral expected value of the floating and fixed cash flows is equal, the projected floating cash flows are expected to be smaller at the beginning and larger at the end of the swap.

The net result of this effect is that the exposure of the payer swap is higher due to the expectation to pay net cash flows (the fixed rate against the lower floating rate) in the first periods of the swap and receive net cash flows later in the lifetime (Figure 8.14).

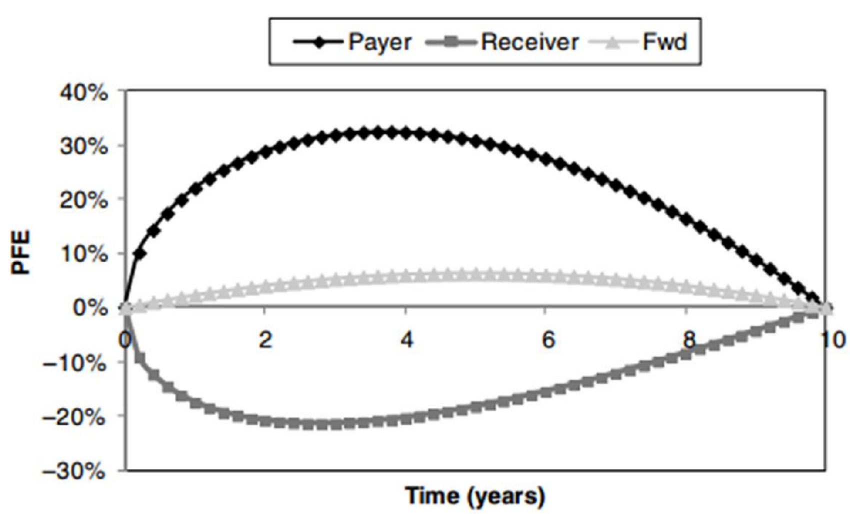


Figure 8.14 Illustration of the PFE for payer and receiver swaps and the associated forward value. The receiver swap is shown for ease of exposition as a negative exposure.

Another way to state this is that the forward value of the swap is positive (by an amount defined by the expected net cash flows). The opposite “receiver” swap has a correspondingly lower exposure.

The above effect can be even more dramatic in cross-currency swaps where a high interest-rate currency is paid against one with lower interest rates (as was the case, for *example, with widely traded dollar versus yen swaps for many years before the dramatic US interest rate cuts of 2008/09), as illustrated in Figure 8.15.

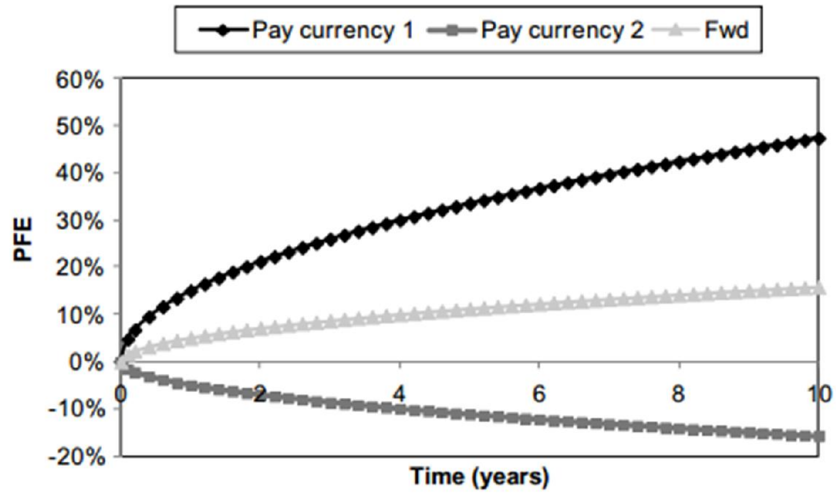


Figure 8.15 Illustration of the PFE for cross-currency swaps with the associated forward value with currency 1 having higher interest rates than currency 2. The latter case is shown for ease of exposition as a negative exposure.

The overall high interest rates paid are expected to be offset by the gain on the notional exchange at the maturity of the contract, and this expected gain on exchange of notional leads to a significant exposure for the payer of the high interest rate. In the reverse swap, it is increasingly likely that there will be a negative MtM on the swap when paying the currency with the lower interest rates. This creates a “negative drift”, making the exposure much lower.

Combination of profiles

Some products have an exposure that is driven by a combination of two or more underlying risk factors. For example: a cross-currency swap essentially combines an interest rate swap and an FX forward trade. This would therefore be represented by a combination of the profiles shown in Figures 8.8 and 8.9, as illustrated by Figure 8.16:

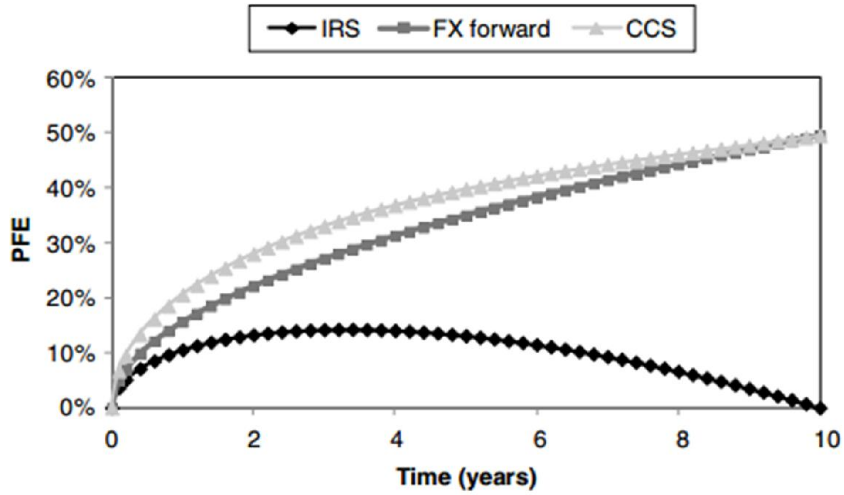


Figure 8.16 Illustration of a cross-currency swap (CCS) profile as a combination of an interest rate swap (IRS) and FX forward.

Foreign exchange exposures can be considerable due to the high FX volatility driving the risk coupled to the long maturities and final exchanges of notional. The contribution of the interest rate swap is typically smaller, as shown. We note also that the correlation between the two interest rates and the FX rate is an important driver of the exposure (in Figure 8.16 a correlation of 20% is assumed, which increases the cross-currency exposure).

In Figure 8.17 Gregory illustrates the exposure for cross-currency swaps of different maturities. The longer-maturity swaps have marginally more risk due to the greater number of interest rate payments on the swap.

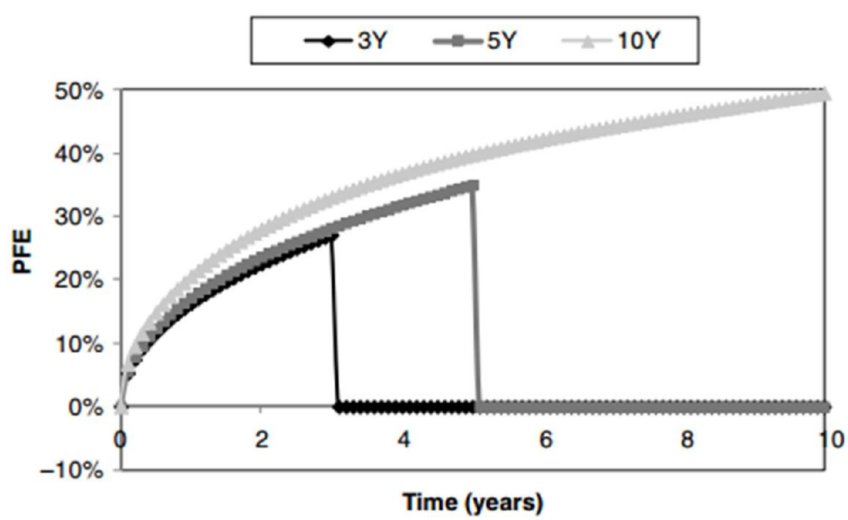


Figure 8.17 Illustration of the PFE of cross-currency swaps of different maturities.

Optionality

The impact of exercise decisions creates some complexities in exposure profiles. In Figure 8.18, we show the exposure for a European-style interest rate swaption that is swap-settled (physical delivery) rather than cash-settled. The underlying swap has different payment frequencies also.

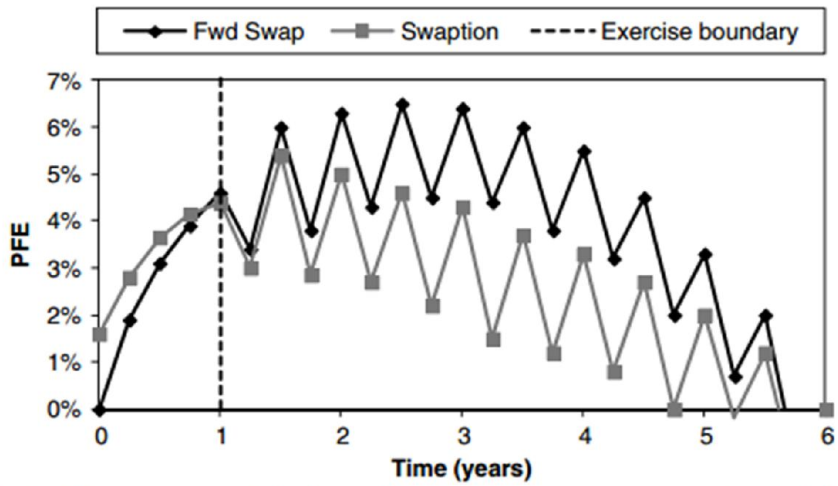


Figure 8.18 PFE for a swap-settled (physically settled) interest rate swaption and the equivalent forward swap. The option maturity is 1 year and the swap maturity 5 years.

We compare it with the equivalent forward swap. Before the exercise point, the swaption must always have a greater exposure than the forward swap but thereafter, this trend will reverse since there will be scenarios where the forward swap has positive value but the swaption would not have been exercised. This effect is illustrated in Figure 8.19, which shows a scenario that would give rise to exposure in the forward swap but not the swaption.

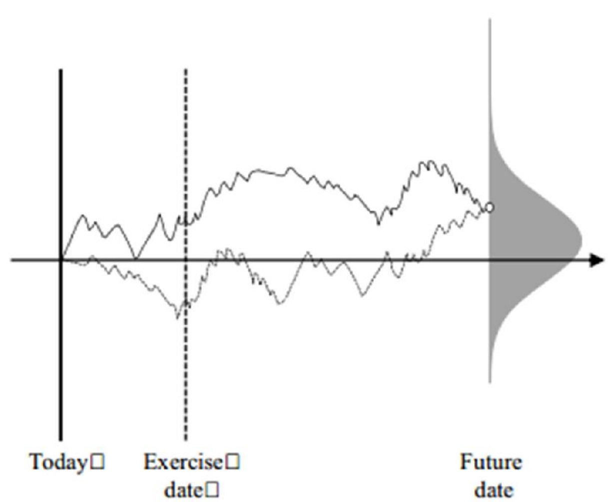


Figure 8.19 Illustration of exercise of a physically settled European swaption showing two potential scenarios of future value for the underlying swap. The solid line corresponds to a scenario where the swaption would be exercised, giving rise to an exposure at the future date. The dotted line shows a scenario that would give rise to an identical exposure but where the swaption would not have been exercised. The exercise boundary (point at which the swaption is exercised) is assumed to be the x-axis.

Credit derivatives

Credit derivatives represent a big problem for counterparty risk assessment due to wrong-way risk. Even without this as a consideration, exposure profiles of credit derivatives are hard to characterize due to the discrete payoffs of the instruments.

Consider the exposure profile of a single-name CDS as shown in Figure 8.20 (long CDS protection). The exposure increases in the early stages, which corresponds to scenarios in which the CDS premium (credit spread) will have widened. However, the maximum exposure on the CDS corresponds to the reference entity experiencing a credit event, which triggers an immediate payment of the notional less a recovery value (60% in the example, assuming a 40% recovery value).

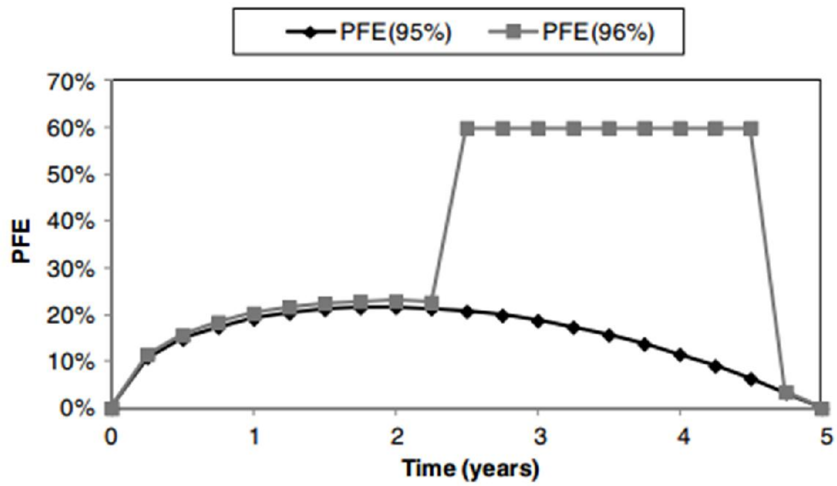


Figure 8.20 PFE for a long protection single-name CDS trade computed at confidence levels of 95% and 96%. A PFE of 60% arises from default with an assumed recovery rate of 40%.

This is a rather unnatural effect (see also Hilleet al., 2005), as it means that PFE may or may not represent the actual credit event occurring and is sensitive to the confidence level used. In the example, at 3 years the 95% PFE is defined by a large credit spread widening whilst the 96% PFE is defined by the credit event (and is three times larger). Using a measure such as expected shortfall partially solves this problem.

Explain how payment frequencies and exercise dates affect the exposure profile of various securities.

Payment frequencies

Unequal payment frequencies (e.g., if semi-annual fixed payments are made and quarterly floating payments received) can substantially alter the specifics of the cash flows in a transaction. The unequal case has a reduced exposure since payments are received more frequently than they are made. This effect is similar to a simple version of collateralization.

A swap where the payments are made more frequently than they are received will have more risk than the equivalent equal payment swap. Simplified methods (e.g., add-ons) of computing exposure are typically unable to account for such details that can be easily handled by a full Monte Carlo simulation with enough time points to capture such granular effects.

Exercise dates

The impact of exercise decisions creates complexities in exposure profiles

Explain the impact of netting on exposure, the benefit of correlation, and calculate the netting factor.

Negativity of MtM

Netting can never increase the exposure to a given counterparty. Since netting allows the MtM of trades to offset each other, we must consider all individual MtM values with a given counterparty together.

For an instrument to give any benefit from netting then there must be some chance of it having a negative MtM at some point in its lifetime. If the MtM of an instrument can only be positive, then it can never have a beneficial impact on the overall exposure (although other trades may be considered to reduce its own exposure). Instruments that fall into this category are long option positions where the entire premium is paid up front, for example:

- Equity options and FX options
- Swaptions; caps and floors

In addition to instruments that cannot have a negative MtM, we should consider instruments that can have a negative MtM but where this is less likely than a positive MtM. Such instruments would give some netting benefit but it would be less significant. Examples include:

- Long option position without an upfront premium;
- Payer interest rate swap with an upwards-sloping yield curve
- Receiver interest rate swap with a downwards-sloping yield curve
- FX forwards and cross-currency swaps paying currency with the lower interest rate
- Off-market instruments (e.g. swaps with a large upfront payment);
- Wrong-way risk exposures

The impact of netting on future exposure

Figure 8.21 illustrates the impact of netting on exposure with exactly opposite transactions. When there is no legal agreement to allow netting then exposures must be considered additive. This means that the positions do not offset one another. With netting allowable (and enforceable), one can add values at the netting set level before calculating the exposure and therefore the profiles shown give a zero exposure at all points in the future.

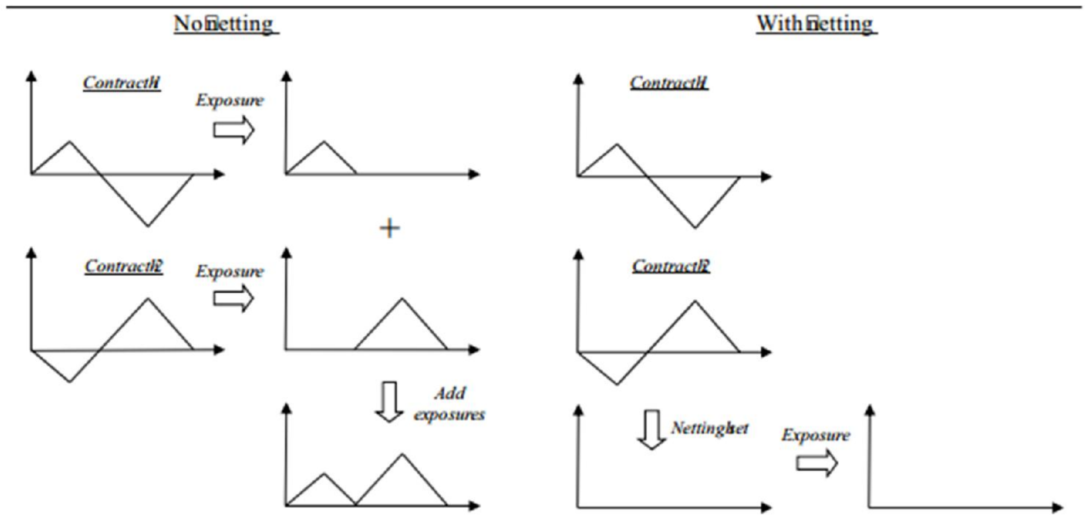


Figure 8.21 Illustration of the impact of netting on exposure.

Netting and the impact of correlation

When considering the netting benefit of two or more trades, the most obvious consideration is the correlation between the future values (and therefore exposures also). A high positive correlation between two trades means that future values are likely to be of the same sign. This means that the netting benefit will be small or even zero. We illustrate this in Table 8.2, where we can see that the two sets of values create very little netting benefit. Netting will only help in cases where the values of the trades have opposite signs, which occurs only in scenario 3. The EE (average of the exposures assuming equally weighted scenarios) is reduced by only a small amount.

Positive Correlation between MtM values --> Little/no benefit
Gregory Table 8.2

	MtM		Total Exposure		
	Trade #1	Trade #2	Without	With Netting	Netting Benefit
Scenario 1	25	15	40	40	0
Scenario 2	15	5	20	20	0
Scenario 3	5	-5	5	0	5
Scenario 4	-5	-15	0	0	0
Scenario 5	-15	-25	0	0	0
Expected exposure (EE)			**13**	**12**	**1**

Highly correlated exposures (as in Table 8.2) will provide the least netting benefit and, in case of identical distributions (add 10 to each scenario for trade 2 to see this effect), this simply corresponds to increasing the size of a given transaction, in which case there will be no netting benefit at all.

Negative correlations are clearly much more helpful as future values are much more likely to have opposite signs and hence the netting benefit will be stronger. We illustrate this in Table 8.3, where we see that netting is beneficial in four out of the five scenarios. The EE is almost half the value without netting.

Negative Correlation between MtM values --> High benefit
Gregory Table 8.3

	MtM		Total Exposure		
	Trade #1	Trade #2	Without	With Netting	Netting Benefit
Scenario 1	25	-15	25	10	15
Scenario 2	15	-5	15	10	5
Scenario 3	5	5	10	10	0
Scenario 4	-5	15	15	10	5
Scenario 5	-15	25	25	10	15
Expected exposure (EE)			**18**	**10**	**8**

The extreme case of perfect negative correlation (as in Table 8.3) will provide the maximum netting benefit. In the case of identical distributions (subtract 10 from each scenario for trade 2 to see this effect), this simply corresponds to perfectly offsetting transactions (perhaps due to a cancellation via an unwind) in which case the netting benefit is 100% since there is no overall risk.

Netting factor

A majority of netting may occur across instruments of different asset classes that may be considered to have only a small correlation. One should note that this would still create a positive benefit. We derive the following formula for the “netting factor” with respect to exposure under the assumption that future values follow a multivariate normal distribution:

$$\text{Netting factor} = \frac{\sqrt{n + n(n-1)\bar{\rho}}}{n}$$

Where (n) represents the number of exposures and rho-bar is the average correlation. The netting factor represents the ratio of net to gross exposure and will be +100% if there is no netting benefit and 0% if the netting benefit is maximum.

We illustrate the above expression in Figure 8.22, where we can see that the netting benefit improves (lower netting value) for a large number of exposures and low correlation as one would expect, since these conditions maximize the diversification benefit. We note that this is a stylized example but it shows the general impact of correlation and the size of the netting set.

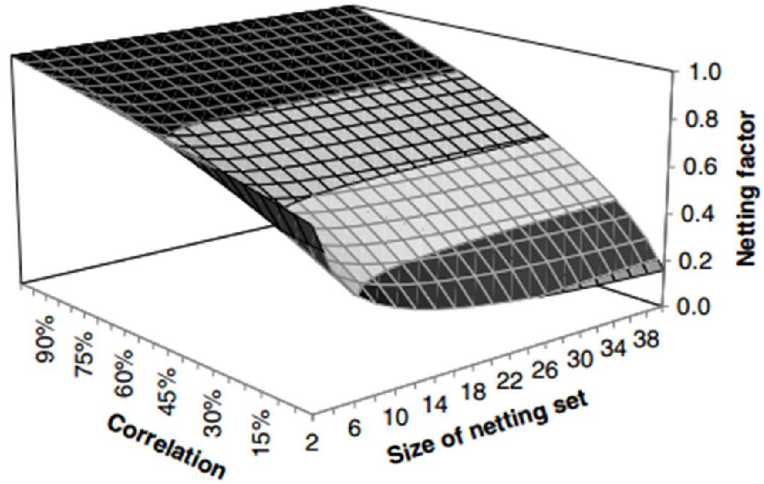


Figure 8.22 Illustration of the netting benefit in a simple example as a function of the size of the netting set (number of trades) and correlation as derived in Appendix 8E. Only positive correlations are shown.

With no correlation, the simple formula tells us that the overall netting factor for n exposures is 1/SQRT(n). This means, for example, that two independent exposures with zero mean and equal volatility have a netted exposure reduced to 71% of the exposure without netting. For five exposures, the netting factor decreases to 45%.

Netting and absolute value

In Table 8.2 the correlation between future values is 100% but the correlation of exposures is only 96%. We can therefore see that the netting benefit depends not only on the correlation of future values but also on the relative offset of the future values (in Table 8.2, trades 1 and 2 have positive and negative expected future values respectively which reduces the netting benefit). Netting not only depends on the structural correlation between the future values of trades, but also on the relative offset of those values from zero.

Trade 1 has strongly negative initial value (MtM) (ρ = 0)
Gregory Table 8.4

	MtM		Total Exposure		
	Trade #1	Trade #2	Without	With Netting	Netting Benefit
Scenario 1	-20	25	25	5	20
Scenario 2	-25	15	15	0	15
Scenario 3	-15	5	5	0	5
Scenario 4	-15	-5	0	0	0
Scenario 5	-25	-15	0	0	0
Expected exposure (EE)			**9**	**1**	**8**

Consider the results shown in Table 8.4. Trade 1 has a strongly negative future value in all scenarios and therefore offsets the positive future value of trade 2 in scenarios 1–3. The EE is reduced from 9 to just 1. This is a result of trade 1 having an overall negative future value and is not solely linked to the structural correlation between the trades (indeed the future values have been constructed to have zero correlation). For example, if the trade 1 future values are increased by +10 then the reduction is only 3 even though the correlation of future values is the same.

An illustration of the impact of negative future value of a netting set is shown in Figure 8.23. Negative future value will create netting benefit irrespective of the structural correlation between trades.

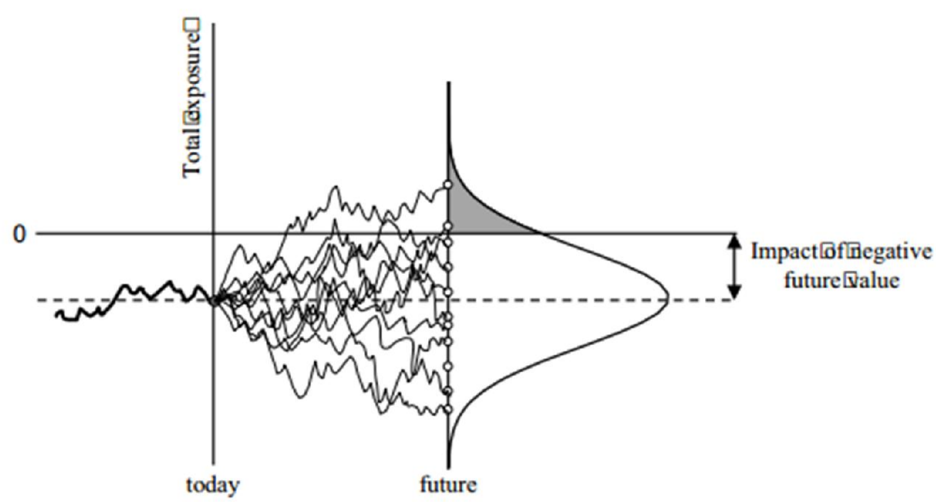


Figure 8.23 Schematic illustration of the impact of a negative future value.

A positive future value can be considered also to have a beneficial impact with respect to netting. Consider the results shown in Table 8.5. Trade 1 has positive future value in all scenarios, which nets with the negative future value of trade 2 in scenarios 4 and 5 even though the correlation of the trade 1 and trade 2 future values is 100%.

Trade 1 has positive initial value (MtM) (ρ= 0)
Gregory Table 8.5

	MtM		Total Exposure		
	Trade #1	Trade #2	Without	With Netting	Netting Benefit
Scenario 1	45	15	60	60	0
Scenario 2	35	5	40	40	0
Scenario 3	25	-5	25	20	5
Scenario 4	15	-15	15	0	15
Scenario 5	5	-25	5	0	5
Expected exposure (EE)			**29**	**24**	**5**

An illustration of the impact of the positive future value of a netting set is shown in Figure 8.24. It is important to emphasize that even highly correlated trades can give rise to netting benefits as the exposure may not be as highly correlated (as in the example in Table 8.2). A practical example of this could be two otherwise identical swaps but with different swap rates.

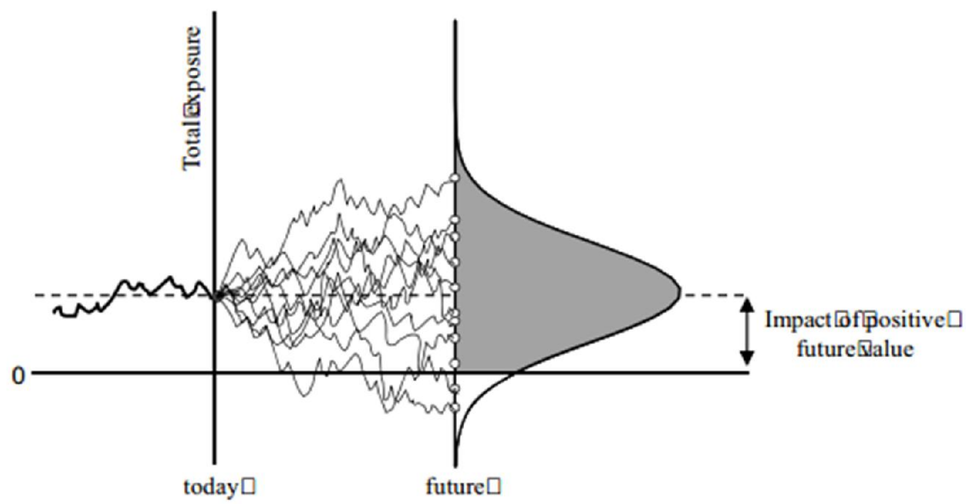


Figure 8.24 Schematic illustration of the impact of a positive future value.

Explain the impact of collateralization on exposure, and assess the risk associated with the remargining period.

Margin period of risk

Now we consider how long it will take to receive collateral. This involves estimating the “margin period of risk”, which is much more than the contractual time between collateral (margin) calls. Such a period is crucial since it defines the length of time without receiving collateral where any increase in exposure will remain uncollateralised. It is important to model the exposure evolution over the margin period of risk to understand properly the impact of collateral. Where collateral is in a different currency and/or security then the variation in the FX rate and collateral price must also be accounted for as this adds additional risk.

In order to assess the margin period of risk, it is important to consider all of the following effects that may slow down the collateral process:

- **Valuation/margin call**. This represents the time taken to compute current exposure and the current market value of collateral, working out if a valid call can be made and finally making that call. This should include the time delay due to the contractual period between margin calls (often daily calls are contractual but sometimes longer periods may apply).
- **Receiving collateral**. The delay between a counterparty receiving a collateral request (fax/email) to the point at which they release collateral. The possibility of a dispute (i.e., the collateral giver does not agree with the amount called for) should be incorporated here.
- **Settlement**. Collateral will not be received immediately as there is a settlement period depending on the type of collateral. Cash collateral may settle on an intraday basis whereas other securities will take longer. For example, government and corporate bonds may be subject to 1-day and 3-day settlement periods, respectively.
- **Grace period**. In the event a valid collateral call is not followed by the receipt of the relevant collateral, there may be a relevant grace period before the counterparty would be deemed to be in default. This is sometimes known as the cure period.
- **Liquidation/closeout and re-hedge**. Finally, it will be necessary to liquidate collateral and closeout and re-hedge positions.

We finally note that all of the above assessments should be considered in a scenario where the relevant counterparty is defaulting. This worst-case scenario is valid since one must base all calculations on the assumption that a counterpartywilldefault. An institution is not concerned with the time taken to receive collateral innormal cases and normal market conditions (which may well be small) because collateral performs no function (in terms of mitigating counterparty risk at least) in these situations. Instead, the institution must consider a scenario where their counterparty is in default and market conditions may be far from normal. In such a scenario, the time before being able to take delivery of collateral after a valid call (or alternatively to put the counterparty into default) can be significant.

Under Basel II rules the minimum margin period of risk which must be assumed for OTC derivatives is 10 days (business) assuming collateral may be called for on a daily basis. OTC derivatives and repo transactions are considered separately since they are governed by different documentation. Collateralisation in repo markets is generally tighter and the minimum period assumed is therefore lower due partly to the more complex nature of OTC derivatives, which makes valuation more complex. A possible scenario equating to such an assumption is shown in Table 8.8.

Table 8.8 Example timeline for the margin period of risk in a worst-case scenario based on the assumption of a daily margin call. This does not consider the additional delay potentially caused by disputes. The Basel II minimum period (see Chapter 11 for more details) is also shown

	OTC derivatives (CSA[a])	*Repo (GMRA[b])*
Valuation/margin call	2 days	—
Receiving collateral	1 day	1 day
Settlement	2 days	1 day
Grace period	3 days	—
Liquidation/closeout and re-hedge	2 days	1 day
Total	10 days	3 days
Basel II minimum period	10 days	5 days

[a] Credit support annex.

[b] Global master repurchase agreement.

The above periods could easily be argued to be different depending on the precise assumptions and legal interpretations. Longer margin periods of risk could be appropriate depending on the collateral agreement and counterparty in question, as well as legal considerations and even the management structure of the institution concerned (institutions may be more lenient with certain counterparties to maintain good relations). In particular, Table 8.8 does not assess potential delays because of disputes or longer grace periods, which may be likely in practice. In particular, under Basel III, a margin period of risk of 20 days must be assumed in certain cases. An institution should decide carefully on the relevant margin period of risk with all of these considerations taken into account.

For example, in the case of a dispute, the protocol that should be followed is that the undisputed amount is transferred and then the parties involved enter into negotiations to agree on the disputed amount. The latter procedure may take some significant time, as experienced by many institutions during the financial crisis. This process is illustrated in Figure 8.26. In theory, receiving collateral should be divided into two parts, the undisputed and disputed amounts with associated periods. In practice this is probably extraneous.

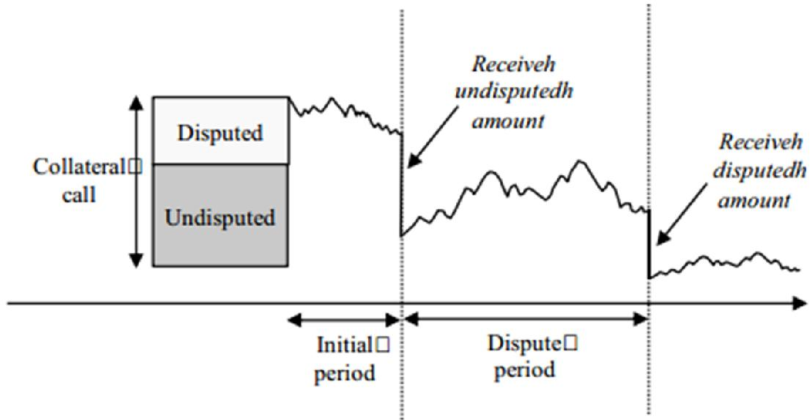


Figure 8.26 Illustration of the impact of a dispute on the margin period of risk period assuming that the institution does eventually receive the full amount, including the disputed component. We note that a fixed margin period of risk is a simple representation of the two periods above.

Impact of collateral on exposure

A simple example of the impact of collateral on exposure is given in Table 8.9 assuming a two-way CSA. In scenarios 1–3 the exposure is reduced significantly, since collateral is held. The exposure is not perfectly collateralised, which may be the case in practice due to factors such as thresholds and minimum transfer amounts. In scenario 4, the value of the portfolio is negative and collateral must therefore be posted but this does not increase the exposure (again in practice due to aspects such as thresholds and minimum transfer amounts).

Finally, in scenario 5, the posting of collateral createsexposure. In comparison with the benefits shown in the other scenarios, this is not a particularly significant effect, but it is important to note that collateral can increase as well as reduce exposure.

Figure 8.27 shows an example of the impact of collateral on exposure. There are two main effects to notice. Firstly, the effect of a threshold is effectively to cap the exposure around the Threshold amount. The collateral has little effect at the beginning and end of the profile where the exposure is relatively small. The second effect is the impact of the delay in receiving collateral; the need to post collateral and parameters such as minimum transfer amounts create some risk above the threshold.

Table 8.9 Illustration of the impact of collateral on exposure. The expected exposure is shown assuming each scenario has equal weight

	Future value		*Exposure*		
	Portfolio	*Collateral*	*No collateral*	*With collateral*	*Benefit*
Scenario 1	25	23	25	2	23
Scenario 2	15	12	15	3	12
Scenario 3	5	3	5	2	3
Scenario 4	−5	−2	0	0	0
Scenario 5	−15	−18	0	3	−3

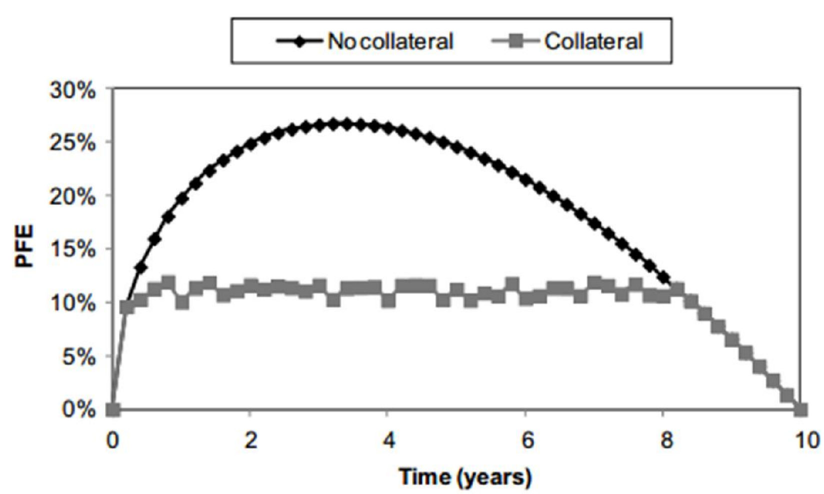


Figure 8.27 Illustration of the impact of collateral on exposure. The collateral threshold is assumed to be 10%.

Repos and overcollateralisation

Repos represent collateralised loans. An institution borrowing cash and pledging some security as collateral is entering into a repo (repurchase agreement) whilst the other party is entering into a reverse repo.

As a reverse repo is effectively a collateralised loan, it carries counterparty risk. The exposure on a reverse repo transaction is Exposure = Max (cash value – bond value,0). To protect against counterparty risk, the collateral will attract a haircut meaning that the bond value at trade inception will exceed the amount of cash borrowed.

In some repo transactions, variation margin (collateral) may be taken which will minimise the impact of changes in the bond price. Since a reverse repo is overcollateralised by the embedded haircut then the counterparty risk should be relatively small. There is a chance that a decline in the bond price (in-between variation margin calls) can create some counterparty risk.

Figure 8.28 illustrates the exposure of a reverse repo transaction for different haircut levels assuming that variation margin is also used. The exposure (shown in terms of a bond notional of 100) is quite small and almost negligible if the haircut is reasonably large.

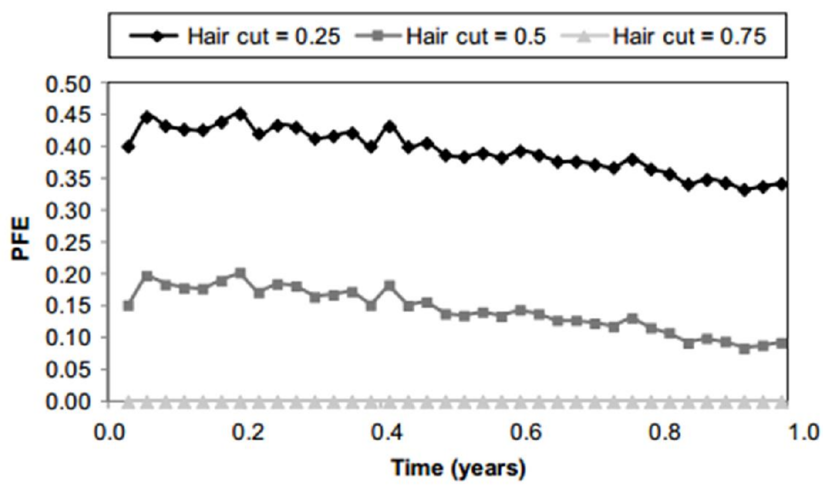


Figure 8.28 Illustration of the risk of a reverse repo transaction as a function of the haircut of maturity 1-year with the underlying collateral being a 5-year bond of notional amount 100. The margin period of risk is assumed to be 5 days.

The above example assumes a 1-year repo transaction. Whilst this is possible, repos are typically of much shorter term (e.g., overnight or 1 week). This and the overcollateralisation mean that the counterparty risk in reverse repos is typically small in comparison with other cases.

Explain the difference between risk-neutral and real-world parameters, and describe their use in assessing risk.

A final consideration in terms of defining credit exposure is whether it should be done with respect to risk-neutral or real-world parameters. In the most simple terms, pricing (CVA) should use the former whilst risk management (PFE) the latter. However, the actual situation is more complicated.

The importance of measure

Scenario generation for risk management purposes and arbitrage pricing theory use different “measures”. Arbitrage-based pricing uses the so-called risk-neutral measure, which is justified through hedging considerations. Parameters (and therefore probability distributions) such as drifts and volatilities are market-implied and need not correspond to the real distributions (or even comply with common sense). For a risk management application, one does not need to use the risk-neutral measure and should be focused rather on the real-world measure, estimated using, for example, historical data. Risk-neutral parameters are typically used in pricing applications (CVA), whilst real-world parameters generally form the basis of risk management models (PFE). This is the general distinction but there are necessary exceptions, which we discuss below.

The types of parameters to be considered are:

- **Drift** –the trend of market variables.
- **Volatility** –the future uncertainty of market variables.
- **Correlation** –the co-movement between market variables.

In addition to the above general definitions, effects like mean-reversion should be considered. Many market variables (for example, commodities and interest rates) tend to mean-revert over time, which pulls long-term rates back to some average level.

- **Mean-reversion** has an impact on future spot prices and volatilities.
- **Risk-neutral mean reversions**, whilst often hard to calibrate, tend to be smaller than mean-reversions estimated from historical data.

Drift

A key difference between VAR analysis for market risk (for example) and credit exposure quantification for CVA purposes is the time horizon concerned. In the relatively short market risk horizon (for example, 10-days in VAR approaches), the drift of an underlying asset is of secondary importance vis-à-vis its volatility and is often ignored. However, in the longer time horizons required for assessing credit exposure and CVA, drift will be a key consideration alongside volatility. In other words, the trend of an underlying variable can be just as important as its uncertainty.

One area where risk-neutral parameters tend to be used even for risk management simulations is the determination of the drifts of underlying risk factors, which are typically calibrated from forward rates. The consideration of drifts is important since the impact of volatility approximately follows the square root of time scaling whereas the drift scales more linearly – so in the end a strong drift will eventually dominate. Futures (or equivalently forward) prices have long been an important mechanism of price discovery in financial markets as they represent the intersection of expected supply and demand at some future point in time. Forward rates can sometimes be very far from spot rates and it is important to understand whether or not this is truly the “view of the market”.

Some important technical factors are:

- **Commodity prices.** In addition to market participants’ view of the direction of commodity prices, storage costs (or lack of storage), inventory and seasonal effects can move commodities futures apart from spot rates. For high inventories the futures price is higher than the spot price (contango). When inventories are low, commodity spot prices can be higher than futures prices (backwardation).
- **Interest rates.** Yield curves may be upwards-sloping or downwards-sloping (and a variety of other shapes) due to the risk appetite for short-, medium- and long-term interest rate risk and the view that rates may increase or decrease.
- **Credit spreads.** Credit curves may be increasing or decreasing either due to demand for credit risk at certain maturities or the view that default probability will be increasing or decreasing over time.
- **Foreign exchange (FX) rates.** Forward FX rates are determined from an arbitrage relationship between the interest rate curves for the relevant currency pair. Expectation of future FX rates may have an influence on the current interest rate curves in the corresponding currencies. For example, FX forward rates are determined by a differential in the underlying interest rates. There has long been doubt regarding the ability of long-term forward rates to predict future spot rates; see, for example, Meese and Rogoff (1983) and a review by Sarno and Taylor (2002).

There has been much empirical testing of the relationship between spot and futures prices across different markets. It is a generally held belief that the futures price is a biased forecast of the future spot price, contrary to the efficient market hypothesis. If we take the view that the forward rate is the best expectation of the future spot rate then this may lead to a strong drift assumption. If this assumption is wrong then it will significantly overstate or understate the risk.

Despite the above problems with drifts, most PFE and CVA calculations will calibrate to forward rates in the market. From the CVA point of view, this is justified by hedging. For PFE purposes, this is often done more for convenience’s sake, since it means that simple instruments are by construction priced properly and circumvents the need to attempt to estimate the “real-world” drift of risk factors.

The key point to take away is that markets are imperfect and so we cannot always expect current futures prices to be the best estimate of spot prices in the future. We should bear this in mind when assessing and pricing counterparty risk, especially for long time horizons. Advocating the estimation of real-world drifts is not the intention here. However, it is important to be aware of the implications of using risk-neutral drifts for PFE quantification and for CVA calculations when hedging is not perfect.

Example. Consider a transaction whose future value has a volatility of 10% and a drift of 5% over 1 year.

The expected exposure based on the usual formula is

$$[5\% \times \Phi(5\%/10\%) + 10\% \times \varphi(5\%/10\%)] = 6.98\%$$

On the other hand, consider the reverse transaction. The expected drift would be −5% and the expected exposure

$$[-5\% \times \Phi(-5\%/10\%) + 10\% \times \varphi(-5\%/10\%)] = 1.98\%$$

Is it correct that the first transaction has a CVA that is approximately three and a half times greater than the second?

Volatility

To quantify exposure, one might use a historical estimate of volatility. However, to calculate CVA, implied volatilities are more relevant. Again there is the caveat related to the extent to which the volatility component of CVA can (and will) be hedged. We also note that (positive) mean-reversion has the effect of reducing long-term volatilities and thus is an important parameter to estimate.

If one uses a historical estimate of volatility then the implicit assumption is that the past will be a good indication of the future. It is also necessary to decide what history of data to use; a short history will give poor statistics whereas a long history will give weight to “old” meaningless data. In quiet markets, the lack of volatility in historical time series will give low risk numbers which may be misleading (recent changes to Basel capital rules require always using a stress period of data to overcome this), creating procyclicality. When markets suddenly become more volatile, the historical estimate will only gradually increase to reflect this as the window of data moves.

For most markets, there is likely to be implied volatility information, potentially as a function of strike and the maturity of the option. Implied volatility which will react quickly when the market becomes more uncertain and may be justified via the “market knows best” (or at least the market knows better than historical data). However, risk premiums embedded in market-implied volatilities will lead to a systematic overestimate of the overall risk. It has been argued that implied volatility is a superior estimator of future volatility (e.g., see Jorion, 2007, chapter 9) compared with historical estimation via time series approaches. The stability of the volatility risk premium and the fact that an overestimate of volatility will always lead to a more conservative risk number give greater credence to this idea.

Correlations

Whilst it is at least conservative to assume volatilities are high, the same is not true of other quantities. When estimating correlation for modelling exposure, there may not be an obvious way of knowing whether a high or low (or positive or negative) value is more conservative. Indeed, in a complex portfolio it may even be that the behavior of the exposure with respect to correlation is not monotonic. Therefore, the use of some market-implied parameters cannot be justified on the basis that the resulting risk numbers will be conservatively high.

Implied correlations are sometimes available in the market. For example, a quanto option has a payoff in a different currency and thus gives information on the implied correlation between the relevant FX rate and the underlying asset. One key aspect of correlation is to determine wrong-way risk. For example, a quanto CDS (a CDS where the premium and default legs are in different currencies) potentially gives information on the correlation between the relevant FX rate and the credit quality of the reference entity in the CDS).

Whilst implied correlation can sometimes be calculated, for most quantities no market prices will be available. This also means that the sensitivity of CVA to correlation parameters cannot generally be hedged and historical data will probably be used. A sensitivity analysis of correlation will be useful to understand the importance of a particular correlation parameter.

Conclusion

In summary, exposure quantification for risk management (PFE) should generally focus on real parameters, with market-implied parameters used when there are good reasons (such as in the example of using drifts and implied volatility above). Exposure quantification for pricing (CVA) should generally focus on (risk-neutral) market-implied parameters. An obvious exception here would be the need to use historical correlations since market-implied parameters are typically not observed.

Chapter Summary (TBD: next version, literal as placeholder)

In this chapter we have discussed credit exposure. Some key definitions of potential future exposure, expected exposure and expected positive exposure have been given. The factors impacting future exposures have been explained and we have discussed the impact of netting and collateral.

Questions & Answers

1. Each of the following is true about the Monte Carlo Simulation approach to quantifying credit exposure, EXCEPT which is false?

a) Roll-off risk is greater if the exposure profile is highly discontinuous
b) Compared to semi-analytical methods which are designed to produce a distribution, Monte Carlo simulation "suffers a weakness in its inability to produce a full distribution."
c) Compared to semi-analytical methods, Monte Carlo simulation is better suited to capturing exposures that are path dependent
d) A Monte Carlo Simulation might include these steps, in this order: 1. Factor Choice, Scenario Generation, 3. Revaluation, 4. Aggregation, 5. Post-processing, 6. Statistics extraction

2. While there are important exceptions, which is the best general advice in regard to the selection of real or risk-neutral probabilities in credit exposure models?

a) Exposure management (e.g., scenario generation) should focus on risk-neutral, market-implied parameters; but pricing should focus on real, historical parameters especially when counterparty risk is actively managed.
b) Exposure management (e.g., scenario generation) should focus on real, historical parameters; but pricing should focus on risk-neutral, market-implied parameters, especially when counterparty risk is actively managed.
c) Both exposure management and pricing should focus on risk-neutral, market implied parameters
d) Both exposure management and pricing should focus on real, historical parameters

3. Consider the following statements about possible parameters used, to model different asset classes, when simulating credit exposures:

I. FX rates might assume a standard geometric Brownian motion, possibly amended to include a mean-reversion level.
II. Commodities might include a deterministic trigonometric function (sin or cos) to model seasonal periodicity; and might also include a mean-reversion level.
III. Credit spreads require a model that prevents negative values and include a term for discontinuous jumps; and are likely to include a mean-reversion level.
IV. Interest rates might follow a one-factor Hull and White, or extended Vasiek, but tend to include mean reversion; if sophisticated, non-parallel term structure shifts are required, then a multi-factor model is probably required.

According to Gregory, which of the above is true?

a) None, all are false
b) I. and III. Only
c) II. and IV. Only
d) All are true

4. Suppose we have two trades with mark to market (MtM) distributions at a future date being normally distributed with the following parameters; e.g., Trade 1 has a mean of 6% and standard deviation of 10%. Further, for both trades, the calculated standalone expected exposure (EE) and marginal EE are given:

Parameters		
	Trade 1	**Trade 2**
Mean	6%	-10%
Std Dev	10%	30%
Correlation	10%	
Expected Exposure		
Standalone EE	**7.69%**	**7.63%**
Marginal EE	**4.29%**	**6.80%**

The portfolio contains both trades. Each of the following is true EXCEPT which is false:

a) the portfolio EE without netting is about 15.31%
b) the portfolio EE with netting is about 11.09%
c) If the correlation increases, the portfolio EE with netting will increase
d) If the correlation increases, the portfolio EE without netting will increase

5. A certain portfolio is covered by a netting agreement. Let EE(total) represent the portfolio expected exposure with netting; let EE(i) represent the EE of individual component (i); and let EE(i*) represent the marginal expected exposure of each component in the portfolio . Each of the following statements is true about marginal expected exposure EXCEPT for which is false?

a) As expected exposure is always positive, so too is marginal EE always positive
b) The sum of marginal EE, EE(i*), equals the total portfolio exposure with netting, EE(total)
c) Marginal EE, EE(*), varies with correlation between portfolio components
d) If there is no netting, the portfolio's expected exposure will equal the sum of individual components, EE(i)

6. For a normal distribution with zero mean, Gregory shows the potential future exposure (PFE) is given by:

$$PFE_0 = \Phi^{-1}(\alpha) \times \sigma_E \times \sqrt{T_M}$$

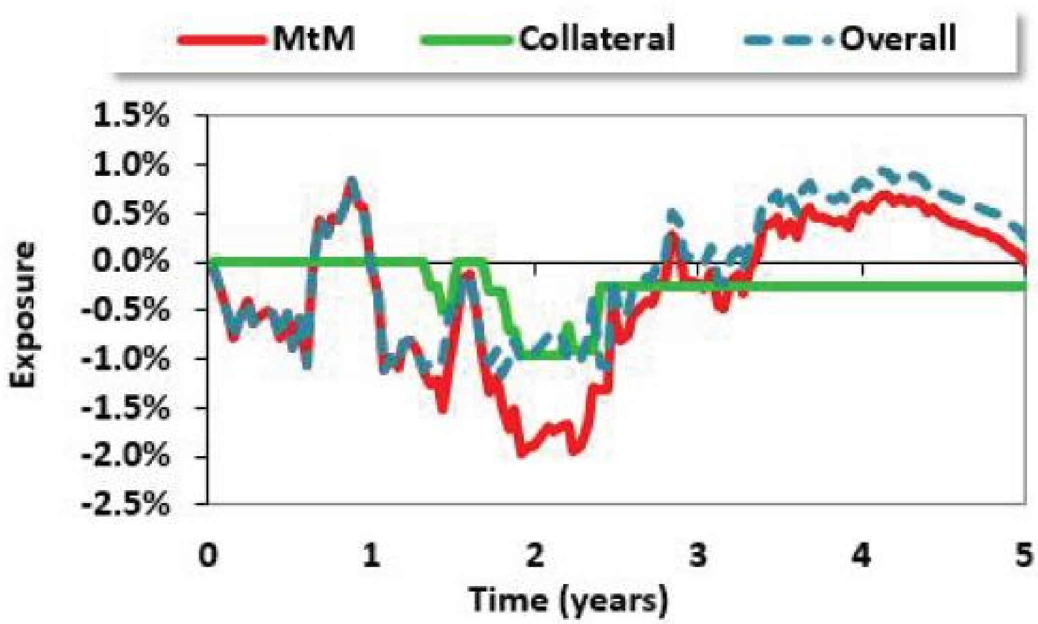
where sigma is the (annual) volatility for a collateralized exposure (all netted positions and the impact of current collateral held against the exposure where relevant), and T(M) is remargin frequency in years. Suppose an exposure with a volatility of 15.0% per annum is perfectly collateralized by a cash amount, while the remargin period (which accounts for worst case delays) is thirty (30) days. If there are 250 trading days, which is nearest to the 99.0% confident PFE?

a) 8.77%
b) 12.11%
c) 23.64%
d) 34.95%

7. About modeling the credit exposure of collateralized positions, Gregory asserts each of the following as true EXCEPT which is false?

a) If a position is "strongly collateralized," instead of a long-term risk, the primary concerns are (i) the length of the remargin period and (ii) the volatilities of the exposure and collateral
b) For risk assessment purposes, the remargin period (i.e., when collateral will be received in a worst case scenario) will be equal to the legal margin call frequency; i.e., the remargin period is typically one day
c) A source of risk is the imperfect collateralization at a given date due to the terms in the collateral agreement (threshold, minimum transfer amount and rounding) which will not permit a call for the full credit support amount.
d) A source of risk is the risk that the exposure increases in-between margin calls and it is therefore not possible to collateralize that portion of the exposure.

8. The chart below plots an exposure scenario for an interest rate swap over its five year life, based on simulations, from the perspective of Counterparty A. Plotted are the mark-to-market(MtM) in red, collateral in green, and the overall collateralized exposure in dotted blue:



The chart represents the exposure profile from Counterparty A's point of view. Each of the following is plausible, according to the chart, EXCEPT which of the following is not plausible?

a) Counterparty A's threshold is 1.0%; i.e., with respect to calls that require A to post collateral
b) Counterparty B's threshold is zero; i.e., with respect to calls which require B to post collateral
c) Minimum transfer amount is non-zero; e.g., 0.25%
d) Collateral actually increases risk in the last three years

9. Under a scenario of positive and increasing exposure (increasing mark-to-market), each of the following would tend to increase the risk of the overall expected exposure (EE) profile for a collateralized exposure EXCEPT for which would not?

a) Longer re-margin period
b) Higher threshold
c) Larger independent amount
d) Larger minimum transfer amount

10. What is the primary motivation for a higher collateral threshold?

a) Reduce operational costs
b) Reduce default risk
c) Reduce liquidity risk
d) Reduce wrong-way risk

Answers:

1. B. False, the reverse: while "often semi-analytical calculations will give us just single risk measure (such as PFE) rather than the full distribution," Monte Carlo Simulation is well-suited to producing the full distribution. (Source: Question 326.3.)

2. B. Exposure management (e.g., scenario generation) should focus on real, historical parameters; but pricing should focus on risk-neutral, market-implied parameters, especially when counterparty risk is actively managed. (Source: Question 327.2.)

3. D. All are true. (Source: Question 327.3.)

4. D. If the correlation increases, the portfolio EE without netting will increase
In regard to (A), (B) and (C), each is TRUE. **(Source: Question 328.2.)**

5. A. False. Although it is true that individual component expected exposures must be positive, a trade (component) can be risk-reducing with a negative marginal EE; i.e., its contribution to the portfolio's total EE can be negative.
In regard to (B), (C), and (D), each is TRUE. **(Source: Question 328.3.)**

6. B. 12.107% = 2.33 * 15.0% * SQRT(30/250)

7. B. FALSE: The remargin period will be significantly longer than the actual legal margin call frequency; e.g., 10 days versus 1 day.
Gregory: "The main point above is to show that for risk assessment purposes, the remargin period (when collateral will be received in a worst case scenario) will be significantly longer than the actual legal margin call frequency. For the examples in subsequent chapters, we will use a period of 10 days (or multiples thereof) which we consider to be a reasonable assessment of the true risk period for daily margin calls. This period also corresponds to the time horizon for most VAR calculations and is the minimum period for assessment of collateral specified under Basel II."
In regard to (A), (C) and (D), each is TRUE.

8. B. Neither counterparty can have a zero threshold; in this profile, both have 1.0% threshold. If Counterparty B had a zero threshold, then from the period ~ 3.5 years to ~ 5.0 years, Counterparty B would be required to post collateral such that collateral (blue line) would track nearer to MtM and overall would track near the zero (with minor volatility due to the minimum transfer amount).

- In regard to (A), this is plausible as counterparty A does not post collateral until about fully 1.3 years when the MtM drops below 1.25% (1.0% threshold + 0.25% minimum transfer amount).
- In regard to (C), this is plausible: in the last two years, zero minimum transfer amount would be realized as zero collateral and MtM = Overall
- In regard to (D), this is illustrated: overall is greater than MtM due to posted collateral by Counterparty A

9. C. Any independent amount will reduce the uncollateralized exposure
In regard to (A), (B) and (D), each is TRUE.

Gregory: "When working out the impact of collateral on a credit exposure, the factors that we must consider are listed below.

(i) Remargin period
As discussed in Section 5.2.1, one must first consider the remargin period since this is the effective time assumed between a collateral call and receiving the appropriate collateral (or in a worst case scenario putting the counterparty in default, closing out the trade, liquidating existing collateral and re-hedging the trade). Intervals between simulation time points are often significantly greater than the length of the remargin period. In such cases, extra ‘‘look-back’’ simulation points can be introduced for collateralized trades only.

(ii) Threshold
Collateral cannot be called below the threshold and hence any exposure level within the Threshold will typically be uncollateralized (unless an amount of collateral is already held which does not need to be returned due to a minimum transfer amount).

(iii) Minimum transfer amount
Collateral cannot be transferred in blocks that are smaller than the minimum transfer amount and hence this must be considered when calculating the amount of collateral that could be called. This will typically mean that an increasing exposure will be slightly undercollateralised due to minimum transfer restrictions. On the other hand, a decreasing exposure will typically mean an institution has a small overcollateralization since they do not need to return collateral continuously.

(iv) Independent amount
Any independent amount should be considered and will reduce the uncollateralized exposure. It is typically held as a cushion against ‘‘gap risk’’, the risk that the market value of a transaction(s) may gap substantially in a short space of time. An independent amount can be significant and reduce exposure to practically zero.”

10. A. Reduce operational costs

Gregory, Chapter 10: Default Probability, Credit Spreads, and Credit Derivatives

Explain the difference between cumulative and marginal default probabilities.

Calculate risk-neutral default probabilities, and compare the use of risk-neutral and real-world default probabilities in pricing derivative contracts.

Explain the various approaches for estimating price: historical data approach, equity based approach, and risk neutral approach.

Describe how recovery rates may be estimated.

Describe credit default swaps (CDS) and their general underlying mechanics.

Describe the credit spread curve and explain the motivation for curve mapping.

Describe types of portfolio credit derivatives.

Describe index tranches, super senior risk, and collateralized debt obligations (CDO).

Explain the difference between cumulative and marginal default probabilities.

We refer to the **cumulative default probability**, F(t), which gives the probability of default any time from now (assuming the counterparty is not currently in default) until time *t*. This is illustrated in Figure 10.2. The function must clearly start from zero and tend towards 100% (every counterparty defaults eventually!).

A **marginal default probability**, which is then the probability of a default between two specified future dates, is given by

$$q(t_1,t_2) = F(t_2) - F(t_1) \qquad (t_1 \le t_2)$$

We can see that *F*(.) must be monotonically increasing to avoid negative marginal default probabilities.

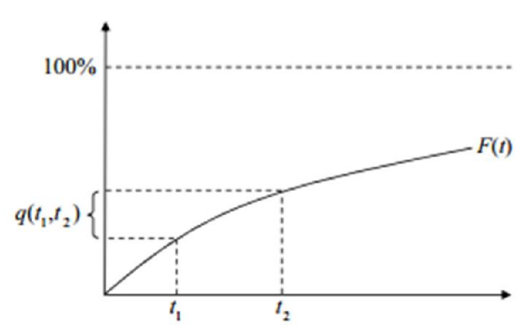


Figure 10.2 Illustration of cumulative default probability function, $F(t)$, and marginal default probability, $q(t_1, t_2)$.

Calculate risk-neutral default probabilities, and compare the use of risk-neutral and real-world default probabilities in pricing derivative contracts.

Real and risk-neutral default probabilities

It is well known in finance that there is a difference between a real-world parameter (for example, the historical volatility of an asset) and a risk-neutral one (for example, the implied volatility derived from an option price). Real-world (also known as physical) parameters aim to reflect the true value of some financial underlying whilst risk-neutral parameters reflect parameters derived from market prices. The distinction between real and risk-neutral parameters is important.

For our current purpose, real default probabilities will be the assessment of future default probability for the purposes of risk management or other analysis. Risk-neutral default probabilities are not estimates of the actual probabilities of default but rather reflect the market price of default risk.

There is reason to expect that real and risk-neutral default probabilities will be very different. This can be understood from a simple example illustrated in Figure 10.3, which is a bet in which there are two possible outcomes: a gain of $100 with 99% probability or a zero gain with 1% probability.

This example is equivalent to a zero-recovery, zero-coupon bond in a zero-interest-rate environment. A quick calculation would suggest that the price of the bond is $99 (99% x $100 + 1% x $0). However, no rational investor would enter into such a bet for $99 as the expected payoff is no greater and there is the risk of losing the entire stake.

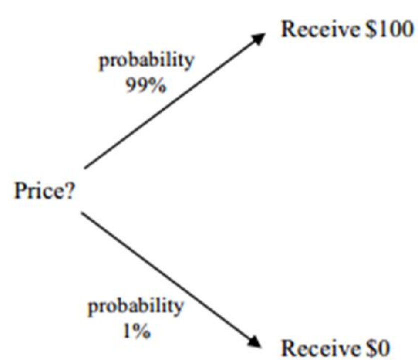


Figure 10.3 Illustration of the difference between real and risk-neutral default probabilities.

Rational investors are risk-averse and would never accept risk without the expectation of making a positive return. Suppose an investor was willing to pay only $97 for the “bond” in the example above. They are (quite rationally) expecting a $2 reduction as compensation for the uncertainty of the return. We could call this a default risk premium, i.e., the premium that investors need in order to accept default risk. This would require probabilities in Figure 10.3 of 97% and 3%.

Furthermore, suppose the investor is worried about the liquidity of the bond above as they may need or want to sell it at some point in the future. For this reason, they may only pay \$94 for the bond. The further \$3 could be described as a liquidity premium. The probabilities would now have to be 94% and 6%. These are not the real default probabilities, but rather constructed risk-neutral probabilities to make the numbers balance assuming that investors have no aversion to risk and will therefore take on the fair bet that Figure 10.3 will then represent. If \$94 were the market price of the bond then the risk-neutral default probability would be 6%. We emphasize that this is an artificial probability derived from the market price and has nothing to do with the actual likelihood of the bond defaulting (which is 1%), as illustrated in Figure 10.4.

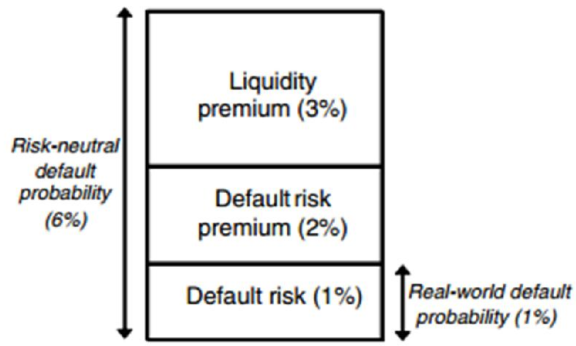


Figure 10.4 Example illustration of different components of a bond price and the difference between real and risk-neutral default probabilities.

It is important to understand that a difference in real-world and risk-neutral default probabilities is not conflicting and simply represents a difference in what they represent. Indeed, in line with the above, Altman (1989) tracks the performance of portfolios of corporate bonds for a given rating and finds that the returns outperform a risk-free benchmark (which is a portfolio of Treasury bonds). The reason for the outperformance is that the return on the corporate bonds is more than adequate to cover the default losses experienced. This shows clearly that bond investors are being compensated for components above expected default losses and that the size of these components is significant. Risk-neutral default probabilities are materially higher than real-world ones.

There is no conflict between risk-neutral and real default probabilities. Real-world default probabilities are the actual assessment of the probability of a counterparty defaulting, which is therefore relevant for any quantitative assessment of return or risk management approach.

Risk-neutral default probabilities reflect the market price and are therefore relevant for hedging purposes. We note that the above discussion applies to risk-neutral default probabilities from bond prices, but similar behavior should be expected with respect to CDS-implied default probabilities.

Explain the various approaches for estimating price: historical data approach, equity based approach, and risk neutral approach.

Estimating real default probabilities – historical data

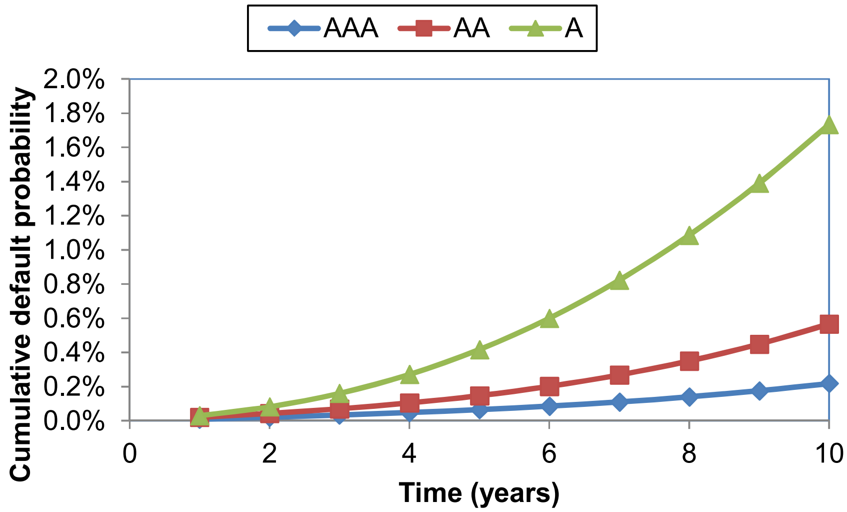
The most obvious assessment of real default probability comes from examining historical data and using past default experience to predict future default likelihood. For example, in Table 10.1 we show a transition matrix based on many years of data as published in Tennant et al. (2008). This matrix gives the historical probability of moving from a given rating (on the left-hand column) to another rating (in the top row) during a period of 1 year. It also defines the default probabilities in the far right column. For example, the probability of an A rating being downgraded to BBB after 1 year is 5.14% and the chance of it defaulting is 0.03%.

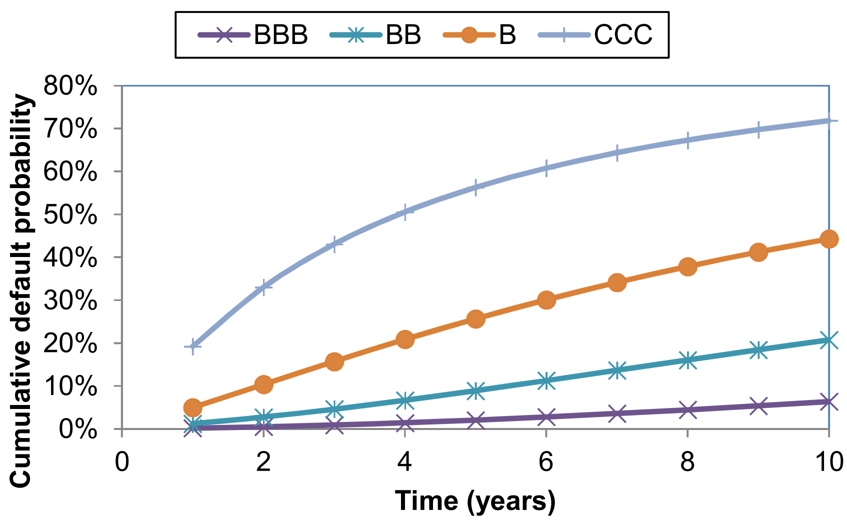
Table 10.1 1-year transition matrix for Moody's ratings								
1	**AAA**	**AA**	**A**	**BBB**	**BB**	**B**	**CCC**	**Def**
AAA	**91.61%**	**7.70%**	**0.66%**	**0.00%**	**0.02%**	**0.00%**	**0.00%**	**0.01%**
AA	**1.13%**	**91.29%**	**7.21%**	**0.27%**	**0.06%**	**0.02%**	**0.00%**	**0.02%**
A	**0.07%**	**2.84%**	**91.30%**	**5.14%**	**0.51%**	**0.09%**	**0.02%**	**0.03%**
BBB	**0.05%**	**0.20%**	**5.15%**	**88.83%**	**4.54%**	**0.81%**	**0.24%**	**0.18%**
BB	**0.01%**	**0.06%**	**0.42%**	**6.25%**	**82.95%**	**8.48%**	**0.63%**	**1.20%**
B	**0.01%**	**0.05%**	**0.18%**	**0.39%**	**6.21%**	**81.93%**	**6.23%**	**5.00%**
CCC	**0.00%**	**0.03%**	**0.03%**	**0.19%**	**0.73%**	**11.22%**	**68.57%**	**19.23%**

Not only does Table 10.1 give information on the probability of default, it also provides greater structure for defining how defaults occur. For example, we see that a Triple-A credit has only a 0.01% chance of defaulting in a year but a 7.7% chance of deteriorating to a Double-A credit. A Triple-C has a large 19.23% chance of default but a 12.2% chance 1 of improving in credit rating over a year.

By making several assumptions, we can derive the cumulative default probabilities, *F* (.), for each credit rating from Table 10.1. The main assumption required in order to do this is that the matrix is constant through time. This is clearly a naïve assumption as default and transition probabilities would be expected to change through the economic cycle, but it is reasonable for estimating default probabilities over long periods. Under such assumptions, we can simply multiply this matrix by itself $n - 1$ times to derive an n – year matrix. The resulting cumulative default probabilities are shown in Table 10.2 and plotted below.

Table 10.2 Cumulative default probabilities implied from the 1-year transition matrix (10.1) above							
	AAA	**AA**	**A**	**BBB**	**BB**	**B**	**CCC**
1	0.01%	0.02%	0.03%	0.18%	1.20%	5.00%	19.23%
2	0.02%	0.04%	0.08%	0.48%	2.75%	10.37%	32.99%
3	0.03%	0.07%	0.16%	0.90%	4.60%	15.72%	43.03%
4	0.05%	0.10%	0.27%	1.43%	6.68%	20.85%	50.54%
5	0.07%	0.15%	0.42%	2.06%	8.92%	25.65%	56.27%
6	0.09%	0.20%	0.60%	2.78%	11.26%	30.09%	60.77%
7	0.11%	0.27%	0.82%	3.58%	13.65%	34.15%	64.36%
8	0.14%	0.35%	1.09%	4.45%	16.05%	37.85%	67.30%
9	0.18%	0.45%	1.39%	5.39%	18.43%	41.22%	69.75%
10	0.22%	0.57%	1.73%	6.38%	20.76%	44.28%	71.83%



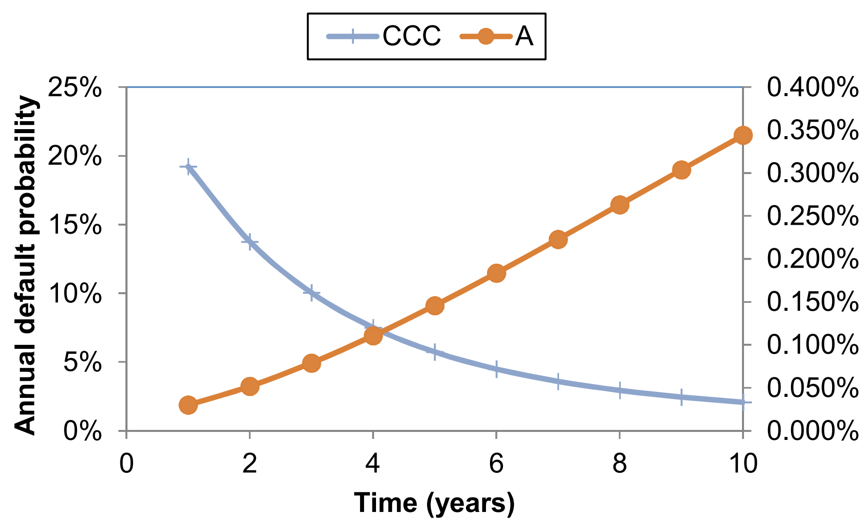


Looking at the above results, apart from the obvious conclusion that firms with good credit ratings default less often than those with worse ratings, we can also notice the following.

- **Investment-grade credits.** These tend to have default probabilities that increase over time. For example, the 5-year Single-A (A) default probability is 0.42% but the 10-year probability is 1.73%, which is more than four times bigger.
- **Non-investment-grade credits.** These credits tend to show the reverse effect, with default probabilities that increase much less strongly over time. For example, the 2-year Triple-C default probability is less than double the 1-year one (32.99% compared with 19.23%).

The above results can be explained by the mean-reversion of credit ratings, where above-average counterparties tend to deteriorate and vice versa. Hence (conditioning on no prior default), a good credit quality counterparty is much more likely to be downgraded than upgraded whilst the reverse is true for a counterparty with a low rating. Such trends can easily be seen when looking at transition matrices as shown in Table 10.1. For example, the probabilities of being upgraded and downgraded from A are respectively 2.91% and 5.76%, whilst the equivalent numbers for CCC are 12.2% and zero.

In computing CVA, not only will the cumulative default probability be important but also so will the way in which this is distributed marginally. We illustrate this below, which shows annual default probabilities for A- and CCC-rated credits. The former increases significantly through time and the latter reduces. If an A-rated credit defaults then it is likely to be towards the end of the 10-year horizon considered, whilst a CCC-rated credit is likely to default much earlier.



Estimating real default probabilities – equity-based approaches

Equity-based approaches aim to estimate default probability from stock market information. In the classic Merton (1974) framework, the value of a firm (asset value) is considered stochastic and default is modelled as the point where the firm is unable to pay its outstanding liabilities when they mature. The original Merton model assumes that a firm has issued only a zero-coupon bond and will not therefore default prior to the maturity of this debt. Through option-pricing arguments, Merton then provides a link between corporate debt and equity via pricing formulas based on the value of the firm and its volatility (analogously to options being valued from spot prices and volatility).

The problem of modelling default is transformed into that of assessing the future distribution of firm value and the barrier where default would occur. Such quantities can be estimated non-trivially from equity data and capital structure information. A key contribution of the Merton approach is that low frequency binary events can be modelled via a continuous process and calibrated using high frequency equity data.

KMV™ (now Moody's KMV) developed the Merton-style approach (e.g., see Kealhofer and Kurbat, 2002; Kealhofer, 2003) with the aim of predicting default via the assessment of 1-year default probability defined as EDF™ (expected default frequency). The KMV approach relaxed many of the stylized Merton assumptions.

Their approach can be summarized broadly in three stages:

- estimation of the market value and volatility of a firm's assets;
- calculation of the distance to default, which is a standardized measure of default risk;
- scaling of the distance to default to the actual probability of default using a historical default database.

The distance to default (DD) measure is a standardized distance a firm is away from default. A key element of the KMV approach is to recognize the model risk inherent in this approach and rather to estimate the default probability empirically from many years of default history (and the calculated DD variables). For a firm with a DD of 4.0 (say), the question KMV attempt to answer is how often firms with the same DD have defaulted historically. The answer is likely to be considerably higher than the theoretical result of 0.003%.

This mapping of DD to actual default probability could be thought of as an empirical correction for model error. Note that, although the KMV approach relies on historical data, the EDF measure will still be dynamic due to constantly changing equity data.

A more recent and related, although simpler, approach is CreditGrades™. The aims of CreditGrades are rather similar to those of KMV, except that the modelling framework (see Fingeret al., 2002) is rather simpler and more transparent; in particular, there is no use of empirical data in order to map to an eventual default probability. In CreditGrades, default probability is defined by a simple formula with just a few model parameters.

Equity-based models for default probabilities have a place due to their ability to define default probability dynamically. This can be an advantage in a situation where historical default probabilities are considered too static a measure whilst probabilities defined directly from the credit market (discussed next) may be considered highly volatile and conservative due to the embedded default risk and liquidity premiums.

Estimating risk-neutral default probabilities

Risk-neutral default probabilities are those derived from credit spreads observed in the market. There is no single definition of a credit spread and it may be defined in slightly different ways and with respect to different rates.

Common ways to define a credit spread are:

- from the premiums of single-name CDSs;
- from the traded spreads of asset swaps;
- from bond prices, typically compared with some benchmark such as a treasury or LIBOR curve;
- using some proxy or mapping method.

All of the above are (broadly speaking) defining the same quantity, but small differences do exist in practice. For now, we will focus on deriving risk-neutral default probabilities from the defined credit spread, which reflects the market price of credit risk.

Suppose a counterparty has a certain constant probability of default each year of (say) 10%. This must be the conditional default probability (i.e., the default probability assuming default has not yet occurred) as otherwise, after more than 10 years, the total default probability would be greater than 100%. This is illustrated in Figure 10.7. The probability of defaulting in the second year is equal to the probability of surviving the first year and defaulting the next, which would be 90% x 10% = 9%. The probability of defaulting at any time in the first two years is then 10% + 9% = 19%. By similar arguments, the probability of defaulting in the third year must be 90% x 90% x 10%= 8.1%, and so on.

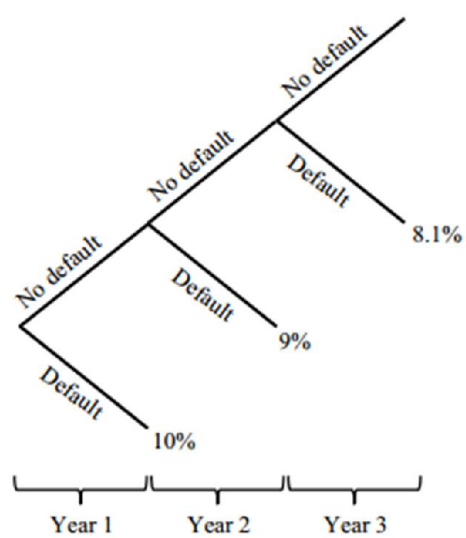


Figure 10.7 Illustration of the default process through time assuming a conditional default probability of 10% per year.

A more formal mathematical description of the above (see Gregory's Appendix 10B) is that default is driven by a Poisson process and the default probability for a future period *u* is given by

$$F(u) = 1 - \exp(-hu)$$

Where *h* defines the hazard rate of default, which is the conditional default probability in an infinitesimally small period. By choosing a hazard rate of 10.54%, we can reproduce the results corresponding to the 10% annual default probability; for example, 1 – exp(-10.54% x 2) = 19% is the default probability in the first two years.

In Gregory's Appendix 10B, he shows that **an approximate relationship between the hazard rate and credit spread is given by**:

$$h \approx \frac{\text{spread}}{(1 - \text{recovery})}$$

where the assumed recovery rate is a percentage. Combining the above two equations gives the following approximate expression for risk-neutral default probability up to a given time *u:*

$$F(u) = 1 - \exp\left[-\frac{\text{spread}}{(1 - \text{recovery})}u\right]$$

The reason that risk-neutral default probability depends on recovery can be explained as follows. Suppose a bond will default with a probability of 2% but the recovery value would be 50%. The expected loss is 1%, which is the same as if the bond had a 1% probability of default but the recovery value was zero. In the market we see only a single parameter (the credit spread) and must imply two values from it. Common practice is then to fix the recovery rate and derive the default probability. A higher recovery must be balanced (good for the bondholder) by a larger assumed default probability (bad for the bondholder).

The above formula is a good approximation generally, although to compute the implied default probabilities accurately we must solve numerically for the correct hazard rate, assuming a certain underlying functional form.

In terms of marginal default probability between dates t_{i-1} and t_i, an obvious approximation would be to take the difference between the relevant cumulative default probabilities in equation (10.4), leading to

$$q\left(t_{i-1}, t_i\right) \approx \exp\left[-\frac{\text{spread}_{t_{i-1}}}{(1 - \text{recovery})}t_{i-1}\right] - \exp\left[-\frac{\text{spread}_t}{(1 - \text{recovery})}t_i\right]$$

This approach is used to define CVA under Basel III. It is only an approximation because it does not account for the shape of the credit curve prior to the time t_{i-1} (and the more sloped the curve is, the worse the approximation).

Comparison between real and risk-neutral default probabilities

The difference between real and risk-neutral default has been characterized in a number of empirical studies. For example, Gieseckeet al. (2010) use a dataset of bond yields that spans a period of almost 150 years from 1866 to 2008 and find that average credit spreads (averaging across all available bond data) have been about twice as large as realized losses due to default. Studies that are more specific include Fons (1987), the aforementioned work by Altman (1989) and Hullet al. (2005a). For example, Fons finds that 1-year risk-neutral default probabilities exceed actual realized default rates by approximately 5% corresponding therefore to the numbers shown in Figure 10.4). The difference between real and risk-neutral default probabilities from Hullet al. (2005a) is shown in Table 10.4 as a function of credit rating. We see that the difference is large, especially for better quality credits.

Table 10.4 Comparison between real and risk-neutral default probabilities in basis points (source: Hull 2005)

	Real default intensity	Risk-neutral default intensity	Ratio
Aaa	4	67	16.8
Aa	6	78	13.0
A	13	128	9.8
Baa	47	238	5.1
Ba	240	507	2.1
B	749	902	1.2
Caa	1690	2130	1.3

There has been much work on understanding the components of credit spreads and their relation to actual default rates and recoveries. See, for example, Collin-Dufresneet al. (2001) and Downing et al. (2005).

These studies find that the difference between credit spreads and actual default losses is due to:

- the relative illiquidity of corporate bonds requiring a liquidity risk premium;
- the limited upside on holding a bond portfolio, or negative skew in bond returns;
- the non-diversifiable risk of corporate bonds requiring a systemic risk premium.

We do not require here to understand in detail the relationship between credit spreads and historical default losses, but it is important to appreciate the impact on quantifying and managing counterparty risk. If one does not seek to hedge the default component of counterparty risk, then it is more relevant to consider the real world default probabilities estimated empirically via (for example) historical data. If, on the other hand, one intends to hedge against counterparty defaults then it is important to consider market credit spreads and associated risk-neutral default probabilities. Clearly, hedging counterparty risk appears to be much more costly than not hedging (Table 10.4).

Most of the empirical evidence compares risk-neutral default probabilities from bond spreads with historical default probabilities. Longstaffet al. (2005) argue that the CDS market, being more liquid, will not give rise to the liquidity premium represented in Figure 10.4. This would imply that the corresponding ratio between CDS-implied risk-neutral and historical default probabilities would be lower. However, this assumption is not supported by a consistently negative CDS–bond basis (Section 10.2.4). Hence, it seems reasonable that the relationship discussed above is broadly the same when using risk-neutral default probabilities from the CDS market.

Describe how recovery rates may be estimated.

In order to estimate risk-neutral default probabilities, we must know the associated recovery rate. Recovery rates refer to the amount that would be recovered in the event of a counterparty defaulting. Common recovery rates are assumed to be a percentage of the notional amount (the exposure). This is in line with the legal right of all creditors to receive a proportion of what they are owed. Recovery rates are sometimes expressed via loss given default (LGD), which is simply one minus the recovery rate (in percentage terms). For example, a low recovery rate of 20% implies a high loss given default of 80%.

Ideally, recovery rates would be derived from market prices. A recovery swap is an agreement between two parties to swap a realized recovery rate (when and if the relevant credit event occurs) with a fixed recovery rate that is specified at the start of the contract. The reference price reflects the fixed recovery such that the recovery swap has zero value initially.

Since the swap is issued at a price of zero, if the reference entity does not default in the term of the swap, then the swap expires with no cash flows having taken place. If a default does occur, the fixed recovery payer in the swap will compensate the other party, if the actual recovery is less than the fixed recovery, and vice versa. Since recovery swaps do not trade (except occasionally for distressed credits), we must normally look to historical analysis of recovery rates.

Recovery values, like default probabilities, tend to show a significant variation over time, as illustrated in Figure 10.10. We can see further variation according to variables such as sector (Table 10.5). Recoveries also tend to be negatively correlated with default rates (e.g., see Hamiltonet al., 2001). This negative correlation means that a high default rate will give rise to lower recovery values. Hence, the random nature of default probability and recovery over time coupled to the negative correlation creates strong variability in default losses.

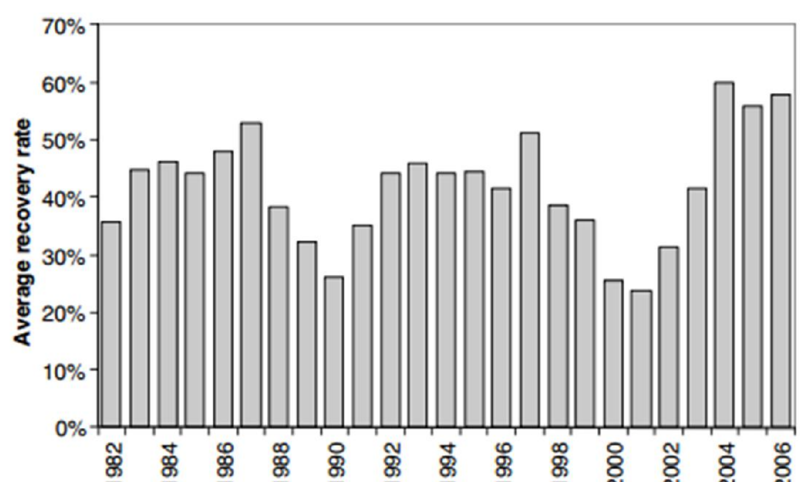


Figure 10.10 Average recovery values across all debt seniorities.

Table 10.5 Recovery rates by sector

Industry	*Recovery rate average*
Public utilities	70.5%
Chemicals, petroleum, rubber and plastic products	62.7%
Machinery, instruments and related products	48.7%
Services (business and personal)	46.2%
Food and kindred products	45.3%
Wholesale and retail trade	44.0%
Diversified manufacturing	42.3%
Casino, hotel and recreation	40.2%
Building material, metals and fabricated products	38.8%
Transportation and transportation equipment	38.4%
Communication, broadcasting, movie production, printing and publishing	37.1%
Financial institutions	35.7%
Construction and real-estate	35.3%
General merchandise stores	33.2%
Mining and petroleum drilling	33.0%
Textile and apparel products	31.7%
Wood, paper and leather products	29.8%
Lodging, hospitals and nursing facilities	26.5%
TOTAL	**41.0%**

Source: Altman and Kishore (1996)

Recovery rates also depend on the seniority of the claim (Table 10.6). Normally, OTC derivatives would rank *pari passu* with senior unsecured debt, which in turn is the reference in most CDS contracts. When the recovery claim for counterparty risk is different than this must be quantified.

Table 10.6 Recovery rates by original debt seniority

Debt seniority	*Recovery rate average*	
	Investment grade	*Sub-investment grade*
Senior secured	54.8%	56.4%
Senior unsecured	48.2%	48.7%
Senior subordinated	32.7%	39.9%
Subordinated	31.9%	31.7%
Discount and zero-coupon	24.1%	24.4%
Total	41.0%	

Source: Altman and Kishore (1996)

A final point on recovery is related to the timing. CDSs are settled quickly following a default and bondholders can settle their bonds in the same process. However, OTC derivatives cannot be settled in a timely manner. This is partly due to their bespoke nature and partly due to netting (and collateral), which means that many trades are essentially aggregated into a single claim and cannot be traded individually. The net claim (less any collateral) is then often quite difficult to define for the portfolio of trades.

This creates two different recovery values:

- **Settled recovery**. This is the recovery that could be achieved following the credit event; for example, by selling a defaulted bond.
- **Actual recovery**. This is the actual recovery paid on the debt following a bankruptcy or similar process.

In theory, settled and actual recoveries should be very similar but in reality, since bankruptcy processes can take many years, they may differ materially. This is illustrated in Figure 10.11. It should be possible to agree on the claim with the bankruptcy administrators prior to the actual recovery, although this process may take many months. This would allow an institution to sell the claim and monetize the recovery value as early as possible. In the case of the Lehman Brothers bankruptcy, the settled recovery was around 9% whereas some actual recoveries traded to date have been substantially higher (in the region of 30–40%).

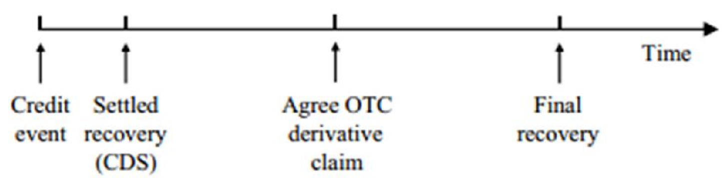


Figure 10.11 Schematic illustration of recovery settlement after a credit event. The settled recovery rate is achieved very close to the credit event time (for example, by participating in the CDS auction). The final recovery occurs when the company has been completely wound up. The actual recovery for a derivative claim may be realised sometime between the settled and final recoveries.

Describe credit default swaps (CDS) and their general underlying mechanics.

The credit derivatives market has grown quickly in recent years, fuelled by the need to transfer credit risk efficiently and develop ever-more sophisticated products for investors. A credit derivative is an agreement designed to shift credit risk between parties and its value is derived from the credit performance of a corporation, sovereign entity or security. Credit derivatives can be traded on a single-name basis (referencing a single component such as a corporate) or a portfolio basis (referencing many components such as 125 corporate names).

Credit derivatives instruments are important since they represent opportunities for trading, hedging and diversification of counterparty risk. However, credit derivatives as a product class give rise to a significant amount of counterparty risk. Indeed, the continued development of the credit derivative market is contingent on control of this counterparty risk.

Basics of CDSs

Many credit derivatives take the form of a CDS, which transfers the default risk of one or more corporations or sovereign entities from one party to another. In a single-name CDS, the protection buyer pays an upfront and/or periodic fee (the premium) to the protection seller for a certain notional amount of debt for a specified reference entity. If the reference entity specified undergoes a credit event then the protection seller must compensate the protection buyer for the associated loss by means of a pre-specified settlement procedure (the protection buyer must also typically pay an accrued premium at this point as compensation, due to the fact that premiums are paid in arrears). The premium is paid until either the maturity date or the credit event time, whichever comes first. The reference entity is not a party to the contract, and it is not necessary for the buyer or seller to obtain the reference entity's consent to enter into a CDS. The mechanics of a single name CDS contract are shown in Figure 10.12.

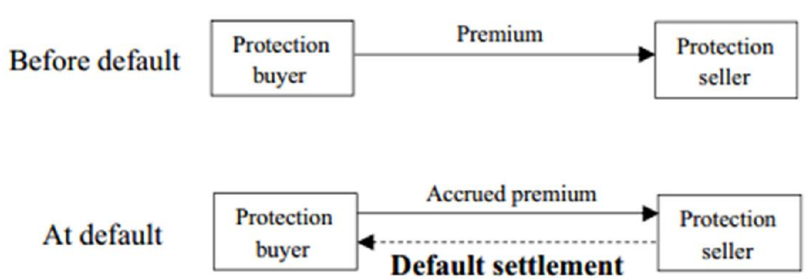


Figure 10.12 Illustration of a typical CDS contract on a single reference entity.

CDS contracts trade with both fixed premiums and upfront payments. This reduces annuity risk in the hedge and unwinding of CDS contracts. Although it is not compulsory, the standard is that a CDS, on investment-grade reference entities, typically has a fixed premium of 100 basis points whilst high-yield reference entities trade at 500 basis points. The scheduled termination dates of CDSs are March 20th, June 20th, September 20th or December 20th.

CDS documentation refers to a reference obligation and reference entity. The reference entity may be a corporate, a sovereign or any other form of legal entity which has incurred debt. The reference obligation defines the seniority of the debt that can be delivered. Commonly, all obligations of the same or better seniority can be delivered (in the case of no reference obligation being specified then the seniority is senior unsecured).

Credit events

Generally, the term "default" is used (as in default probability, for example) instead of the more accurate generic term "credit event". There are various credit events, which can all potentially lead to losses for creditors. Some credit events are well-defined, such as Chapter 11 bankruptcy in the US, whereas some other technical credit events, for example involving a breach of some contractual terms, are less so.

The three most important credit events are:

- **Bankruptcy**. This will be triggered by a variety of events associated with bankruptcy or insolvency proceedings, such as winding up, administration and receivership, under English and New York law or analogous events under other insolvency laws.
- **Failure to pay**. This event covers the failure to make a payment of principal or interest. A minimum threshold amount must be exceeded before this event is triggered (default value $1m). Failure to make a collateral posting even after the relevant grace period falls into this category.
- **Restructuring**. This covers the restructuring of debt causing a material adverse change in creditworthiness.

A significant risk when hedging with CDS contracts is that there is an economic loss but the credit event in the contract is not triggered. Obvious examples of this may be restructuring-type credit events such as a debt-to-equity swap, a distressed exchange or another form of restructuring. The voluntary haircuts taken by most holders of Greek debt in 2012 were not enough to trigger a credit event. Whilst the exercise by Greece of the "Collective Action Clause" forcing all bondholders to participate did eventually trigger a restructuring credit event, this illustrates that default losses and the triggering of a credit event are in danger of being misaligned. CDSs may well appear to be good hedges for counterparty risk but may completely or partially fail when the credit event actually occurs.

CDS settlement

The fundamental aim of a CDS is to compensate the protection buyer for the loss of par value on a defaulted security such as a bond. However, debt securities will typically not be worth zero when there has been a credit event, but will rather trade at some recovery value. Hence, the protection buyer needs to be paid par minus this recovery value.

There are fundamentally two ways in which this payoff has been achieved in CDSs:

- **Physical settlement**. In this case, the protection buyer will deliver to the protection seller defaulted securities of the reference entity with a par value equal to the notional amount of the CDS contract. In return, the protection seller must make a payment of par in cash. For example, an investor buying a bond and holding CDS protection for the same notional may deliver the defaulted bond against receiving par. This mechanism is clearly attractive since no other parties need to be involved and there can be limited dispute over payments.
- **Cash settlement**. Here, the protection seller will compensate the protection buyer in cash for the value of par minus recovery value. An obvious problem with this is that the recovery value must be determined through some market consensus of where the debt of the defaulted entity is trading (dealer poll or more recently an auction process described below).

In a CDS contract settled via physical delivery, since the credit event is not specific to a given security, there is no single bond that needs to be delivered. The protection buyer therefore has some choice over the security that can be delivered and will naturally choose the cheapest available in the market (the "cheapest-to-deliver option"). Obvious choices for cheapest-to-deliver bonds may include those with low coupons (including convertible bonds) and illiquid bonds.

Restructuring credit events are particularly significant in this respect, as bonds are more likely to be trading at different levels. The market has evolved to different restructuring options in CDS contracts to try to minimize cheapest-to-deliver risk. The current standards in the US and Europe are modified restructuring (MR) and modified modified restructuring (MMR), respectively. These both include restructuring as a credit event in a CDS contract but limit the securities that can be delivered following such a credit event.

A large proportion of protection buyers do not hold the original risk in the form of bonds. This "naked" CDS position may arise due to pure speculation or may be linked to counterparty risk hedging. There have been efforts and calls to ban naked CDSs and only allow the buying of CDS protection when the buyer holds the underlying debt security (as is the case in insurance contracts where the owner of insurance needs to own the insured risk at the claim time).

Aside from the fact that this will make the CDS market inefficient, this can restrict CDS protection being held against credit exposure to hedge counterparty risk. Since future credit exposure is uncertain, it is not clear what an appropriate amount of CDS protection to hold as a hedge would be. An institution may understandably want to buy more CDS protection than their current exposure to mitigate a potential increase in exposure in the future.

Another problem in the CDS market is a delivery squeeze that can be created if the amount of notional required to be delivered (total outstanding CDS protection on the reference entity) is large compared with the amount of outstanding debt. In a delivery squeeze, bond prices will increase to reflect a lack of supply and this in turn will suppress the value of the CDS (since the payoff is par less recovery). This is another important consideration in the hedging of counterparty risk since it can create a significant discrepancy between the recovery value of the security itself and the recovery as defined by the CDS contract.

The problems of cheapest-to-deliver options and delivery squeezes have been limited by the adoption of an auction protocol in settling credit events. In 2009, there were a number of changes to CDS documentation and trading practices, aimed at reducing some of the risks described above and improving standardization. One was the incorporation of auction settlement provisions as the standard settlement method for credit derivatives transactions.

The so called “Big Bang Protocol” allowed this auction to also be included for legacy CDS trades (as long as both counterparties signed up to the Big Bang Protocol). Most major credit events on liquid reference credits should now be settled in this fashion, via a pre-planned auction of defaulted bonds to determine a fair price for cash settlement of all CDSs referencing the credit in question. Whilst this eliminates most basis risks, the problems of settled and final recovery in the hedging of counterparty risk (Figure 10.11) remains.

Table 10.7 Recovery rates for CDS auctions for some credit events in 2008. The impact of a delivery squeeze can be seen in that Fannie Mae and Freddie Mac subordinated debt traded at higher levels than the senior debt

Reference entity	*Seniority*	*Recovery rate*
Fannie Mae	Senior	91.5%
	Subordinated	99.9%
Freddie Mac	Senior	94.0%
	Subordinated	98.0%
Washington Mutual		57.0%
Lehman		8.6%
Kaupthing Bank	Senior	6.6%
	Subordinated	2.4%
Landsbanki	Senior	1.3%
	Subordinated	0.1%
Glitnir	Senior	3.0%
	Subordinated	0.1%
Average		38.5%

In Table 10.7 we show recovery values settled following credit events for some CDS auctions in 2008. We see a wide range of recoveries from Fannie Mae and Freddie Mac that were close to 100%, thanks largely to the guarantee from the US government, making this a more technical credit event than Lehman Brothers and Icelandic banks that recovered very little.

The CDS–bond basis

It is possible to show theoretically (Duffie, 1999) that, under certain assumptions, a (short) CDS protection position is equivalent to a position in an underlying fixed-rate bond and a payer interest rate swap. This combination of a bond and interest rate swap corresponds to what is known as an asset swap. This implies that spreads, as calculated from the CDS and bond markets, should be similar. However, a variety of technical and fundamental factors means that this relationship will be imperfect. The difference between CDS and bond spreads is known as the CDS–bond basis. A positive (negative) basis is characterized by CDS spreads being higher (lower) than the equivalent bond spreads.

Factors that drive the CDS–bond basis are:

- *Counterparty risk.* CDSs have significant wrong-way counterparty risk, which tends to make the basis negative.
- *Funding.* The theoretical link between bonds and CDSs supposes that LIBOR funding is possible. Funding at levels in excess of LIBOR will tend to make the basis positive, as CDSs do not require funding. Contributing further to this effect is that shorting cash bonds tends to be difficult, as the bond needs to be sourced in a fairly illiquid and short-dated repo market in which bonds additionally might trade on special, making it expensive to borrow the bond.
- *Credit event definition.* CDS credit events should, in theory, perfectly coincide with the concept of credit-related losses for bondholders. However, credit events are vulnerable to divergence from bond documentation, despite improvements by ISDA in standardizing and harmonizing CDS legal documentation. Technical credit events may cause CDS protection to pay out on an event that is not considered a default by bondholders. Alternatively, a credit event may not be triggered even though bondholders take credit losses. The former effect would tend to push the basis into positive territory whilst the latter would make it negative.
- *Cheapest-to-deliver option.* The delivery option in a CDS contract may have some additional values in certain circumstances, such as restructuring credit events. This would tend to make the basis positive.
- *Delivery squeeze*. A delivery squeeze involves a shortage of CDS deliverable debt and would tend to make the basis negative.
- *Bonds trading above or below par.* Fixed-rate bonds can trade significantly above or below par because of changes in interest rates. CDS protection is essentially indexed to the par value of a bond and bonds trading above (below) par will tend to make the basis negative (positive). The use of fixed coupon CDS reduces this effect.
- *Accrued interest.* In the event of default, a bond typically does not pay accrued interest for any coupons owed, whereas a CDS does require protection buyers to pay the accrued premium up to the credit event. This will cause the basis to be negative.
- *Other technical factors.* Historically, other technical factors, such as synthetic CDO issuance, have had an impact on the basis.

Generally, prior to the global financial crisis, the basis tended to be positive due to effects such as funding and the cheapest-to-deliver option. More recently, the basis has been negative due partially to CDS counterparty risk concerns.

Contingent credit default swaps

In a standard single-name CDS, the protection buyer has protection on a fixed contractual notional amount. Such a contract is reasonably well tailored towards credit exposures arising from instruments such as loans and bonds. For example, $10m of CDS protection would give protection against holding bonds with par value of $10m. However, a key aspect of counterparty risk is that the loss as determined by the credit exposure at the credit event time is usually unknown.

A CCDS is an instrument that is the same as a standard single-name CDS but with one key difference, in that the notional amount of protection is referenced to another transaction(s). This underlying transaction can be potentially any product across any asset class. Hence, a CCDS can provide perfect protection against the counterparty risk on a derivative since the protection amount can be linked directly to the exposure of that derivative. Whilst CDSs are generally products which have many applications, CCDSs are products that are tailor-made to hedge counterparty risk. As such, CCDSs potentially allow for the possibility of a complete disentangling of counterparty risk from all other financial risks.

A CCDS represents a contract tailor-made to transfer counterparty risk from one institution to another. However, except in limited cases, CCDSs have not proved particularly popular.

Some reasons for this are:

- **Complexity of documentation.** A CCDS must contain a “termsheet within a termsheet” since it must reference the transaction for which the counterparty risk is to be transferred. Confidentiality may also be a problem here since a CCDS counterparty would have information on all trades with the counterparty whose risk is being hedged.
- **No recognition of netting/collateral.** A CCDS typically references a single trade and not a netting set, which would be more relevant. A CCDS referring an entire netting set would be complex and would not cover subsequent trades within that netting set. Additionally, a CCDS does not account for the potential collateralization of a credit exposure.
- **Double default.** A CCDS is not effective unless the CCDS provider has a very high credit quality and/or is uncorrelated with the original counterparty. These aspects are very hard to achieve, the latter especially so for counterparties of good credit quality.
- **Lack of sellers of protection.** As with the single-name CDS market, there is a lack of sellers of single-name CCDS protection.

There have been attempts to ignite the CCDS market. For example, Novarum group set up a dedicated vehicle to sell fully collateralized CCDS protection in 2009. However, this initiative has not seen great success, probably mainly due to the double default aspect mentioned above. For example, for an OTC derivative dealer to hedge a large component of their CVA with such an entity they would have to be very certain of this entity’s ability to withstand a high default rate environment in order to feel that the hedges were effective. Regulators would need to have the same confidence to allow capital relief and provide a strong credit rating to the protection seller.

Describe the credit spread curve and explain the motivation for curve mapping.

Basics of mapping

The fundamental aim of credit curve mapping is to use some relevant points to achieve a general curve based on observable market data, as illustrated in Figure 10.13. This illustrates a case where a number of points can be used at various different maturities (as in the case of the secondary bond market). A best fit to these spreads (perhaps with some underlying weighting scheme also used to bias towards the more liquid quotes) gives the entire curve.

The classification may be rather broad (e.g., a Single-A curve), in which case there will be a large number of data points to fit but less distinguishing between different counterparties. In contrast, a more granular classification (e.g., rating, sector and geography – for example, a Single-A US utility company) distinguishes better between different counterparties but provides less data for each curve calibration.

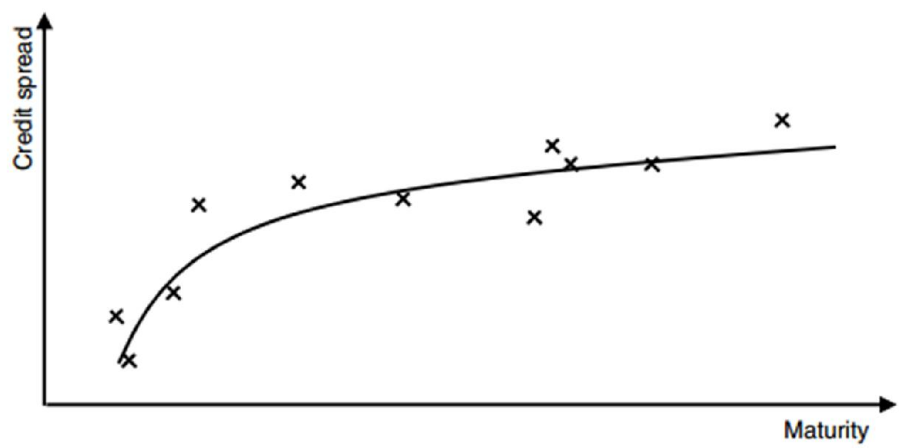


Figure 10.13 Illustration of a mapping procedure. The crosses represent observable spreads as a function of maturity.

We note that this representation is troublesome from a hedging perspective as all points represent hedging instruments. There is also the problem that a recalibration (either periodic or, for example, due to removal of an illiquid data point) will cause a curve shift and a resulting move in CVA with an associated (unhedgeable) PnL impact.

Indices and classification

Whilst bond spreads provide some mapping information, a key component of a mapping methodology is the link to the hedging of CVA. Credit indices therefore represent a better choice for mapping credit curves. An example classification of European counterparties according to credit indices is given in Figure 10.14. Reading from the bottom, the first choice would obviously be to map to a single-name CDS or a relevant proxy such as a parent company. If such information were not available then the counterparty would be mapped to the relevant index depending on whether it is a corporation, financial or sovereign entity. Corporations may be further sub-divided according to credit quality.

Note that further, more detailed classifications can be made that are not shown in Figure 10.14. For example, iTraxx SovX is sub-divided into Western Europe (WE) and Central & Eastern European, Middle Eastern and African (CEEMEA). Corporates may also be sub divided into sectoral indices (in addition to financials and non-financials), such as TMT, industrials, energy, consumers and autos. Whilst these sub-divisions give a more granular representation, they have to be balanced against the available liquidity in the CDS market.

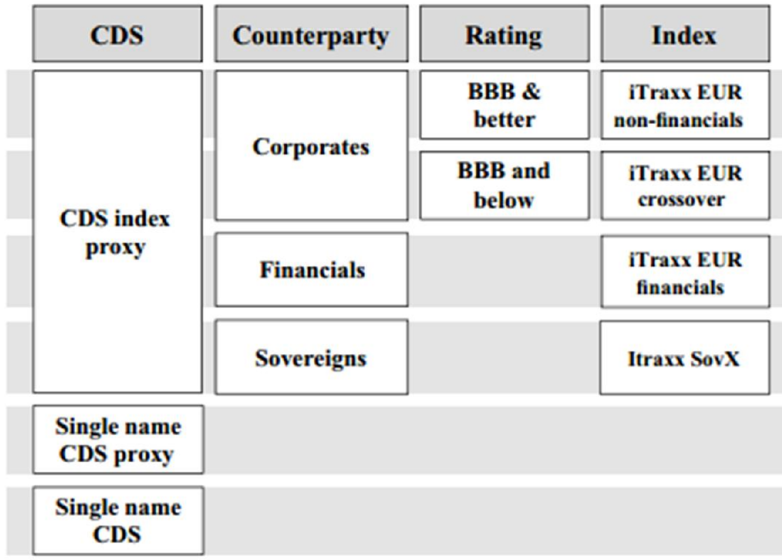


Figure 10.14 Illustration of a classification of counterparties according to European credit indices.

Curve shape

A final consideration that is relevant is the case where a single-maturity credit spread (typically 5 years) can be defined (either directly or via some mapping) but the rest of the curve cannot. The obvious solution in such a case is to use the most appropriate index to define the curve shape, as illustrated in Figure 10.15. So, for example, if the 5-year point defined is 130% times the equivalent index maturity, then all points are mapped to 130% of the index curve.

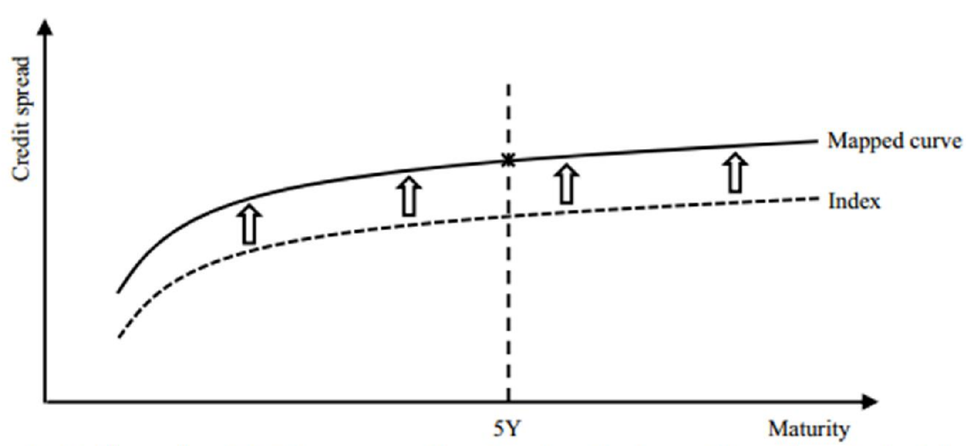


Figure 10.15 Illustration of defining a curve shape based on the shape of the relevant index. The cross shows the 5-year point that is assumed to be known for the curve in question.

Describe types of portfolio credit derivatives.

CDS index products

Up until 2004, the majority of credit default swaps were written on single names, but thereafter a major impetus to growth and market liquidity of the credit derivative market has been credit default swaps on indices. A credit index can usually be thought of as an equally weighted combination of single-name CDSs and hence the fair premium on the index will be close to the average CDS premium within that index.

The two most common credit indices are:

- **DJ iTraxx Europe.** This contains 125 European corporate investment-grade reference entities, which are equally weighted.
- **DJ CDX NA IG.** This contains 125 North American (NA) corporate investment-grade reference entities, which are equally weighted.

Other indices exist for different underlying reference entities and regions but they are less liquid. Indices can be traded in either CDS (unfunded) or CLN (funded) form. Buying CDS protection on $125m of the DJ CDX NA IG index is almost equivalent to buying $1m of CDS protection on each of the underlying reference entities within the index.

An important feature of credit indices is that they "roll" every 6 months. A roll will involve:

- Adjustment of maturity. Typical traded maturities are 5, 7 and 10 years. Fixed maturity dates will be used such that the initial maturities are 5.25, 7.25 and 10.25 years. After 6 months, the maturities will have become 4.75, 6.75 and 9.75 and these will be re-set to their original values.
- Adjustment of portfolio. Names will be removed from a credit index according to predefined criteria in relation to credit events, ratings downgrades and increases in individual CDS premiums beyond a certain threshold. The overall aim is to replace defaulted names and maintain a homogenous credit quality. Names removed from the index will be replaced with other names meeting the required criteria.
- Premium. In the 6-month period before a roll, the index premium is fixed at a given level of either 100 or 500 bps and trades on the index will involve an upfront payment from one party to the other to compensate for the difference between the fair premium and traded premium. This greatly facilitates unwinding positions and monetizing MtM gains (or losses), and is similar to the use of a fixed premium for US CDS contracts. At the roll, the index premium may be reset (to either 100 or 500 bps) depending on its fair theoretical level based on the individual CDS levels at that time.

We note that rolls only influence new trades and not existing ones (which still reference the old index and other terms).

Describe index tranches, super senior risk, and collateralized debt obligations (CDO).

Index tranches

Following on from the standardization of credit indices was the development of index tranches. Whilst a credit index references all losses on the underlying names, a tranche will only reference a certain portion of those losses. So, for example, an [X%,Y%] tranche will reference losses between X% and Y% on the underlying index. The “subordination” of the tranche is X% whilst Y% is referred to as the “detachment point”. The size of the tranche is (Y–X)%. The standard index tranches for the DJ iTraxx Europe and DJ CDX NA indices are illustrated in Figure 10.16. The index tranche that takes the first loss, [0–3%], is referred to as the equity tranche, with the very high-up tranches referred to as senior or super senior and the intermediate tranches referred to as mezzanine.

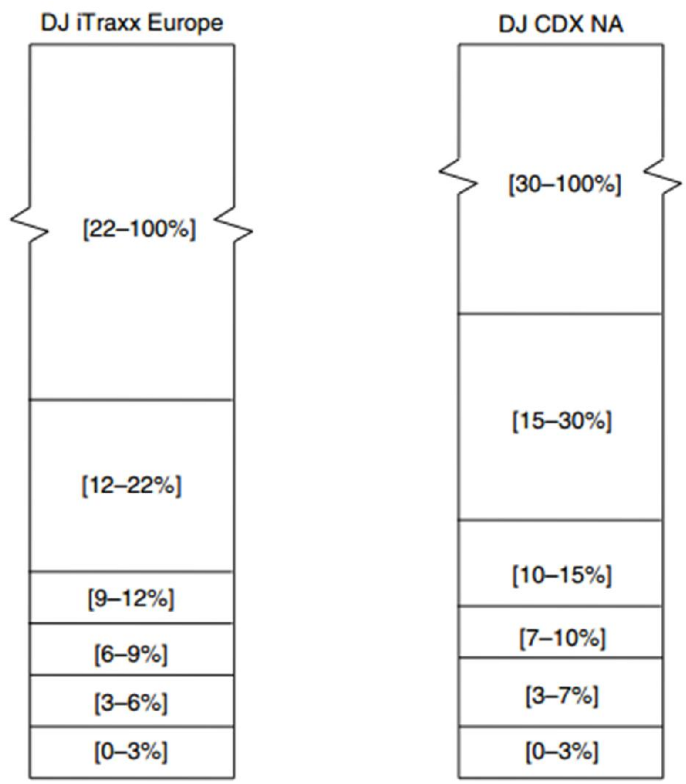


Figure 10.16 Illustration of the index tranches corresponding to the DJ iTraxx and DJ CDX North American credit indices. All tranches are shown to scale except the [22–100%] and [30–100%].

Irrespective of trading convention, the important aspect of an index tranche is that it covers only a certain range of the losses on the portfolio. Index tranches vary substantially in the risk they constitute: equity tranches carry a large amount of risk and pay attractive returns whilst tranches that are more senior have far less risk but pay only moderate returns. At the far end, super senior tranches might be considered to have no risk whatsoever (in terms of experiencing losses). Tranching creates a leverage effect since the more junior tranches carry more risk than the index whilst the most senior tranches have less risk.

Super senior risk

The more senior a tranche, the more counterparty risk it creates. Not surprisingly then, super senior tranches have created a big headache for the credit market in terms of their counterparty risk. Let us start by asking ourselves how many defaults would cause a loss of either super senior tranche of DJ iTraxx and DJ CDX. We can represent the number of defaults a given tranche can withstand by

$$\text{Number of defaults} = n\frac{X}{(1\text{-}\,\text{recovery})}$$

Where X represents the attachment point of the tranche (%), *n* is the number of names in the index and the recovery is the (weighted) average recovery rate for the defaults that occur.

Example. How many defaults can the super senior tranches of DJ iTraxx and DJ CDX withstand at assumed average recoveries of 40% and 20%?

From the previous formula, we have for DJ iTraxx

$$125 \times 22\%/(1 - 40\%) = 45.8 \text{ defaults } (40\% \text{ recovery})$$

$$125 \times 22\%/(1 - 20\%) = 34.4 \text{ defaults } (20\% \text{ recovery})$$

And for DJ CDX

$$125 \times 30\%/(1 - 40\%) = 62.5 \text{ defaults } (40\% \text{ recovery})$$

$$125 \times 30\%/(1 - 20\%) = 46.9 \text{ defaults } (20\% \text{ recovery})$$

Super senior tranches clearly have very little default risk. Let us consider a super senior tranche of the longest maturity (10-years).From Table 10.2, the Moody's cumulative default probability for the worst investment-grade rating of Triple-B for this period is 6.38%. The even assuming the lower 20% recovery, default rates of 4.3 and 5.9 times the historical average would be required to wipe out the subordination on the iTraxx and CDX super senior tranches respectively. This default remoteness has led to terms such as "super Triple-A" or "Quadruple A" being used to describe the risk on super senior tranches. From the counterparty risk perspective, the important question is: from whom can an institution buy super Triple-A protection?

Collateralized debt obligations

There are many different types of collateralized debt obligations. They contain different asset classes and have different structural features. However, the approximate classification of risk defined in the last section (equity, mezzanine, senior) will always follow. For example, any CDO structure will have an associated super senior tranche that will be considered extremely unlikely ever to take credit losses.

CDOs can be broadly divided into two categories:

- **Synthetic CDOs**. Alternatively called collateralized synthetic obligations (CSOs), these are very similar to index tranches except that the underlying portfolio, attachment and detachment points, maturity and other specifics will be bespoke or tailor-made for a given transaction(s). Most commonly, a tranche will be traded in isolation from the rest of the capital structure. Banks have traditionally had large “correlation desks” that trade many different tranches of synthetic CDOs on various different portfolios.
- **Structured finance securities**. This very large class of securitization structures covers cash CDOs, collateralized loan obligations (CLOs), mortgage-backed securities (MBSs) and CDOs of ABSs. The main difference between these structures and synthetic CDOs is that the structure and tranche losses occur by means of a much more complex mechanism. This means that tranches of these deals cannot be traded in isolation and all tranches must be sold more or less simultaneously as a so-called “full capital structure” transaction.

From the point of view of counterparty risk, the key aspect is that issuers of CDOs need to place (buy protection) on all tranches across the capital structure. In a full capital structure or structured finance-type structure, this is clear from the need to place all of the risk. In a synthetic CDO, it is less obvious but arises because a book cannot be risk-managed effectively unless it has a reasonable balance between equity, mezzanine and senior tranches.

Therefore, issuers of CDOs are super senior protection buyers, not necessarily because they think super senior tranches have value but rather because:

- They need to buy protection or place the super senior risk in order to have efficiently distributed the risk. Failure to do this may mean holding onto a very large super senior piece and potentially not being able to recognize P&L on a transaction.

OR

- Buying super senior protection is required as a hedge for other tranche positions. Without going into too much detail, we note that structured product traders may buy a product such as an option or tranche, not because they think it is undervalued, but rather because it allows them to hedge. In options terminology they may pay for the “gamma” (the convexity of the price with respect to market movements). In this case, a CDO correlation trader may buy protection on a super senior tranche, not because he thinks it will have a payoff (losses hitting the tranche), but rather because it provides positive gamma.

Chapter Summary (literal)

This chapter has been concerned with an overview of default probability, credit spreads and credit derivatives. We have described default probability, estimation methods and the differences between real and risk-neutral default probabilities. The impact of recovery rates has also been discussed. Detail necessary to calculate risk-neutral default probabilities from credit spreads, which will be required in CVA calculations later, has been given. We have described the important credit derivatives instruments that will be essential for discussing wrong-way risk and hedging. Finally, we have discussed curve mapping procedures that are an important component of CVA quantification.

Gregory, Chapter 12: Credit Value Adjustment

Explain the motivation for and the challenges of pricing counterparty risk.

Describe credit value adjustment (CVA).

Calculate CVA and the CVA spread with no wrong-way risk, netting, or collateralization.

Explain the impact of changes in the credit spread and recovery rate assumptions on CVA.

Explain how netting can be incorporated into the CVA calculation.

Define and calculate incremental CVA and marginal CVA, and explain how to convert CVA into a running spread.

Explain the impact of incorporating collateralization into the CVA calculation.

Explain the motivation for and the challenges of pricing counterparty risk.

Accurate pricing of counterparty risk involves attaching a value to the risk of all outstanding positions with a given counterparty. This is important in the reporting of accurate earnings information and incentivizing trading desks and businesses to trade appropriately. If counterparty risk pricing is combined with a systematic charging of new transactions, then it will also be hedged generated funds that will absorb potential losses in the event that a counterparty defaults. Counterparty risk charges are increasingly commonly associated with hedging costs.

We will make **three key assumptions** that will greatly simplify the initial exposition and calculation of CVA. The key assumptions are:

- **The institution themselves cannot default**. The first assumption corresponds to ignoring the DVA (debt value adjustment) component
- **Risk-free valuation is straight forward**. We have to assume that the risk-free valuation can be performed. However, this is far from simple due to the lack of a clear discount rate (in the past Libor was considered acceptable) and the increased importance of funding.
- **The credit exposure and default probability are independent**. This involves neglecting wrong-way risk.

This above separation of concepts should make it easier to explain all the key features around CVA.

Pricing the credit risk for an instrument with one-way payments, such as a bond, is relatively straightforward – one simply needs to account for default when discounting the cash flows and add any default payment. However, many derivatives instruments have fixed, floating or contingent cash flows or payments that are made in both directions. This bilateral nature characterizes credit exposure and makes the quantification of counterparty risk dramatically more difficult.

Whilst this will become clear in the more technical pricing calculations, a simple explanation is provided in Figure 12.1, which compares a bond to a similar swap transaction. In the bond case a given cash flow is fully at risk (its value may be lost entirely) in the event of a default, whereas in the swap case only part of the cash flow will be at risk due to partial cancellation with opposing cash flows. The risk on the swap is clearly smaller due to this effect. However, the fraction of the swap cash flows that are indeed at risk are hard to determine as this depends on many factors such as yield curve shape, forward rates and volatilities.

Describe credit value adjustment (CVA).

Accurate pricing of counterparty risk involves attaching a value to the risk of all outstanding positions with a given counterparty. This is important:

- To accurately report profit and loss (earnings) information,
- To incentivize trading desks and businesses to trade appropriately.
- If counterparty risk pricing is combined with a systematic charging of new transactions, then it will generate funds that can be used to absorb potential losses in the event the counterparty defaults. Counterparty risk charges may also be associated with hedging costs in relation to credit risk aspect

Gregory uses an example to illustrate the motivation for pricing counterparty risk:

> "A trader wants to execute a swap transaction with a single-A counterparty whose outstanding debt is priced at a credit spread of around 300 basis points per annum. However, the size of the transaction is large ($1bn) and the maturity is long (10 years). The relevant credit officer is not comfortable with the transaction since he estimates that the exposure could easily reach $50m but the head trader is keen to proceed since profitability for the desk is excellent. Also, the head of fixed income is also pushing to go ahead with this big trade since the counterparty is a good client trading across several different product area… the **problem is more than simply deciding whether to trade or not**. This trade should not be a simple yes/no decision."

By accurately pricing the counterparty risk, someone in the firm can tell the trader the cost of the counterparty risk and theoretically incorporate several considerations:

- The firm's other trades with the counterparty, which may be rather diverse and, thanks to netting, may lessen the risk of this new trade.
- The firm may have a collateral agreement (or could negotiate one given a large trade) with the counterparty that may further reduce the risk of this new trade.
- The default of the counterparty can be potentially hedged (at least to some degree) since it has debt trading in the market

Credit Valuation Adjustment (CVA) refers to the pricing of counterparty risk.
In practice as well as in accounting standards, it's a bilateral calculation, i.e., it prices the credit risk faced by both the bank and the counterparty.

Definition: CVA is an adjustment made to the credit risk-free value (mid-market value) of a derivative contract or a portfolio to take into account the market value of credit risk faced by both the counterparties. It is the credit risk premium of the derivative contract or the portfolio.

Calculate CVA and the CVA spread with no wrong-way risk, netting, or collateralization.

CVA formula

We first define the formula for calculating CVA and will discuss after this the motivation and precise use of CVA within an institution. When valuing a financial transaction such as an OTC derivative or repo, counterparty risk must be included. However, it is possible to separate the components according to

Risky value = risk-free value - CVA

This separation is useful because the problem of valuing a transaction and computing its counterparty risk can be completely separated.

- The separation (i.e., between the value of a transaction and its counterparty risk) renders it possible to deal with all CVA components centrally and "transfer price" this away from the originating trader or business.
- This is critical since it allows **separation of responsibilities within a financial institution**: one desk is responsible for risk-free valuation and one for the counterparty risk component. Transactions and their associated counterparty risk may then be priced and risk-managed separately. Therefore, for example, a swap trader in a bank need not understand how to price and hedge CVAs as this will be handled by the bank's "CVA desk" who will charge the appropriate CVA for the trade in question.

However, **there is a hidden complexity in the seemingly simple equation** (i.e., risky value = risk-free value – CVA): **it is not linear**. Due to risk mitigants such as netting and collateral, CVA is not additive with respect to individual transactions. This means that the risky value of a given transaction cannot be calculated individually, as it is defined with respect to other transactions within the same netting set.

CVA calculation

If we assume independence between default probability, exposure and recovery, we are ignoring **wrong-way risk**. Under this simplifying assumption (i.e., no wrong-way risk) the simplified credit value adjustment (CVA) expression is given by:

$$CVA \approx \left(1-\bar{\delta}\right)\sum_{j=1}^{m} B\left(t_j\right)EE\left(t_j\right)q\left(t_{j-1},t_j\right), \text{ or with alternative notation}$$

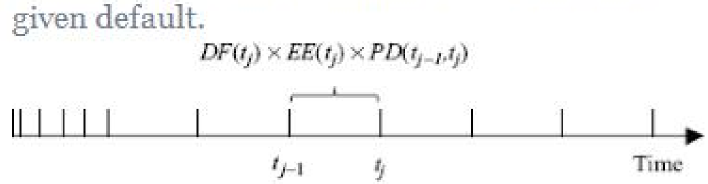
$$CVA \approx \left(1-\text{Rec}\right)\sum_{i=1}^{m} DF\left(t_i\right)EE\left(t_i\right)PD\left(t_{i-1},t_i\right) \qquad \text{(Gregory 12.2)}$$

CVA depends on the following components:

- **Loss given default (LGD)**: LGD = (1-recovery rate). This is the percentage amount of the exposure expected to be lost if the counterparty defaults.
- **Discount factors**. The expression B(t[j]) gives the risk-free discount factor at time t[j]. This is relevant since any future losses must be discounted back to the current time. It is sometimes hard to obtain risk-free discount factors that are not contaminated with some credit risk component and it should be emphasized that LIBOR rates have sometimes been above Treasury bond yields.
- **Expected exposure (EE)**. The term EE(t[j]) is the expected exposure (EE) for the relevant dates in the future given by t[j] for j = 0, n →m.
- **Default probability**. The expression q(t[j-1], t[j]) gives the marginal default probability in the interval between date t[j+1] and t[j].

An illustration of the CVA formula is given in Figure 12.2.

Figure 12.2 Illustration of CVA formula. The component shown is the CVA contribution for a given interval. The formula simply sums up across all intervals and multiplies by the loss given default.



Hence, CVA simply depends on combining components from potentially different sources. For example, an exposure team within a financial institution may compute EE, which is a market risk. The credit department and/or credit derivatives trading desk may provide loss given default and default probability information. Crucially, none of the areas needs to be aware of what the other is doing, as all the components are assumed independent.

A further important advantage of computing CVA via equation (12.2) is that default enters the expression via default probability only. This means that, whilst one may require a simulation framework in order to compute CVA, it is not necessary to simulate default events, only the exposure (EE). This saves significantly on computation time by avoiding the need to simulate relatively rare default events.

We emphasize that, under the assumption of no wrong-way risk, equation (12.2) provides a very efficient way to compute CVA from components that may already be calculated by a financial institution (exposures, default probabilities, discount factors and loss given default). Historically, for many institutions this route has been a very important way to price counterparty risk in a realistic and practical way.

CVA as a spread

Suppose that instead of computing the CVA as a stand-alone value, one wanted it to be expressed as a spread (per annum charge). In Appendix 12C Gregory derives an approximate formula for CVA that will be at least of intuitive interest and will also help in expressing CVA as a running spread. The formula assumes that the EE is constant over time and equal to its average value (EPE).

This yields the following approximation based on EPE:

CVA = credit spread × EPE (Gregory 12.3)

where the CVA is expressed in the same units as the credit spread, which should be for the maturity of the instrument in question, and EPE is as defined in Chapter 8.

For example:

- If expected positive exposure (EPE) is 1.54%,
- and constant credit spread is 500 bps, then:
- The CVA approximation is 1.54% × 500 = 7.71 bps

A simple calculation would involve dividing the CVA by the risky annuity value for the maturity in question. For the previous calculation, a risky annuity of 3.65 would be obtained using the simple formula described in Appendix 10B (the accurate result for an interval of 0.25 years is 3.59). From the result above, we would therefore obtain the CVA as a spread, being 0.253%/3.65 x 10,000 = 6.92 bps (per annum).

The approximate calculation works reasonably well in this case. The simple formula is an overestimate because, whilst the EE profile is certainly not constant as assumed, the marginal default probabilities are reasonably constant. This approximate formula tends to be more accurate for swap-like profiles where the symmetry of the profile helps but is less accurate for monotonically increasing profiles such as the one used in the example above.

The approximate formula in equation (12.2) is often not used for actual calculations but can be useful for intuitive understanding of the drivers of CVA. As counterparty risk became a common component of derivatives transactions from the late 1990s onwards, the above method of representing CVA would be rather common. For example, a bank might tell a corporate client that they would have to pay an extra *X* bps on a swap to cover the “credit charge” or CVA. The simple formula allows the charge to be broken down into the credit component (the credit spread of the counterparty in question) and the market risk component (the exposure, or EPE, in question).

CVA semi-analytical methods

In the case of some specific product types, it is possible to derive analytical formulas for the CVA. Whilst such formulas are of limited use since they do not account for netting or collateral, they are valuable for quick calculations and an intuitive understanding of CVA.

The first simple example is the CVA of a position that can only have a positive value, such as a long option position with an upfront premium. In this situation, it is possible to show (Appendix 12C) that the CVA is simply

$$CVA \approx LGD \times F(T) \times V$$

Where (T) is the maturity of the transaction in question and (V) is its (risk-free) valuation. The term *F(T)* represents the probability that the counterparty will default during the lifetime of the transaction in question. It is intuitive that one simply multiplies the standard risk-free price by this default probability and corrects for the recovery value.

Explain the impact of changes in the credit spread and recovery rate assumptions on CVA.

In each of Gregory's examples below, we consider the CVA of the same 5-year GBP payer interest rate swap. The base case assumptions will be a flat credit curve of 500 bps and a recovery rate of 40%. The base case CVA is then calculated to be £91,389.

Credit spread impact

The increase in credit spread clearly increases the CVA (see Table 12.1 below), but this effect is not linear since default probabilities are bounded by 100%. Another way to understand this is that the "jump to default" risk of this swap is zero, since it has a current value of zero and so an immediate default of the counterparty will not cause any loss. As the credit quality of the counterparty deteriorates, the CVA will obviously increase but at some point, when the counterparty is very close to default, the CVA will decrease again.

Table 12.1 CVA of the base case IRS as a function of the credit spread of the counterparty

Spread (bps)	*CVA (GBP)*
100	20,915
250	49,929
500	92,593
750	129,004
1000	160,033
10,000	289,190
25,000	224,440
50,000	180,455
Default	0

Shape of credit curve

Next, we look at the impact of changes in shape of the credit curve considering three scenarios: upwards-sloping, flat and inverted credit curves. All assume a terminal 5-year credit spread of 500 bps. While the cumulative default probabilities are approximately the same, the marginal default probabilities differ substantially. For a flat curve, default probability is approximately equally spaced whilst for an upwards (downwards)-sloping curve, defaults are back (front) loaded. We show the impact of curve shape on the CVA in Table 12.2. Even though the spread at the maturity of the swap (5Y) is the same in all cases, there are quite different results for the different curve shapes. Indeed, going from an upwards- to a downwards sloping curve increases the CVA by 11%. We note that for EE profiles that are monotonic, such as forward contracts and cross-currency swaps, this impact is typically stronger (for example, for the case represented in Figure 12.3 the corresponding increase is 40%). This illustrates why we emphasized the shape of the credit curve as being an important part of the mapping process.

Table 12.2 CVA of the base case IRS for different shapes of credit curve. The 5-year credit spread is 500 bps in all cases

	CVA (GBP)
Upwards-sloping	84,752
Flat	92,593
Downwards-sloping	94,358

Recovery impact

Table 12.3 shows the impact of changing settled and actual recoveries. Recall that the settled recovery is the recovery at the time of default (for example, settled in the CDS auction) whilst the actual recovery is the amount that will actually be received for the claim (i.e., used in equation (12.2)). Changing both recovery rate assumptions has a reasonably small impact on the CVA since there is a cancellation effect: increasing recovery increases the implied default probability but reduces the resulting loss. Indeed, the simple approximation in equation (12.3) has no recovery input. The net impact is only a second order effect, which is negative with increasing recovery, because the implied default probability increase is sub-linear in recovery, but the loss amount is linear. Different assumptions for settled and actual recovery rates will obviously change the CVA more significantly. For example, assuming a 10% recovery for calculating implied default probabilities and a higher 40% actual recovery (similar to Lehman Brother values) gives a much lower CVA.

Table 12.3 CVA of the base case IRS for different recovery assumptions. Simultaneous changes in the settled and final recovery ("both") and a 10% settled recovery and 40% final recovery are shown

Recovery	*CVA (GBP)*
20% both	96,136
40% both	92,595
60% both	86,003
10%/40%	64,904

Explain how netting can be incorporated into the CVA calculation.

A netting agreement is likely to reduce the CVA but cannot increase CVA. For a set of netted trades (NS):

$$CVA_{NS} \leq \sum_{i=1}^{n} CVA_i^{\text{stand-alone}}$$

where CVA_{NS} is the total CVA of all trades under the netting agreement and $CVA_i^{\text{stand-alone}}$ is the stand-alone CVA for trade *i*. The above reduction can be substantial and the question then becomes how to allocate the netting benefits to each individual transaction. The most obvious way to do this is to use the concept of incremental CVA, analogous to incremental expected exposure (incremental EE). Here the CVA of a transaction (i) is calculated based on the incremental effect this trade has on the netting set:

$$CVA_i^{\text{incremental}} \leq CVA_{NS+i} - CVA_{NS}$$

The above formula ensures that the CVA of a given trade is given by its contribution to the overall CVA at the time it is executed. Hence, it makes the most sense when the CVA needs to be charged to individual traders and business. The CVA depends on the order in which trades are executed but does not change due to subsequent trades. A CVA desk charging this amount will directly offset the impact on their PnL from the change in CVA from the new trade.

Define and calculate incremental CVA and marginal CVA, and explain how to convert CVA into a running spread.

As shown in Gregory's Appendix 12E, we can derive the following formula for incremental CVA:

$$CVA_i^{\text{incremental}} \leq (1-\text{Rec})\sum_{j=1}^{m} \text{DF}(\text{t}_j) EE_i^{\text{incremental}}\left(t_{j-1}, t_j\right) PD\left(t_{j-1}, t_j\right)$$

This is the same as equation (Gregory 12.2) but with the incremental EE replacing the previous stand-alone EE. This should not be surprising since CVA is a linear combination of EE, and netting changes only the exposure and has no impact on recovery values, discount factors or default probabilities. Incremental EE can be negative, due to beneficial netting effects, which will lead to a CVA being negative and, in such a case, it would be possible to transact at a loss due to the overall gain from CVA.

It is worth emphasizing, in the relationship defined above, that, due to the properties of EE and netting, the incremental CVA in the presence of netting will never be higher than the stand-alone CVA without netting (except in bilateral CVA cases discussed in the next chapter – see also Duffie and Huang, 1996). The practical result of this is that an institution with existing trades under a netting agreement will be likely to offer conditions that are more favorable to a counterparty with respect to a new trade. Cooper and Mello (1991) first quantified such an impact, showing specifically that a bank that already has a trade with a counterparty can offer a more competitive rate on a forward contract.

The treatment of netting makes the treatment of CVA a complex and often multidimensional problem. While some attempts have been made at handling netting analytically (e.g., Brigo and Masetti, 2005b), CVA calculations incorporating netting typically require a general Monte Carlo simulation for exposure (EE) quantification.

We will now look at an example of incremental CVA. As before, we consider a 5-year GBP payer interest rate swap (Payer IRS GBP 5Y) and in Table 12.4 consider the CVA under the assumption of four different existing trades with the counterparty.

Table 12.4 Incremental CVA calculations for a 5-year GBP swap paying fixed (Payer IRS GBP 5Y) with respect to four different existing transactions and compared to the stand-alone value. The credit curve is assumed flat at 500 bps with a 40% recovery rate and continuously compounded interest rates of 5% are used

Existing trade	*Incremental CVA (GBP)*
None (stand-alone calculation)	92,593
Payer IRS GBP 6Y	90,076
Payer IRS EUR 5Y	63,832
Receiver IRS EUR 5Y	−42,446
CCS GBPUSD 5Y	−35,801

We can make the following observations:

- The incremental CVA is never higher than the stand-alone CVA (which assumes no netting benefit due to existing trades). This is not surprising since in Chapter 9 we saw that netting could not increase exposure.
- The incremental CVA is only slightly reduced for a very similar existing trade (6-year GBP swap). This follows from the high positive correlation between the two trades.
- The incremental CVA is reduced moderately in the case of a similar swap in a different currency. This is since the trades are still positively correlated.
- The incremental CVA is negative in the last two cases due to the structurally negative correlation. A trader may therefore expect a positive P&L in this situation due to reducing the overall risk to the counterparty in question and may therefore execute a trade with otherwise unfavorable terms.

Marginal CVA

Marginal CVA may be useful to break down a CVA for any number of netted trades into trade-level contributions that sum to the total CVA.

While it might not be used for pricing new transactions (due to the problem that marginal CVA changes when new trades are executed, implying PnL adjustment to trading books), marginal CVA may be required for pricing trades transacted at the same time (perhaps due to being part of the same deal) with a given counterparty. Alternatively, marginal CVA is the appropriate way to calculate the trade-level CVA contributions at a given time. This may be useful where a CVA desk is concerned about their exposure to the default of a particular counterparty.

We compute the marginal CVA corresponding to the marginal EE (Figure 9.16) of the interest rate swap (Payer IRS GBP 5Y) and the cross-currency swap (CCS GBPUSD 5Y). We do this for two different credit curves, one flat at 500 bps and one having the form [300 bps, 350 bps, 400 bps, 450 bps, 500 bps] for maturities [1Y, 2Y, 3Y, 4Y, 5Y]. The results are shown in Table 12.5.

Table 12.5 Illustration of the breakdown of the CVA of the interest rate and cross-currency swap via incremental (CCS first), incremental (IRS first) and marginal. The credit curve is assumed flat or upwards-sloping, recovery rates are 40% and continuously compounded interest rates are 5%

	Flat credit curve			*Upwards-sloping credit curve*		
	Incremental (IRS first)	*Incremental (CCS first)*	*Marginal*	*Incremental (IRS first)*	*Incremental (CCS first)*	*Marginal*
IRS	92,593	27,133	71,178	84,752	18,995	59,580
CCS	34,098	99,558	55,513	48,902	114,660	74,075
Total	**126,691**	**126,691**	**126,691**	**133,655**	**133,655**	**133,655**

We see the effect that the first trade is charged for the majority of the CVA, as seen before, whilst the marginal CVA charges are more balanced. Notice also that, whilst the overall CVA is not changed by much, the breakdown of CVA changes significantly for a differently shaped credit curve. For example, the marginal contribution of the CCS is significantly lower with a flat curve and significantly higher with an upwards-sloping curve. This is because most of the contribution from the CCS to marginal EE comes in the last year of the lifetime (Figure 9.16), which is where the upwards-sloping curve has the highest default probability.

There are some important practical points to understand when incorporating CVA into trades. We start by looking at various CVA decompositions for the four trades in Table 12.6. It can be seen that incremental CVA depends very much on the ordering of the trades. For example, the incremental CVA of the CCS can be almost 20 times smaller if it is the last and not the first trade to be executed.

Clearly, the amount of CVA charged can be very dependent on the timing of the trade. This may be problematic and could possibly lead to “gaming” behavior by traders. However, whilst the marginal contributions are fair, it is hard to imagine how to get around the problems of charging traders and businesses based on marginal contributions that change as new trades are executed with the counterparty.

Table 12.6 Illustration of the breakdown of the CVA for four trades via incremental (the ordering of trades given in brackets) and marginal contributions. The credit curve is assumed flat at 500 bps, recovery rates are 40% and continuously compounded interest rates are 5%

	Stand-alone	*Incremental (1-2-3-4)*	*Incremental (4-1-2-3)*	*Marginal*
Payer IRS GBP 5Y	92,593	92,593	27,133	84,011
Payer IRS GBP 6Y	124,816	122,299	95,520	107,995
Payer IRS EUR 5Y	76,006	37,191	35,694	45,286
CCS GBPUSD 5Y	99,558	5,822	99,558	20,613
Total	**392,973**	**257,905**	**257,905**	**257,905**

CVA as a spread

Another point to consider when pricing CVA into trades is how to convert an upfront CVA to a running spread CVA. This would facilitate charging a CVA to a client via, for example, adjusting the rate paid on a swap. One simple way to do such a transformation would be to divide the CVA by the risky duration for the maturity in question.

GBP IRS above (notional 100m), for the stand-alone CVA, we would obtain:

$$\frac{92{,}593}{3.59 \times 100{,}000{,}000} \times 10{,}000 = 2.58 \text{ bps}$$

However, when adding a spread to a contract such as a swap, the problem is non-linear since the spread itself will have an impact on the CVA. The correct value should be calculated recursively (since the spread will be risky also) until the risky MtM of the contract is zero. Hence, we need to solve an equation V(C*) = CVA (C*), where V(.) is the value of the contract for the adjusted rate C*. This would ensure that the initial value perfectly offsets the CVA and hence C* is a minimum hurdle for the trade to be profitable.

In this case, for the accurate calculation, the relevant spread is 2.34 bps. Obviously, calculating this spread quickly can be an important component. Vrins and Gregory (2011) consider this effect (including the impact of netting and DVA) and show that it is significant in many cases. There are also accurate approximations for computing the correct spread without the need for a recursive solution.

Another point to emphasize is that the benefit of netting seen in the incremental CVA of a new trade depends also on the relative size of the new transaction. As the transaction size increases, the netting benefit is lost and the CVA will approach the stand-alone value. This is illustrated in Figure 12.9, which shows the incremental CVA of the 5-year IRS EUR payer examined as a function of the relative size of this new transaction. We assume that the existing trades are the other three shown in Table 12.6. The stand-alone and standard incremental CVA values are 76,006 and 35,694, which can be converted approximately into running spreads as in equation (12.8), giving 1.77 bps and 0.99 bps respectively. For a smaller transaction, the CVA decreases to a lower limit of 0.67 bps whereas for a large transaction size it approaches the stand-alone value. Clearly, a CVA quote in basis points is only valid for a particular transaction size.

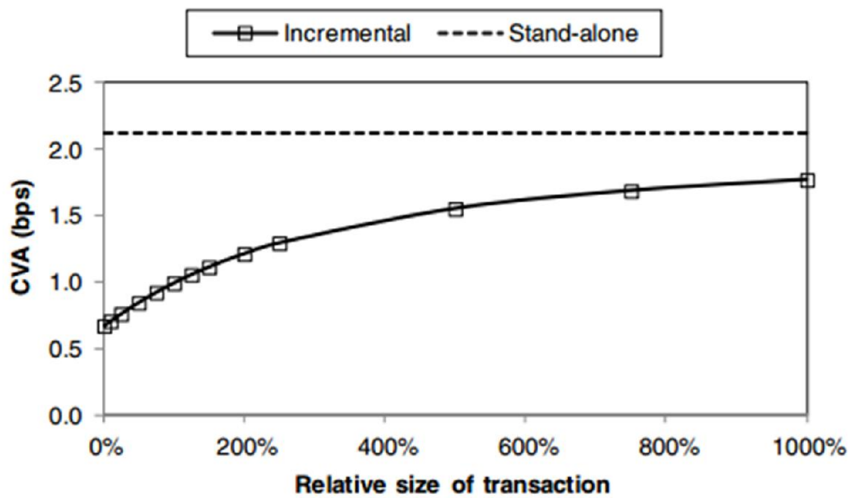


Figure 12.9 Incremental CVA (as a spread in basis points per annum) for a 5-year EUR swap paying fixed (Payer IRS EUR 5Y) with respect to the other three trades in Table 12.6.

Explain the impact of incorporating collateralization into the CVA calculation.

Collateral only changes the expected exposure (EE); collateral does not change the default probability of the counterparty or recovery value and hence the same formula may be used with the EE based on assumptions of collateralization.

The base case scenario will consider the four trades:

- **Base case**. Payer interest rate swap, GBP, 5-year maturity, “Payer IRS GBP 5Y”.
- **Trade 1**. Payer interest rate swap, GBP, 6-year maturity, “Payer IRS GBP 6Y”.
- **Trade 2**. Payer interest rate swap, EUR, 5-year maturity, “Payer IRS EUR 5Y”.
- **Trade 3**. Receiver interest rate swap, EUR, 5-year maturity, “Receiver IRS EUR 5Y”.
- **Trade 4**. Cross-currency swap paying GBP, receiving USD, “CCS GBPUSD 5Y”.

The base case exposure, with and without collateral, can be seen in Figure 9.19.

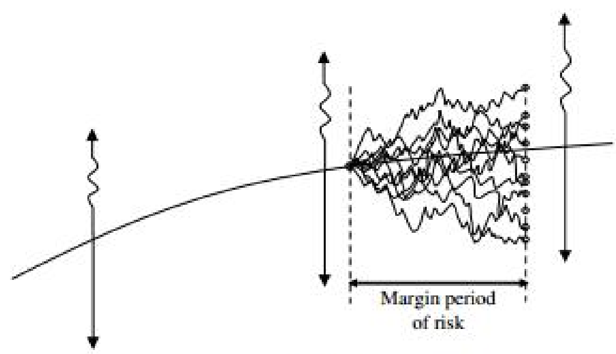


Figure 9.19 Schematic illustration of the impact of collateralisation on potential future exposure.

This assumes a zero-threshold, two-way CSA with a minimum transfer amount of 100,000 and a rounding of 20,000. For the CVA calculation, a flat credit curve of 500 bps and recovery value of 40% is assumed. The base case CVA without any collateral considered is 257,905.

Impact of margin period of risk on zero-threshold CVA

The CVA increases, from small at a zero margin period of risk towards the uncollateralized value (as shown in Figure 12.12). At a margin period of risk of 30 calendar days, the CVA is almost half the uncollateralized CVA. This aligns with the conservative assumption of a minimum of 20 business days required (generally) under the Basel III capital rules.

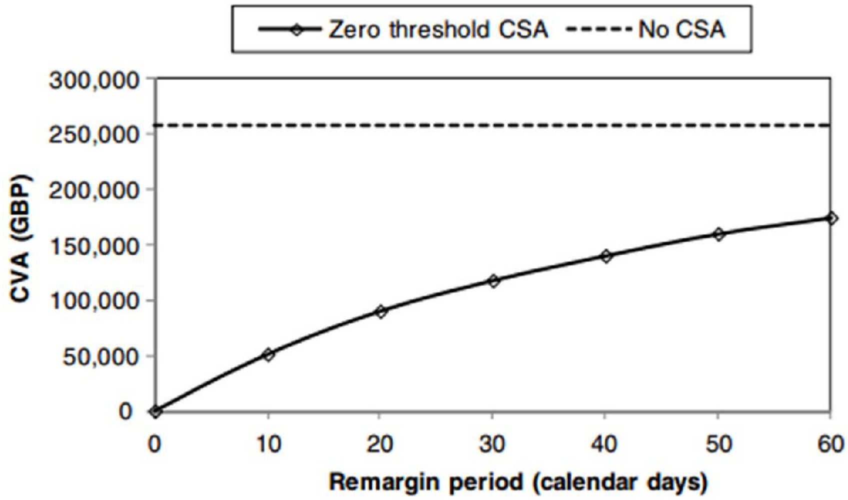


Figure 12.12 Impact of the margin period of risk on CVA. The CVA with no CSA is shown by the dotted line.

Threshold CSAs and independent amounts

Figure 12.13 shows the impact of a threshold on various different CSAs. In the case of a one way CSA, in favor of the counterparty (and therefore against the institution), the overall CVA is increased compared to the uncollateralized CVA (dotted line). A one-way CSA in favor of the institution (for) reduces the CVA significantly. In both one-way CSA cases, the impact of an increasing threshold is to make the CVA converge to the uncollateralized result. In the case of a two-way CSA the behavior is not completely monotonic with respect to an increasing threshold such that a (two-way) threshold of $1m appears slightly more beneficial than a zero-threshold CSA. It is interesting to explain this effect in a bit more detail.

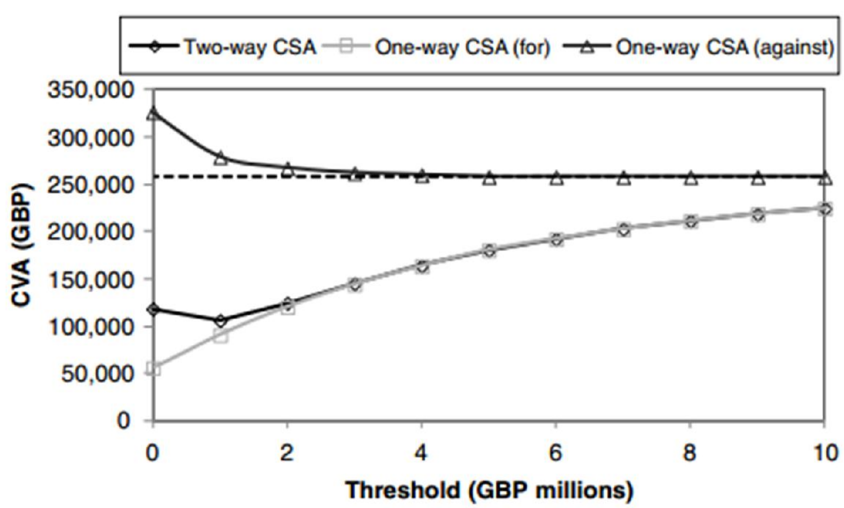


Figure 12.13 Impact of the collateral threshold on CVA. Shown are a two-way CSA, a one-way CSA in the institution's favour (for) and vice versa (against). The dotted line is the uncollateralised CVA.

This non-monotonic behavior in the two-way CSA case is related to EE being less than NEE while 95% PFE is greater than 5% PFE. Recall that we are dealing with a set of four trades, three of which have a positive sensitivity to overall interest rates. In the zero-threshold case, there are many scenarios where the institution must post a relatively small amount of collateral due to a negative drift (relating to the NEE being greater than the EE). This tends to weaken the benefit of the collateralization. On the other hand, with a small threshold, many of these scenarios do not result in collateral posting and the ability to mitigate the paths around the 95% PFE, where interest rates are high, outweighs the need to post collateral for the paths around the (smaller) 5% PFE.

Figure 12.14 shows the impact of independent amount and threshold on the CVA. Note that an independent amount can be considered as a negative threshold. We can see an increase from zero, where the independent amount is large, to the uncollateralized CVA (dotted line) where the threshold is large.

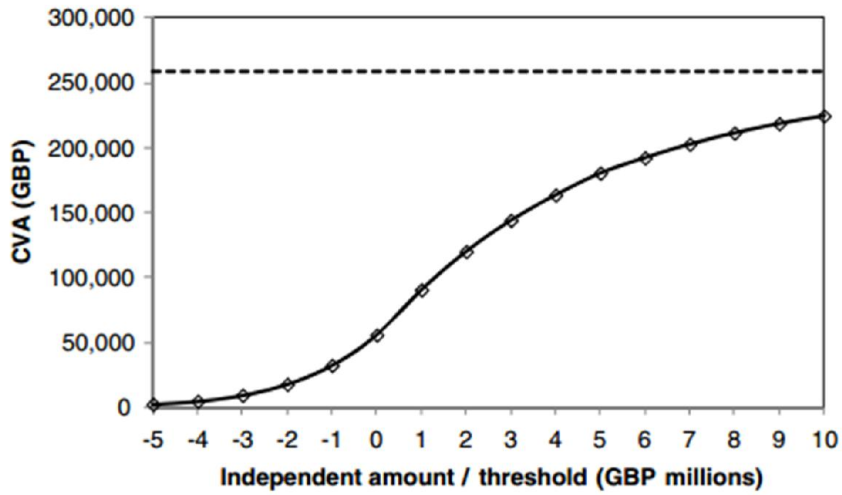


Figure 12.14 Impact of the independent amount (negative values) and threshold (positive values) on CVA. A one-way CSA in the institution's favour is assumed. The dotted line is the uncollateralised CVA.

In Figure 12.15 we look more carefully at the impact of the independent amount on the CVA. We also show error bars arising from an assumed uncertainty in the margin period of risk of ± 10 days (i.e., 20 days or 40 days). Whilst an increase in the independent amount reduces the CVA substantially, the uncertainty over the CVA is relatively greater. With an independent amount, we may believe that the CVA is small but the uncertainty of the estimate is large.

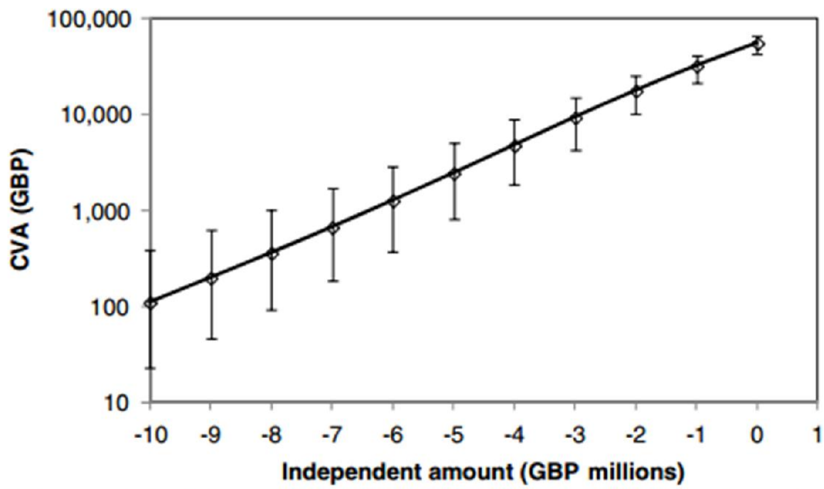


Figure 12.15 Impact of the independent amount (represented as a negative value as in the previous figure) on CVA with a logarithmic *y*-axis. Also shown are error bars corresponding to changing the assumed margin period of risk by ±10 calendar days.

Chapter Summary (Gregory's literal)

This chapter has been concerned with the pricing of counterparty risk via CVA. The computation of CVA has been detailed from the commonly made simplification of no wrong-way risk, which assumes that the credit exposure, default of the counterparty and recovery rate are not related. We have shown the relevant formulas for computing CVA in their simplest possible forms (all the details can be found in the appendices to this chapter, found on cvacentral.com). The concepts of incremental and marginal CVA have been introduced and illustrated in order to provide a means to price new or existing trades. We have discussed the specifics of calculating CVA, including collateral and netting, and covered some more complex aspects such as numerical implementation, exotic products and path dependency.

Questions & Answers

1. The following gives an expression for the simplified credit value adjustment (CVA) when no wrong-way risk is present; and the four components are numbered (1) to (4):

$$CVA \approx \left(1-\bar{\delta}\right)\sum_{j=1}^{m} B\left(t_j\right)EE\left(t_j\right)q\left(t_{j-1},t_j\right)$$

$$CVA \approx \underbrace{\left(1-\bar{\delta}\right)}_{1}\sum_{j=1}^{m} \underbrace{B\left(t_j\right)}_{2}\underbrace{EE\left(t_j\right)}_{3}\underbrace{q\left(t_{j-1},t_j\right)}_{4}$$

This CVA expression has four components. Each of the following is accurate, except which is inaccurate?

a) The first component is loss given default; i.e., unity less expected recovery fraction
b) The second component gives the risk-free discount factor at time t(j)
c) The third component is the expected exposure for the relevant dates in the future
d) The fourth component is the conditional default probability; i.e., probability of default conditional on survival at time t(j-1)

2. In regard to the nature of, and motivation for, pricing counterparty risk, Gregory asserts each of the following as true EXCEPT which is false?

a) The bilateral nature of derivatives contracts makes the quantification of counterparty risk "dramatically more difficult" than bonds for which principal is paid and cash flows (subsequent to investment) are unilateral
b) An advantage of CVA is that pricing (valuation) and counterparty risk management can be centralized at one desk "which improves coordination"
c) We can express the risky value of several transactions with a given counterparty as two components: [risky value] = [risk-free value] – CVA
d) The current risk-free value of a position, with respect to a counterparty, is simply the sum of the individual transactions values; however, CVA is not similarly additive

3. A trader needs to have a very quick idea of the CVA on the swap and has no time for complex calculations. The exposure management group work out the following calculations for this type of trade: expected exposure (EE) at maturity = 100 basis points; potential future exposure (PFE) at maturity = 300 basis points; expected positive exposure (EPE) = 250 basis points; and maximum PFE = 600 basis points. The credit spread of the counterparty is considered to be 200 basis points per annum. Which is nearest to an approximation of CVA as a running spread?

a) 2.0 basis points
b) 5.0 basis points
c) 6.0 basis points
d) 12.0 basis points

4. Each of the following is true about Marginal CVA except which is false?

a) By definition, Marginal CVA must be less than or equal to Incremental CVA
b) Unlike Incremental CVA, Marginal CVA is additive: the sum of Marginal CVAs is the total CVA
c) Marginal CVA is more relevant (than Incremental CVA) for apportioning CVA contributions fairly across existing trades or assessing the CVA of more than one new trade
d) Whereas it is difficult to price simultaneous trades with Incremental CVA, Marginal CVA is the appropriate way to calculate the trade-level CVA contributions of several trades at the same time

5. The following calculation for credit value adjustment (CVA) has four components:

$$CVA \approx \left(1-\bar{\delta}\right)\sum_{j=1}^{m} B\left(t_j\right)EE\left(t_j\right)q\left(t_{j-1},t_j\right)$$

$$CVA \approx \overbrace{\left(1-\bar{\delta}\right)}^{1}\sum_{j=1}^{m} \overbrace{B\left(t_j\right)}^{2}\overbrace{EE\left(t_j\right)}^{3}\overbrace{q\left(t_{j-1},t_j\right)}^{4}$$

Which of the four components is impacted by collateral?

a) 1 only
b) 3 only
c) 4 only
d) All except for 2

Answers:

1. D. The fourth component is a marginal probability (Hull refers to this as an unconditional default probability) between t(j-1) and t(j)
In regard to (A), (B), and (C), each is TRUE.

2. B. False. A key point of the discussion is the ability to parse valuation from counterparty risk into two different desks.
In regard to (A), (C) and (D) each is TRUE.
Gregory: "The isolation of the above two terms [i.e., risk-free value versus CVA] is critical since it allows separation of responsibilities within a financial institution: one desk is responsible for risk-free valuation and one for the counterparty risk component. Derivatives and their associated counterparty risk may then be priced and risk-managed separately. In our above example the swap trader should be responsible for the first component (pricing the swap accurately as if it were risk-free) and may then rely on someone else in the institution to tell him what the counterparty risk charge or CVA should be."

3. B. 5.0 basis points = 200 bps * 2.5% EPE;

4. A. False; e.g., in Table 7.4., Marginal CVAs are greater than Incremental CVAs.
In regard to (B), (C) and (D), each is TRUE.

5. B. Expected exposure

Gregory, Chapter 15: Wrong Way Risk

Describe wrong-way risk and contrast it with right-way risk.

Identify examples of wrong-way risk and examples of right-way risk.

Describe wrong-way risk and contrast it with right-way risk

“Wrong-way risk” is used to indicate an unfavorable dependence between exposure and counterparty credit quality – i.e., the exposure is high when the counterparty is more likely to default and vice versa. While it may often be a reasonable assumption to ignore wrong-way risk, its manifestation can be rather subtle and potentially dramatic. In contrast, “right-way” risk can also exist in cases where the dependence between exposure and credit quality is a favorable one. Right-way situations will reduce counterparty risk and CVA.

Note that we can express the correlation in terms of credit quality or default probability:

- Right-way (wrong-way) exposures are exposures that are positively (negatively) correlated with the credit quality of the counterparty. This is Gregory’s definition, but we can see why some authors will express
- Right-way (wrong-way) exposures are exposures that are negatively (positively) correlated with the default probability the counterparty

Classic examples include:

- A company writing put options on its own stock creates wrong-way exposures for the buyer of the put option
- An oil producer selling oil in a swap creates right-way exposures for the buyer.

Identify examples of wrong-way risk and examples of right-way risk.

Wrong-way Risk: Simple example

Imagine tossing two coins and being asked to assess the probability of getting two heads – that is an easy question to answer. Now suppose that you are told that the coins are linked in some way: the first coin to land can magically have some impact on which way up the other coin lands. Clearly, the question is now much more complex.

CVA could be generally represented as credit spread multiplied by exposure. Indeed, an approximate formula for CVA was simply CVA = credit spread x EPE. However, the multiplication of the default probability (credit spread) and exposure (EPE) terms relies on a key assumption, which is that the different quantities are independent. If they are dependent then the analysis is far more complicated and the relatively simple formulas are no longer appropriate. Essentially this corresponds to the integration of credit risk (default probability) and market risk (exposure), which is a very complex task. We could have other dependence such as between loss given default (and equivalently recovery rate) and either exposure or default probability, which will also give rise to other forms of wrong-way risk.

The market events of 2007 onwards have illustrated clearly that wrong-way risk can be extremely serious.

Classic example and empirical evidence

Wrong-way risk is often a natural and unavoidable consequence of financial markets. One of the simplest examples is mortgage providers who, in an economic regression, face both falling property prices and higher default rates by homeowners.

In derivatives, examples of trades that obviously contain wrong-way risk across different asset classes, which will be studied in more detail later, are:

- Put option. Buying a put option on a stock (or stock index) where the underlying in question has fortunes that are highly correlated to those of the counterparty is an obvious case of wrong-way risk (for example, buying a put on one bank's stock from another bank). The put option will only be valuable if the stock goes down, in which case the counterparty's credit quality will be likely to be deteriorating. As we shall see later, an out-of-the money put option will have more wrong-way risk than an in-the-money one. Correspondingly, equity call options should be right-way products.
- FX forward or cross-currency products. Any FX contract must be considered in terms of a possible linkage between the relevant FX rate and the default probability of the counterparty. In particular, a potential weakening of the currency received by the counterparty vis-a-vis the paid currency should be a wrong-way risk concern. This would obviously be the case in trading with a sovereign and paying their local currency. Another way to look at a cross-currency swap is that it represents a loan collateralized by the opposite currency in the swap. If this currency weakens dramatically, the value of the collateral is strongly diminished. This linkage could be either way: first, a weakening of the currency could indicate a slow economy and hence a less profitable time for the counterparty. Alternatively, the default of a sovereign or large corporate counterparty may itself precipitate a weakening of its local currency.
- Interest rate products. Although this is probably an area with limited wrong-way risk, it is important to consider a relationship between the relevant interest rates and the counterparty default probability. Such a relationship could be considered in either direction: high interest rates may trigger defaults whereas low interest rates may be indicative of a recession where defaults are more likely.
- Commodity swaps. In an oil swap, one party pays cash flows based on a fixed oil price and receives cash flows based on an average spot price of oil over a period. The exposure of payer swap will be high when the price of oil has increased. Suppose the counterparty is an oil company: high oil prices should represent a scenario in which they are performing well. Hence, the contract should represent "right-way risk". The right-way risk arises due to hedging (as opposed to speculation). However, it may not always be as clear-cut as this, as we shall see later.
- Credit default swaps. When buying protection in a CDS contract, an exposure will be the result of the reference entity's credit spread widening. However, one would prefer that the counterparty's credit spread is not widening also! In the case of a strong relationship between the credit quality of the reference entity and counterparty then clearly there is extreme wrong-way risk. On the other hand, with such a strong relationship then selling CDS protection should be a right-way trade with little or no counterparty risk. In portfolio credit derivatives, this effect becomes more subtle and potentially dramatic and helps to explain the failure of CDOs.

All of the above cases have been studied and general empirical evidence supports the presence of wrong-way risk. For example, Duffee (1998) shows a clustering of corporate defaults in the US during periods of falling interest rates. Regarding the FX example, results from Levy and Levin (1999) look at residual currency values upon default of the sovereign and find average values ranging from 17% (Triple-A) to 62% (Triple-C). This implies the amount by which the FX rate involved could jump at the default time of the counterparty.

Losses due to wrong-way risk have also been clearly illustrated. For example, many dealers suffered heavy losses because of wrong-way risk during the Asian crisis of 1997/1998. This was due to a strong link between the default of sovereigns and of corporates and a strong weakening of their local currencies. A decade later, the credit crisis starting in 2007 caused heavy wrong-way risk losses for banks buying insurance from so-called monolines, as discussed later.

Right-way risk and hedging

Right-way risk indicates a beneficial relationship between exposure and default probability that actually reduces counterparty risk. Hedges should naturally create right-way risk because the aim of the hedge is to reduce risk, which should in turn mean less uncertainty over counterparty credit quality.

Wrong-way risk *should* be rather rare in an ideal world. Suppose a mining company wishes to hedge (lock in) the price of gold at some date in the future. This can be achieved via a forward contract on gold. When such a contract is in an institution's favor (and against the mining company), the price of gold will be high. Mining companies are not expected to default when gold is expensive. Assuming most counterparties are hedging and not speculating then they should generate right-way rather than wrong-way risk.
It could be assumed that wrong-way risk will generally be offset by right-way risk. However, we will show later that these assumptions can sometimes be shown to be quite naïve. In the real world, speculation, failed hedges and systemic effects mean that wrong-way risk can occur frequently. Institutions that have exposures to certain market events (such as hedge funds and monolines) will almost surely create wrong-way risk for those trading with them.

Wrong-way risk challenges

Quantifying wrong-way risk will involve somehow modelling the relationship between default probability and exposure.

At a high level, there are two potential pitfalls in doing this, which are:

- Lack (or irrelevance) of historical data. Unfortunately, wrong-way risk may be subtle and not revealed via any historical time series analysis.
- Misspecification of relationship. The way in which the dependency between credit spreads (default probability) and exposure is specified may be inappropriate. For example, rather than being the result of a correlation, it may be the result of a causality– a cause-and effect type relationship between two events.

Suppose an institution makes a statistical study of the correlation between the credit quality of their counterparty and a variable driving the exposure (e.g., an interest rate or FX rate) and finds this correlation is close to zero. There seems to be little evidence of wrong-way risk in this transaction. However, both of the above problems may exist.

Concerning historical data, wrong-way risk by its very nature is extreme and often rather specific. Hence, historical data may not show the relationship. For example, in 2010, the European sovereign crisis began and was accompanied by deterioration in the credit quality of many European sovereigns and a weakening of the euro currency. There is a clear relationship here with sovereign credit spreads widening and their underlying currency weakening. However, historical data did not bear out this relationship, largely since neither the sovereigns concerned nor the currency had ever previously been subject to any adverse credit effects.

Concerning possible misspecification, correlation is only one measure of dependency. It measures only the linear relationship between variables. Suppose one believes that a small move in a market rate will have little or no impact on the credit quality of a counterparty but a much larger move will. This is a second-order relationship that will not be captured by correlation. There may be a causal relationship: for example, the counterparty's credit quality deteriorating significantly moves market variables significantly even though the credit spread of that counterparty previously showed no relationship to the market variable during normal times. It is important to emphasize here, whilst two independent random variables will have zero correlation, the reverse is not true. If the correlation between two random variables is measured as zero then this does not prove that they are independent.

Wrong-way risk and CVA

The presence of wrong-way risk will (unsurprisingly) increase CVA. However, the magnitude of this increase will be hard to quantify, as we shall show in some examples. Wrong-way risk also prevents one from using the (relatively) simple formulas used for CVA in Chapter 12. Whilst independence may exist in everyday life, it almost certainly does not in the interconnected and systemic financial markets.

All is not lost though. We can still use the same CVA expression as long as we calculate the exposure *conditional* upon default of the counterparty. Returning to equation (12.2), we simply rewrite the expression as

$$CVA \approx (1-\text{Rec})\sum_{j=1}^{m} DF(t_j)\,EE(t_j \mid t_j = \tau_C)\,PD(t_{j-1},t_j) \qquad \text{(Gregory 15.1)}$$

where $EE(t_j|t_j = \tau_C)$ represents the expected exposure at time t_j conditional on this being the counterparty default time (τ_C). This replaces the previous exposure, which was unconditional. As long as we use the conditional exposure, everything is correct.

Obviously, calculating the conditional exposure is not at all easy because it depends on the counterparty and future time in question. Two equivalent portfolios of trades with different counterparties will have the same unconditional exposure but different conditional exposures.

Broadly speaking, there are two ways to go about computing conditional exposure:

- Consider the exposure and default of the counterparty together and quantify the economic relationship between them. This method is the "correct" approach but the economic relationship may be extremely hard to define and there may be computation issues in calculating quantities such as CVA in this manner.
- Incorporate wrong-way risk via simple conservative assumptions, "rules of thumb" or simple generic models. This is a much simpler approach that involves minimal effort in the way of systems re-engineering or additional computational requirements.

Simple example

Exposure should always be computed conditionally on the counterparty default. In Appendix 15A Gregory derives a simple formula for the conditional expected exposure for a forward contract-type exposure (an extension of the previous unconditional case given in Appendix 8B). The correlation is introduced by assuming the exposure follows a normal distribution and that the default time is generated from a normal distribution using the so called Gaussian copula approach. Under these assumptions, the conditional expected exposure can be calculated directly. This gives the EE at a times under the assumption that the counterparty will have defaulted at time s. The relationship between exposure and counterparty default is expressed using a single correlation parameter. This correlation parameter is rather abstract, with no straightforward economic intuition, but it does facilitate a simple way of quantifying and understanding wrong-way risk.

Let us now consider the impact of wrong-way risk on the example forward contract using the following base case parameters:

μ = 0%	drift of the value of the forward contract
σ = 10%	volatility of the value of the forward contract
h = 2%	hazard rate (default probability) of the counterparty
ρ = ± 50%	correlation between the value of the forward contract and the default time of the counterparty

Figure 15.1 shows the impact of wrong-way (and right-way) risk on the EE. We can see that with 50% correlation, wrong-way risk approximately doubles the EE whilst with 50% correlation the impact of right-way risk reduces it by at least half. This is exactly the type of behavior expected: positive correlation between the default probability and exposure increases the conditional expected exposure (default probability is high when exposure is high), which is wrong-way risk. Negative correlation causes right-way risk. Note that since the drift is zero, the negative expected exposure would follow exactly the same trend.

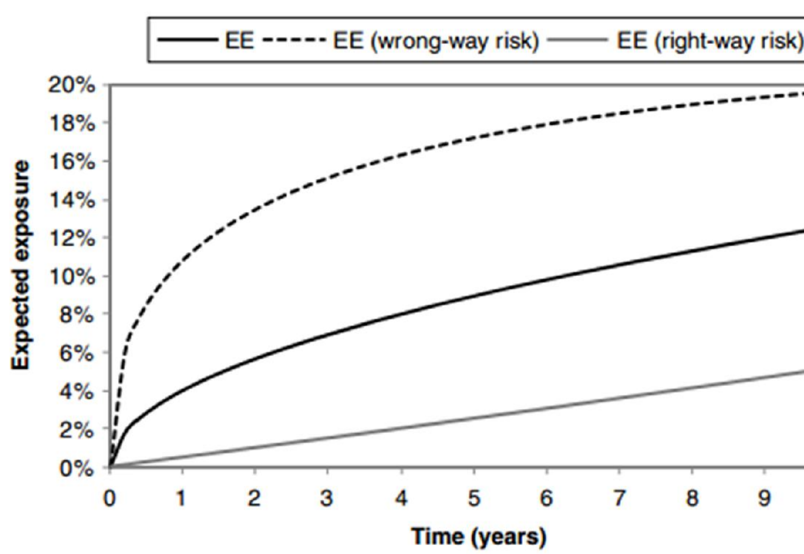


Figure 15.1 Illustration of wrong-way and right-way risk EE profiles using the base-case scenario with correlations of 50% and −50%, respectively.

Let us look into this simple model in a bit more detail. Consider now the impact of counterparty default probability on the EE with wrong-way risk. Figure 15.2 shows the EE using three different hazard rates, indicating that the exposure decreases as the credit quality of the counterparty also decreases. This result might seem at first counterintuitive but it makes sense when one considers that for a better credit quality counterparty, default is a less probable event and therefore represents a bigger surprise when it comes.

We note an important general conclusion:

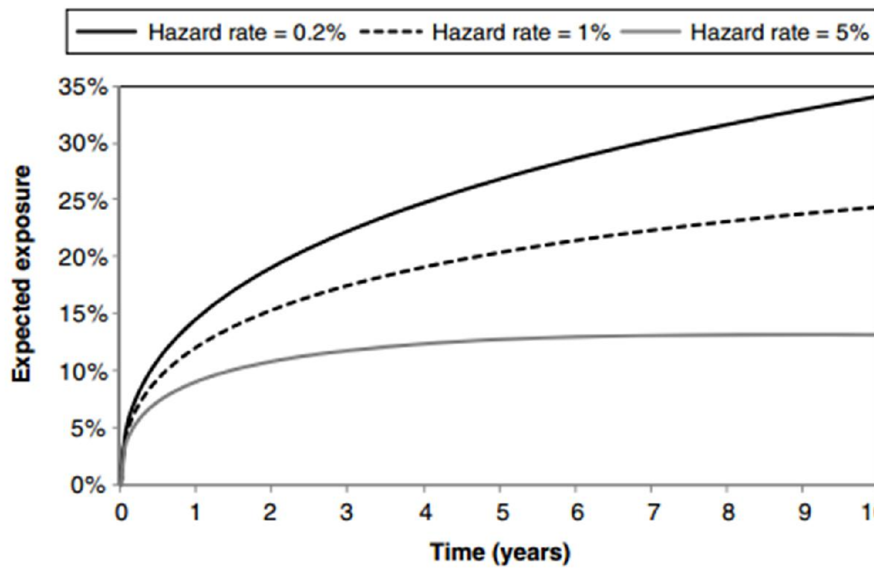


Figure 15.2 Illustration of EE under the assumption of wrong-way risk as a function of the hazard rate. The correlation is assumed to be 50%.

Wrong-way risk increases as the credit quality of the counterparty increases.

Finally, we change the drift of the forward contract to be μ = -2% and use a larger hazard rate of *h* = 6%. The EE profile with and without wrong-way risk is shown in Figure 15.3.

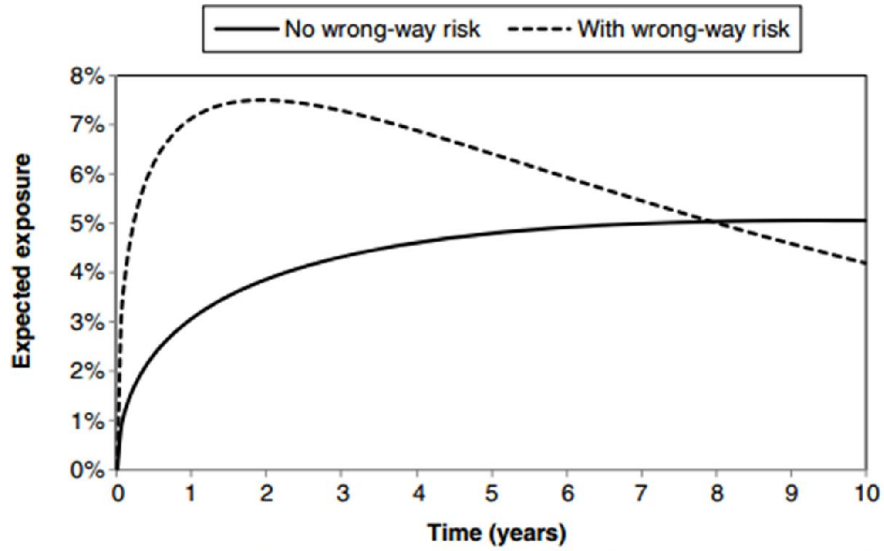


Figure 15.3 Illustration of EE with and without the assumption of wrong-way risk for a drift of $\mu = -2\%$ and hazard rate of $h = 6\%$.

Negative drift will reduce the overall exposure, as we can see. However, there is another effect, which is that the wrong-way risk EE is actually smaller than the standard EE after 8 years. This is because counterparty default in later years is not such a surprise as in earlier years (with a hazard rate of 6% the 8-year default probability is 38%, whilst the 2-year default probability is only 11.3%). Hence, default in early years represents "bad news" whilst in later years default is almost expected! This suggests that wrong-way risk has a term structure effect, with conditional exposure in the shorter term showing a more dramatic effect than in the long-term.

Chapter Summary (Gregory's literal)

In this chapter we have discussed wrong-way counterparty risk, which is a phenomenon caused by the dependence between exposure and default probability. Wrong-way risk is a subtle, but potentially devastating, effect that can increase counterparty risk and CVA substantially. Portfolio and trade-level wrong-way risk have been described. We have examined some classic examples arising in different asset classes (interest rates, FX, equity and commodities) and associated quantitative approaches. Counterparty risk in credit derivatives has been analyzed and the failure of CDOs has been linked to this. Finally, we have considered the impact of wrong-way risk on collateral and argued that it represents a very serious concern for central counterparties.