CHAPTER 2

Supervisory Requirements and Expectations for Portfolio-Level Counterparty Credit Risk Measurement and Management

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INTRODUCTION

A bank's *counterparty credit risk* (CCR) exposure quantifies how much money the counterparty might owe the bank in the event of default. The CCR quantity is broken down into *current exposure* (CE), which measures the exposure if the counterparty were to default today, and *potential exposure* (PE), which measures the potential increase in exposure that could occur between today and some time horizon in the future.

The time of default is typically modeled as a stochastic stopping time. As opposed to the known CE, the PE must be estimated, usually by simulation. First, the *expected positive exposure* (EPE) is computed by simulating a large number (on the order of 10^2 to 10^3) of different paths for the various underlying future prices in the possible market environments, using a so-called regularized variance-covariance matrix. Then the system prices each of the derivative transactions on each path for each sample date,[1] computes collateral call amounts based on relevant marked-to-market (MTM) calculations,

[1]Typical sample dates are: daily for the first two weeks, once a week out to a quarter, once a month out to a year, once a quarter out to 10 years, and once a year up to 50 years.

applies the portfolio effects of netting and collateral, and aggregates exposure results to compute the average exposure along a term structure.

While an EPE may be a good indicator of the cost to replace a contract should the counterparty default, EPE is not helpful in the trade inception approval process because of its volatility and the need for a high confidence interval. Therefore, many banks will also report a very high percentile (e.g., 97.7th or 97.5th) of the exposure distribution over a large number of paths.

Note that these peaks in exposure profiles are not simply added over different products for a given counterparty, as these peaks may happen at different points in time. Rather, the time profiles of exposures are summed over products traded with a single counterparty, and the peak of that time profile is the summary PE measure. This methodology is conservative, as PEs are simply added over counterparties, while the bank may enter trades that mitigate each other in terms of PE with different counterparties.

We can readily see that CCR measurement necessarily combines the tools of standard market risk measurement with the tools of standard credit risk determination, a unique challenge to both: This frequently requires calculating *probability-of-default* (PD), *loss-given-default* (LGD), *exposure-at-default* (EAD), and a credit rating of the counterparty.[2]

The *credit valuation adjustment* (CVA) is defined as the product of the EPE times the LGD times the *cumulative mortality rate* (CMR), where the CMR is simply a multi-period PD rate. This is structurally equivalent to pricing EPE as the contingent leg of a *credit default swap* (CDS) by applying the counterparty spread to it. Such a spread is either a market quote if the name has a bespoke traded CDS, or a pseudo-CDS spread computed along a grid arrayed by region, industry, rating, and tenor. In the worst case, bond or loan spreads are used, giving rise to basis risk. It can be recognized that it is this part of the process that joins the market and the credit risk aspects of the algorithm. Practices for measuring market risk are used in mapping derivatives exposures to a set of market risk factors (e.g., spreads, volatilities, or correlations), simulating those factors out to a forward-looking time horizon, and determining the distribution of the level of exposures over various realizations of these risk factors in the simulation. Separately, standard credit risk processes provide assessments of the credit quality of the counterparty, such as PD and LGD estimation.

Direct or originating businesses (i.e., trading desks) are viewed as credit portfolios: As their positions get in the money, this gives rise to CCR, since

[2]See Araten and Jacobs 2001; Araten, Jacobs, and Varshney 2004; Araten, Jacobs, Varshney, and Pellegrino 2004; Carey and Gordy 2004; Carey and Hrycay 2001; Frye and Jacobs 2012; Jacobs 2010a, b; Jacobs and Kiefer 2010; and Jacobs, Karagozoglu, and Layish 2012.

the counterparty may default while owing money to the bank. The CVA represents a daily MTM transfer price of default risk charged to the originating business for insuring default risk, which is the price of a pseudo-CDS hedge with the EPE as underlying notional. The group (e.g., the market risk management department) that sells insurance to the business at inception of the trade will cover any loss due to counterparty default. As the exposure rises, due to either an increase in the position or a decrease in the credit quality of the counterparty, the CVA increases as it is marked to market. On the other hand, a profit is reported if the CVA decreases, due either to the bank's position becoming less in the money, an improvement in the counterparty's credit rating, or just the passage of time without any credit event. However, no further credit-related charges or costs are incurred by the business. In the limit, the CVA disappears as the maturity of the derivative contract is reached, and payment—if any is due—is made to the bank.

Products that are new or too complex to be properly simulated within the main CCR engine are dealt with "offline." This usually means assigning them "risk factors" or more generally "add-ons" that are conservative and do not allow for netting; for this reason, such offline trades may account for up to 50 percent of the total exposure, although only 5 to 10 percent of trades made. The problem is that *the counterparty credit exposure* (CCE) is not sensitive to actual risk any longer: The sum of these add-ons may lead to the same measure of CCE for a set of offsetting trades as it does for a set of trades that have no offsets. Hence, these add-ons are really suited only for CCE with counterparties having single trades. Moreover, the large exposures they generate are not taken seriously by management, and these products do not undergo the complementary/downstream risk management processes such as stress testing, which results in risk measures that do not provide a comprehensive view of the risks that banks face. Worse still, management may increase limits for these products, aware that their CCR is overstated, thus defeating the purpose of these add-ons.

A relatively new but expanding practice is to model *debt valuation adjustment* (DVA) in the CCR framework, reflecting an institution's own option to default. Counterparties implicitly charge for an option to default, as when an institution holding a derivative position that is out of the money is in effect borrowing from the counterparty and implicitly pays for its outstanding liability through its credit spread. One way for a bank to fund its CVA would be to generate income from the sale of credit default swaps on itself, which cannot be done, hence the remaining portion of credit risk as reflected by the CVA. However, note that such "gut " appeal DVA stems from the realization that if a bank enters a par swap agreement with a counterparty that has the same credit spread, then theoretically, credit risk considerations should not enter the pricing decision (i.e., the CVA and DVA should cancel for both parties in the transaction).

Analogous to the CVA, scenarios for underlying market factors are generated and averaged over the resultant negative portfolio marked-to-market values (liabilities), taking into account legal netting and collateral agreements. The resulting *expected negative exposure*, floored at zero if a bank gets in the money in any given scenario, is what risk managers expect to owe its counterparties on its derivative portfolio at the time of its default. It is priced as the contingent leg of a credit default swap using the bank's bank spreads, assuming that all deals are netted where possible, reflecting the fact that within the bank's jurisdiction it is likely that its counterparties would legally seek to net all positions upon its default.

For collateral considerations, often two types of default are considered. First, consider the case in which a bank defaults idiosyncratically, and a "springing" unilateral collateral agreement is assumed. This reflects the likely behavior of counterparties, who upon a worsening of a bank's credit worthiness will either demand to enter into unilateral collateral agreements where there are none or renegotiate existing collateral agreements to terms favorable to them. Second, there is the case of a systemic default, where a bank's default is part of a broad economic downturn. In this case it is much less clear that counterparties will be able to impose or change collateral agreements in their favor, and thus springing collateral is not considered. The final expected negative exposure value is a weighted average of the two cases, such that the relative weight is the relative likelihood of an idiosyncratic as opposed to a systematic default. These weights could be determined by the relative intensities of default implied by a bank's par spread curve and its risk premium spread curve backed using a *capital asset pricing model* methodology.

REVIEW OF THE LITERATURE

Supervisory rules and guidance on CCR can be found in the Basel Committee on Banking Supervision (BCBS) frameworks of Basel I (BCBS 1988); Basel II (BCBS 2006); Basel III (BCBS 2011); and BCSB (2012). The U.S. Office of the Comptroller of the Currency (OCC) and the Board of Governors of the Federal Reserve System (BOG-FRS) issued supervisory guidelines (OCC & BOG-FRS 2011). Kang and Kim (2005) provide simple closed-form pricing models for floating-rate notes and vulnerable options under the CCR framework, deriving closed-form pricing models for them and illustrating the impact of the counterparty default intensity on the prices of floating-rate notes and vulnerable options.

Brigo and Chourdakis (2009) consider CCR for credit default swaps when default of the counterparty is correlated with default of the CDS reference credit. They incorporate credit spread volatility, adopt stochastic intensity models for the default events, and connect defaults through a copula function. The authors find that both default correlation and credit spread volatility have a relevant impact on the positive CCR valuation adjustment to be subtracted from the counterparty risk-free price. Jorion and Zhang (2009) observe that standard credit risk models cannot explain the observed clustering of default, sometimes described as "credit contagion," and provide the first empirical analysis of credit contagion via direct counterparty effects. They find that bankruptcy announcements cause negative abnormal equity returns and increases in CDS spreads for creditors, and that creditors with large exposures are more likely to suffer from financial distress later, suggesting that counterparty risk is a potential additional channel of credit contagion. Arora, Gandhi, and Longstaff (2012) use proprietary data from 14 CDS dealers and find that counterparty risk is priced in the CDS market and the magnitude of the effect is small. Brigo, Capponi, Pallavicini, and Papatheodorou (2013) value bilateral CCR through stochastic dynamical models when collateral is included with possible rehypothecation. The authors show for credit default swaps that a perfect collateralization cannot be achieved under default correlation.

Brigo, Buescu, and Morini (2012) compare two different bilateral counterparty valuation adjustment formulas (an approximation based on subtracting the two unilateral credit valuation adjustment formulas as seen from the two different parties in the transaction) and a fully specified bilateral risk formula where the first-to-default time is taken into account. Finally, Acharya and Bisin (2014) study financial markets where agents share risks but have incentives to default and their financial positions might not be transparent, that is, not mutually observable. The authors show that a lack of position transparency results in a counterparty risk externality, which manifests itself in the form of excess "leverage" in that parties take on short positions that lead to levels of default risk that are higher than Pareto-efficient ones.

SUPERVISORY REQUIREMENTS FOR CCR

CCR is defined as the risk that the counterparty to a transaction could default or deteriorate in creditworthiness before the final settlement of a transaction's cash flows. Unlike a loan, where only a bank faces the risk of loss, CCR creates a bilateral risk of loss because the market value of a transaction can be positive or negative to either counterparty. The future market value of the exposure and the counterparty's credit quality are uncertain and may vary over time as underlying market factors change. The regulatory focus is on institutions with large derivatives portfolios setting their risk management practices as well as on supervisors as they assess and examine CCR management.

CCR is multidimensional, affected by both the exposure to and credit quality of the counterparty, as well as their interactions, all of which are sensitive to market-induced changes. Constructing an effective CCR management framework requires a combination of risk management techniques from the credit, market, and operational risk disciplines. CCR management techniques have evolved rapidly and improved over the last decade even as derivative instruments under management have increased in complexity. While institutions substantially improved their risk management practices, in some cases implementation of sound practices has been uneven across business lines and counterparty types. The financial crisis of 2007–2009 revealed weaknesses in CCR management of timely and accurate exposure aggregation capabilities and inadequate measurement of correlation risks. The crisis also highlighted deficiencies in monitoring and managing counterparty limits and concentrations, ranging from poor selection of CCR metrics to inadequate infrastructure.

The Basel II "Revised Framework" (BCBS 2004) was intended to promote a more forward-looking approach to capital supervision that encourages banks to identify and manage the risks they face. Treatment of CCR arising from over-the-counter (OTC) derivatives and repos in either trading or banking books was first set forth in an amendment to the original 1988 Basel Accord (BCBS 1988) treatments for the CCR of repo-style transactions. The Basel II framework (BCBS 2004) represents joint work with the International Organization of Securities Commissions (IOSCO) on the treatment of CCR for over-the-counter derivatives, repo-style transactions, and securities financing.

The regulations specify three methods for calculating EAD for transactions involving CCR: the internal model method (IMM), a standardized method (SM), and the (at-the-time existing) current exposure method (CEM).

Commonalities across Approaches to CCR

Positions that give rise to CCR exposures share certain generic characteristics. First, the positions generate a credit exposure—the cost of replacing the transaction if the counterparty defaults, assuming there is no recovery of value. Second, exposures depend on one or more underlying market factors. Third, transactions involve an exchange of payments or financial instruments identified with an explicit counterparty having a unique PD.

CCR for a position at any point in time equals a maximum of zero or replacement cost (market value) for each counterparty over tenure. This may include the use of collateral to mitigate risk, legal netting or "rights of offset" contracts, and the use of re-margining agreements. The fact that similar risk characteristics, products, and related activities with CCR are managed by institutions using similar methods and processes imply they may merit similar capital requirements. However, there are differences in rule treatment between OTC exposures and *securities financing transactions* (SFTs). SFTs include securities lending and borrowing, securities margin lending, and repurchase and reverse repurchase agreements.

The Basel II revised framework (BCBS 2004) already provides three methods for SFTs: a simple approach, a comprehensive approach with both supervisory and nonsupervisory haircuts, and a value-at-risk (VaR) model.

An *internal model method* (IMM) to CCR is available for both SFTs and OTC derivatives, but the nonmodel methods available for the latter are not applicable to the former. Institutions use several measures to manage their exposure to CCR, including *potential future exposure* (PFE), *expected exposure* (EE), and *expected positive exposure* (EPE). Banks typically compute these using a common stochastic model as shown in Figure 2.1. PFE is the maximum exposure estimated to occur on a future date at a high level of statistical confidence, often used when measuring CCR exposure against credit limits. EE is the probability-weighted average exposure estimated to exist on a future date. EPE is the time-weighted average of individual expected exposures estimated for given forecasting horizons (e.g., one year). EPE is generally viewed as the appropriate EAD measure for CCR as such are treated similarly to loans, and EPE reduces incentives to arbitrage regulatory capital across product types; therefore, internal and standardized model methods employ this for EAD.

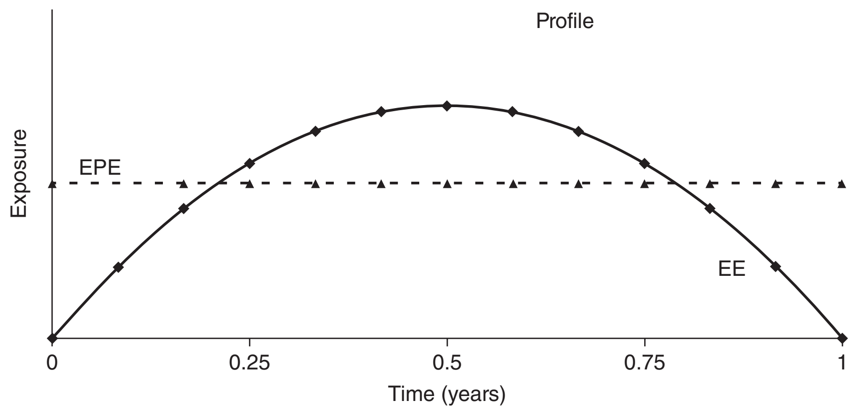

FIGURE 2.1 Expected positive exposure for CCR.

Consistent with the Basel I Revised Framework for credit risk, the EAD for instruments with CCR must be determined conservatively and conditionally on an economic downturn (i.e., a "bad state"; BCBS 1998). In order to accomplish such conditioning in a practical, pragmatic, and conservative manner, the internal and standardized model methods proposed scale EPE using "alpha" and "beta" multipliers. Alpha is set at 1.4 in both the internal model method and the standardized model method, but supervisors have the flexibility to raise alpha in appropriate situations. Banks may internally estimate alpha and adjust it both for correlations of exposures across counterparties and potential lack of granularity across a firm's counterparty exposures. The alpha multiplier is also viewed as a method to offset model error or estimation error. Industry and supervisors' simulations suggest alphas may range from approximately 1.1 for large global dealers to more than 2.5 for new users of derivatives with concentrated or no exposures. Supervisors proposed to require institutions to use a supervisory specified alpha of 1.4 with the ability to estimate a firm portfolio–specific alpha subject to supervisory approval and a floor of 1.2. To estimate alpha, a bank would compute the ratio of *economic capital* (EC) for counterparty credit risk (from a joint simulation of market and credit risk factors) to EC when counterparty exposures are a constant amount equal to EPE (see Figure 2.2). Under the internal model method, the resulting risk weight may be adjusted to reflect the transaction's maturity.

Banks may estimate EAD based on one or more bilateral "netting sets," a group of transactions with a single counterparty subject to a legally enforceable bilateral netting arrangement. Bilateral netting is recognized for purposes of calculating capital requirements within certain product

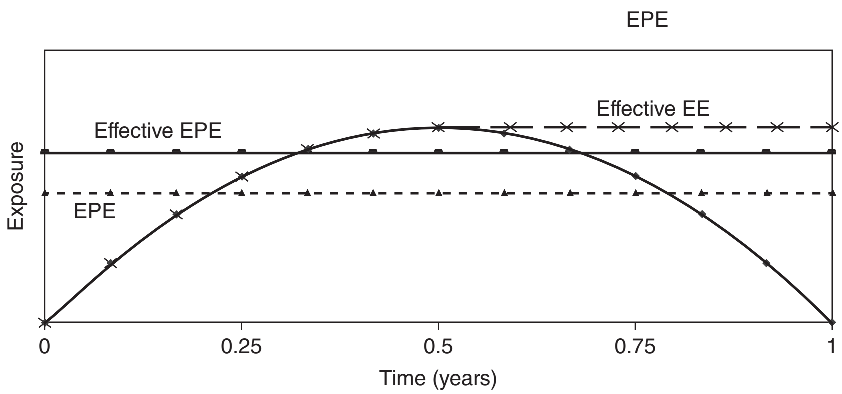

FIGURE 2.2 Effective EE and effective EPE for CCR.

categories: OTC derivatives, repo transactions, and on-balance-sheet loans/deposits. However, under the BCBS Amended Accord and Revised Framework, netting across product categories is not recognized for regulatory capital computation purposes. The intent is to allow supervisors discretion to permit banks to net margin loans secured by purchased securities and executed with a counterparty under a legally enforceable master agreement. This is not intended to permit banks to net across different types of SFTs or to net SFTs against OTC derivatives that might be included in a prime brokerage agreement. The Basel c*ross-product netting rules* recognize such between OTC derivatives and SFTs subject to national supervisor determination that enumerated legal and operational criteria are widely met. A bank should have obtained a high degree of certainty on the legal enforceability of the arrangement under the laws of all relevant jurisdictions in the event of a counterparty's bankruptcy. It is also important that the bank demonstrate to the supervisory authority that it effectively integrates the risk-mitigating effects of cross-product netting into its risk management systems. Requirements are added to those that already exist for the recognition of any master agreements and any collateralized transactions included in a cross-product netting arrangement. Netting other than on a bilateral basis, such as netting across transactions entered by affiliates under a cross-affiliate master netting agreement, is not recognized for regulatory capital computation.

Summary of Regulatory Methods for CCR

The BCBS has articulated the principle that banks should be allowed to use the output of their "own estimates" developed through internal models in an advanced EAD. In order to achieve this, the regulators permit qualifying institutions to employ internal EPE estimates of defined netting sets of CCR exposures in computing the EAD for capital purposes. In general, internal models commonly used for CCR estimate a time profile of EE over each point in the future, which equals the average exposure over possible future values of relevant market risk factors (e.g., interest rates, FX rates). The motivation for this was the need for more consistent treatments and is particularly critical if banks may make use of their own estimates to calculate EAD through an internal model.

Relatively short-dated SFTs pose problems in measuring EPE because estimating a time profile of EE in an internal model only considers current transactions. For some SFT portfolios, the expected exposure might spike up rapidly in the first few days before dropping off sharply at maturity. However, a counterparty may enter new or roll over existing SFTs, generating new exposure not reflected in a current EE time profile. An additional problem arises when short-term are combined with long-term transactions, so that EE is U-shaped, which implies that if short-term transactions roll over, the decline in EE might understate the CCR amount. These issues can also apply to short-term OTC derivatives.

Effective expected positive exposure measurements always lie somewhere between EPE and peak EE. In the case of upward- versus downward-sloping EE profiles, effective EPE will equal EPE or peak EE, respectively. In general, the earlier that EE peaks, the closer effective EPE will be to peak EE; and the later that EE peaks, the closer effective EPE will be to peak EPE. Under the internal model method, a peak exposure measure is more conservative than effective EPE for any counterparty and can be used with prior supervisory approval. While banks generally do not use effective EPE for internal risk management purposes or in economic capital models, it can easily be derived from a counterparty's EE profile.

The consensus is that this is a pragmatic way of addressing rollover of short-dated transactions and differentiating counterparties with more volatile EE time profiles. EEs can be calculated based on risk-neutral or physical-risk factor distributions, the choice of which will affect the value of EE but not necessarily lead to a higher or lower EE. The distinction often made is that the risk-neutral distribution must be used for pricing trades, while the actual distribution must be used for risk measurement and economic capital.

The calculation of effective EPE has elements of both pricing (e.g., in the calculation of an effective maturity parameter) and simulation. Ideally, the calculation would use distribution appropriate to whether pricing or simulation is being done, but it is difficult to justify the added complexity of using two different distributions. Because industry practice does not indicate that one single approach has gained favor, supervisors are not requiring that any particular distribution be used.

Exposure on netting sets with maturity greater than one year is susceptible to changes in economic value from deterioration in the counterparty's creditworthiness short of default. Supervisors believe that an effective maturity parameter (M) can capture the effect of this on capital and the existing maturity adjustment in the revised framework is appropriate for CCR. However, the M formula for netting sets with maturity greater than one year must be different than that employed in the revised framework in order to reflect dynamics of counterparty credit exposures. The approach for CCR provides such a formula based on a weighted average of expected exposures over the life of the transactions relative to their one-year exposures. As in the revised framework, M is capped at five years, and where all transactions have an original maturity less than one year that meet certain requirements, there is CCR-specific treatment.

If the netting set is subject to a margin agreement and the internal model captures the effect of this in estimating EE, the model's EE measure may be used directly to calculate EAD as above. If the internal model does not fully capture the effects of margining, a method is proposed that will provide some benefit, in the form of a smaller EAD, for margined counterparties. Although this "shortcut" method will be permitted, supervisors would expect banks that make extensive use of margining to develop the modeling capacity to measure the impact on EE. To the extent that a bank recognizes collateral in EAD via current exposure, a bank would not be permitted to recognize the benefits in its estimates of LGD.

Supervisory Requirements and Approval for CCR

Qualifying institutions may use internal models to estimate the EAD of their CCR exposures subject to supervisory approval, which requires certain model validations and operational standards. This applies to banks that do not qualify to estimate the EPE associated with OTC derivatives but would like to adopt a more risk-sensitive method than the current exposure method (CEM). The standardized method (SM) is designed both to capture some certain key features of the internal model method for CCR and to provide a simple and workable supervisory algorithm, with simplifying assumptions. Risk positions in the SM are derived with reference to short-term changes in valuation parameters (e.g., durations and deltas), and assumed open positions remain over the forecasting horizon. This implies that the risk-reducing effect of margining is not recognized and there is no recognition of diversification effects.

In the SM, the exposure amount is defined as the product of two factors: (1) the larger of the net current market value or "supervisory EPE" times, and (2) a scaling factor termed *beta*. The first factor captures two key features of the internal model method (IMM) not mirrored in CEM with respect to netting sets that are deep in the money: The EPE is almost entirely determined by the current market value at the money (current market value is not relevant), and CCR is driven only by potential changes in values of transactions. By summing the current and add-on exposures, CEM assumes that the netting set is simultaneously at and deep in the money. The CEM derives replacement cost implicitly at transaction and not at portfolio level as the sum of the replacement cost of all transactions in the netting set with a positive value. The SM derives current market value for CCR as the larger of the sum of market values (positive or negative) of all transactions in the netting set or zero.

The second factor serves two purposes. First, as with the alpha in the IMM conditioning on a downturn, the beta addresses stochastic dependency of market values of exposures across counterparties as well as estimation and modeling errors. It also seeks to compensate for the fact that the first factor may at times be lower than the effective EPE under the IMM. This second concern is relevant for netting sets that are narrowly focused on certain risk areas (e.g., interest swaps that are mostly denominated in the same currency). Unless the netting set is very deep in the money, the effective EPE will exceed both the net current market value and the "supervisory EPE," as the latter is calibrated to transactions that are at the money. Supervisory EPE does not allow for basis risk, and price risk is reflected only by deltas, so beta is set considerably higher than alpha. However, some allowance is made for nonrecognition of diversification, which tends to make the first factor larger than effective EPE.

The recognition of hedging within netting sets is another key conceptual difference between the SM and IMM in comparison to the CEM. In CEM, the size of the netting effect depends not on hedging but on the portion of the transactions that is in the money: If none is out of the money, that implies no netting is recognized. For example, consider two at-the-market (ATM) and exactly identical but offsetting transactions with the same party subject to netting. Under the CEM there is positive exposure, whereas under either the SM or the IMM there is zero exposure. In general, the recognition of netting increases with the extent to which out-of-the-money transactions are present within a netting set.

Under the SM, supervisory EPE is determined by mapping to risk positions that represent certain key drivers of potential change in value, following a technique commonly employed in market risk modeling (e.g., delta/gamma hedging). Risk positions of the same category (e.g., the same currency) that arise from transactions within the same netting set, form a so-called hedging set within which hedging is fully recognized. Hedging sets are designed to capture general market risk. With respect to interest rate risk, there is no differentiation of the categories by the issuer of any underlying debt instrument. However, there is a differentiation with regard to the type of reference rate used—for example, sovereign versus corporate-issued instruments.

In the case of floating rate instruments, the sensitivity to interest rate changes with the remaining maturity is synonymous to the time to next adjustment. On the other hand, for equities price changes across issuers too different to permit netting at a national index level, netting is only permitted on an individual level. Nonlinear instruments require the capability of being represented in delta-equivalent form, which is compliant under the SM or the IMM. Unlike the CEM that considers only purchased options, in the SM sold options enter with negative signs and give rise to CCR. Modified duration/delta and an imperfect model of basis risk imply limited recognition of offsets by narrowed time bands of hedging sets.

Regulators expect that a bank's risk tolerance for CCR should be clearly articulated by its board through policies and a framework for establishing limits. Further, they expect that management should establish a comprehensive risk measurement and management framework consistent with this. At a minimum, supervisors require that policies should clearly address risk measurement, reporting, tools, processes, and legal and operational issues with respect to CCR. Furthermore, the view is that policies should be detailed and should contain an escalation process for the review and approval of policy exceptions. Banks are expected to report counterparty exposures at a frequency commensurate with the materiality and complexity of exposures. Reporting should include concentration analysis and CCR stress testing for an understanding of exposures and potential losses. Finally, reports should include an explanation of issues influencing accuracy and reliability of CCR measures.

Supervisory Guidance Regarding CCR

Given the complexity of CCR exposures, banks should employ a range of risk metrics for a comprehensive understanding of this risk. These metrics should be commensurate with the size, complexity, liquidity, and risk profile of the bank's CCR portfolio. Banks typically rely on certain primary metrics for monitoring, and secondary metrics for a more robust view, of CCR exposures. Banks should apply these metrics to single exposures, groups of exposures, and the entire CCR portfolio, and should be applying special assessing of their largest exposures.

CCR Supervisory Guidance: General Guidelines Sophisticated banks and large dealers should measure and assess the following:

- Current and potential exposure (both gross and net of collateral);
- Stressed exposure (broken out by market risk factors);
- Aggregate exposures and stressed exposure, as well as CVA, segmented by market factors;
- Additional relevant metrics, such as for credit derivatives, jump-to-default risk on the reference obligor, and economic capital usage;
- Correlation risks, such as wrong-way risk;
- Credit quality of collateral.

Banks' CCR systems should:

- Have sufficient capacity to aggregate at varying levels (industries, regions, products, business line, legal entity) or other groupings to identify concentrations;
- Be sufficiently flexible to allow for timely aggregation of all CCR exposures and other forms of credit risk

- Calculate counterparty CE and PE on a daily basis on the previous day's position exchange of collateral;
- Include all trades at each level of aggregation.

Banks should consider the full range of credit risks in conjunction with CCR: on- and off-balance-sheet activities; contractual, noncontractual, contingent, and noncontingent risks; and underwriting and pipeline risks.

While a common metric across all risks is not required, banks should be able to view exposures to a given counterparty in one report. Such reports should exhibit consistency in exchange rate and account for legal enforceability of any netting agreements they may have to a counterparty. Management should have an understanding of the specific approaches used and the internal capital adequacy models should incorporate CCR.

CCR Supervisory Guidance: Concentrations Concentrations pose a significant concern as they can add to sudden increases in CCR with potentially large unexpected losses. Banks should have processes to identify, measure, monitor, and control concentrations at both a legal entity and firmwide basis. Concentration risk should be identified both quantitatively and qualitatively, as breaches of risk tolerance limits could result in material loss or damage to a bank's reputation. All credit exposures should be considered part of concentration management (e.g., loans, OTC derivatives, CDO tranches). Total credit exposures should include the size of settlement and clearing lines or other committed lines. CCR concentration management should identify, quantify, and monitor counterparty exposures with certain characteristics:

- Large exposures driven by a market factor, transaction type, or the same risk factors (*crowded trades*);
- Aggregations of risk exposures by industries/other obligor groupings, or geographic/country groupings sensitive similar macro shocks;
- Collateral concentrations, including a single counterparty or portfolios of counterparties;
- Noncash collateral for all product lines covered by agreements;
- *Special purpose entities* (SPEs), which represent payment capacity.

Banks with significant CCR should have a comprehensive, organizationally integrated stress-testing framework. This framework should inform day-to-day exposure/concentration management through identifying extreme conditions that could strain the bank's resources. No less than quarterly, management should evaluate test results for evidence of excessive risk and formulate the appropriate reduction strategy.

The severity of factor shocks should be consistent with the purpose of the stress testing. If the object is to test solvency, then banks should model historically extreme, but plausible, stressed market conditions and evaluate their impact on capital resources and earnings. On the other hand, if the purpose is day-to-day portfolio monitoring, hedging, and management of concentrations, then the scenarios should be of a lesser severity and of higher probability of occurrence. Furthermore, in stress tests, risk managers should challenge the strength of assumptions made about the legal enforceability of netting and the ability to collect and liquidate collateral.

Finally, a sound stress-testing framework should include the following elements:

- Measurement of largest counterparty impacts across portfolios and material concentrations within segments of a portfolio;
- Complete trade capture and exposure aggregation across all forms of trading at the counterparty level, including outside of the main credit system at frequencies consistent with that of tests;
- Stress of principal market risk factors individually for all material counterparties on a consolidated basis, and on at least a quarterly frequency;
- Tracking of concentrations in volatile currencies, particularly for repos and SFTs where liquidation large collateral may be difficult;
- Assessment of nondirectional risks from multifactor stress-testing scenarios, at a minimum addressing separate scenarios for severe economic or market events on the one hand, and a significant decrease in broad market liquidity on the other;
- Consideration of stressed joint exposures and counterparty creditworthiness at specific and group level in aggregate for the bank;
- If CVA methodology used, assurances that the stress test sufficiently captures additional losses from potential default, and basic stress testing of CVA to assess performance under adverse scenarios, incorporating any hedging mismatches;
- Concurrent stress testing of exposure and noncash collateral for assessing wrong-way risk;
- Identification and assessment of exposure levels for certain counterparties (e.g., sovereigns and municipalities), where the bank may be concerned about willingness to pay;
- Integration of CCR stress tests into firmwide stress tests.

CCR Supervisory Guidance: CVA CVA can be defined as a fair value adjustment to transaction valuation reflecting a counterparty's credit quality. The market value of CCR and a market-based framework to understand and value CCR are embedded in all derivatives contracts when counterparties are subject to credit risk that includes default, downgrade, and credit spread risks. CVA may be unilateral, only reflecting the counterparty's credit quality, or bilateral, reflecting the bank's own credit quality as well.

Bilateral CVA is one-sided CVA plus a DVA. In the case of credit risk due to counterparties subject to default risk, one-sided CVA is typically used, but for pricing derivatives with a counterparty (or the market risk of derivatives transactions), a two-sided CVA should be used. CVA is not new but the importance has grown due to changes in accounting rules that require banks to recognize CVA in earnings. CVA has become a more critical component of modeling CCR to mitigate banks' exposure to the MTM impact of CCR.

CVA management should be consistent with sound practices for other material MTM risks and should include the following:

- Business units engaged in trades related to CVA management should have independent risk management functions.
- Systems for CVA risk metrics should be subject to the same controls as other MTM risks (e.g., independent validation and benchmarking through alternative modeling frameworks).
- CVA cost and risk should be allocated to the business unit of origination and be incorporated into the RAROC of a given business, respectively.
- CVA measurement and management frameworks should provide incentive for prudent risk-taking decisions and risk mitigation.
- CVA engines should measure sensitivities to changes in credit and market risk factors to determine material drivers of MTM changes (e.g., a regular test that CVA MTM sufficiently explained by these, including a backtesting of CVA VaR).

If a bank is hedging marked-to-market CVA, the framework or model should gauge the effectiveness of this activity through the measurement of basis risk and similar sensitivities, which is important to capture nonlinearities (e.g., correlations between market and credit risk). Banking organizations with material CVA should measure the risk on an ongoing basis, including VaR models with CVA measurement capabilities. While currently in the early stages of development, such models may prove to be effective tools for risk management purposes. Key advantages of CVA VaR, as opposed to more traditional metrics, include the capture of CCR exposure variability, a counterparty's spread, and correlation. This is significantly more complicated than VaR for market risks as it should match the percentile and horizon and include all risks for the CVA change. All material counterparties covered by the credit valuation adjustment should be included in the VaR model. A CVA VaR calculation that keeps the exposure or counterparty PD static is not adequate, as this will omit dependence between the two variables and risk from the uncertainty of a fixed variable. The framework should assess the ability of the VaR measure to accurately capture the types of hedging used by the banking institutions.

Banking organizations with material CVA should measure the risk on an ongoing basis, including VaR models with CVA.

CCR Supervisory Guidance: Wrong-Way Risk *Wrong-way risk* (WWR) occurs when the exposure to a counterparty is positively correlated with the PD of the counterparty. *Specific* WWR arises from the nature of the transaction, while *general* WWR is attributed to counterparties' PD positively correlated to general factors.

WWR is an important aspect of CCR, since it has caused major bank losses and so should generally be avoided due to the increased risk. Banks need a process to systematically identify, quantify, and control both specific and general WWR across OTC derivative and SFT portfolios. Banks' senior management should maintain policies for both types of WWR with respect to tolerance limits, ongoing identification processes, escalation, and management of situations when there is a legal connection between the counterparty and underlying exposure. Banks should regularly perform WWR analysis for OTC derivatives at least at industry/regional levels and for SFTs on broad asset classes of securities.

CCR Supervisory Guidance: Limits Limits are an integral part of a CCR management framework and these limits should be formalized in CCR policies and procedures. For limits to be effective, a bank should incorporate them into an exposure-monitoring system independent of business lines. The system should perform ongoing monitoring of exposures and have risk controls that require action to mitigate exceptions. A review of exceptions should include escalation to a managerial level commensurate with the size or nature of mitigation.

Supervisors expect that a sound limit system should include several mandates:

- Regularly review limits by a designated committee and process to escalate approvals to higher levels depending on the size of counterparty exposures, credit quality, and tenor.
- Establish limits based on potential future exposure, other metrics, and market risk arising through CVA (which does not eliminate the need to limit CCR).
- Establish individual CCR limits based on peak exposures rather than expected exposures.
- Include peak exposures as appropriate for individual limit monitoring purposes, as they represent the risk tolerance for exposure to a single counterparty.

- Include expected exposure as an appropriate measure for aggregating exposures across counterparties in a portfolio credit model or for use within CVA.
- Take into consideration risk factors like counterparty credit quality, tenor of the transactions, and liquidity of the positions or hedges.
- Sufficiently automate monitoring processes to provide updated exposure measures at least daily.
- Monitor intraday trading activity for conformance with exposure limits and exception policies.
- Include monitoring of trade procedures and impact on limit utilization prior to execution, limit-warning triggers at specific utilization levels, and restrictions by credit risk management on allocation of limits.

CCR Supervisory Guidance: Collateral Banks are expected to control the rehypothecation or other reinvestment of collateral received from counterparties, including the potential liquidity shortfalls resulting from the reuse of such collateral. In regard to the CCR associated with segregated margins, banks should perform a legal analysis concerning the risks of agreeing to allow cash to be commingled with a counterparty's own cash and rehypothecation. Policies and processes to monitor margin agreements with third-party custodians, as with bilateral counterparties, should identify the location of the account to which collateral is posted or from which it is received. Such policies should also obtain periodic account statements or other assurances that confirm the custodian is holding the collateral in conformance with the agreement. Furthermore, it is important that banks understand the characteristics of the account where the collateral is held (e.g., whether it is in a segregated account), as well as the legal rights of the counterparty or any third-party custodian regarding this collateral.

CCR Supervisory Guidance: Model Validation A bank should validate its CCR models initially and on an ongoing basis, and this process should include the following standard elements (Jacobs 2010b):

- Evaluation of the conceptual soundness and developmental evidence;
- Ongoing monitoring including processes verification and benchmarking;
- An outcomes-analysis process that includes backtesting.

The validation process should identify key assumptions and potential limitations, assessing their possible impact on risk metrics across all components of the model subject to validation individually and in combination. The evaluation of conceptual soundness should assess quality of design and construction of CCR models/systems, including documentation and empirical evidence supporting the theory, data, and methods. Ongoing monitoring confirms that systems perform as intended and includes both process verification as well as the assessment of model data integrity and systems operation.

Benchmarking to intended outcomes assesses the quality of a given model. Benchmarking is a valuable diagnostic tool in identifying potential weaknesses with respect to a CCR model. This involves a comparison of the bank's CCR model output with that using alternative data, methods, or techniques. Benchmarking can also be applied to particular CCR model components, such as parameter estimation methods or pricing models. Management should investigate the source of any differences in output and determine whether gaps indicate model weakness.

Outcomes analysis compares model outputs to actual results during a sample period not used in model development. This is generally accomplished using backtesting and should be applied to components of models, risk measures, and projected exposure. While there are limitations to backtesting, especially for testing the longer time horizon predictions of a given CCR model, it is an essential component of model validation. Banks should have a process for the resolution of model deficiencies that are detected, including further investigation to determine the problem and an appropriate course of action. If the validation is not performed by staff that is independent from the developers then independent review should be conducted by technically competent and independent personnel.

The scope of the independent review should include:

- Validation procedures for all components;
- The roles of relevant parties;
- Documentation of the model and validation processes.

This review should document its results, what action was taken to resolve findings, and its relative timeliness. Senior management should be notified of validation results and take appropriate/timely corrective actions. The board should be apprised of summary results, and internal audits should review and test models and systems validation and overall systems infrastructure as part of their regular audit cycle.

CCR Supervisory Guidance: Close-Out Banks should have the ability to effectively manage counterparties in distress, including execution of a close-out, with policies and procedures outlining sound practices (Jacobs, Karagozoglu, and Layish 2012). Requirements for hypothetical close-out simulations should be done at least once every two years for the bank's complex counterparties. Standards should be established for executing a close out that address decision-making responsibilities, the sequence of critical tasks, and the speed and accuracy with which the bank can compile comprehensive counterparty exposure data and net cash outflows, including the capacity to aggregate exposures within a few hours.

The periodic review of documentation related to counterparty terminations and confirmations should require that the appropriate and current agreement defines the events of default, and that the termination methodology that will be used is in place, current, active, and enforceable. Management should document their decision to trade with counterparties that are either unwilling or unable to maintain appropriate and current documentation. Established close-out methodologies should be practical to implement, particularly with large and potentially illiquid portfolios. Dealers should consider using the "close-out amount" approach for early termination upon default in inter-dealer relationships.

There should be a requirement that the bank transmit immediate instructions to its appropriate transfer agent(s) to deactivate collateral transfers, contractual payments, or other automated transfers contained in "standard settlement instructions" in the event that counterparties or prime brokers default on the contract or declare bankruptcy.

CONCEPTUAL ISSUES IN CCR: RISK VERSUS UNCERTAINTY

In this section we will survey some of the thought regarding the concept of risk and consider how it applies to CCR. A classical dichotomy exists in the literature. The earliest exposition is credited to Knight (1921), who defines uncertainty as the state in which a probability distribution cannot be measured or is unknown. This is contrasted with the situation in which the probability distribution is known or knowable through repeated experimentation. Arguably, in economics and finance (and more broadly in the social or natural as opposed to the physical or mathematical sciences), uncertainty is the more realistic scenario that we are contending with (e.g., a fair vs. loaded die, or a die with an unknown number of sides). We are forced to rely on empirical data to estimate loss distributions, which is complicated by changing economic conditions that invalidate forecasts that our econometric models generate.

Popper (1945) postulated that situations of uncertainty are closely associated with, and inherent with respect to, changes in knowledge and behavior. This is also known as the rebuttal of the historicism concept, that our actions and their outcomes have a predetermined path. He emphasized

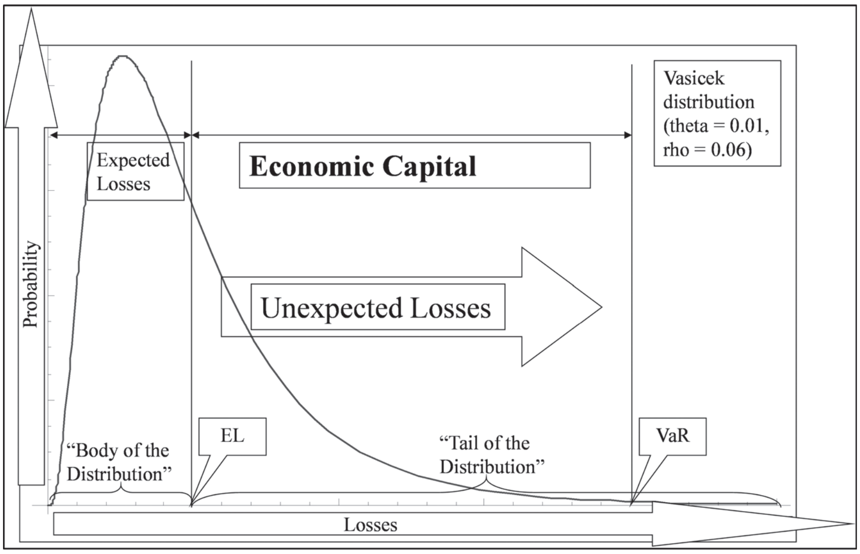

FIGURE 2.3 Stylized representation of economic capital.

that the growth of knowledge and freedom implies that we cannot perfectly predict the course of history. For example, a statement that the US currency is inevitably going to depreciate if the United States does not control its debt, is not refutable and therefore not a valid scientific statement according to Popper. See Figure 2.3.

Shackle (1990) argued that predictions are reliable only for the immediate future. He contends that such predictions impact the decisions of economic agents, and this has an effect on the outcomes under question, changing the validity of the prediction (a feedback effect). This recognition of the role of human behavior in economic theory was a key impetus behind rational expectations and behavioral finance. While it is valuable to estimate loss distributions that help explicate sources of uncertainty, risk managers must be aware of the model limitation that a stress testing regime itself changes behavior (for example, banks "gaming" the regulators' CCAR process). The conclusion is that the inherent limitations of this practice is a key factor in supporting the use of stress testing in order to supplement other risk measures. Finally, Artzner et al. (1999) postulate some desirable features of a risk measure, collectively known as *coherence*. They argue that VaR measures often fail to satisfy such properties.

In light of these considerations, we may see a meta-problem that CCR exposure over long horizons (e.g., 10, 20, 30 years) may simply be inestimable. When trying to forecast prices one or more days ahead for trading

VaR purposes, or even one year ahead for other regulatory capital purposes (e.g., credit capital for banking book exposures), one is dealing with quantifiable risk. But when trying to forecast an exchange rate or a commodity price 30 years ahead, one is dealing with unquantifiable Knightian uncertainty. We take past history as a single homogeneous sample and believe that we have considerably increased our knowledge of the future from the observation of the sample of the past. For example, the study of the US financial markets of the early twentieth century will certainly be of great help to an economic historian, but we should question any kind of inference that comes out of this analysis with respect to current applicability, as the structure of the institutions and the markets has changed to such a degree.

In order to illustrate this issue, consider the evolution of the rates markets in the United States. In the last 30 years, short-term interest rates in this jurisdiction went from nearly 20 percent at the peak of the 1980s bull market, to the very low single digits in the wake of the Fed's quantitative easing following the financial crisis. Therefore, we see how this non-stationarity can make past data quite irrelevant in such situations of dramatic regime change. However, this is not only a problem for long-dated FX or IR contracts, as trying to make multiyear commodity or equity forecasts can be seen as pointless endeavor. There exist no qualitative adjustments, such as the conservative factors applied by many large banks to exposures they can't really model within their main CCR engine, which can lend credence to this practice.

It has been said that what began with the best intentions from a collection of idealistic modeling enthusiasts has degenerated into pseudoscience at best and fraud at worst. In this view, the game is to disguise charlatanism under the veneer of mathematical sophistication, which leads to propositions that cannot be validated or refuted (as we are not dealing in controlled experimentation) and to the illusion that we understand markets. This self-attribution phenomenon usually gets worse with mathematical knowledge: The more complex the equations, the more we believe in our models. However, financial engineering still measures risks using models built on historical data as the core tool deployed to future events. We will just say at this point that the mere possibility of the distributions not being stationary makes the entire long-dated CCR estimation seem like a costly mind game. As we rely increasingly on models of increasing mathematical complexity, our confidence becomes greater that we have correctly modeled all price dynamics, and this may be a false sense of security. We see the phenomenon that new traders on the block dismiss past traders who blew up spectacularly as not sophisticated enough, and we are persuaded that their models are more refined and better able to forecast future market movements, until they blow up quite dramatically themselves.

CONCLUSIONS

In this paper, we have performed a survey of CCR, including the following elements. First, we have introduced various concepts in CCR measurement and management, including prevalent practices, definitions, and conceptual issues. Then, we have summarized various supervisory requirements and expectations with respect to CCR. This study has multiple areas of relevance and may be extended in various ways. Risk managers, traders, and regulators may find this to be a valuable reference. Directions for future research could include empirical analysis, development of a theoretical framework, and a comparative analysis of systems for analyzing and regulating CCR.

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