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Counterparty Risk

Gabor Fath
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Counterparty credit risk - definition

Counterparty credit risk (CP risk) is the risk that the counterparty to a financial contract will default prior to the expiration of the contract and will not make all the payments required by the contract.

Counterparty credit risk

What to investigate?

- Exposure
  The potential/expected loss in case when CP defaults
- CP default probability
  From bond or CDS prices
- Pricing counterparty risk:
  The value adjusment on top of the fair (non-defaultable CP) market value of a transaction reflecting the „price" of CP risk

Mark-to-market (M2M)

Banks' trading book valuation is based on fair value accounting. Positions are „marked to market" (by models calibrated to the market) daily.

- Trades are „fair" at inception, PV(t=0)=0
- As time passes the contract is „marked to market" and its M2M value become non-zero PV(t)≠0
- At time zero PV(t) is a random variable, which has a distribution
- At time t the trade can be *in-the-money* or *out-of-the-money*

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Loss in case of CP default

Assumptions:

- Counterparty defaults
- Bank closes out its positions with CP
- Bank enters into a similar contract with another CP in order to maintain its market position

Since the bank's market position is unchanged after replacing the contract, the loss is determined by the contract's replacement cost at the time of default.

Loss in case of CP default

If the contract M2M value V(τ) is <u>negative</u>
for the bank at the time τ of default, the bank

- closes out the position by paying the defaulting CP the M2M V(τ) of the contract
- enters into a similar contract with another CP and receives M2M V(τ) for contract
- bank has <u>neither loss nor gain</u>.

Loss in case of CP default

If the contract M2M value V(τ) is <u>positive</u>
for the bank at the time τ of default, the bank

- closes out the position, but only receives recovery R_CV(τ) from the defaulting CP
- enters into a similar contract with another CP and pays V(τ) for the contract
- bank has a <u>net loss</u> equal to (1-R_C)V(τ).

Loss in case of CP default

In which case does the Bank have counterparty risk?

Position	**CP risk**	**Why?**
long option		
short option		
forward		
swap		

Loss in case of CP default

In which case does the Bank have counterparty risk?

Position	CP risk	Why?
long option	yes	always an asset, PV(t)>0
short option		
forward		
swap		

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Loss in case of CP default

In which case does the Bank have counterparty risk?

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long option	yes	always an asset, PV(t)>0
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forward		
swap		

Loss in case of CP default

In which case does the Bank have counterparty risk?

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swap		

Loss in case of CP default

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long option	yes	always an asset, PV(t)>0
short option	no	always a liability, PV(t)<0
forward	yes	asset or liability, PV(t)>0 or <0
swap	yes	asset or liability, PV(t)>0 or <0

Exposure

- Contract level exposure
- Counterparty level exposure

Contract level exposure

$$E_i(t) = \max[V_i(t), 0]$$

Bank's exposure in contract *i* at time *t*

Forward PV
Value of contract *i* at time *t*
Only cashflows in (t,T) should be counted

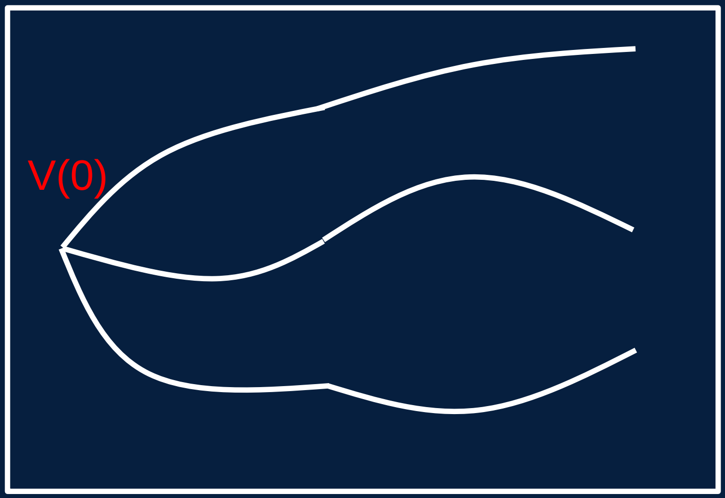
- Current exposure at t = 0 is certain
- Future exposure at t > 0 is a random variable

PV and Forward PV

deterministic value

PV = V(0) =
Value of contract at present (t=0)

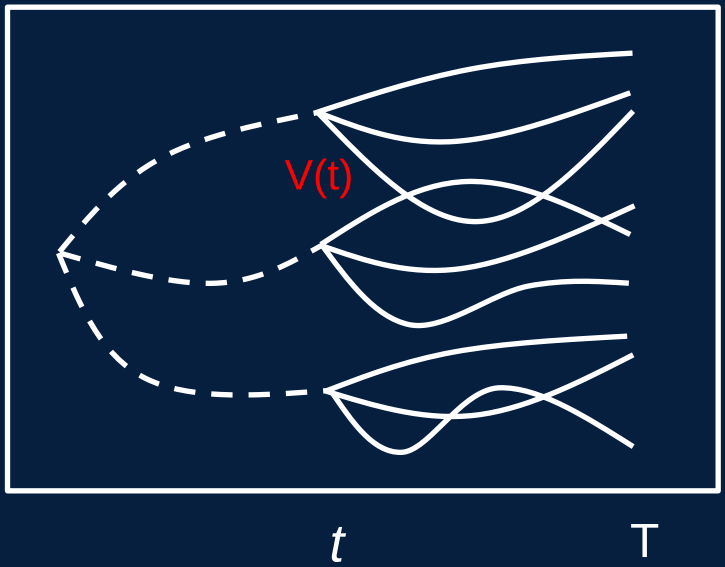
- Model provides
  probability distribution
- V(0) calculated by
  averaging cashflows [0,T] over paths



random variable

Forward PV = V(*t*) =
Value of contract at future time t

- Model provides:
  probability distribution for [0,t]
  prob distribution [t,T] given path [0,t]
- V(t) calculated by
  averaging cashflows [t,T] over paths [t,T]
  has a different value for each path [0,t]



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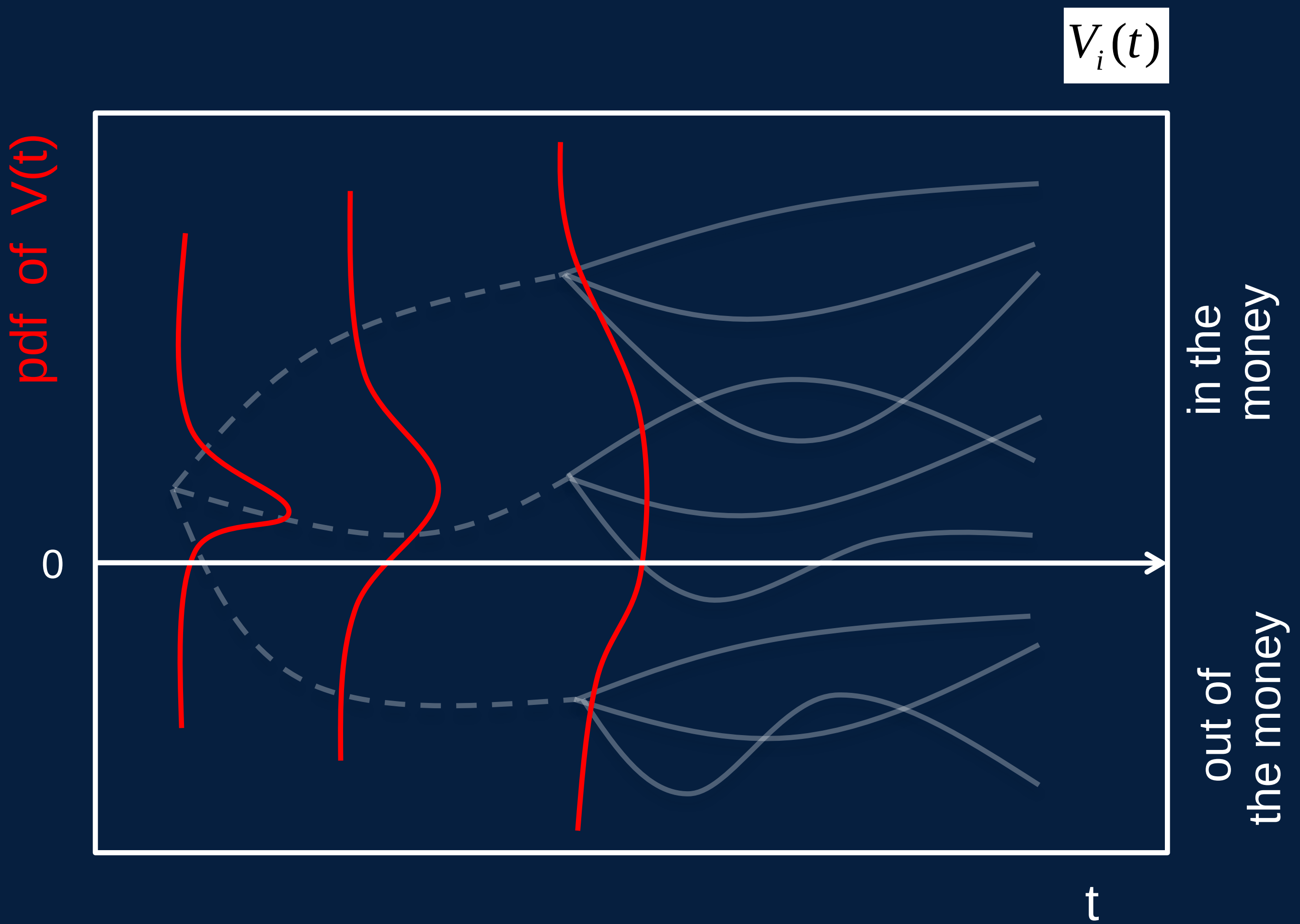
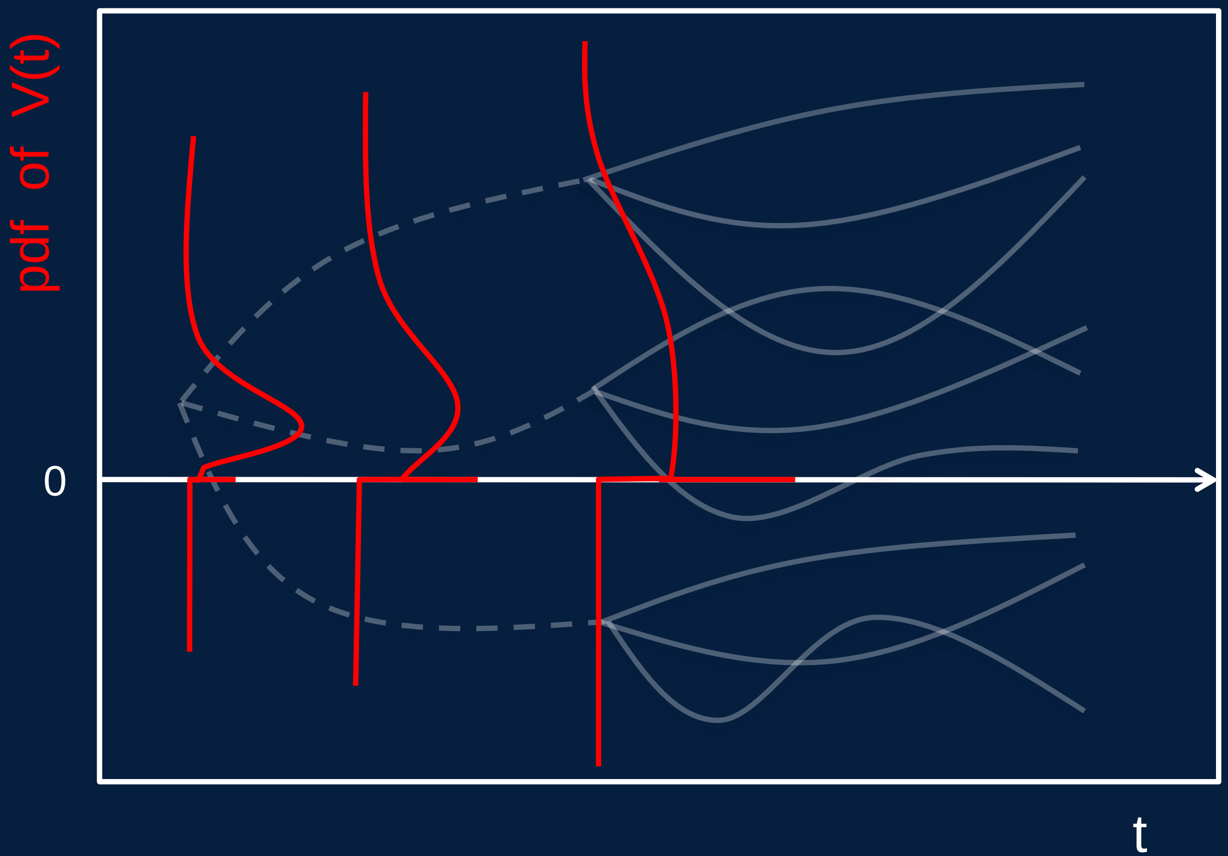
Forward PV distribution



Exposure distribution

$$E_i(t) = \max[V_i(t), 0]$$



Mitigating CP risk (1) - netting

Portfolio level exposure

without netting

$$E(t) = \sum_i E_i(t) = \sum_i \max[V_i(t), 0]$$

with netting

$$E(t) = \max[\sum_i V_i(t), 0]$$

A netting agreement is a contract between two counterparties that allows aggregation of transactions between the counterparties – i.e., transactions with negative values can be used to offset ones with positive values and only the net positive value represents credit exposure at the time of default. Netting plays a crutial role in reducing CP exposure.

Mean positive/negative exposure, potential future exposure

Mean positive exposure (discounted to today):

$$\mathrm{MPE}(t) = \mathbf{E} D(t) E(t) = \mathbf{E} D(t) \max[V(t), 0]$$

Usually the discount factor is part of the definition

Mean negative exposure:

$$\mathrm{MNE}(t) = -\mathbf{E} D(t) \min[V(t), 0]$$

Potential future exposure (at 95%):

$$\mathrm{PFE}(t) = X : \Pr(D(t) E(t) < X) = 0.95$$

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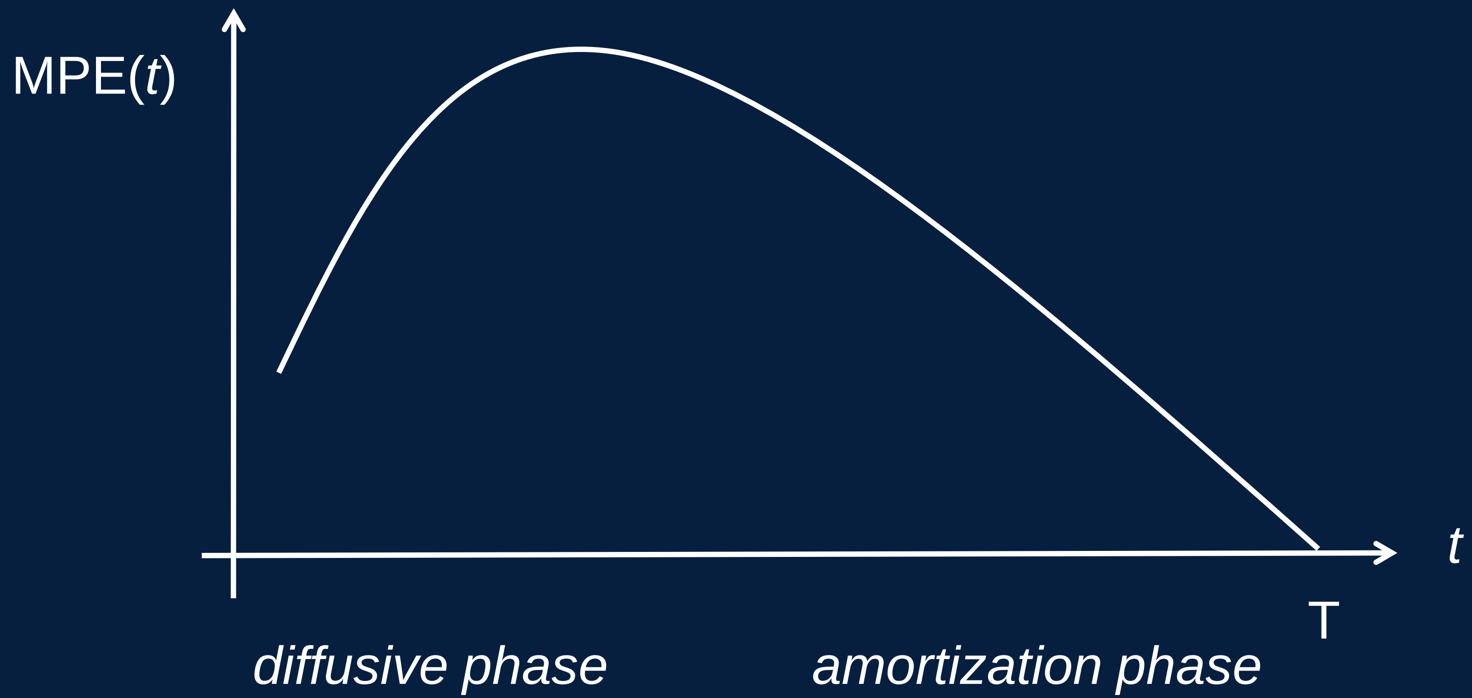
Exposure profile

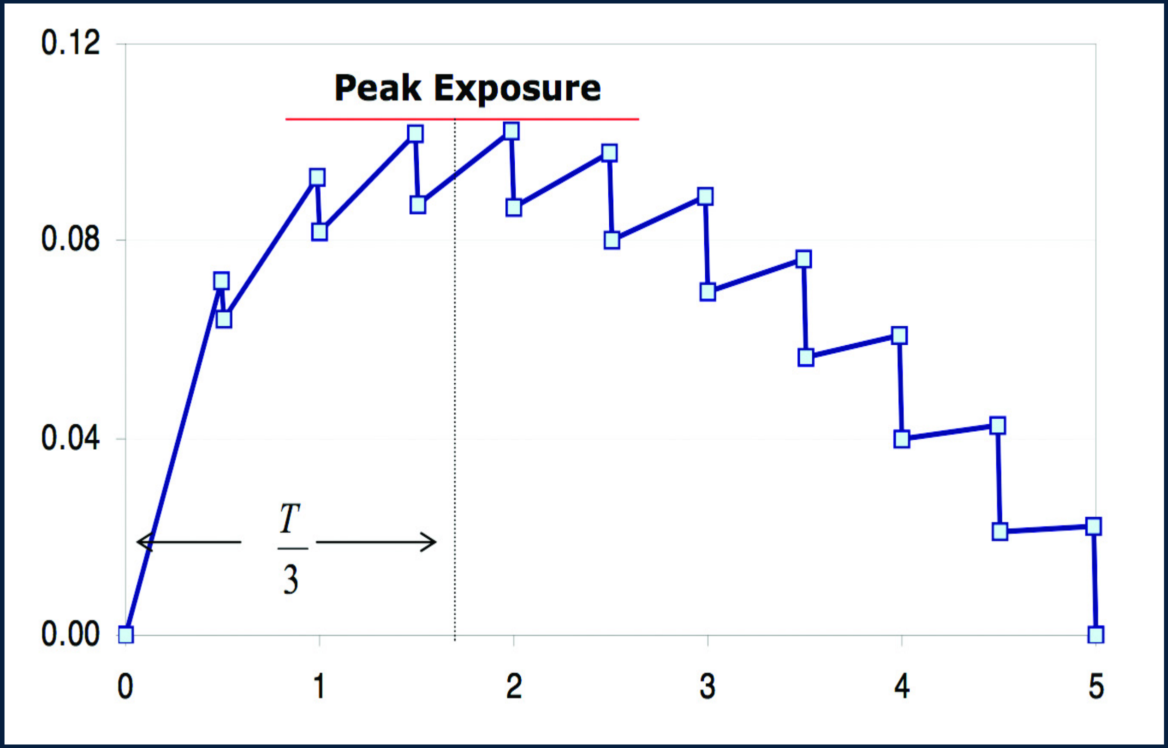


- long remaining maturity
- many remaining CFs
- sensitivity to market uncertainty

- short remaining maturity
- few remaining CFs
- little sensitivity to market uncertainty

Exposure profile - example

IR swap



Mitigating CP risk (2) – margin agreements

A margin agreement is a contract that requires one or both counterparties to post collateral when the uncollateralized exposure exceeds a threshold.

Residual CP risk remains („gap risk") because:

- Threshold is non-zero
- Finite time („margin period of risk" ~2weeks) needed to
  1) initiate margin call,
  2) CP to pose additional collateral
  3) liquidate position and rehedge
- Market can jump (crash) within this time

Mitigating CP risk (3) – downgrade triggers

A downgrade trigger is a close stating that if the credit rating of the CP falls below a certain level, than the Bank has the option to close out the derivatives contract at M2M.

Residual CP risk remains because:

- The CP may have downgrade triggers with many other banks thus its downgrade may trigger simulataneous sell-offs („crowded market”) leading to falling market (gap risk)
- Downgrading depends on rating agencies
- Client relationship issues

Enron defaulted in Dec 2001. It was not downgraded until the very last moment, becase downgrade triggers at BBB- were defined in many of its derivatives contracts. Premature downgrading would have killed it immediately, even if had had a chance to survive otherwise.

Mitigating CP risk (4) – central counterparties

Central counterparties (CCP) would provide broader and more effective netting as well as daily marking-to-market and margining. Banks would face the CCP as opposed to each other and the CCP would be sufficiently capitalized and would impose sufficiently strict margin requirements to eliminate counterparty risks to a large extent. CCPs will also lead to more standardization of derivatives over time.

E.g., CCPs for CDS:

ICE Trust, LCH.Clearnet, Eurex, …

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Valuating counterparty credit risk

Credit valuation adjustment (CVA) is the difference between the risk-free portfolio value and the true portfolio value that takes into account the possibility of the counterparty's default.

CVA is the market value of counterparty credit risk.

CVA valuation

If we knew the time of default, the discounted loss would be

$$L = (1 - R_C) D(\tau) E(\tau)$$

loss

random variable

recovery

discount factor

exposure

random variable

CVA valuation

Unilateral CVA is the risk-neutral expectation of the discounted loss

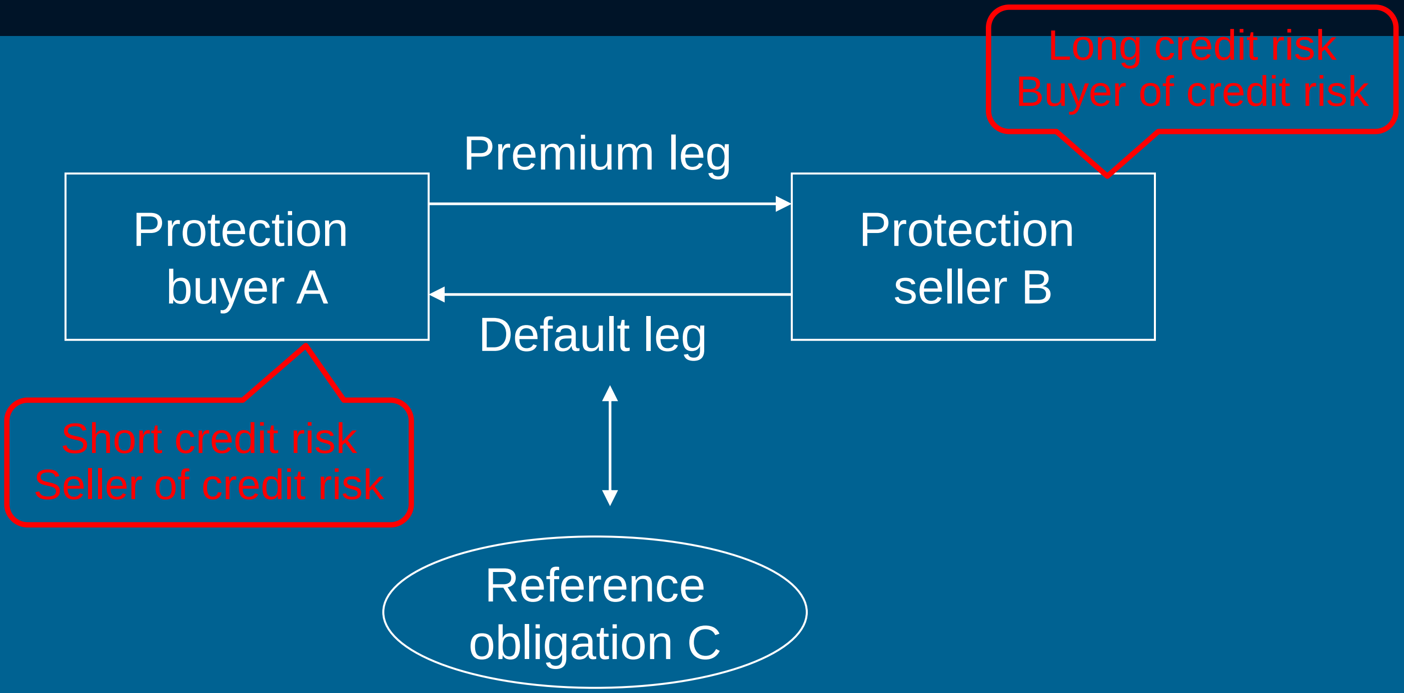
$$\text{uCVA} = \mathbf{E}^{Q} L = \mathbf{E}^{Q} \int_{0}^{T} (1 - R_C) D(\tau) E(\tau) p_C(\tau) d\tau$$

risk neutral expectation

default time pdf of counterparty C

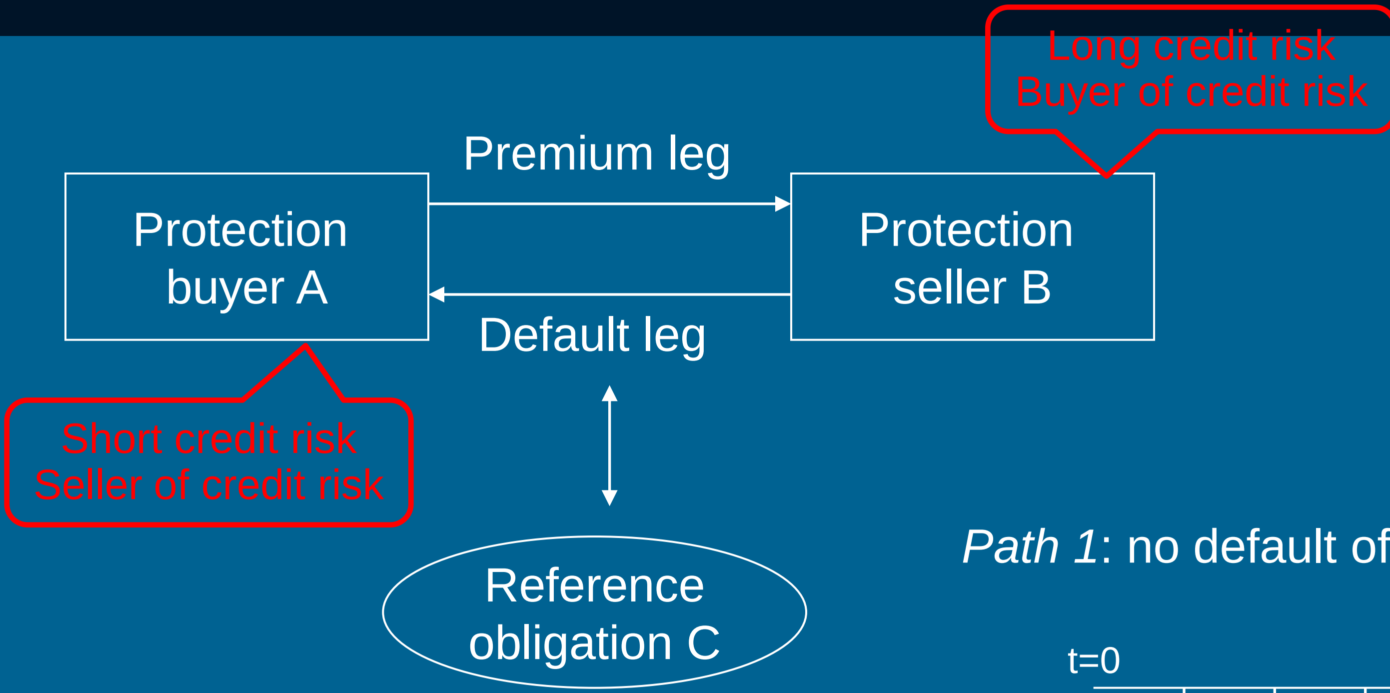
Can be computed from the CDS term structure of C

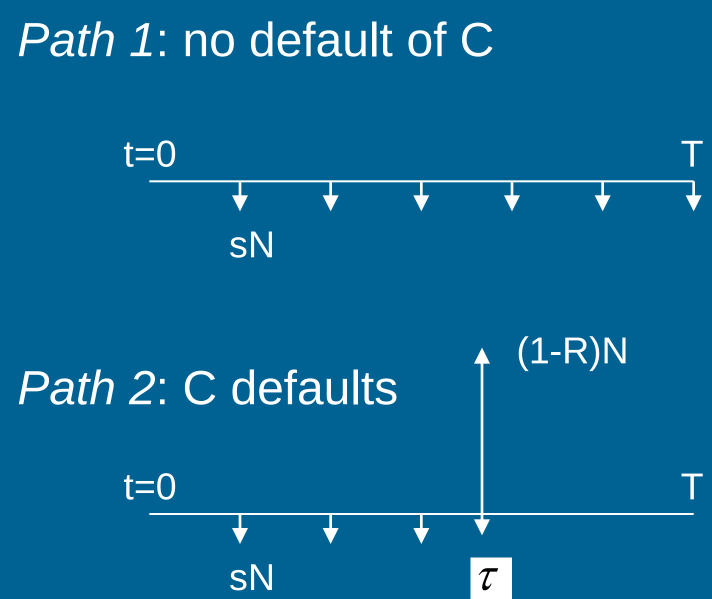
CDS - Kinetics



N – notional [$]
s – spread [bps/year]
R – recovery [1]
T – maturity [year]

CDS - Kinetics





N – notional [$]
s – spread [bps/year]
R – recovery [1]
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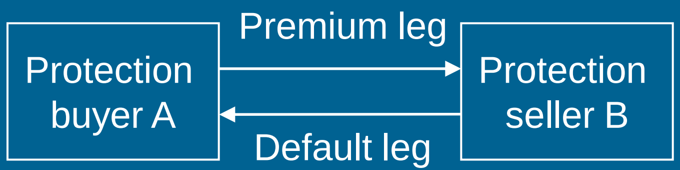
CDS – Constant hazard rate (toy) model



- Default intensity h=const
- Continuous premium payment
- Fixed recovery
- Const interest rate

Default probability

$$P(t<\tau<t+\Delta t)=\underline{e^{-ht}}\cdot\underline{h\Delta t}$$

$h\Delta t$ → defaults in interval

e^{-ht} → survives up to t

Default leg

$$\text{DefPV}=N\int_0^T e^{-rt}\cdot\underline{(1-R)e^{-ht}hdt}$$

→ expected default payment at t

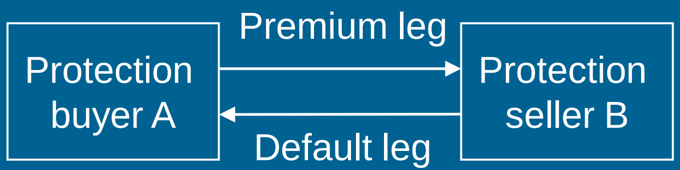
Premium leg

$$\text{PremPV}=N\int_0^T e^{-rt}\cdot\underline{se^{-ht}}\,dt$$

→ expected premium payment at t

$$\text{PremPV}_1=N\int_0^T e^{-rt}\cdot e^{-ht}\,dt$$

CDS – a more general model



- Default intensity h=const
- Continuous premium payment
- Fixed recovery
- Const interest rate

Default probability pdf

$$\mathrm{P}(t < \tau < t + \Delta t) = p(t)\Delta t$$

Δt → defaults in interval

$p(t)$ → survives up to t

Default leg

$$\mathrm{DefPV} = N(1-R)\int_0^T e^{-rt} \cdot p(t)dt$$

$e^{-rt} \cdot p(t)dt$ → expected default payment at t

Premium leg

$$\mathrm{PremPV} = Ns\int_0^T e^{-rt} \cdot (1-P(t))dt$$

$(1-P(t))$ → expected premium payment at t

$$\mathrm{PremPV}_1 = N\int_0^T e^{-rt} \cdot (1-P(t))dt$$

$$\mathrm{P}(\tau < t) = P(t) = \int_0^t p(t')dt'$$

default probability

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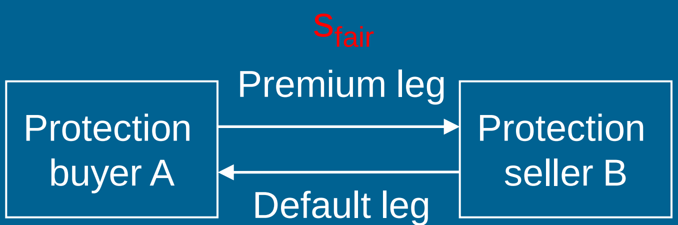
CDS – Fair spread

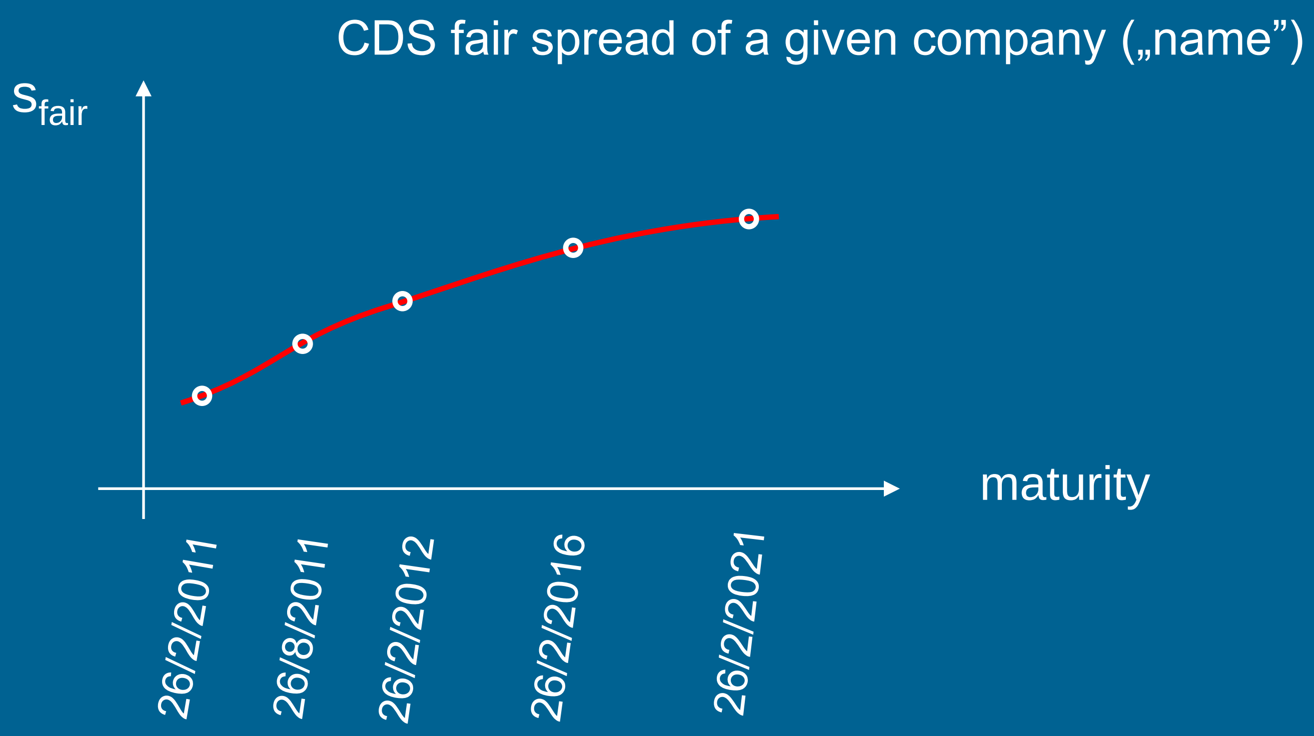


The <u>fair spread</u> s_{fair} makes the contract worth 0

$$\text{DefaultPV} = s_{fair} \cdot \text{PremPV}_1$$

$$s_{fair} = \frac{\text{DefaultPV}}{\text{PremiumPV}_1} = (1 - R)h$$

CDS - Term structure

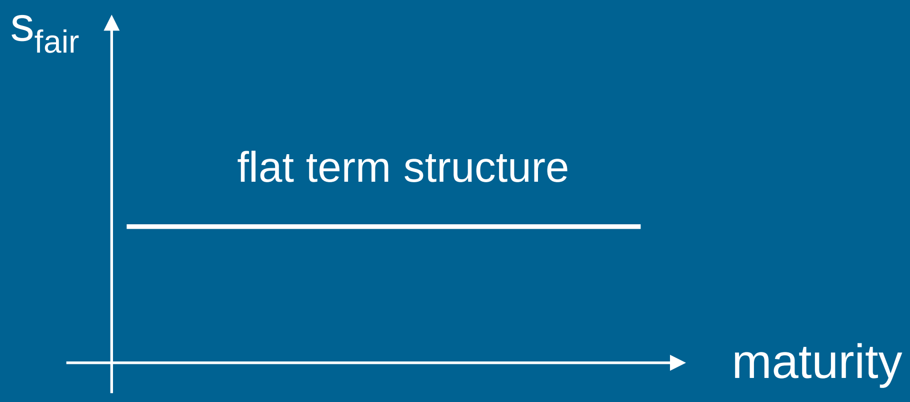


CDS - Term structure

Simple model:

$$s_{fair} = (1-R)h$$

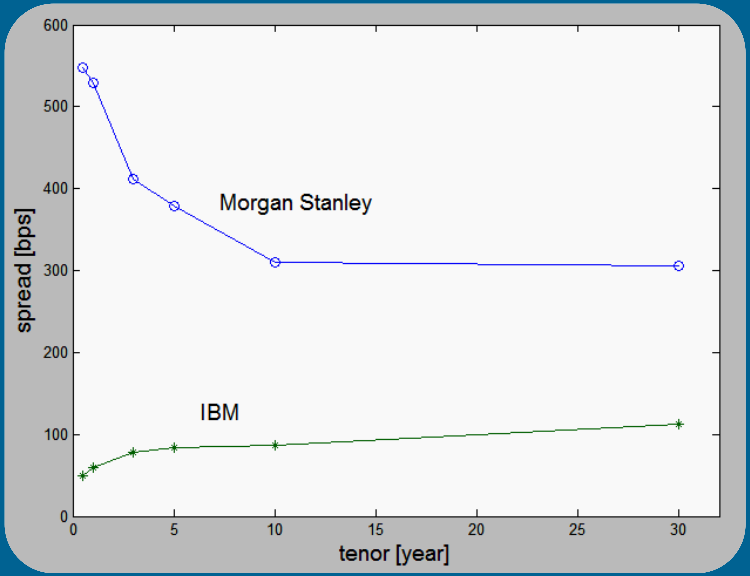
Does not depend on maturity T



Market term structure of CDS spreads on 26/2/2009

⇩

Default intensity is time dependent



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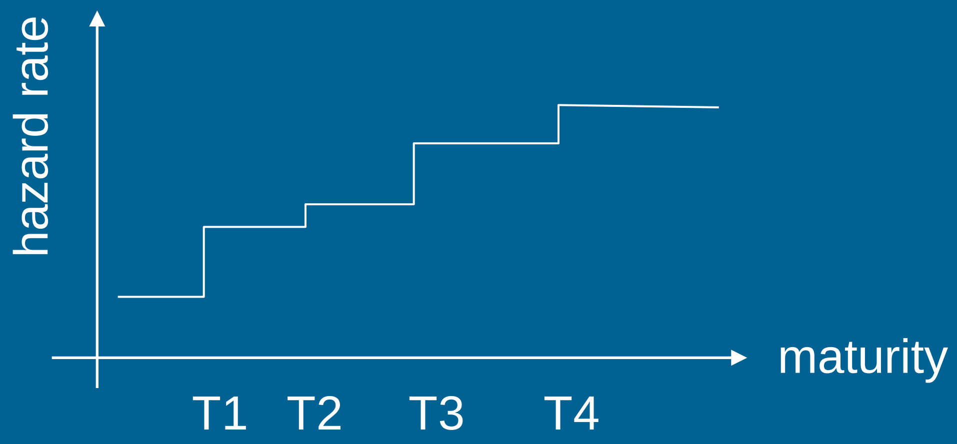
CDS - Calibration



Piece-wise constant hazard rate model can be calibrated to market term structure by bootstrapping

$$\{s_1, s_2, ..., s_T\} \rightarrow h_1 \rightarrow h_2 \rightarrow ... \rightarrow h_T$$

CDS - Calibration

Piece-wise constant hazard rate model can be calibrated to market term structure by bootstrapping

$$\{s_1, s_2, \ldots, s_T\} \rightarrow h_1 \rightarrow h_2 \rightarrow \ldots \rightarrow h_T$$

The survival probability follows:

$$\mathrm{P}(\tau < t) = P(t) = e^{-h_1 T_1} e^{-h_2 (T_2 - T_1)} \ldots e^{-h_N (t - T_{N-1})}$$

CVA valuation

Unilateral CVA is the risk-neutral expectation of the discounted loss

$$\text{uCVA} = \mathbf{E}^Q L = \mathbf{E}^Q \int_0^T (1 - R_C) D(\tau) E(\tau) p_C(\tau) d\tau$$

risk neutral expectation

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CVA valuation

$$\text{uCVA} = \mathbf{E}^Q L = \mathbf{E}^Q \int_0^T (1 - R_C) D(\tau) E(\tau) p_C(\tau) d\tau$$

In general, R_C, *D, E, and* p_C can correlate

Especially:

if corr(E, p_C)>0 this is called wrong-way risk

if corr(E, p_C)<0 this is called right-way risk

Wrong-way / right-way risk

Wrong-way risk

- Typical if V(t)>>0 („out-of-the-money risk”). CP has huge liability thus high probability to default.
- Bank enters a swap with an oil producer (CP) where Bank receives fixed and pays floating crude oil price
- Bank buys credit protection on an underlying reference entity whose credit quality is positively correlated with that of CP
- Bank selling CDS (selling protection) on its own name

Right-way risk

- Bank enters a swap with an oil producer (CP) where Bank pays fixed and receives the floating crude oil price
- Bank sells credit protection on an underlying reference entity whose credit quality is positively correlated with that of CP
- Bank selling call options on its own stock

CVA – decoupling case

Calculation simplifies when correlations can be neglected

$$\mathrm{uCVA} = \mathbf{E}^Q L = \mathbf{E}^Q \int_0^T (1 - R_C) D(\tau) E(\tau) p_C(\tau) d\tau$$

$$= (1 - R_C) \int_0^T \mathrm{MPE}(\tau) p_C(\tau) d\tau$$

$$\approx (1 - R_C) \sum_{i=1}^{N} \mathrm{MPE}(t_i) P_C[t_{i-1}, t_i]$$

Bilateral CVA

By now bilateral CVA (aka. CVA, simply) is the industry standard.
For the uncorrelated case:

$$\mathrm{CVA} = (1-R_C)\int_0^T \mathrm{MPE}(\tau)\, p_C(\tau)\, d\tau - (1-R_B)\int_0^T \mathrm{MNE}(\tau)\, p_B(\tau)\, d\tau$$

„unilateral CVA"
or
„asset CVA"

DVA
or
„liability CVA"

CVA = Credit Valuation Adjustment
DVA = Debt Valuation Adjustment

Literature

- M. Pykhtin and S. Zhu, A Guide to Modelling Counterparty Credit Risk, GARP Risk Review,July–August 2007

- *E. Canabarro,* Pricing and Hedging Counterparty Risk, *Counterparty Risk, Risk Books, 2010*