

Chapter 1 Introduction to Counterparty Credit Risk

Even though the credit risk in various underlying assets and reference obligations has been trading in the market for many years or decades in terms of, e.g., risky bonds and credit derivatives, the trading of the counterparty credit risk in derivatives instruments is a relatively new field.

The counterparty credit risk comes from the fact that as one enters into an OTC (over-the-counter) derivatives transaction, one (implicitly or explicitly) grants one's counterparty an option to default and, at the same time, one also receives an option to default oneself. Equivalently, in the transaction, one sells credit protection on one's counterparty to one's counterparty and buys credit protection on oneself from one's counterparty. Various authors have published research papers on how to model the counterparty credit risk.²

In essence, pricing the counterparty credit risk is the same as pricing defaultable derivatives (or defaultable baskets of derivatives) or the default premium in derivatives (or baskets of derivatives), which is a relatively new area of the derivatives modeling. In some cases, the counterparty credit risk is more significant than any other risks and a derivatives instrument becomes a hybrid derivatives instrument with credit or a compound credit derivatives instrument if the underlying derivatives instrument is a credit derivatives instrument.

For instance, a plain vanilla interest rate (IR) swap becomes a defaultable IR swap. Also, in the prevailing credit derivatives, pricing a

² See, e.g., Litzenberger (1992), Duffie and Huang (1996), Jarrow and Turnbull (1995), and Jarrow and Yu (2001).

credit default swap (CDS) is essentially to price the default premium in the underlying bond or asset, whereas pricing the counterparty credit risk is to price the default premium of the default protection seller of the CDS or, more precisely, the premium of the joint default of the underlying asset and the default protection seller.

The term of counterparty credit risk may remind the reader of a back office risk management functionality. We emphasize that it should be an integral part of the front office derivatives pricing, trading, and hedging activities, which is the same as pricing, trading, and hedging defaultable derivatives. This is the approach that we shall adopt in this book and we shall also address many practical issues. With this approach, a large part of the counterparty credit risk becomes market risk that can be traded and hedged with market oriented trading strategies (in addition to the classical strategies for counterparty credit risk management).

Just like the credit risk in a bond (with respect to the bond issuer) reduces the market value of the bond (relative to the same bond that is default-free), the counterparty credit risk should also reduce the market value of one's (net) receivables in an OTC derivatives instrument (relative to the same receivables that are default-free).

The PV (present value) of the counterparty credit risk can be a significant percentage of the overall P&L (profit and loss) of the derivatives desks and can reach many hundreds of millions of dollars for a top investment bank. In other words, typically, one's overall profit needs to be marked down by the PV of the (net) counterparty credit risk that one takes.

The PV of the counterparty credit risk needs to be actively hedged and risk managed, just like other risks in derivatives trading. Simple back of envelop calculations can show that the credit spread PV01 of the counterparty credit risk can reach several millions of dollars.³ This is a huge Delta exposure to a market maker or dealer.⁴

Even before default happens, the counterparty credit risk can have

³ The credit spread PV01 is the PV change for 1bp increase of the credit spread. 1bp is one hundredth of 1%. For the credit spread PV01 estimation, we have assumed that the average or equivalent counterparty credit spread is about 100 to 200bp. Then, the credit spread PV01 can be estimated by the PV of the counterparty credit risk divided by the credit spread. Similarly, we can also estimate the loss given default (LGD). For details, please refer to Chapter 8.

⁴ By market maker or dealer, we typically mean OTC derivatives market maker or dealer, unless otherwise indicated. We often use the word "market maker" and "dealer" interchangeably.

significant impact on trading and hedging strategies in many ways, such as in the pricing of cash-settled versus physically settled options, the early exercise decisions of Bermudan or American options, as well as the put-call parity and the bid/ask spread.

There are also arbitrage strategies that one can employ to capitalize or monetize the counterparty credit risk, which can bring in cashflows in some cases and reduce the outgoing cashflows in some other cases. These strategies can also be applied to achieve trade price cheapening to one's counterparties and thus can bring in more business. In other words, while one usually needs to charge a premium from one's counterparty due to the counterparty's default risk, one can actually structure a trade whereby one pays a premium to one's counterparty due to the counterparty's likelihood of default. The reader may want to think about how to structure such a trade and we shall come back to this point later on.

All these have created and will create more trading opportunities in the market and are major driving factors for the development of the credit hybrid market and modeling.

It is important to point out that these arbitrage strategies are not the case that financial institutions arbitrage against one another, but rather to achieve the fair values of the default probabilities and recoveries priced by the market, which is a less transparent area. Not only can these arbitrage strategies benefit individual firms, they can also make the market more transparent and efficient with more information discovery and production, including possibly more implied views on the default events and recoveries.

In the current practice, the PV of the counterparty credit risk enters into the MTM (mark-to-the-market⁵) values for the corresponding portfolios as credit valuation adjustments (CVA) or the credit charge or premium. The IRS (Internal Revenue Service) also cares about this for tax purposes, which is highlighted by the BankOne case in United States Tax Court.⁶

Proper pricing and management of counterparty credit risk are important to a firm's long-term economic soundness and can help reducing

⁵ Or mark-to-the-model, if mark-to-the-market values are not easily obtained, which is common in OTC derivatives business, especially for exotic derivatives.

⁶ For more details on the case of BankOne regarding the swap valuation, see, e.g., the Expert Report of Darrell Duffie (<http://www.stanford.edu/~duffie/bankone.pdf>) and the court's ruling (<http://www.ustaxcourt.gov/InOphistoric/bankone.TC.WPD.pdf>).

the potential default losses and to increase its earnings and/or reduce the earning volatility, which will help to increase the shareholders' equity and/or reduce its volatility. It is also beneficial to a firm's bondholders and other investors, as well as the economic soundness of the entire financial industry. Proper management of the counterparty credit risk can also help banks reduce the amount of their regulatory capital, particularly under the forthcoming Basel II Accord,⁷ and thus boost the return on regulatory capital. This, in turn, will create more trading opportunities in the market place.

Proper pricing and management of the counterparty credit risk are also critical for a financial institution to expand its derivatives business to non-investment grade counterparties, such as high yield and emerging market counterparties. In these cases, the PV of the counterparty credit risk can be significantly outside of the broker's bid/ask spread of the underlying derivatives trade, in which case, one is really trading the counterparty credit risk more than any other risks and the underlying derivatives trade becomes a hybrid derivatives instrument with credit or a compound credit derivatives instrument.

As we shall see, the prevailing derivatives models focusing on pricing of specific trade (which we shall term as trade-level or *micro* models) normally do not and often cannot price the (specific) counterparty credit risk, even though they can price expected market risks, expected credit risks in the underlying assets or reference obligations in the case of credit derivatives, and some generic counterparty credit risk. This is due to that the specific counterparty credit risk is essentially a basket option on the counterparty portfolio and has highly non-linear portfolio effect. Therefore, additional portfolio level models (which we shall term as *macro* models) are needed for pricing the specific counterparty credit risk.

Another area that the trade-level or micro derivatives models normally do not and often cannot price accurately are the unexpected risks, such as VAR (Value at Risk)⁸ and PE (Potential Exposure)⁹ that can contribute to the hedging cost and are the driving factors for the regulatory capital cost. Pricing of such unexpected risks need the portfolio level or macro models and can leverage similar models and system infrastruc-

⁷ For more information, see www.bis.org.

⁸ Coherent risk measures, such as the expected tail loss (ETL) or the expected shortfalls, are superior to VAR due to their subadditivity.

⁹ Credit VAR or credit coherent risk measures are superior to PE due to their capabilities of handling portfolio effects or benefit of diversification.

tures used for pricing the counterparty credit risk. In addition, in order to accurately model the bid/ask spread, one also needs the portfolio level or macro models.

We shall address various subtleties in the counterparty credit risk, some of which come from the asymmetry of the prevailing default treatment and its impact on the default recovery. In other words, if the defaulting party is in the money on the portfolio with a counterparty,¹⁰ then upon the default, to the first order, all the trades are terminated as if there were no default and the defaulting party will be paid the MTM of the portfolio by its counterparty, and, thus, to the first order, there is no default loss or gain to either party. On the other hand, if the defaulting party is out of the money on the portfolio with a counterparty, then upon the default when all the trades are terminated, the defaulting party will only need to pay a fraction of the net MTM of the portfolio, i.e., the recovery on the portfolio, to its counterparty and thus the defaulting party will have a default gain and its counterparty will have a default loss.¹¹

One particular subtle and interesting issue in the counterparty credit risk is how to realize (or monetize) and lock in one's default gain *before* one defaults, i.e., how to convert one's default gain into a stream of cash-flows *before* one defaults. This is very important to the business as the PV of such default gain can possibly reach hundreds of millions of dollars for a top investment bank. There are trading and arbitrage strategies available for this, some of which shall be discussed later on.

It seems that there are dealers who do not accurately price in the counterparty credit risk in their trades and portfolios. If they price the counterparty credit risk too aggressively (or too low), then, not only they are exposed to the default risk of their counterparties without proper compensation, they are also exposed to the credit spread risk of their counterparties without proper compensation. If they price the counter-

¹⁰ To be more precise, it is on the net basis for each of the netting node, i.e., a collection of legally and enforceably nettable trades. Going forward, for the simplicity of disposition, when we refer to a counterparty portfolio, we mean a netting node in the portfolio, unless indicated otherwise. When we say that one is in the money on a portfolio, it is the same as saying that one has a positive net MTM value or a positive exposure on the portfolio, one is owed money on the portfolio, one has net receivables on the portfolio, and the portfolio is one's asset. Similarly, when we say that one is out of the money on a portfolio, it is the same as saying that one has a negative net MTM value or a negative exposure on the portfolio, one owes money on the portfolio, one has net payables on the portfolio, and the portfolio is one's liability.

¹¹ If there are collaterals involved, then MTMNC (MTM net of the collaterals) is what is at risk and should be used in the discussion.

party credit risk too conservatively (or too high), they may lose business opportunities to other dealers.

One subtlety is that it may not be inline with the interests of the traders and the trading desks. Thus, the successful implementation of models, systems, and policies for proper management of counterparty credit risk often requires the support of top executives in a firm, such as the head of derivatives trading business and the CFO (Chief Financial Officer).

In addition, the quantification or modeling of counterparty credit risk and its management also impose challenges and additional requirements on pricing theory, pricing engine, trading system architecture, and back office process, and require dedicated human resources and dedicated systems. Nonetheless, these challenges and the benefit to be capitalized by overcoming these challenges will open up new opportunities in, e.g., trading and modeling.

In summary, without proper modeling and management of counterparty credit risk, one is missing a significant part of the big picture of OTC derivatives modeling and business.

This chapter focuses on concepts and intuitions. Detailed modeling issues are discussed in later chapters.

1.1 Credit Charge, Credit Benefit, and Credit Premium

The question is after one enters into an OTC (over-the-counter) derivatives transaction or trade, what else can happen? Of course, one's counterparty can default. But, there is more – one can default oneself too.

In other words, when one enters into an OTC derivatives transaction or trade, one (explicitly or implicitly) grants one's counterparty an option to default¹² (or is short of counterparty default protection). Similarly, one also receives an option to default (or is long of self default protection) from one's counterparty. In a rational and efficient market, each party should be compensated for the credit risk that they undertake and

¹² Such default options may not be explicitly on the term sheet of the derivatives transaction. Nonetheless, such default options are real and defaults do happen. The default can happen exogenously or endogenously. By using the word “option”, we do not mean that the default always happens endogenously. Rather, we use the word ‘option’ in the sense of the Merton framework whereby the default of a bond is characterized as a (down-and-in) put option. Furthermore, the bond holder has a short position in this option and the bond issuer has a long position in this option. Similarly, a stock is equivalent to a long position on a (down-and-out) call option.

the net PV (present value) of such default options should also be reflected in the price or PV of the OTC derivatives.

In other words, the price or premium of a trade can be broken down into a few parts, such as the market price (for capturing the market value and risk in the trade without the consideration of the counterparty credit risk, but including the value and credit risk from the underlying obligations) and the credit premium (for compensating the counterparty credit risk in the trade).¹³ The market price is what brokers quote or what trading systems or models normally report. The credit premium is a relatively less explored and less transparent area in market practice, Quant modeling, and trading systems.

These default options should be treated much the same way as the underlying trades. When additional OTC transactions occur (including the termination and assignment of an existing trade), the corresponding transactions of these default options will also occur. More specifically, when OTC derivatives terminate, the associated default options also terminate. For dealers, these default options should be hedged in a similar way as other trades.

The PV of the default option of one's counterparty is one's expected default loss (due to the counterparty's default), which translates to one's credit charge. This is also the credit valuation adjustment for one's asset, or CVA asset. On the other hand, the PV of the default option of oneself is one's expected default gain (due to one's own default), which translates to one's credit benefit. This is also the credit valuation adjustment for one's liability, or CVA liability.

Theoretically, e.g., ignoring the bid/ask spread, in order for the two parties to agree on the same price on the trade, we need the symmetry of the credit charge and credit benefit, i.e., one's credit charge is one's counterparty's credit benefit, and *vice versa*.

The total or net credit charge or the credit premium is the net PV of the two default options or the net of the credit charge and the credit benefit. Similarly, the net CVA is the net of the CVA asset and the CVA liability.

¹³ It should also include premium of unexpected risk and liquidity premium.

Figure 1.1 depicts a more complete picture of OTC derivatives trade.

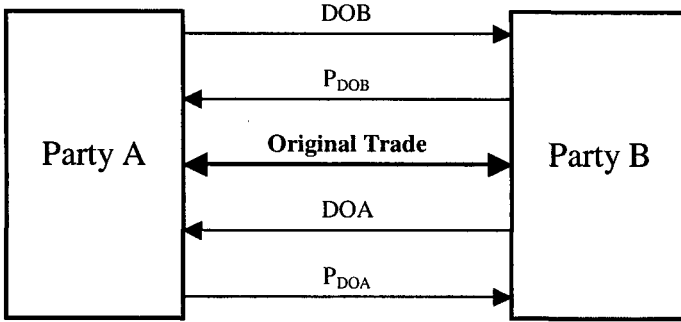


Figure 1.1. A more complete picture of an OTC derivatives trade. More specifically, in addition to the original trade, Party A implicitly grants a default option to Party B (DOB) and Party B pays Party A a premium (P_{DOB}) for such default option, and vice versa. Thus, the derivatives trade is actually a credit hybrid trade. In the case of credit derivatives, the derivatives trade itself can also reference the default of underlying asset(s) or obligations(s), in which case the trade is a compound credit derivatives trade.

The readers may recognize that we emphasize the attribution of the counterparty credit risk to real (albeit embedded) trades or default options, whereas some of the prevailing approaches simply use credit valuation adjustments (CVA). While these approaches give the same valuation adjustments, our approach can help us gain insights and intuitions, adopt more market oriented approaches to modeling and management of the counterparty credit risk, and avoid confusions in many cases, as, in our approach, the adjustments are explicitly associated with the sources (i.e., the default options).

Some of these cases include trade termination, restructuring, and assignment. It is interesting to analyze the classic example whereby Party A has a trade with Party B and then Party B assigns the trade to Party C. Particularly, Party C can have no existing trade, or existing offsetting trades, or non-offsetting trades with Party A.

Let's make a simple comparison between the premium of a CDS and the credit charge. The premium of a CDS is the default premium (or the protection premium on such default) in an underlying bond, whereas the premium of the credit charge is the default premium (or the protection premium on such default) in an underlying OTC derivatives instrument.

Question 1.1. Analyze in details what happens when Party A has a trade with Party B and then Party B assigns the trade to Party C.

Commonly, the net credit charge or the credit premium (or the net CVA) is not paid as a lump-sum upfront premium, but rather is structured into the original trade as a series of cashflows in terms of, e.g., a (additional) funding spread or an annuity leg. In this sense, the counterparty default options are structured similar to credit default swaps (CDS), except the defaults payoffs of the counterparty default options can be highly stochastic (or volatile). In this case, the credit premium will not be paid in full should the credit premium paying party default before the end of the trade, thus additional credit premium (on the credit premium itself) needs to be charged to cover the potential loss of the credit premium itself.

In general, one's credit charge would make the trade more expensive to one's counterparty, and one's credit benefit would make the trade less expensive. The net credit charge or the credit premium can make the trade price or PV go either way, depending on, e.g., the credit quality and exposure differential between the two parties. Similarly, the impact of the net credit charge or the credit premium on the trade price or PV (or the par coupon, the funding spread, etc.) can be within or outside the broker's bid/ask spread that does not take into account specific counterparty credit risk and, for the swap market, assumes all the parties are of LIBOR¹⁴ credit quality.

If one of the parties is of low credit quality, particularly, if one of the parties is a high yield name or of non-investment grade, then the impact of net credit charge can be significantly outside of the broker's bid/ask spread. For this situation, the market has started to explicitly provide quotes on the net credit charges.

Based on the asymmetry of default treatment that we discussed earlier, we can also see that one party's default would cancel the option to default of the other party going forward. Therefore, these default options are first-to-default options. The first-to-default feature is typically not significant unless one of the parties involved is of very low credit quality.

¹⁴ LIBOR stands for London Interbank Offered Rate. For more information, see www.bba.org.uk.

Often times, the portfolio of a counterparty can contain trades modeled by different pricers, booked in different systems, from different desks, or even from different product areas. Accurately pricing options on such portfolio is one of the most challenging tasks in modeling the credit charge.

Due to the option feature of the credit premium, simple financial instruments, such as forwards and swaps that, by themselves, do not have Vegas,¹⁵ now can have Vegas for their net PVs due to the credit premium. In addition, the incremental credit premium of a trade with a counterparty depends on other existing trades with the same counterparty.

The counterparty credit risk can have significant impact on trading strategies and decisions in many ways. For instance, if one is long a Bermudan or American option, then one is faced with making decisions whether to early exercise or to continue. Such decisions (or early exercise boundaries) can be different with or without the consideration of the counterparty credit risk. To the first order, the credit premium should come into the early exercise decision as exercise or non-exercise gain or cost, depending on whether the credit risk decreases or increases upon the early exercise. Ideally, a trade with significant counterparty credit risk should be treated as hybrid derivatives and priced and risk managed as such.

Question 1.2. Analyze in details how the credit premium (or the net credit charge) affects the early exercise decision.

Another example concerns cash settled swaptions versus physically settled swaptions. Without the consideration of the counterparty credit risk, these two settlement types would result in the same PV for a swaption.¹⁶ However, these two settlement types can result in a significant

¹⁵ Vega is the sensitivity of the PV of a trade with respect to volatility. If a swap is hedged with futures contracts, the swap plus its hedges can have a minor Vega due to the convexity adjustment.

¹⁶ There is another type of cash settlement, cash discount, whose settlement amount, instead of a dealer poll, is determined by PV'ing the underlying swap discounted using the future swap rate at the swaption expiry (or, equivalently, assuming the yield curve is flat with the yield equal to the future swap rate at the swaption expiry). This would make a PV difference as compared to the other settlement types even without the consideration of the counterparty credit risk.

difference in the credit premium or the net credit charges.

A further example is the common put-call parity needs to be modified, which we shall quantify in Section 3.3.

It is important to point out that the prevailing micro or trade-level models do incorporate some generic counterparty credit risk. For instance, they normally use LIBOR to discount the derivatives payoffs. This takes into account LIBOR credit quality, which is normally lower than that of the Treasury of the corresponding domestic currency (except for lower credit rated sovereign entities). Therefore, the premium of the counterparty default options that we have been discussing should be relative to the LIBOR credit quality or to capture the default options not priced in (or priced accurately) by the LIBOR credit quality. In other words, if one is below the LIBOR credit quality, one needs to pay a positive premium for one's option to default, whereas if one is above the LIBOR credit quality, then one can get paid for the fact that one's default option is of lower premium than that of the LIBOR credit quality which is priced in the derivatives price.

To build intuition on the credit charge, credit benefit, and credit premium, it is often helpful to think that derivatives are similar to loans in some sense. For instance, if one has payables to one's counterparty in a derivatives trade, then, roughly speaking, one has a loan (or borrowed money) from one's counterparty. The prevailing micro or trade-level models tell us that the loan is priced at LIBOR flat or one has borrowed money at LIBOR flat. This clearly is a benefit - the credit benefit, if one is below the LIBOR credit quality, as one would need to borrow money at LIBOR plus a positive spread, if one were to issue a senior unsecured bond.¹⁷ In other words, the credit benefit in this case is one's saving on one's funding cost, the cost resulting from the positive spread above LIBOR. If one is above the LIBOR credit quality, then getting a loan from a derivatives trade at LIBOR flat is actually a cost, rather than a credit benefit.

Similarly, under various simplified assumptions, one can decompose one's trade into two parts, i.e., a receivable part and a payable part, and then one should PV the receivables by discounting at the funding rate of one's counterparty and PV the payables by discounting at one's own funding rate.

Going forward, we shall always use LIBOR as the reference credit

¹⁷ Typically, the (uncollateralized) OTC derivatives are of the same priority in the capital structure as senior unsecured bonds.

quality, unless otherwise indicated. Similarly, we shall also assume that the entities involved are of LIBOR credit quality or lower for the simplicity of disposition. The treatment of entities with credit qualities better than LIBOR is similar. Essentially, as we pointed out earlier, we just need to price the specific counterparty credit risk not priced in or not priced accurately by assuming LIBOR credit quality in micro or trade-level pricing models.

When sovereign credit risks are involved, there are additional subtle issues that we need to handle, which we shall discuss later on.

1.2 Credit Cost, Accrued Funding Cost, and Accrued Funding Benefit

Aside from credit charge and credit benefit, there is another quantity of importance. That is the credit cost.

While the credit charge on a counterparty portfolio comes from the scenarios of one's counterparty's default when one is in the money in the portfolio (net of collaterals received) and the credit benefit comes from the scenarios of one's own default when one is out of the money in the portfolio (net of collaterals posted), the credit cost comes from the scenarios when one is in the money in the portfolio (net of collaterals received) and one defaults on one's hedges or funding obligations for the portfolio (net of collaterals received).¹⁸

To put it in another way, if one has receivables from a counterparty portfolio, then one needs to charge one's counterparty the credit charge (to cover one's potential loss due to one's counterparty's default). Similarly, if one has payables from a counterparty portfolio, then one needs to pay one's counterparty the credit benefit (to cover one's counterparty's potential loss due to one's own default).

On the other hand, if one has receivables from a counterparty portfolio, then one also incurs the credit cost (cover the potential loss in the one's funding obligation, such as one's senior unsecured bonds, due to one's own default). In other words, the credit cost is the credit charge

¹⁸ It is important to point out that in order to use the collaterals received to offset one's credit cost, one must be allowed to rehypothecate these collaterals, or reposting these collaterals to another party, e.g., to obtain funding at the repo rate of these collaterals. Rehypothecation, which makes the market more efficient, is a common practice in the U.S. market. In the cases where rehypothecation is not allowed, then one cannot use the collaterals received to offset one's credit cost.

charged by one's bond holders that is a part of the bond price as price cheapening or yield enhancement as compared to a LIBOR quality bond.

The credit cost should be handled differently from the credit charge and credit benefit. In other words, unlike the credit charge and credit benefit, in an efficient market, the credit cost should not be passed through to one's counterparty.

More specifically, in an efficient market, if one tries not to pay the credit benefit and/or tries to pass the credit cost to one's counterparty, then one's counterparty can arbitrage and enter the same trades with entities of better credit quality. It is important to point out that one does not necessarily lose money by paying credit benefit and by not passing the credit cost to one's counterparty, as one can apply arbitrage trading strategies to make a profit and monetize the credit benefit and credit cost. If one does not apply these arbitrage trading strategies, then one would lose money. And the lost money would benefit one's creditors, such as bondholders in terms of higher default recoveries. We shall revisit these topics later on.

We have discussed the symmetry between the credit charge and credit benefit, i.e., one's credit charge on a counterparty portfolio is one's counterparty's credit benefit on the same portfolio, and *vice versa*. There is also a symmetry between the credit cost and credit benefit. If one uses exactly offsetting portfolio to hedge the original portfolio, then the credit cost on the original portfolio is the credit benefit on the hedge portfolio (assuming that the collaterals are rehypothecatable), and *vice versa*.

To put it in another way, the credit cost in the OTC derivatives business for an entity below LIBOR credit quality comes from the fact that it needs to borrow at LIBOR plus a positive funding or credit spread to finance or fund the receivables from OTC derivatives. So one's credit cost is the interest expense that one needs to pay on one's funding or credit spread and the expected amount that needs to be funded throughout the life of the OTC derivatives, which really is the cost of one's credit quality.

Another way to understand the credit cost is to compare it with repo.¹⁹ If one's receivables are from assets that can be repoed, then one can finance or fund the receivables at the corresponding repo rate (which can be lower than LIBOR). In this case, the receivables are also dis-

¹⁹ For more discussions on repo, the reader can refer to, Section 2.2.2, Fleming and Garbade (2003), and Duffie (1996).

counted or PVED at the corresponding repo rate and thus one does not suffer from the credit costs based on one's credit quality or credit spread. OTC derivatives typically cannot be repoed and thus would incur the credit cost. This credit cost can be possibly arbitrated away with various strategies, including a synthetic repo strategy (which shall be discussed later).

The cash accrued funding benefit on a portfolio is the benefit brought in by the realized incoming cashflows in the portfolio and the futures hedges (which reduces the borrowing at the desk level or the firm level). In other words, the cash accrued funding benefit is the interest earned by the realized incoming cashflows based on one's funding spread. The cash accrued funding benefit is included in the credit benefit, which also includes the benefit of the expected future incoming cashflows. Thus, care must be taken in order to avoid double counting.

The cash accrued funding cost on a portfolio is the cost generated by the realized outgoing cashflows in the portfolio and the futures hedges. In other words, the cash accrued funding cost is the interest paid by the outgoing cashflows based on one's funding spread. The cash accrued funding cost is included in the credit cost, which also includes the cost of the expected future outgoing cashflows.

The collateral accrued funding benefit on a portfolio is the benefit brought in by the currently received (or realized) collaterals that can be used as collaterals posted in a secured loan to obtain a lower funding rate. If the collaterals are posted to a custodian account, then the treatment is different.

The collateral accrued funding cost on a portfolio is the cost generated by the currently posted (or realized) collaterals that needs to be funded at LIBOR plus one's funding or credit spread.

The accrued funding benefit and the accrued funding cost are Treasury and accounting functions based on one's current (or realized) cash balance and collateral balance, whereas the credit charge, credit benefit, and credit cost involve both realized and unrealized (or expected) futures values and thus require sophisticated modeling. A dealer also needs to be careful to achieve proper allocation or distribution of these benefits and costs within the firm.

For entities with better than LIBOR credit quality, their credit costs and credit benefits switch signs, i.e., the credit benefits become costs and

the credit costs become benefits.²⁰

1.3 Trading Strategies and Opportunities

Here we discuss some examples of trading and arbitrating strategies involving counterparty credit risk, such as hedging of one's credit charge, monetizing one's credit benefit, reduction of one's credit cost, and achieving trade cheapening for one's counterparty.

Like any other trading strategies, these trading strategies involve trading or balancing between the PV and future state payoffs or risks. In other words, more (or more likelihood of) future receivables and/or less (or less likelihood of) future payables in a trade means a higher value in the PV of the trade, and *vice versa*.

To facilitate our discussion, we thus partition the joint market and credit states of two trading parties of A and B as follows. The market states (M) can be partitioned based on the sign of the MTM of the portfolio to one of the parties, say Party A, which can be positive (+) or in the money or negative (-) or out of the money to Party A. The credit states (C) can be partitioned into 4 states, i.e., none of the parties defaults (ND), A defaults first (AD), B defaults first (BD), and both parties default (D) at the same time (or within the same time interval). See Table 1.1.

Furthermore, we use $V_A(M, C)$ to denote the MTM value of the portfolio to Party A at a joint market and credit state (M, C), and R_A and R_B to denote the default recovery rates for Party A and B, which can also be state dependent. Here we assume the recovery as a fraction of the MTM value or the replacement value $V_A(M, ND)$ of the corresponding non-defaultable or LIBOR quality trade. Other recoveries assumptions can be handled in a similar manner.

²⁰ It can happen that an entity's short term debt has a credit quality above LIBOR, but its long term debt is below LIBOR quality.

Table 1.1. The joint market and credit states for two trading parties of A and B. The MTM for the trade (or the nettable portfolio) or the market states can be positive (+) or negative (-) to Party A. The credit states include none of the parties default (ND), A defaults first (AD), B defaults first (BD), and both parties default (D).

Market States (M) or MTM to A	Credit States (C)			
+	ND	AD	BD	D
-	ND	AD	BD	D

The prevailing asymmetric default treatment has asymmetric loss given default (LGD) or, more generally, loss given event (LGE) as illustrated in the following Table 1.2 and Figure 1.2.

Table 1.2. LGE from the point view of part A under the prevailing asymmetric default treatment. The asymmetry comes from the fact that Party A has default gain in state (-,AD), but no default loss in state (+,AD). Similarly, Party A has default loss in state (+,BD), but no default gain in state (-,BD).

	ND	AD	BD	D
+	0	0	$(1-R_B)V_A(+,ND)$	$(1-R_B)V_A(+,ND)$
-	0	$(1-R_A)V_A(-,ND)$	0	$(1-R_A)V_A(-,ND)$

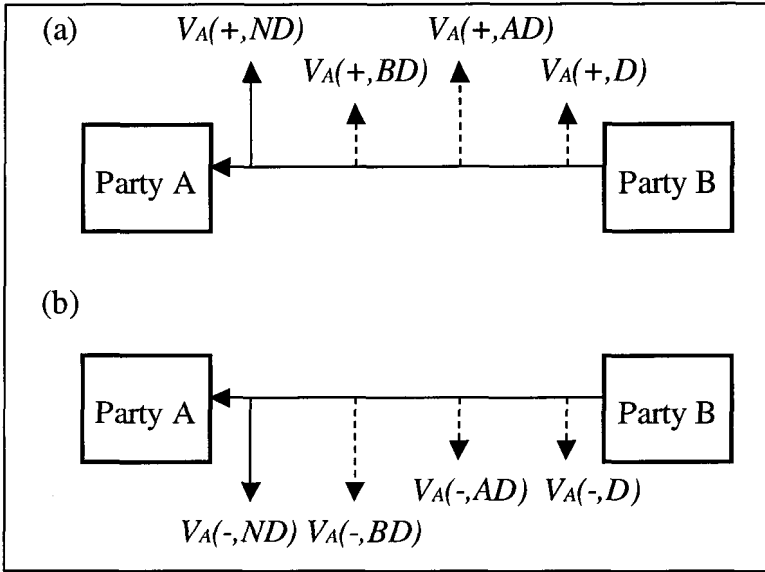


Figure 1.2. The MTM to Party A at various states.

The asymmetry comes from the fact that Party A has default gain in state (-,AD), but no default loss in state (+,AD), or equivalently, Party B has no default gain in state (+,AD). Similarly, Party A has default loss in state (+,BD), but no default gain in state (-,BD), or equivalently, Party B has no default loss in state (+,BD). In other words, the asymmetry can be expressed as

$$\frac{V_A(+,AD)}{V_A(+,ND)} \neq \frac{V_A(-,AD)}{V_A(-,ND)} \tag{1.1}$$

$$\frac{V_A(+,BD)}{V_A(+,ND)} \neq \frac{V_A(-,BD)}{V_A(-,ND)}$$

The symmetric LGE used in some of the trading strategies for monetizing the credit benefit or reducing the credit cost are shown in Table 1.3.

Table 1.3. Symmetric LGE from the point view of part A. Party A has default gain in state (-,AD) and default loss in state (+,AD). Similarly, A has default loss in state (+,BD) and default gain in state (-,BD).

	ND	AD	BD	D
+	0	$(1-R_A)V_A(+,ND)$	$(1-R_B)V_A(+,ND)$	$(1-R_A)(1-R_B)V_A(+,ND)$
-	0	$(1-R_A)V_A(-,ND)$	$(1-R_B)V_A(-,ND)$	$(1-R_A)(1-R_B)V_A(-,ND)$

The symmetry can be achieved by credit contingent derivatives or adding credit contingent terms on the existing trades. The easiest way of structuring a symmetric LGE trade is to structure a credit contingent knock-out trade (which is also termed as credit extinguisher), i.e., a trade that is knocked out (typically with zero-recovery or rebate) if either party defaults regardless who is in the money. These are also termed as zero-recovery swaps or derivatives or credit extinguishers. These trades are not legal in all jurisdictions.

With the above strategy, one can structure a trade whereby one pays a premium to one's counterparty due to the counterparty's likelihood of default. An example of such trade is that one longs a zero-recovery receiver interest rate swap (i.e., a receiving-fixed-and-paying-floating swap) in an upward sloping yield curve environment, as, in this case, one can have more counterparty default gain than counterparty default loss. Another example is a zero-recovery cross-currency swap where one receives a weaker currency and pays a stronger currency.

This is also one way for one to sell default protection on oneself (which is not legal in all jurisdictions). The reader may want to think more carefully about the rationales in our conclusion and where does the value come from.

In general, a credit contingent derivatives instrument has a payoff contingent on a credit event happening and a payoff contingent on a credit event not happening. Such payoffs are further linked to an underlying trade (or asset) or a basket of underlying trades (or assets).

The credit event typically is a default event, but can be other events such as credit rating downgrade or change. In an equity default swap (EDS), the contingent event is the equity price being below a certain level, typical a level much lower than the spot equity price. Essentially, an equity default swap is a series of deeply out-of-the-money equity put options.

Broadly speaking, credit derivatives and defaultable derivatives are naturally credit contingent derivatives. However, the defaultable derivatives are often more complicated and are often hybrid derivatives between credit derivatives and the underlying trades and assets, which, in turn, can be highly complicated or compound derivatives.

Examples of credit contingent instruments include CCDS and credit extinguishers. A CCDS is a contingent CDS whose notional is contingent on or linked to the PV of an OTC derivatives instrument. It provides default protection (to the protection buyer) on the OTC derivatives instrument by providing the replacement of the same instrument upon the default of the reference credit. In other words, it is an OTC derivatives instrument with a knock-in feature upon the default of the reference credit.

A credit extinguisher, on the other hand, is an OTC derivatives instrument with a knock-out feature upon the default of the reference credit with a pre-specified rebate (that can be zero or non-zero). The rebate can also be linked to the face value of the defaulted bonds of the reference credit, which is similar to the ISDA²¹ set-off provision whereby, under proper circumstances, one is allowed to offset one's payables to a counterparty by delivering defaulted bonds of the counterparty with the face value equal to the PV of the payables.

The typical motivation of a CCDS is to trade the credit risk in an OTC derivatives instrument and provide a static hedge of the counterparty credit risk (as apposed to a dynamic hedge with CDS). The typical motivation of a credit extinguisher is to achieve trade or funding cheapening for the counterparty. It is important to point out that the credit extinguishers are not legal in all jurisdictions.

Some brokers are working on sourcing liquidity for the market for some of these instruments. For more information, the reader may want to refer to, e.g., <http://www.SwapMeCredit.com>.

Below we present a few examples on credit charge, credit benefit, credit cost, and various strategies to help the reader build intuitions.

Let's first take a look at a simple example one-side exposures whereby one of the parties has only credit benefit and the other party has only credit charge and how the credit benefit can be naturally monetized.

Example 1.1. One-sided exposures. Suppose a dealer, Party A (with

²¹ ISDA stands for International Swaps Dealers Association. The reader can refer www.isda.com for more details.

lower than LIBOR credit quality), sells an option to Party B with the full upfront premium. In this case, both parties have one sided exposures, or more specifically, Party A (with only payables and no receivables) has no credit charge and only has credit benefit, and Party B (with only receivables and no payables) has only credit charge and no credit benefit. Theoretically, the credit benefit of Party A (which, by symmetry, is also the credit charge on Party A from the point of view of Party B) should be passed to Party B to compensate the credit risk that Party B undertakes. Otherwise, Party B would rather trade with a counterparty of higher credit quality.

Let's further assume that the PV of this trade to Party A is -\$20MM based on LIBOR discounting (broker's quote) and the credit benefit for Party A is \$1MM and the credit charge for Party A is zero, and, by symmetry, the credit charge from the perspective of Party B is -\$1MM and the credit benefit from the perspective of Party B is zero.²²

Thus, theoretically, Party A can only charge Party B \$19MM ($= -(-\$20MM + \$1MM)$) for this trade. In other words, Party A pays Party B \$1MM relative to the LIBOR-discounted PV of \$20MM. Does this mean that Party A has lost \$1MM and Party B has made a profit of \$1MM upon the execution of this trade?

The answer, of course, is no. This \$1MM is the MTM value of the counterparty risk or the embedded default option. In other words, Party A should mark the trade at -\$19MM (with the absolute value of its payables or liability marked down by \$1MM) and Party B should mark the trade at \$19MM (with its receivables or asset marked down by \$1MM). Therefore, both parties have zero P&L upon the execution of this trade.

More specifically, the \$1MM that Party B receives is its credit charge on Party A to cover the cost of buying default protection on Party A (such that Party B will only have LIBOR credit risk). Even if Party B does not buy credit protection, the trade should still be marked down by \$1MM, as this \$1MM is from taking the credit risk of Party A and should be amortized through out the life of the trade. By marking the trade with its credit charges and remarking it, Party B achieves such amortization.

Similarly, \$1MM that Party A pays is its credit benefit that can be monetized or earned back from the cash funding benefit from the

²² Since one has a short position in the option due to the counterparty's default, one's credit charge is zero or negative. Similarly, one has a long position in the option due to one's own default, thus one's credit benefit is zero or positive.

\$19MM cash received from Party B (which, in turn, can be used to retire party's A bonds), and plus, on average, the net cashflows from the hedging futures contracts if this trade is Delta hedged using futures, and if none of the parties default during the life of the trade.

In this case, the credit benefit is not hedged or locked in, as Party A can earn back more or less than \$1MM depending on the future realized market scenarios (or the path that the market follows in the future). In other words, if the market follows a future path whereby this trade is more out of the money for Party A (or its liability increases), then the hedging futures will make money and bring in more cashflows, and thus Party A will earn back more than \$1MM. On the other hand, if the market follows a future path whereby this trade is more in the money for Party A (or its liability decreases), then the hedging futures will lose money and result in outgoing cashflows, and thus Party A will earn back less than \$1MM.

The next example discusses the hedging strategy using offsetting trades.

Example 1.2. Offsetting trades. Assume that we have the same situation as the previous example, except that Party A (a dealer) hedges its trade with Party B by entering an exact offsetting trade with Party C (i.e., by buying the same option). For simplicity, let's further assume that Party C is of LIBOR credit quality.

In this case, Party A does not need to collect a credit charge from Party C for the offsetting trade, as Party C is of LIBOR credit quality. Also, Party A does not have credit benefit from the offsetting trade, as the trade always has positive exposures (or receivables) to Party A. Or equivalently, Party C does not need to collect a credit charge from Party A. In other words, Party A needs to pay Party C \$20MM for the offsetting trade.

As a result, Party A has a pair of offsetting trades, but yet seems to lose \$1MM.

To view this situation from a different angle, we can see that Party A has effectively conducted a lending business by borrowing funds at its own credit quality (from Party B) and lending the funds to another entity (Party C) with better credit quality. We know that an entity with lower credit quality is in a disadvantaged position to conduct lending business, especially to entities with better credit quality.

If none of the parties default during the life of these trades, then Party A will indeed lose the \$1MM. The question is where does this \$1MM go? Since Party B and Party C do not profit from this \$1MM (before Party A defaults), who profits from this \$1MM?

The answer lies in what happens when Party A does default, in which case, Party A receives the full market value from its trade with Party C, but only needs to pay a fraction (or the default recovery) of the market value for its trade with Party B due to the asymmetric treatment of default.

Thus, Party A actually has a net realized default gain. Such default gain essentially can result in an enhanced default recovery to all its creditors, including the bondholders, at the cost of Party A (of \$1MM).

Theoretically, this enhanced recovery should result in a tighter credit spread for Party A. However, from a practical standpoint, this information would not be transparent enough for the market to price in, particularly since the trading parties have the option to terminate or unwind the trades at the prevailing MTM values (which can eliminate the enhanced default recovery).

Nonetheless, Party A has the full knowledge of this valuable information and can apply arbitrage trading strategies to monetize back this \$1MM (which is essentially for Party A to monetize its credit benefit or to reduce its credit cost). By Party A executing these strategies, part of the information is revealed in the market place, which is helpful to the market information discovery and production process, which, in turn, helps the market become more transparent and efficient.

One conceptual trading strategy is that Party A can grant a credit contingent option to its trade with Party C such that when Party A defaults, Party C only needs to pay a fraction of the MTM value of the trade, if the trade is in the money to Party C. This fraction should roughly be the same as the default recovery rate of the original trade between Party A and Party B. This essentially makes the default treatment of Party A symmetric. The reader may realize that this is the same as making the trade between Party A and Party C a credit extinguisher (that extinguishes upon the default of Party A).

Thus, theoretically, Party C should pay Party A roughly \$1MM (or an annuity of \$1MM PV) for this contingency. Clearly, Party C will benefit from Party A's default, and, as such, Party C can sell default protections on Party A to monetize this benefit to make up the \$1MM it pays to Party A. Party C can do so by selling protections using CDS (if it is a

dealer) or by selling the credit contingency to a dealer²³ (who, in turn, can use CDS to dynamically hedge it). Unlike the previous example whereby the amount of the monetized cashflows has a volatility and it works on the expected value sense, the arbitrage strategy by selling the credit contingency locks in the amount of the monetized cashflows with no volatility.

The credit contingency that Party A enters into with Party C essentially is a synthetic repo for Party A to fund its trade with Party C.

The credit contingency that Party A enters into with Party C is actually one way for Party A to sell credit protection on itself fully collateralized by its trade with Party C. It is interesting to point out that Party A may not be able to sell such protection to any other parties, as its trade with Party C may not be accepted as collateral by other parties.

With this credit contingency, Party A will have incentives to unwind its trade with Party C prior to default. In this case, the credit contingency unwinds too, and Party C needs to charge Party A the then MTM value of the credit contingency. Party C may also need to unwind its hedges for this credit contingency. Theoretically, all these activities increase the demand on the credit protection on Party A and thus can create a pressure for the credit spread of Party A to widen, which, in turn, produces more information on the implied views on Party A's credit quality.

Example 1.3. Assume that we have the same situation as in Example 1.1 or Example 1.2. With the strategies discussed, Party A is flat on its credit benefit and credit cost (and its credit charge). However, Party B still suffers a loss on its credit cost if it hedges its trade with Party A by using futures, or a loss on its credit benefit if it hedges its trade with Party A with an exact offsetting trade with Party D of LIBOR quality.

Similar to the previous example, conceptually Party B can arbitrage back its credit cost or credit benefit by granting a credit contingent option on the trade to Party A such that when Party B defaults, Party A only needs to pay a fraction of the MTM value of the trade. This is the same as making the trade between Party A and Party B a credit extinguisher (that extinguishes upon the default of Party B).

Example 1.4. Assume that we have the same situation as in Example 1.3, except that Party A enters into a collateral agreement or an ISDA

²³ Selling protections using CDS is a dynamic trading strategy and selling the credit contingency is a static strategy.

Credit Support Annex (CSA) with Party B such that Party A posts enough collateral on the trade to cover the default loss. Thus, Party B needs to charge Party A no (or minimal) credit charge. In this case, Party B still needs to arbitrage back its credit cost. However, the credit contingent strategy used previously has almost zero value in this case.

If the collateral that Party B receives from Party A can be posted out or rehypothecated to obtain close to LIBOR (or better than LIBOR) funding, then obtaining such funding is the strategy to arbitrage back the credit cost for Party B.

Here are some concluding remarks for the above examples.

The trade between Party A and Party B brings in credit benefit to Party A. The credit benefit is passed to Party B, as it is the same as the credit charge that Party B needs to charge Party A. One question that immediately arises is whether or not Party A loses money because of this.

If Party A hedges its trade with Party B by entering an exact offsetting trade with Party C (of LIBOR credit quality), then there is a puzzle that Party A has two completely offsetting trades and yet has a net \$1MM outgoing cashflow (coming from the extra credit cost from the trade with Party C). This puzzle is solved by the credit contingent (or credit extinguishing) option that Party A grants to Party C, which earns back roughly \$1MM for Party A. This credit contingency or credit extinguisher is a synthetic repo agreement and is also one way for Party A to sell protection on itself to achieve the fair default recovery priced in the market. This credit contingency or credit extinguisher also makes the default treatment of Party A symmetric.

The above discussions are based a portfolio with one-sided exposures. For trades or a portfolio with two-sided exposures, such as swaps, exposures are equivalent to long positions of a series of call options on the portfolio and short positions of a series of put options on the portfolio. Then, the above discussion can be applied to each of the options.

In general, selling the credit contingent option to one's counterparty is a key to monetize one's credit benefit and reduce one's credit cost. Similarly, buying the credit contingent option from one's counterparty is a key to help one's counterparty monetize its credit benefit and reduce its credit cost and is also one way to achieve cheapening of the trade price to one's counterparty.

The credit contingent trades referencing one's own default (or self-referencing) that we discussed above may not be easy to execute. In addition to credit extinguishers, another way of executing these trades is to post one's OTC derivatives receivables as collaterals.

The above examples and strategies deal with how to monetize the credit benefit and credit cost. Another application of the credit contingency strategy, such as using CCDS trades, is to provide static hedging for the counterparty credit risk or to hedge or lock in the credit charge, which is much simpler conceptually.

Another general way of reducing the counterparty credit risk is to revert back to funded trading or securitization of OTC derivatives by embedding a OTC derivatives instrument in a structured note. Examples of this strategy include various structured interest rate or equity notes (with exotic interest rate or equity derivatives embedded), CLN (credit liked notes) as opposed to CDS, funded CDO/CSO²⁴ placement. Other general ways of reducing the counterparty credit risk (and improving liquidity) is through the creation of ETF (exchange traded funds) and futures with daily marking to the market.

Another interesting area is to use equity and equity derivatives (including EDS or Equity Default Swaps) to hedge credit risks.

Based on what has been discussed in this section, in addition to its hedging functionality, the credit charge hedging and trading can also potentially become a profit center through, e.g., monetizing values in credit cost, credit benefit, and credit charge, achieving trade (or funding) cheapening for the counterparty, and facilitating others to statically hedge the counterparty credit risk. These are essentially credit hybrid trading opportunities.

One intriguing way of managing the counterparty credit risk in OTC derivatives is through (tranching) securitization. In other words, the receivables from the OTC derivatives can be used as the underlying assets of a CDeO (Collateralized Derivatives Obligations) structure in a similar way as the receivables from bonds or CDS as the underlying assets of a CDO or CSO.

A specific example is the UBS Alpine structure whereby the receivables from the OTC derivatives in UBS' trading book were structured into different risk/reward tranches that were sold to investors.²⁵ Advan-

²⁴ CDO stands for Collateralized Debt Obligations and CSO stands for Collateralized Swap Obligations.

²⁵ See, e.g., <http://db.riskwaters.com/public/showPage.html?page=11686> for more details.

tages of this securitization are the saving of the hedging cost of the counterparty credit risk as compared to using single-name CDS, saving of the credit cost, and the ability of reducing the balance sheet usage and freeing up credit limits so that more derivatives transactions can be conducted.

Other interesting strategies include OTC IR swaps clearing services provided by SwapClear²⁶ from London Clearing House (LCH). OTCderivNet,²⁷ a consortium formed by world's leading investment banks, is trying to expand the efforts by SwapClear.

1.4 Comparison with Bond Credit Risk

Credit charge is of the same origin as bond credit spread. The bondholders implicitly grant the bond issuer an option to default. In other words, the bond holder has sold a default protection on the bond. The payoff of such default option or protection at default is the payoff of a put option on the bond (struck at the par). In other words, the bondholders are short on a credit contingent (or a knock-in) put option on the bond to the bond issuer. The stock price, on the other hand, is the PV of a down-and-out call option on the shareholder's equity.

A hypothetical LIBOR credit quality entity can issue floating bonds at LIBOR flat, i.e., with par coupon being the same as LIBOR. But an entity with lower credit quality than LIBOR can only issue bonds at LIBOR plus positive spreads²⁸ so as to compensate the bondholders for the credit risk²⁹ that they undertake. These spreads are the bond funding costs for this entity.

The credit charge and the bond credit spread differ in several important ways. To illustrate the impact of such differences, it is interesting to ask the following question. If an entity can fund at, say, LIBOR + 100 bps by issuing a 10-year floating bond at par, what is an estimate of the net credit charge for it to enter a 10-year par swap?

It turns out that the net credit charge, in terms of a swap funding or credit spread, can have a range of values. Particularly, the sign of net

²⁶ See <http://www.lch.com/services/swapclear/>.

²⁷ See <http://www.otcderivnet.com/>.

²⁸ Such spreads typically exhibit a term structure and it can happen that an entity's short term debt can have a credit quality above LIBOR, but its long term debt can be below LIBOR quality.

²⁹ More precisely, the additional credit risk not priced in by the LIBOR credit quality.

credit charge or premium can be either negative (corresponding to a cost) or positive (corresponding to a gain). Also, the magnitude of the swap funding spread can be a small percentage of the bond funding spread, or a few basis points in this case. These can be explained by the following differences between a bond and a swap.

The exposure and the credit risk in the case of a bond are one-sided, i.e., the bondholders are owed money by the bond issuer (or the bondholders have net receivables from the bond issuer) and thus are exposed to the bond issuer, but not *vice versa*. In the case of a swap, since two parties in the swap exchange cashflows, the exposure and the credit risk are two-sided, i.e., each party of the swap can suffer from credit loss if the other party defaults, which means the swap funding spread or the net credit charge is determined by the differential of the expected loss of the two counterparties. In addition, in the case of a bond, all the coupons and the entire principal are at risk, whereas in the case of a swap, only net cashflows are at risk, that means the exposures, in the case of the swap, are much smaller.³⁰

Question 1.3. What about the cases in which derivatives exposure is one-sided?

Even though the net credit charge in terms of the credit spread for swaps, and for derivatives in general, is much smaller than the credit spread of bonds, the impact of the net credit charge can be very significant as it can exceed the bid/ask spread of the derivatives in some cases (especially with lower credit quality counterparties) and can be a significant percentage of the overall P&L of the derivatives desks, especially for the interest rate derivatives desk, as it tends to have longer dated trades and tighter bid/ask spread, and the commodities desk, as it tends to have lower credit quality counterparties and longer dated trades.

The total value of the net credit charges at the firm level can also be significant, as derivatives are highly leveraged³¹ and large amount of transactions in terms of notional can be executed with relatively less

³⁰ Such exposure reduction is less significant in the case of a cross-currency swap which normally involves changing of the principal at end (coupled with the additional FX volatility).

³¹ For instance, one can enter a par swap with zero initial cost (except, in some cases, possibly with initial margins and collaterals).

amount of capital.

1.5 Prevailing Strategies for Counterparty Credit Risk Management

To completely eliminate one's market risk on a trade (with one counterparty), one can enter an exact offsetting trade (with another counterparty). Without considering the counterparty credit risk, a dealer could not be happier, if he or she can do so and still captures some bid/ask spread. However, this strategy alone would not work in general for managing the counterparty credit risk, since if one of the counterparties defaults, one can be left with obligations to the other counterparty. In other words, this strategy makes the dealer market risk neutral, but not credit risk neutral.

Question 1.4. After one enters into offsetting trades with two separate counterparties, what would happen exactly if one or both counterparties default?

Counterparty credit risks are commonly managed by credit enhancement strategies, credit exposure modeling and management strategies, and net credit charge management strategies (including employing credit derivatives). Credit enhancement strategies and credit exposure and modeling management strategies are the first line of defense in managing counterparty risks.

Credit enhancement strategies include netting, margin or collateral, and credit contingency agreements, and mutual termination options, etc.

If two parties have a netting agreement, then only the *net* MTM values of all the trades covered by the netting agreement is at risk when default happens. Since the trading parties often have many trades with each other and often these trades can partially offset one another, netting agreement can significantly reduce the exposure, and both potential and expected credit loss. Such netting agreement (which is often in the form of a master agreement as opposed to trade-level agreement or trade confirm) can cover trades across different desks and even different product areas.

The margin or collateral agreement allows the trading party who has net receivables (or positive MTM values or is owed money) to collect

assets from the one with net payables as collaterals (based on pre-agreed triggers), which, in the event of default, can be liquidated to reduce or cover the default loss. The party with weaker credit quality may also need to post initial margins at the time when the trade is executed (and the two parties may not have net receivables from each other) to cover potential future market moves when the party with weaker credit quality can have net payables (or owe money). Similar to the netting agreement, such margin or collateral agreement (which is often in the form of a master agreement as opposed to trade-level agreement or trade confirm) can cover trades across different desks and even different product areas.

Question 1.5. There is a time lag between a collateral call and actually receiving it. What effects does this have?

The credit contingency agreement provides the trading parties options to take actions contingent upon credit events. For instance, one party can have the option to terminate the trades at their market values if the other party's credit rating is below a certain level. Another example is the credit contingent collateral agreement which specifies the collateral that one needs to post is a decreasing function of one's credit rating, i.e., more collateral if one's credit rating is lowered.

Question 1.6. Why is the credit contingency option valuable and how to quantify it?

The mutual termination agreement grants the trading parties options to terminate the trades at pre-specified dates at the market value. This essentially reduces the lifetime of the trades and the variance of their MTM values, and thus reduces the credit exposures.

Question 1.7. What is the relationship between the variance of MTM values of the trade and the corresponding credit exposures?

There are other strategies for reducing counterparty risks, such as by restructuring or recouping the trades that can be an alternative to the margin or collateral agreement and essentially turns part of the future

receivables into current cash payments.

Credit exposure and modeling management strategies involve modeling or estimating potential exposures (PE) and setting a limit of allowed maximum potential exposures (MPE) to each counterparty after considering the effect of the above strategies. Similar to market risk VAR (value at risk) for characterizing the market risk in a mathematical sense, PE of a portfolio is defined as its MTM values at a certain confidence level, e.g., at 95% level, which means at 95% chance the MTM of the portfolio would not exceed the PE.³² MPE is the maximum potential exposure over the life of the portfolio. By setting the PE limit for each counterparty, one ensures not to be overly exposed to particular counterparties, and hopefully can have a diversified portfolio.

Question 1.8. Normally, the PE is lower considering the collateral effect than the PE without collateral with everything else being the same. Are there any exceptions to this statement?

Question 1.9. What are the major differences between PE and market risk VAR and credit risk VAR?

In order to better quantify whether or not one has a diversified portfolio, one needs to model and set limit for PE for each industry, each rating, each geographical region, so that one is not overly exposed to any of these categories.

Question 1.10. To compute the PE of an industry, can we simply aggregate the PEs of all the counterparties in that industry, and if so, why? There are various coherent risk measures that are additive.

Another way of measuring the counterparty credit risk is the credit VAR and/or the economic capital, which is a step further than PE and measures the credit loss at a given percentile.

³² PE is concerned with the positive MTM (or in the money) scenarios in which case one can potentially suffer from credit risks and VAR is concerned with the negative (or out of the money) scenarios in which case one can potentially suffer from market risks. VAR tends to have a short time horizon (such as one day and two weeks) and PE tends to have a time horizon up to the life time of the portfolio. Also see the answer to Question 1.9.

Other strategies of managing counterparty credit risk include favorable structuring of the cashflows and the timing of the cashflows in the underlying trades. For instance, rather than entering a derivatives trade (that is unfunded), one can enter into a funded trade by issuing a structured note (including credit linked note) with the payoffs linked to those of the derivatives trade. This introduces two additional cashflows, one at the start of the trade and one (the principal) at the maturity of the trade. This can often completely eliminate one's counterparty credit risk, as one would receive a premium close to the principal of the note at the start of the trade and would often have net payables (or owe money) going forward. This type of trade is feasible if one has a high credit rating in absolute terms or much higher credit rating relative to one's counterparty. The funded placement of a CDO tranche uses the same strategy.

In some cases, this funded trading is more difficult for one's counterparty than a derivatives trade, which involves no or much less initial cashflows, which, in turn, is a reason for the popularity of the derivatives. But, in the funded trading, one's counterparty does get the benefit of cheapening in the trade with zero or negative credit premium. Also, in some cases, one's counterparty may not be allowed to engage in derivatives transactions.

Similarly, as for the timing of the cashflows, in order to reduce one's counterparty credit risk, one can structure the trades such that one will receive the receivables sooner and pay the payables later. For instance, when buying an option, one can buy an option with premium paid in arrears or a contingent premium option.

1.6 Wrong-way and Right-way Exposures or Trades

Credit exposure and modeling and management strategies also involve categorizing exposures into wrong-way exposure and right-way exposure and providing certain quantification for them. These are essentially related to the correlation between the market risk processes and the credit risk processes.

Wrong-way exposure or trade refers to a situation whereby the counterparty exposure and the counterparty credit quality have a *negative* correlation, e.g., when one has more exposures to one's counterparty is when one's counterparty is *more* likely to default. Thus, wrong-way exposure results larger expected credit loss (as compared to the case of zero correlation). Equivalently, this is a situation whereby the counterparty

exposure and the counterparty credit spread have a *positive* correlation. This is another significant challenge in the modeling and management of the counterparty credit risk.

Right-way exposure or trade refers to an opposite situation whereby the exposure and the counterparty credit quality have a *positive* correlation, e.g., when one has more exposures to one's counterparty is when one's counterparty is *less* likely to default. Thus, right-way exposure results in smaller expected credit loss (as compared to the case of zero correlation). Equivalently, this is a situation whereby the counterparty exposure and the counterparty credit spread have a *negative* correlation.

There are cases in which wrong-way exposures and right-way exposures can be easily identified. However, there are cases in which wrong-way exposures and right-way exposures can be counter-intuitive and their identification requires close examination of the situation.

For instance, for a commodity producer, is it more or less likely to default when the price of its commodity rises? A dealer who has trades with the commodity producer would often need to face this question.

On the surface, if the commodity price rises, the commodity producer should be better off. But, is this always true? A typical situation is for the commodity producer to short forward contracts³³ on its commodities to hedge the potential downside movement of the price of its future commodity productions. The dealer on the other hand would long these forward contracts.

In one instance, a commodity producer almost went default when its commodity price rose. It was due to that that, as its commodity price rose, the commodity producer owed more money on its hedges or the short forward contracts and had to come up with capital to meet the margin or collateral calls.

³³ Or paying floating on a commodity swap which is a series of forward contracts.

Question 1.11. What are some simple examples of wrong-way exposures and right-way exposures? What about an emerging market sovereign entity entering a cross currency swap paying its own currency and receiving a stronger currency?

1.7 Introduction to Modeling and Pricing of Counterparty Credit Risk

In essence, pricing the counterparty credit risk is the same as pricing defaultable OTC derivatives or the premium of the embedded default options in OTC derivatives, which is a relatively new area of the derivatives modeling.

As we pointed out earlier, these default options, though embedded, are real trades, and thus need to be priced and hedged properly. Just as a CDS is for buying and selling credit protections on a defaultable bond, the default options in OTC derivatives are for buying and selling credit protections on these defaultable OTC derivatives.

To price the counterparty credit risk or to compute the credit charge/benefit or CVA, it typically starts with modeling of loss given default (LGD) and default probabilities. More specifically, it involves modeling market exposures (including the modeling of collateral strategies) and credit spread or default probabilities, and, ideally, also credit rating transitions, default recoveries, as well as correlation between the market process and the credit processes.

A common subtlety is that pricing the counterparty credit risk is really pricing options on a basket of defaultable derivatives in a counterparty portfolio because of the netting agreement and the asymmetric treatment of default (except for extinguishing trades). As we pointed out previously, the prevailing trade-level based derivatives models (or *micro* models) normally do not and often cannot price the specific counterparty credit risk, even though they can price the expected market risks (which include the credit risks of reference obligations in credit derivatives) and some generic counterparty credit risk by discounting at LIBOR. Therefore, additional portfolio-based derivatives models (or *macro* models) are needed for pricing the specific counterparty credit risk.

Furthermore, the trades in a counterparty portfolio can be modeled by different pricers, booked in different systems, from different desks, or even from different product areas. This presents significant challenges to the counterparty credit risk modeling and the system.

More details shall be presented in Chapter 8.