Counterparty Credit Risk and Exposures

QF622 Credit Risk Models

Nanfeng SUN

2024

Table of contents

Key Concepts

Definition and Sources

Counterparty credit risk is the risk that the entity with whom one has entered into a financial contract will fail to fulfil their side of the contractual agreement.

It typically arises from two broad classes of financial products:

1. OTC derivatives including interest rate swaps, FX forwards, and credit default swaps.
2. Securities financial transactions, including repos / reverse repos and securities borrowing / lending.

CCR vs. lending risk

Lending risk

- The notional at risk is known at any time during the lending period with a degree of certainty. Market variables such as interest rate levels only create moderate uncertainty.
- The risk is unilateral, i.e., the lender is exposed to the default of the borrower.

Counterparty credit risk

- The value of the contract is significantly uncertain and driven materially by market variables.
- The risk is bilateral, e.g., a seasoned interest rate swap could be either in the money or out of the money, with the potential to create exposure to both parties.

CCR – market risk vs. credit risk

CCR represents a combination of

1. market risk, which defines the exposure at default (EAD), and
2. credit risk, which defines the counterparty credit quality, e.g., probability of default (PD) and loss-given-default (LGD).

- A counterparty with a high PD and a low EAD may be considered preferable to one with a low PD but a high EAD.
- Credit value adjustment (CVA) is a measuring metrics which combine the two.
- Credit risk risk-weighted asset (RWA) also measures the combined effect of the two.

CCR – settlement risk vs. pre-settlement risk (I)

Settlement risk

This risk arises at settlement times (especially at maturity date) due to timing differences between counterparties when each performs its obligation.

Pre-settlement risk

The risk that a counterparty may default before the final settlement of the transaction. Nowadays this term is used interchangeably with counterparty credit risk.

CCR – settlement risk vs. pre-settlement risk (II)

Example

Say counterparties A and B enter into an FX forward contract to exchange \$11m for £10m at a future time.

Settlement risk

exposes counterparties to a substantial loss of either \$11m or £10m, i.e., the full principal amount, at the maturity of the contract.

Counterparty credit risk

exposes counterparties to the market value of the contract driven by GBP/USD during the lift of the contract but is milder in magnitude.

Components – credit exposure

Credit exposure is the loss in the event of a counterparty default.

- A positive value of the contract corresponds to a claim on the defaulted counterparty.
- A negative value is a liability that still needs to be honoured.
- Exposure is always conditional on counterparty default. What's the implication?

Exposure is time-dependent. Essentially, we need to answer:

1. What's the exposure if the counterparty defaults today?
2. What's the exposure in the future?

Components – credit default, migration, and loss-given-default

- Credit quality of the counterparty must be considered over the entire lifetime of the contract.
- Term structure of the default probability is crucial as exposure is time-dependent and conditional on default.
- The annual default rate will trend up if the counterparty has a negative outlook and vice versa.
- Loss-given-default (LGD) is directly related to the recovery rate, i.e., LGD $= 1 - \pi$.
- Holders of OTC derivatives with a defaulted counterparty normally enjoys the same seniority with senior bondholders.

Should we use risk-neutral or historical PDs?

Components – mitigants

- Netting: Offset positive and negative contract values with the same counterparty. It reduces exposure at the counterparty level. Question is whether the netting agreement could be enforced in the relevant jurisdiction.
- Collateral: Holding cash and liquid securities posted by the counterparty reduces exposure. Collateral management could get very complex and whether the collateral may be liquidated quickly is a question.
- Central clearing: Replace bilateral trades with cleared trades by facing a central counterparty. How about systemic risk?
- Hedging: How effectively could CVA risk be hedged?

Market participants – types of counterparties (I)

Major dealers

- A small number of global banks with international footprints with a large book of derivatives.
- Deal in (almost) all asset classes and are members of major exchanges and CCPs.
- Collateralise exposures with their peers.

Medium-sized players

- Smaller / regional banks or other financial institution with significant OTC derivatives activities.
- Deal in a restricted range of products or markets and are members of local exchanges and CCPs.
- Collaterialise exposures with other players.

Market participants – types of counterparties (II)

End users

- Corporates, sovereigns, supranational entities, or smaller financial institutions.
- Deal in a more restricted range of products with more directional exposure to market risk.
- Less willing to post but may demand receiving collaterals.

CCPs

- Intermediaries between market players running a matched book without market risk exposure.
- Clear vanilla OTC derivatives, such as interest rate swaps, cross currency swaps, etc.
- Collaterialise exposures with their members.

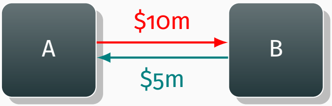
CCR Mitigation

Netting of payments (I)

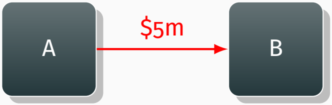
Payment netting involves the netting different payments between two counterparties denominated in the same currency.

- Payments could be from the same transaction, e.g., fixed and floating payments falling on the same day.
- Payments could also be from multiple transactions.

Without payment netting



With payment netting



Netting of payments (I)

Benefits of payment netting

- Reduces operational costs (and risk) associated with making payments.
- Reduces the amounts to pay by both parties.
- Reduces counterparty credits risk and liquidity risk.

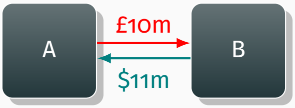
Bilateral portfolio compression

- Payment netting could be extended to reducing the number of transactions between two parties.
- This is by removing bilateral offsetting positions.
- Net exposure remains the same buy gross exposure could be reduced.

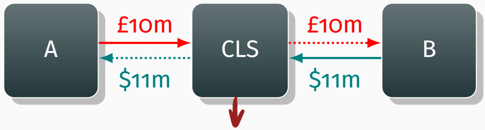
Currency netting

Payment netting is usually for single currency only. Exchanges of different currencies are still subject to gross risk exposure. This is addressed by the continuous linked settlement service (i.e., payment versus payment, or PvP). Through an intermediary, payments are only received once both parties have made them.

Without payment netting



With payment netting

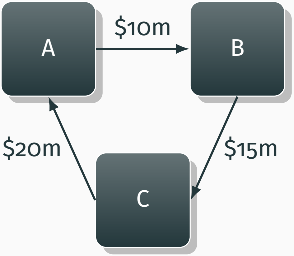


earns from remittance

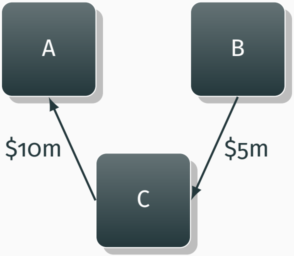
Portfolio compression (I)

On top of bilateral netting, it is possible to further reduce cashflow payments through multi-lateral netting. This could be achieved through portfolio compression.

Without payment netting



With payment netting



Portfolio compression (II)

Portfolio compression could preserve market risk positions while reducing outstanding counterparty credit risk. It relies on counterparties being of comparable credit quality.

1. Participants submit transactions. (How standard are these?)
2. Transaction details are matched.
3. An algorithm is run to determine changes to generate netting benefits, keeping each participant's mark risk positions unchanged. (Subject to constraints specified by participants.)
4. Executing changes by unwind, novation, or entering into new transactions.

Close-out netting (I)

payment netting ≠ closeout netting

Close-out netting aims to minimise counterparty credit risk across a portfolio of transactions with a defaulted counterparty. It could be achieved through contractual terms to facilitate a timely termination and settlement of net value of all transactions with a defaulted counterparty.

Close-out The right to terminate transactions with the defaulted counterparty and cease any contractual payments.

Netting The right to offset the value across transactions and determine a net balance as the close-out amount.

ISDA's master agreement supports close-out and netting, which is legally enforceable in major jurisdictions.

Close-out netting (II)

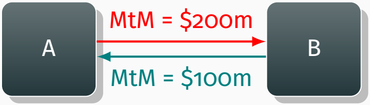
Example

Assuming that there are two transactions between counterparties A and B. They have close-out netting agreement in place.

- If A defaults, B is able to close both transactions and make a bankruptcy claim for $100m against A.
- If B defaults, A is able to close both transactions and make a payment of $100m to B.

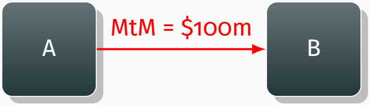
closeout

Without netting



(even if there is payment netting)

With netting



Collateral – fundamentals

Terminology

- Collateral is conventionally used in the OTC derivatives market..
- Margin is conventionally used in the exchange-traded markets.
- Post-GFC, thanks partially to the regulatory reforms, market participants are converging to the term margin.

Basic mechanisms

- In exchange-traded markets, margining represents daily settlement of the value of a transaction.
- For OTC derivative markets, margining is the exchange of cash or securities to reduce CCR.

Collateral – mortgage as a collateralised lending

A bank faces default risk when lending to a home buyer and hence demand the house as a collateral for risk mitigation. However, this risk is not fully neutralised.

- The house may depreciate in its value, e.g., negative equity. This is market risk.
- The bank may not be able to take ownership of the house in the event of default. This is legal and operational risk.
- The bank may not be able to sell the house at market price without discount in the event of default. This is liquidity risk.
- The house value and the default probability may be correlated, e.g., in an economic downturn, high unemployment may lead to default with a falling house price. This is wrong-way risk.

Variation margin (I)

Unlike the traditional collateralised lending, for OTC derivatives,

1. the uncollateralised exposure may increase or decrease during the life of the transaction, and
2. collaterals are not just posted once at the inception of the transaction.

- The “variation” nature of the uncollateralised exposure gives rise to the concept of variation margin (VM).
- VM is exchanged between two parties on a frequent basis.
- The amounts of these exchanges are determined by the net value of transactions between the two parties.

Variation margin (II)

A stylistic example

Say at t_0, A and B enter into an interest rate swap at par with notional of $10m, with A paying a floating rate for a fixed rate.

Time	Interest rate	MtM (for A)	MtM (for B)	VM Posting
t_0	-	$0	$0	-
t_1	increases	-$2,000	$2,000	A pays B $2,000
t_2	increases	-$3,000	$3,000	A pays B $1,000
t_3	decreases	-$1,500	$1,500	B pays A $1,500
t_4	decreases	$1,000	-$1,000	B pays A $2,500

Margin period of risk

The exchange of VM significantly reduces but does not neutralise CCR. In an actual default scenario, the VM may be insufficient to cover the cost to the surviving counterparty:

1. the inherent delay in the process between the time the party last posted margin and the time they were declared in default;
2. the associated costs in replacing and re-hedging the positions with the defaulted counterparty.

The margin period of risk (MPoR) is the period from the last successful margin call in advance of the eventual default to the time when the amount of loss becomes known.

e.g. last VM @ t_4, default @ t_5,
∝ VM insufficient to cover

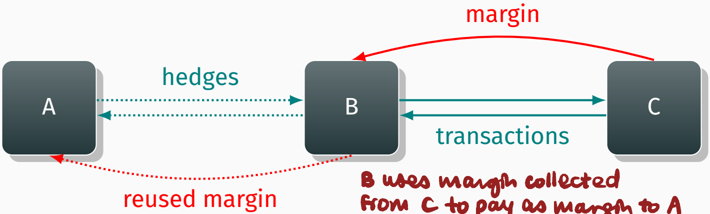
Initial margin

- Initial margin (IM) could mitigate the CCR over the MPoR.
- IM has been common for exchange-traded markets or CCPs.
- It used to be known as independent amount in the OTC derivatives markets and was historically rare.
- With post-GFC regulatory reforms, the posting of IM has become much more common in bilateral OTC markets.
- Conceptually, IM is akin to a value-at-risk measure, i.e., the worst loss with a confidence level over the MPoR.

Rehypothecation and segregation

Rehypothecation

The right to reuse margins received. It is natural for VM which covers the change in valuation (similar to an actual amount owed). It increases CCR but reduces funding costs.



B uses margin collected from C to pay as margin to A instead of paying w its own funds (reduced funding costs)

Segregation

Margin posted is legally protected if the receiving party defaults. IM represents extra collateral not owed and is usually segregated. It reduces CCR but increases funding costs.

The credit support annex

Within an ISDA Master Agreement, it is possible to append a credit support annex (CSA), which is essentially a margin agreement. Within the CSA, two parties can negotiate over a number of key parameters including:

- methods and timing of underlying valuations
- mechanics and timing of margin transfers
- eligible collateral (currencies of cash and types of securities) and haircuts
- remuneration of margin posted
- possible hypothecation of margins
- any initial margin amount
- triggers that may change the margining conditions

Types of CSA

No CSA

A typical example is the relation between a bank and a corporate. The corporate is not able to manage the liquidity needs and the operational cost associated with frequency margining.

Two-way CSA

This is the typical inter-bank arrangement, where two banks post margin to each other with zero thresholds.

One-way CSA

This could be the relationship between a bank and a sovereign or a supranational entity. The latter has a triple-A credit rating, is unwilling to post margin but demands margin from the bank.

Margin types and haircuts

Eligible assets admissible as margin are specified in the CSA.

- Cash is the major form of margin, followed by government securities.
- For margins with a price volatility and FX risk, a haircut is applied as a discount to the value of the asset.

Points to note:

- time taken to liquidate the asset
- volatility of the asset
- default risk of the asset
- wrong-way risk arising from the collateral

Thresholds

The threshold is the amount below which margin is not required.

- When portfolio value is below the threshold, no margin could be called.
- When portfolio value is above the threshold, only incremental value above the threshold may be called.
- Leads to portfolio being under-collateralised.
- Increases CCR but reduces operational costs.
- Zero thresholds are typical for inter-bank CSAs while infinite threshold appears in one-way CSAs.

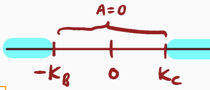
Minimum transfer amount

The minium transfer amount (MTA) is the smallest amount of margin that can be transferred.

- Reduces the operational costs of frequency transfers of insignificant amounts, especially for non-cash margin.
- Additive with threshold, i.e., margin is only posted when exposure exceeds the sum of threshold and minimum transfer amount.

Credit support amount

Credit support amount is the margin that may be called at a given time. For VM, given the portfolio value of V for party B, threshold of K_B for party B, threshold of K_C for party C, the credit support amount for party B is



amount of margin held by party B known as credit support balance

$$A = \max(V - K_C, 0) - \max(-V - K_B, 0) - C$$

non-zero and positive only when $V > K_C \geq 0$

non-zero and positive only when $-V > K_B \geq 0$

- $A > 0 \quad \Rightarrow \quad$ call margin if over the MTA. (C pay margin to B)
- $A < 0 \quad \Rightarrow \quad$ post margin if over the MTA. (B pay margin to C)

Credit support amount – examples (I)

	t_1	t_2	t_3
value V	\$12m	\$10m	\$11m
credit support balance C	\$0m	\$9m	\$7m
credit support amount A	\$9m	-\$2m	\$1m
margin posted / received	\$9m	-\$2m	\$0m

max(10-3,0) - max(-10-3,0) - 9
= 7 - 0 - 9
= -2

With a threshold of \$3m and an MTA of \$2m,

- At time t_1, the portfolio is under-collateralised by \$3m.
- At time t_2, even though the portfolio is already under-collateralised by \$1m, \$2m needs to be returned.
- At time t_3, the credit support amount is below the MTA and no margin is called.

Credit support amount – examples (II)

		t_1	t_2	t_3
Scenario 1	value	\$9m	**\$10m**	**\$12m**
	credit support balance	\$0m	\$9m	\$9m
	margin posted / received	\$9m	\$0m	\$3m
Scenario 2	value	\$12m	**\$10m**	**\$12m**
	credit support balance	\$0m	\$12m	\$10m
	margin posted / received	\$12m	-\$2m	\$2m
Scenario 3	value	\$11m	**\$10m**	**\$12m**
	credit support balance	\$0m	\$11m	\$11m
	margin posted / received	\$11m	\$0m	\$0m

With a zero threshold and an MTA of \$2m, the same value at t_2 and t_3 but completely different margin scenarios at t_3.

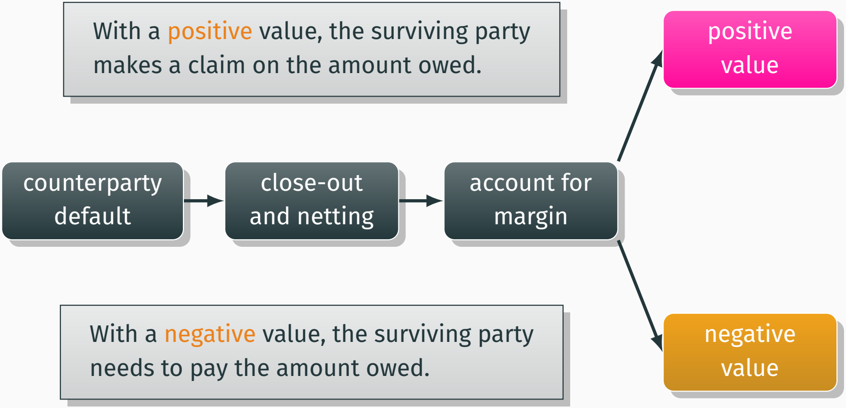
Revisting the mortgage analogue

What are the equivalent risk scenarios in the world of OTC derivatives?

- The house may depreciate in its value, e.g., negative equity. This is market risk.
- The bank may not be able to take ownership of the house in the event of default. This is legal and operational risk.
- The bank may not be able to sell the house at market price without discount in the event of default. This is liquidity risk.
- The house value and the default probability may be correlated, e.g., in an economic downturn, high unemployment may lead to default with a falling house price. This is wrong-way risk.

Credit Exposure

Asymmetric exposure at default



Positive and negative exposures

The asymmetric nature, whereby a party may lose but will not gain if the counterparty defaults, defines counterparty credit risk.

- Positive exposure is defined as $\max(V, 0)$. In A POV: how much A is exposed to B
- Negative exposure is defined as $\min(V, 0)$. In A POV: how much B is exposed to A

From a party's perspective, the former represents its exposure to the counterparty while the latter represents the counterparty's exposure to the said party.

Exposures are directly related to the current and future values of the counterparty portfolio.

Current exposure vs. future exposures (I)

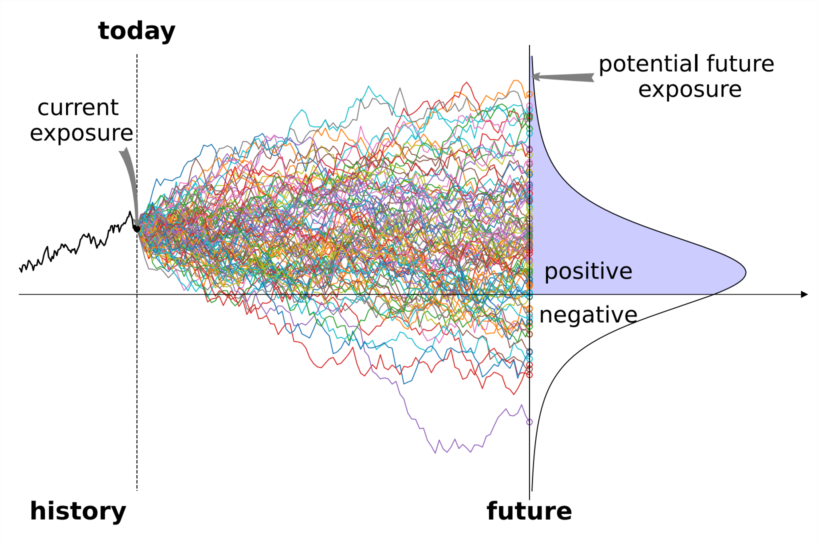
Current exposure

With the current valuation of the counterparty portfolio and the accounting for margin held / posted, the calculation of the current exposure is straightforward. This is known with certainty.

Future exposure

- It is even more important to understand what the exposure may look like in the future.
- The level of future exposure is uncertain, subject to the movements of market risk factors, the contractual features of the transactions, and parameters of the margin agreement.

Current exposure vs. future exposures (II)



Future exposures as a short option

Analogue to options

The combination between a potential downside risk and no upside gain at default is similar to a short option position. It follows that

1. the volatility of the future value (which incorporates market risk factors, portfolio characteristics, and margin arrangements) is an important consideration;
2. quantifying the future exposure of even the most vanilla instruments may be complex.

Future exposures compared to market risk VaR

Similarity with market risk VaR

Market risk VaR models the portfolio loss distribution in the tail (say at the 99th percentile) over a short time horizon (say 1-day). This is similar to the measurement of future exposure for CCR. However,

1. we need to measure future exposures at much longer horizons, where the seasoning of transactions and the "drift" of the portfolio values must be considered;
2. we need to account for risk mitigants, such as netting and collaterals into account.

Expected future value

Expected future value (EFV) is the expectation (or average) of the portfolio value at a given future time. In market risk VaR models, EFV is typically assumed to be the same as the current value.

This assumption does not hold for long time horizons encountered in CCR modelling because

1. the forward values of market risk factors could be different from the their current spots $\Rightarrow$ the drifts matter;
2. the contractual terms of transactions may incorporate cashflow differentials, with the price of these contracts may change without any change in market risk factors $\Rightarrow$ trade seasoning matters.

Future exposure metrics

Potential future exposure (PFE)

The exposure at a given confidence level, e.g., 99th or 97.5th %-tile.

Expected positive exposure (EPE)

The expectation (or average) of all exposures floored at zero.

$$E_t^+ = \mathbb{E}\left(\max\left(V_t, 0\right)\right)$$

This is also known as the expected exposure (EE).

Expected negative exposure (ENE)

The expectation (or average) of all exposures capped at zero.

$$E_t^- = \mathbb{E}\left(\min\left(V_t, 0\right)\right)$$

This is the EPE from the counterparty's point of view.

Future exposure metrics – examples (I)

Discrete future value distribution

Assume at a future time T, the value of a counterparty portfolio could be one of the following five outcomes with equal probability: a) \$5k, b) \$3k, c) \$7k, d) -\$6k, and e) -\$4k.

metrics	calculation	amount
EFV	$(5+3+7-6-4)/5$	\$1k
PFE (max loss)	$\max(5,3,7,-6,-4)$	\$7k
EPE	$(5+3+7+0+0)/5$	\$3k
ENE	$(0+0+0-6-4)/5$	-\$2k

Future exposure metrics – examples (II)

Normal distribution for future value

Assume at a future time T, the value of a counterparty portfolio is normally distributed with mean and standard deviation of $1k.

In this case, $V_T = \mu + \sigma Z$ where $\mu = \sigma = \$1k$ and Z is a standard normal variate.

$\mu - \sigma x > 0$

$x > -\frac{\mu}{\sigma}$

$$\text{EFV} = \mu = \$1k$$

$$\text{PFE}\,(99\%) = \mu + \sigma\Phi^{-1}\,(0.99) = \$3.33k$$

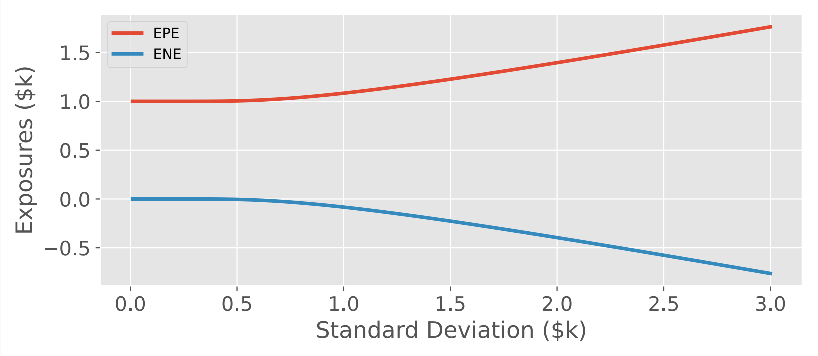
$$\text{EPE} = \int_{-\frac{\mu}{\sigma}}^{+\infty} (\mu + \sigma x)\,\phi(x)dx = \mu\Phi\left(\frac{\mu}{\sigma}\right) + \sigma\phi\left(\frac{\mu}{\sigma}\right) = \$1.08k$$

$$\text{ENE} = \int_{-\infty}^{-\frac{\mu}{\sigma}} (\mu + \sigma x)\,\phi(x)dx = \mu\Phi\left(-\frac{\mu}{\sigma}\right) - \sigma\phi\left(\frac{\mu}{\sigma}\right) = -\$0.08k$$

Future exposure metrics – examples (III)

With the same mean of the normal distribution,

- EFV is a constant, i.e., it is the mean by definition.
- PFE grows linearly as σ increases.
- The magnitudes of both EPE and ENE scale up as σ increases.
- With $\mu > 0$, EPE $\sim$ an ITM option while ENE $\sim$ an OTM option.

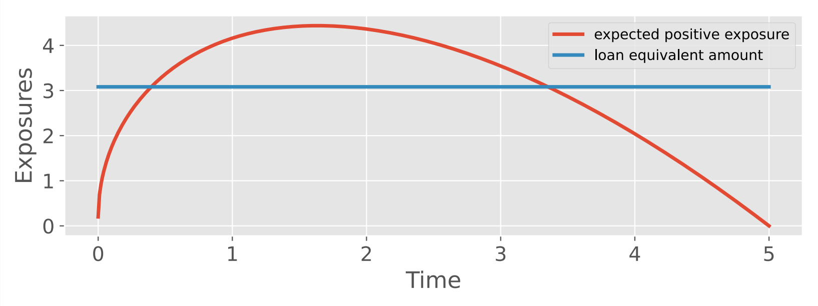


The loan equivalent amount

- What if we need a single number to represent the exposure?
- A rather crude approximation is the time-weight average of EPE, which is a “loan equivalent amount”.

$$\frac{1}{T}\int_0^T E_t^+ dt$$

- An “loan” amount that is effectively made to the counterparty.



Further Reading

1. John Gregory. *Counterparty Credit Risk and Credit Value Adjustment*. Wiley, 2010.

   Chapters 3-5 and 8.