
Counterparty Risk

CVA

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Quantitative Risk Management

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Important note

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Introduction

- Banks currently calculate and manage CVA according to different business models and subject different accounting regimes
- Various large banks already manage CVA risks as part of their Trading Books
- For those banks, CVA meets the Trading Book designation criteria of daily marking-to-market, active hedging, enforced market risk limits and intent to transfer out the CVA risks

CVA volatility

- Banks that mark CVA to market are subject to the volatility of market prices
- Those banks need to hedge CVA risks that are beyond and above the events of counterparty default
- **The recent financial crisis showed that CVA-related losses can be large and larger than default losses**
- CVA risks include changes in the credit spreads of both counterparties as well as changes in the market risk factors that drive the underlying OTC derivative exposures

CVA modeling

- The modeling technology to mark-to-market and hedge counterparty risk has evolved much over the last 15 years
- **Some banks started to price and hedge CVA in the mid 1990s**
- More recently, many more banks started to price and actively hedge their CVA

CVA risk management system

- CVA systems are some of the most complex and computationally demanding systems that banks have ever implemented
- Derivatives dealer banks with large scale OTC derivatives operations have invested many resources to build up these systems

Data Sourcing

Typically 2-10M trades, 2-10k netting sets and margin agreements, market data

Simulation of Markets

Typically 1-2k paths of 2-5k risk factors over 100 future dates per path

Trade Pricing

Typically 2-10M trades, over 1-2k paths at each of 100 dates

Exposure and CVA calculations

Typically 10k netting nodes

Definition of CVA

- Bank A has a portfolio of OTC derivatives with Counterparty B
- Valuations of derivatives are calculated from the perspective of Bank A herein
- **CVA is the adjustment to the credit-risk-free value of the portfolio of OTC derivatives between counterparties A and B to reflect the market value of the credit risks faced by the counterparties**

Economic intuition

- If Bank A faces more credit risk than Counterparty B, the CVA is negative (i.e. it reduces the value of the OTC derivatives from the perspective of Bank A)
- If Bank A faces less credit risk than Counterparty B, the CVA is positive (i.e. it increases the value of the derivatives from the perspective of A)
- If the present values of the credit risks are the same, the CVA is equal to zero

CVA is integral component of valuation

- **CVA is an integral component of the value of derivatives**
- Ideally, it should be part of the trade valuation models
- The reason it is calculated separately is that there are portfolio effects that transcend the valuation of each trade (e.g. netting rights and collateral agreements)
- CVA can be assigned to each trade in a marginal contribution to portfolio sense

CVA pricing

- CVA reflects the credit risks faced by both counterparties as the adjustment to the credit-risk-free value of the OTC derivatives portfolio:

$$CVA = E_A s_A - E_B s_B$$

- E_A is the present-valued expected exposure faced by counterparty B with respect to Bank A;
- s_A is the market loss rate (i.e. the product of risk-neutral PD and risk neutral LGD) of A
- E_B is the present-valued expected exposure faced by A with respect to B;
- s_B is the market loss rate of B.

Example 1

$$E_A = \$200 \quad s_A = 2\%$$

$$E_B = \$100 \quad s_B = 5\%$$

$$CVA = 200 \times 0.02 - 100 \times 0.05 = 4 - 5 = -\$1$$

- The CVA is a negative adjustment to the mid-market value of the portfolio of trades as seen by Bank A because Bank A faces more credit risk than Counterparty B
- If the mid-market value of the portfolio is -\$50, the portfolio would be worth -\$51 for Bank A and +\$51 for Counterparty B. Both counterparties would agree with this value

Example 2: assignment

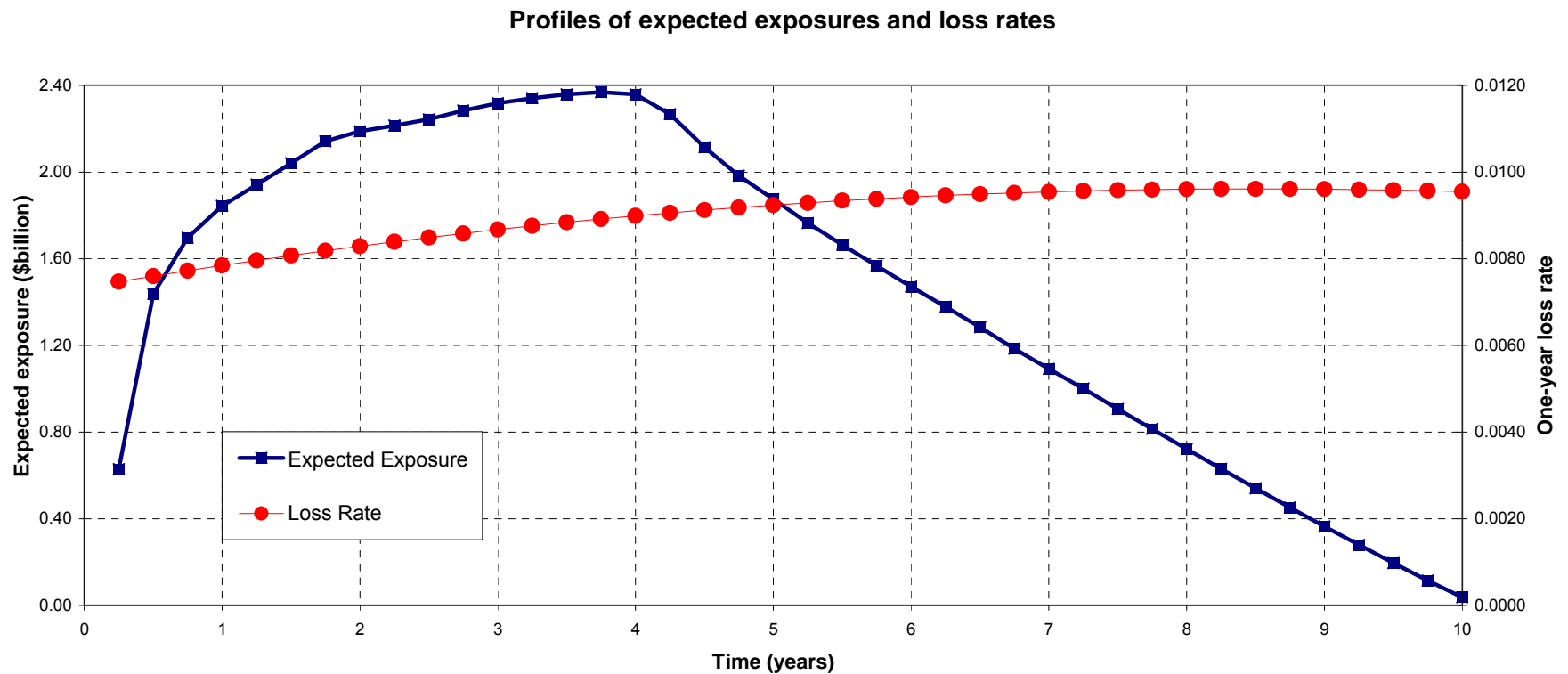
$$E_A = \$200 \quad s_A = 2\%$$

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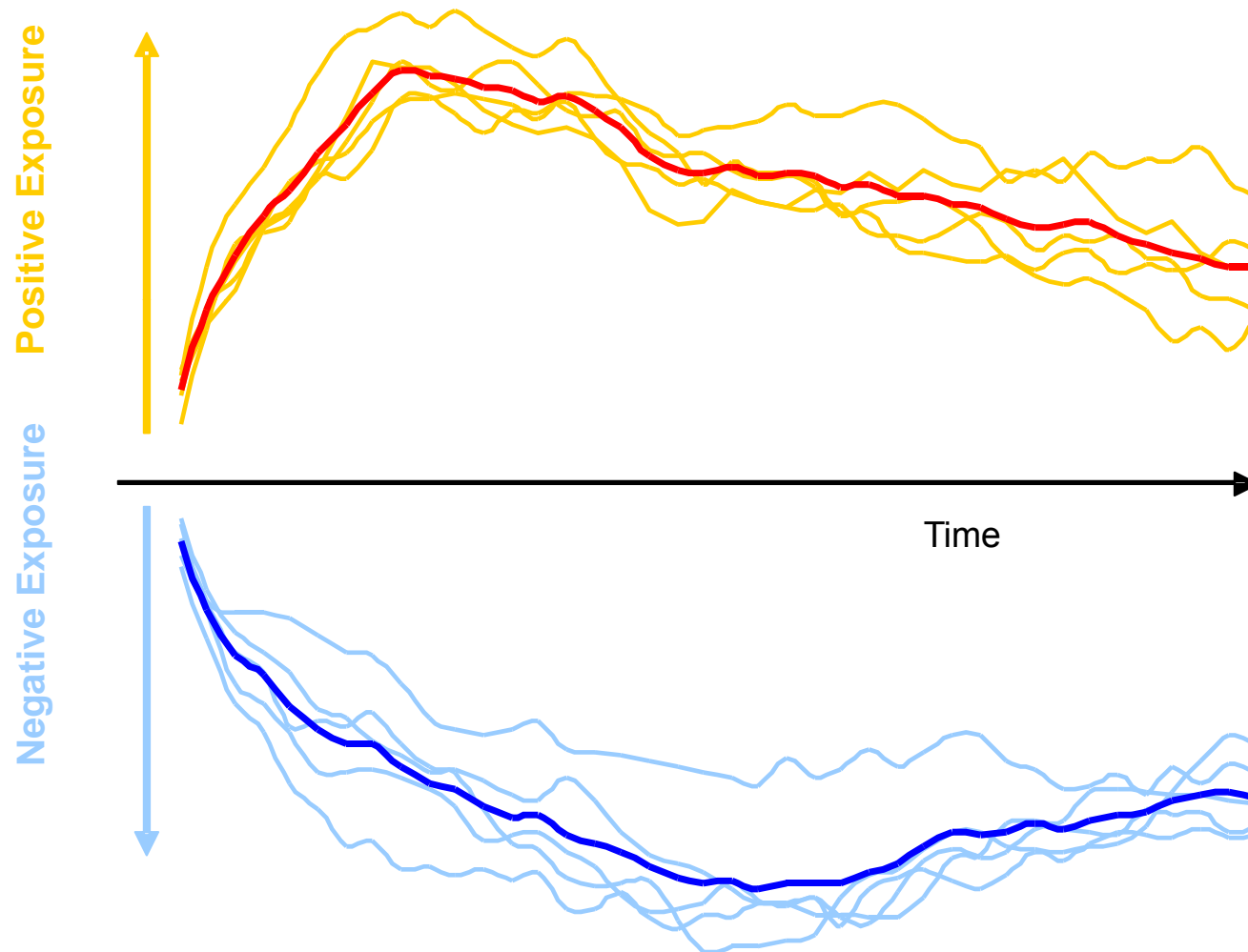
$$CVA = 200 \times 0.02 - 100 \times 0.05 = 4 - 5 = -\$1$$

- Suppose that A is to assign the portfolio of trades with B to C. C has $s_C = 5\%$ and from C's perspective:
$$CVA = 200 \times 0.05 - 100 \times 0.05 = 10 - 5 = +\$5$$
- Thus: A pays +\$51 to C; C pays \$6 to B so that the value of the portfolio for C is -\$45 and the value of the portfolio to B is +\$45.

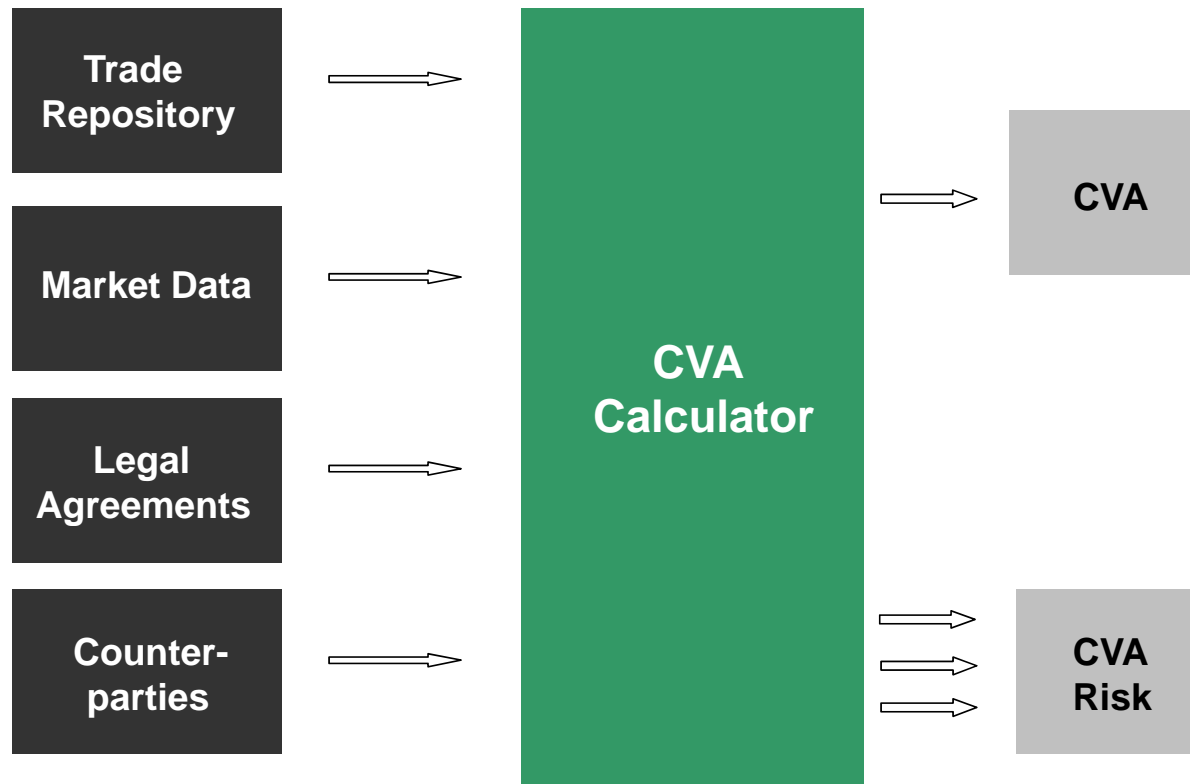
In practice: exposure and loss rate profiles



Positive and negative expected exposures



CVA system



CVA risk sensitivities

- The sensitivities of the CVA with respect to counterparty loss rates and underlying exposures can be schematically represented as:

Counterparty spread sensitivities

- $\partial \text{CVA} / \partial E_A = s_A$
- $\partial \text{CVA} / \partial E_B = -s_B$

Underlying exposure sensitivities:

- $\partial \text{CVA} / \partial s_A = E_A$
- $\partial \text{CVA} / \partial s_B = -E_B$

Cross-convexities:

- $\partial^2 \text{CVA} / (\partial E_B \partial s_B) = -1$
- $\partial^2 \text{CVA} / (\partial E_A \partial s_A) = 1$

VaR of CVA

- A **linear VaR of the CVA** can be calculated based on the sensitivities of the CVA with respect to the risk factors that drive the credit spreads of the counterparties and the underlying exposures
- A **non-linear VaR of the CVA** may require full re-pricing of the CVA
- Full re-pricing is computationally intensive and it requires the use of pre-computed price grids
- Those grids need to span multiple risk factors and require the use of proper sampling and interpolation techniques

IRC of CVA

- The JTD and migration risks of CVA can be computed in the IRC framework
- Depending on the liquidity of the counterparty's CDS hedges, it may be necessary to stress the current exposures to the counterparties prior to default
- Thus, IRC of CVA needs to incorporate the relevant risk factors to stress the current exposures prior to the calculation of the jump to default

CVA in the regulatory trading book

- Banks that price and hedge CVA would like to have CVA fully integrated with the rest of their trading books for the purpose of regulatory capital
- **They want their CVA to be capitalized via VaR, stressed VaR and IRC per Basel 2.5**
- ISDA has been working with Basel RMMG and TBG to progress in this direction
- Basel 3 treats CVA VaR as standalone calculation and continues to apply the EPE-based charge to counterparty risk.
- The hedges of the CVA are naked in the TB and distort the TB charge.

Hedging challenges

- The hedges of the CVA incorporate hedges of the market risk factors driving the exposures and hedges of the credit spreads of the counterparties
- There are important cross-gammas which can be substantial when the changes in spreads and exposures are large
- During the recent credit crisis, due to the large size of the CVAs and the high volatility of markets (i.e. large ΔE and Δs), the cross-gammas created difficulties for CVA desks dynamically hedging the CVAs

Should banks hedge CVA?

- If the bank marks to market its CVA and the bank does not hedge it, it will experience P&L (and earnings) volatility
- Importantly, in a trending and deteriorating credit market environment, the bank could suffer substantial cumulative losses
- In the recent credit crisis, some banks lost many billions of dollars in CVAs
- **This was particularly the case of banks that did not actively hedge their CVAs**

Example: realized CVAs

- Monoline B owes \$2.5 billion (at mid-market) to Bank A
- Unwinds the trades paying \$500 million to Bank A
- Based on the unwinding value:
 - CVA to Bank A was -\$2.0 billion
 - CVA to Monoline B was +\$2.0 billion

Should banks hedge their own spread?

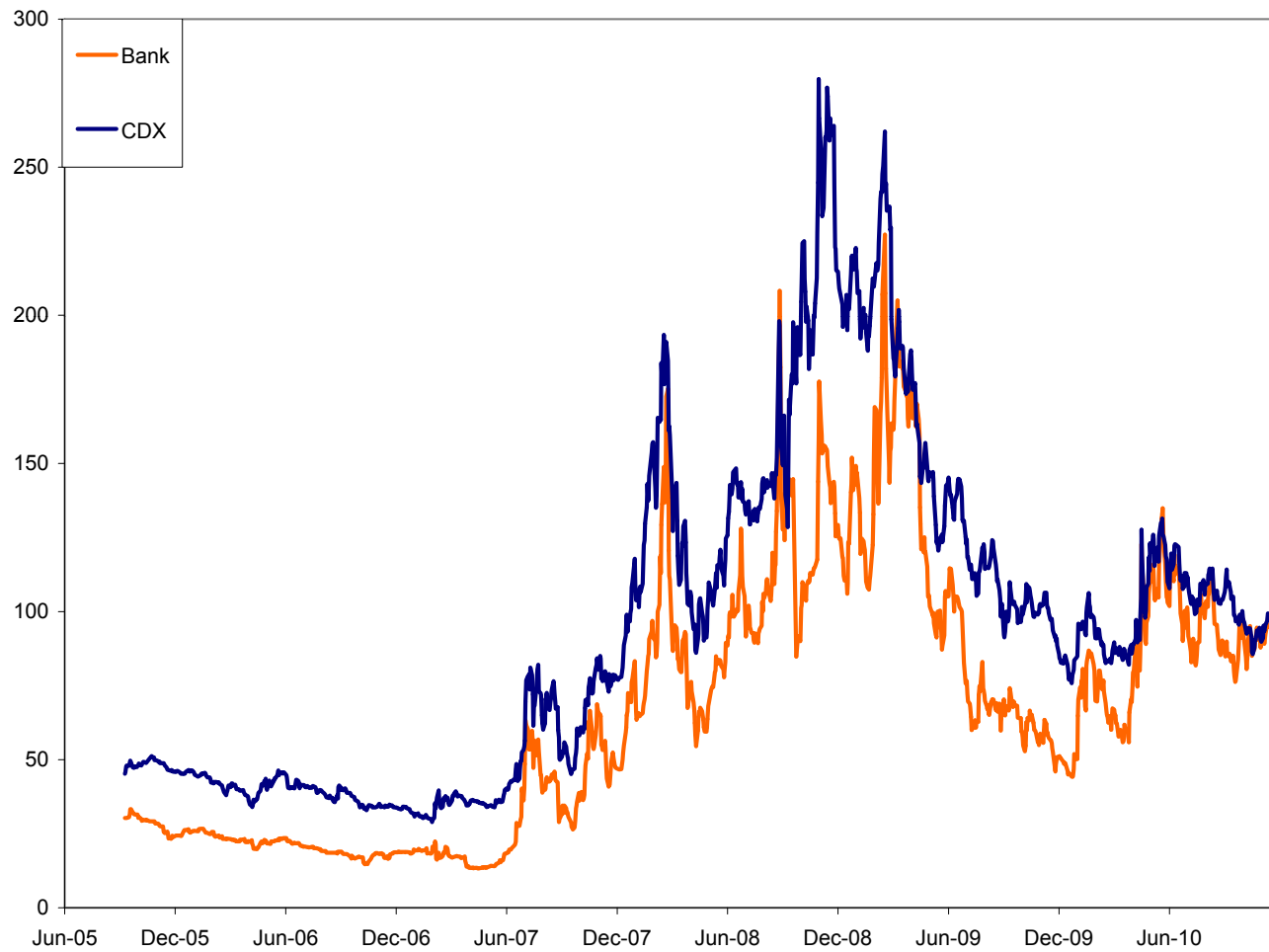
$$\Delta CVA / \Delta E_A = s_A$$

$$\Delta CVA / \Delta s_A = E_A$$

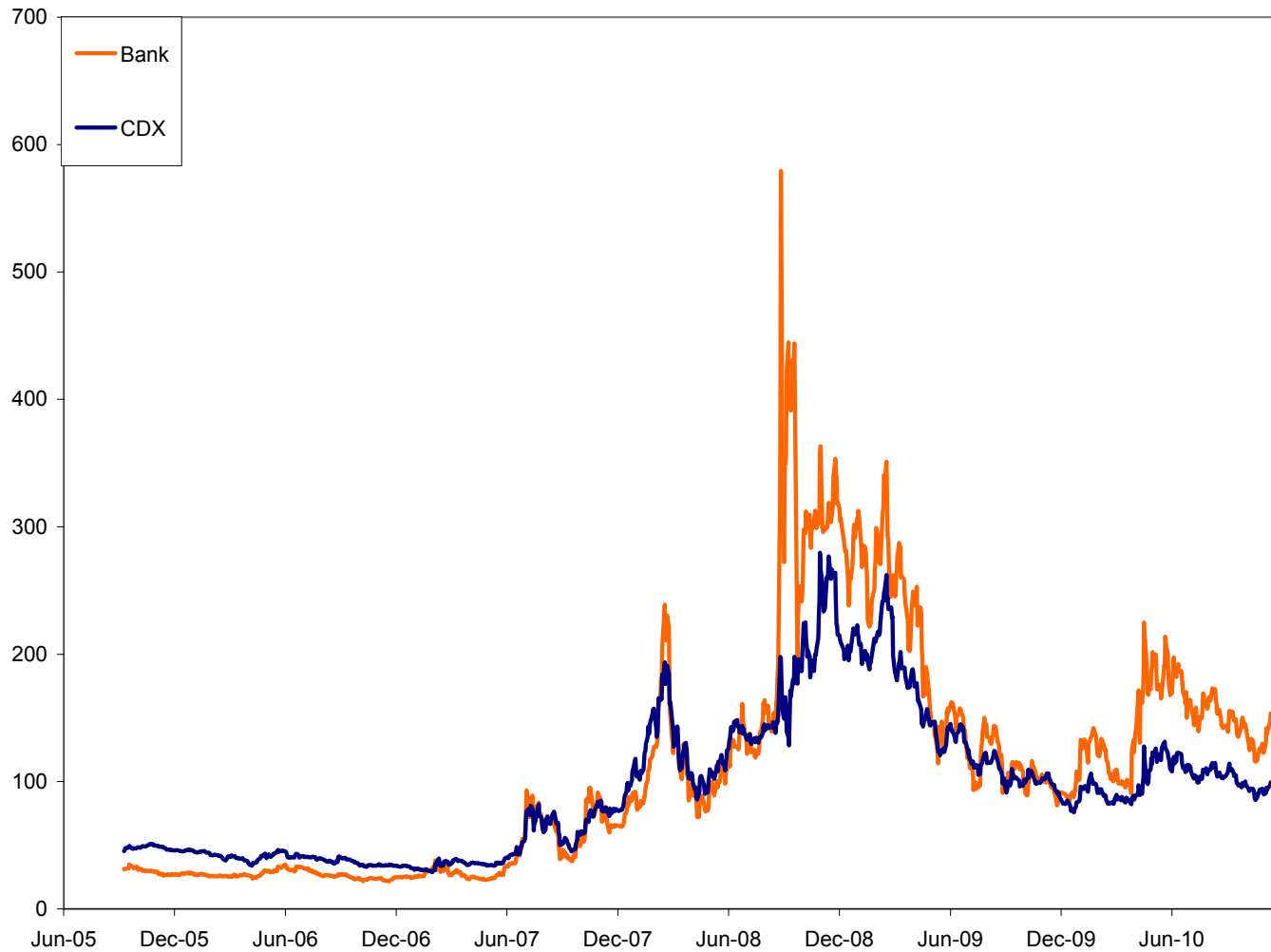
$$\Delta^2 CVA / (\Delta E_A \Delta s_A) = 1$$

- Changes in the exposure E_A can be hedged by taking positions on the market risk factors that drive the exposure
- Changes in Bank A's own loss rate s_A are more challenging to hedge. The systematic risk component can be hedged. The bank-specific, idiosyncratic risk component is more difficult to hedge
- **By hedging the systematic component of their own credit risk, banks can monetize the liability CVA, like they monetize any other hedged derivative risk**

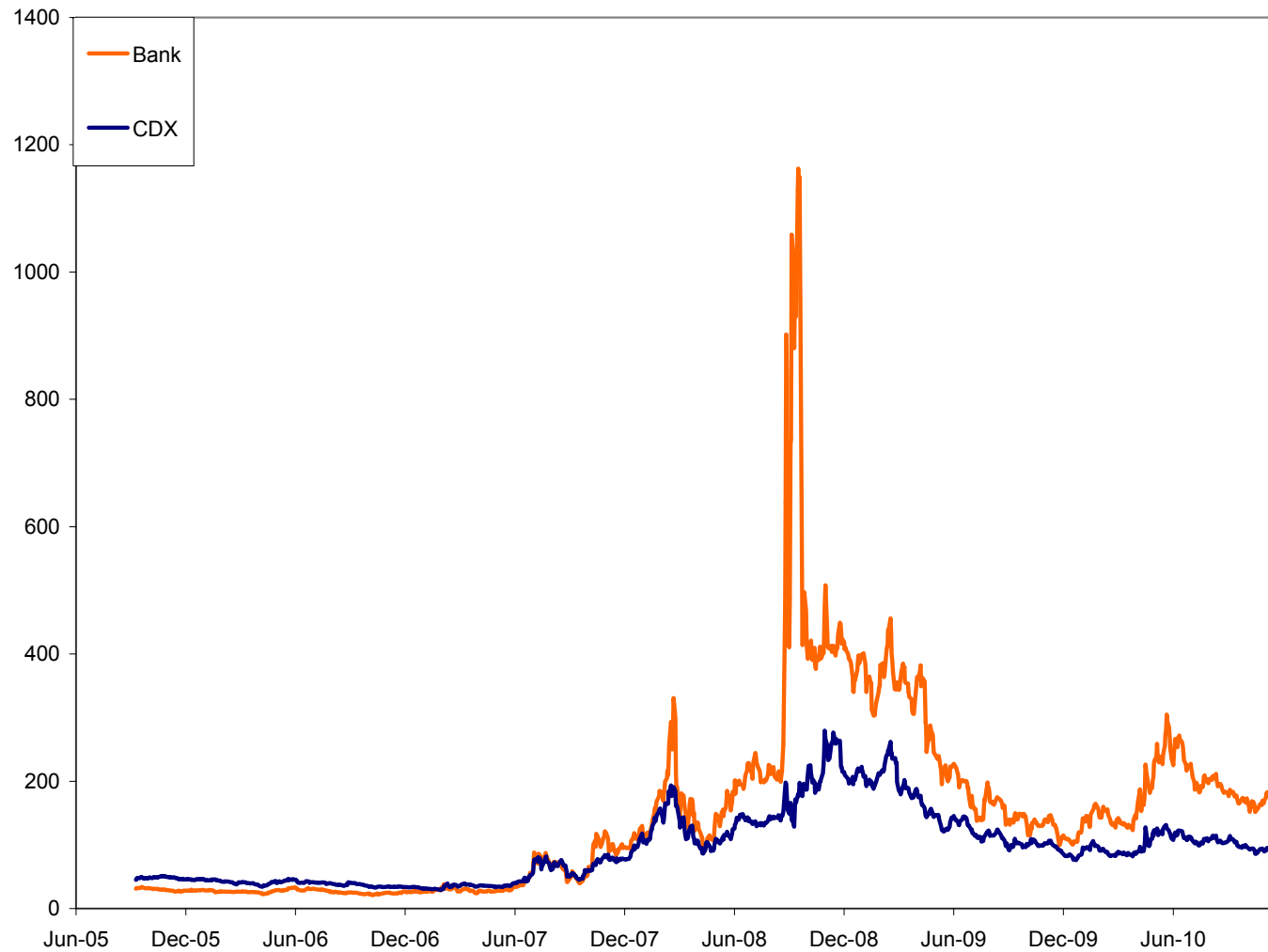
Bank systematic risk



Bank systematic risk (2)



Bank systematic risk (3)



CVA desks

- Some banks have opted for central CVA desk
- Others have opted for various CVA desks deployed in their main business units
- CVA desks sell full counterparty credit insurance to the derivatives trading desks
- They manage the risks of the CVA after inception of the trades
- They are subject to risk limits and usually do not have a revenue generation budget

Dynamic rebalancing and friction costs

- The risk management of CVAs requires dynamic rebalancing of the hedges.
- When the counterparty exposures and the credit spreads of the counterparties are large and volatile, the rebalancing requirements can be intense and costly
- This is due to illiquidity, wide bid-ask spreads and overall market impact of the hedging program, especially when in crowded risk situations
- **Friction costs are usually not explicitly captured in the CVA pricing models but they can be the most relevant cost component of large, concentrated CVA risks**

Simulation of dynamic hedging

- We can use simulation models to assess the size of the costs of replication over the life of the CVA hedging program
- Those simulation models incorporate the frictions mentioned before and provide a more realistic description of the probability distribution of potential CVA hedging costs
- Those costs should be considered in the risk/return analyses of new and large OTC derivative transactions
- **During the 2007-8 crisis, the costs of CVA hedging proved to be quite material in some cases**

Wrong-way risks

- There are wrong-risks that are specific to CVA hedging. Example: crowded counterparty risks
- When a counterparty has entered in similar and large OTC derivatives trades with many banks, the hedging programs of the banks will create wrong-way risk.
- Usually, those wrong way risks do not show up until credit spreads and/or exposure have grown to some materially large levels
- During the recent credit crisis this occurred with respect to monolines as well as other concentrated counterparty exposures.

Wrong-way risks (2)

- **The CVA wrong way risks are dynamic and local**
- That is, they are present in continuous hedging strategy
- They are different from the wrong way risks as usually defined in the Banking Book

Out-of-the-money risks

- Potential future exposure (PFE) models used for CVA calculation are not good predictors of massive market dislocations
- CVA traders need to be cautious in the pricing and hedging of out-the-money counterparty exposures
- The ability to hedge those exposures in the future, as they grow, needs to be assessed prudently considering the overall crowdedness of the market
- The profitability of such trades needs to be evaluated considering the potential CVA risks and dynamic hedging costs embedded in the trades

Replacement costs

- PFE models account for the benefits of collateral in the calculation of counterparty exposures
- The models measure residual exposures that exist because of the thresholds that limit the continuous exchange of collateral and the market risks that exist during the closeout of a defaulted counterparty
- **Banks should not underestimate the all-in costs of replacing trades with a defaulted counterparty**
- Especially when that counterparty is a large market participant and its default can impair the liquidity and increase the volatility of the markets where the derivatives trade

Stress tests

- Stress tests are a fundamental component of a sound CVA risk management program
- The fundamental goals of the stress test framework should be:
 - Identification of concentrations of market and credit risks
 - Identification of out-of-the-money exposures
 - Identification of wrong-way risks
 - Identification of potentially large dynamic hedging costs

CVA system design

- Calculation of the CVA is computationally intensive and expensive
- It is important to engineer the CVA system and model efficiently
- Various analytical and computational techniques have evolved to allow for fast calculations
- **One of the most effective and which has been used since the very early days of CVA is the use of price grids**
- The simulation and pricing models used within a CVA framework need to be designed to meet the requirements of computational efficiency and speed

CVA system design

- The banks that implemented the most successful CVA systems were the ones that:
 - Modularized their CVA system
 - Built parallel processing capabilities
 - Built analytics using sound and pragmatic financial engineering

CVA system design

- The planning of what data to store and in what form is a key element for the success of the implementation.
- **Grids of trade values and exposures per netting node seem to be quite useful storage units**
- On a typical day, a large sophisticated bank will process millions of derivatives trades over 1000-2000 market paths, each containing 50-100 future dates from 0 to 50 years in the future
- And the CVAs will be calculated multiple times in order to construct the hedge ratios and risk metrics used by the bank

CVA system design

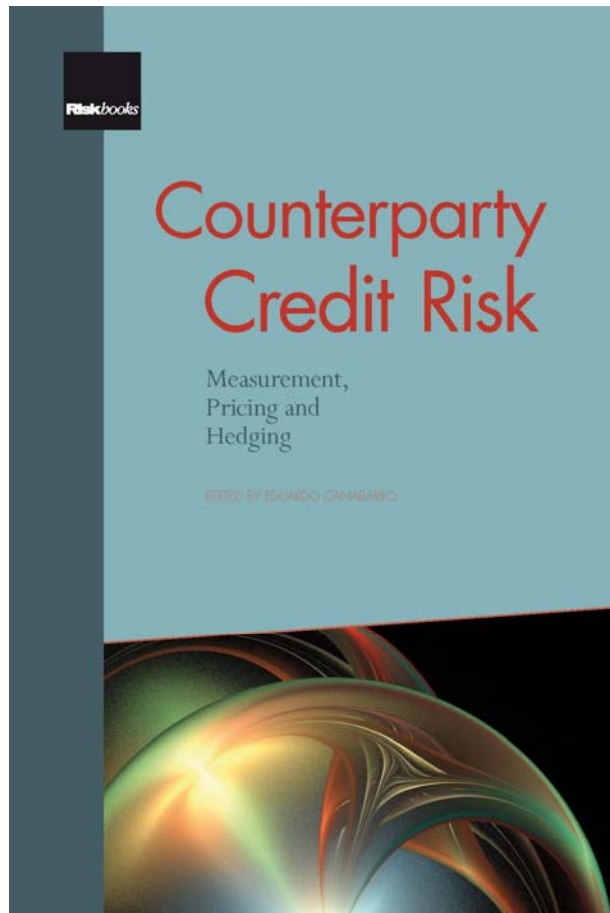
- Large CPU farms: a structure with thousands of CPUs is typical at the largest sophisticated banks
- As technology continues to evolve, the capability of using faster and more CPUs is very important
- **This requires that the design of the CVA system be founded on modularity and scalability**

Counterparty Credit Risk

Measurement, Pricing and Hedging

Edited by Eduardo Canabarro

Riskbooks



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