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Market Risk - Measurement and challenges in a negative interest rate environment

XXXV Heidelberg Physics Graduate Days

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Agenda

1. **Motivation** – What is Market Risk?
2. **Risk Factors and Stochastic Models** – Modelling market risk drivers
3. **Measurement of Market Risk** – Value at Risk as a central tool
4. **Negative Interest Rates –** Challenges for Market Risk measurement

Motivation – What is Market Risk?

Market Risk – Definition and Treatment

As the market values of financial instruments depend on market conditions that are of stochastic nature they themselves are stochastic variables and are therefore subject to market risk:

» **Market Risk: Potential losses in the value of financial instruments due to (stochastic) changes in the market conditions.**

Market conditions can be quantified by (or from) quantities that can be **observed** in the market, e.g., exchange rates or equity courses.

The quantities that quantify market conditions are more or less **unpredictable economic variables** Therefore the quantities quantifying the market conditions need to be modelled as **stochastic variables**.

- Interest rate products
- Equity products
- FX products
- Commo-dity products
- Credit products

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Market Risk applies to Financial Instruments

A financial instrument is any contract that gives rise to a financial asset of one entity and a financial liability or equity instrument of another entity. (definition according to **IAS 39.8)**

Simple **classification** of financial instruments according to the **main market risk drivers**:

Interest rate products	Equity products	FX products	Commodity Products	Credit products
• Corporate Bonds • Government Bonds • Swaps • Loans • Bond Options • Swaptions • Caps/Floors • IR Futures • …	• Shares • Equity Options • Index Options • Equity Certificates • Basket Options • ...	• FX Cash • FX Forwards • FX Options	• Crude Oil • Gas Oil • Base Metals • Precious Metals • Coal • Power • …	• Credit Default Swaps • Securitisations • Credit Index Products • Credit Basket Derivatives • ...

Different financial instruments are sensitive to different aspects of market risk.

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Risk Factors and Stochastic Models – Modelling market risk drivers

Quantification of Market Conditions – Risk Factors (1/2)

The **current (market) value** of a financial instrument is subject to **market risk** due to the stochastic nature of the market conditions. On the other hand, once the market conditions are specified / quantified the corresponding current value of financial instruments is fixed. The **pricing functions are deterministic** functions that relate the current market conditions to the current price/value.

Example: Portfolio of 10 Intel Corp. stocks (Sep 27th)

» Price: 19.42 USD

» EUR/USD exchange rate: 1 EUR = 1.3442 USD

» Portfolio-Value:

10 · 19.42 USD / 1.3442 (USD/EUR) = 144.47 EUR

» For the example portfolio above the relevant **market conditions** are specified by the Intel stock price and the USD/EUR exchange rate.

» Stock price and exchange rate are **valuation parameters** for the pricing function.

» Stock price and exchange rate are also the **sources of market risk** for the portfolio and are therefore called **risk factors**.

Risk factors quantify market conditions and are the sources of market risk.

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Quantification of Market Conditions – Risk Factors (2/2)

For **quantitative measurements** of market risk the market conditions need to be formulated in **mathematically tangible quantities** and structures that can be represented by numbers, vectors or arrays. These quantities and structures or their elements are called **risk factors**.

Examples:

» Equity prices: BASF, E.on, Toyota, Pfizer, …
» Exchange rates: EUR/XAU, EUR/GBP, …
» Equity Indices: Dax, MDax, Nikkei 225, …
» Commodity spot prices: Brent, WTI, XAG, …

» **Risk factors** are closely related to the **valuation parameters** of pricing functions (see previous slide).
» Current information about the risk factors can be **extracted from the market** and also historical data is usually available (can be bought).
» From these data **time series** can be constructed that allow the analysis of the risk factor's **stochastic properties**.

Stochastic properties of risk factors are determined from historical time series.

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Risk Factors – Return Types

Usually it is not the risk factors themselves but their **returns** that are **used for market risk calculations** (therefore sometimes the returns are called risk factors). This is because the returns can **usually be better described by basic stochastic processes** than the risk factors themselves and in risk management one is more interested in the changes of quantities than in their absolute values.

A risk factor return r describes the change in a risk factor ρ between two points in time. There are three kinds of returns used for the different risk factors:

» absolute return: $$r_{abs} = \rho_t - \rho_{t_0}$$

» relative return: $$r_{rel} = \left(\rho_t - \rho_{t_0}\right) / \rho_{t_0}$$

» logarithmic return: $$r_{\log} = \ln\left(\rho_t / \rho_{t_0} \right)$$

The **choice** of the return type depends on **characteristics** of the respective risk factor.

Market risk is measured via absolute, relative or logarithmic risk factor returns.

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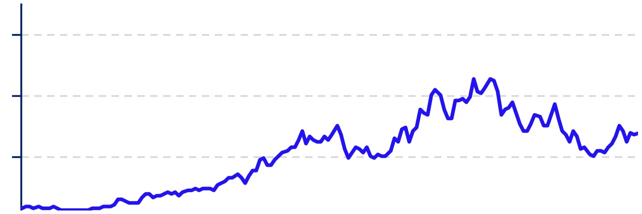
Risk Factors – Stochastic Processes (1/2)

Central Limit Theorem: The sum of identically distributed random variables that are “independent enough” has a **normal distribution.**

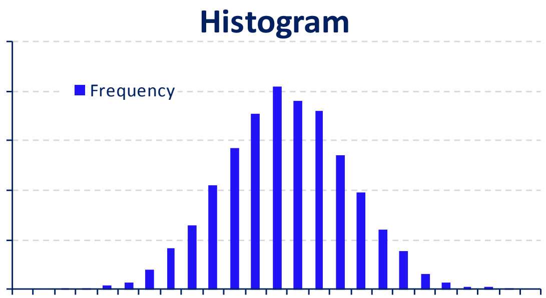
➔ The well known **Wiener process** $\boldsymbol{W(t), t \geq 0}$, is a natural model for the risk factor development over time:

- $W(0) = 0$
- $W(t) - W(s)$ is normally distributed with mean 0 and variance $t - s$
- increments are independent



The latter two properties imply self-similarity of the process, i.e., for infinitesimal time intervals:

$dW \sim X\sqrt{dt}$ with $X \sim N(0,1)$, $\mathrm{var}(dW) = dt$



Wiener processes are standard stochastic processes, commonly used for modelling market conditions.

Risk Factors – Stochastic Processes (2/2)

Usually not the risk factor itself, but a suitable transformation is modelled as a Wiener process.

For equity prices, usually log prices are used, i.e.

$$\ln(\rho_t) = \ln(\rho_0) + \sigma \cdot W_t$$

To reflect the expected rate of return in the process model we add a deterministic drift term:

$$d\ln(\rho_t) = \mu \cdot dt + \sigma \cdot dW$$

i.e., the **discounted price process** is a **martingale**.

Because the **drift** term is deterministic, the increments of the process are still normally distributed with variance $\sigma^2(t-t_0)$ but now the expectation value is $\mu(t-t_0)$.

Drift components in diffusion processes allow to account for expected rates of return.

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Risk Factors – Determining Process Parameters from Time Series

Process Parameters

Based on the assumption of **stationary markets** drift and volatility of the stochastic process can be calculated from time series of the risk factor returns.

$$\mu = E[r_{t/t_0}] \quad , \quad \sigma = \sqrt{\frac{1}{(t-t_0)}\mathrm{var}(r_{t/t_0})}$$

This volatility is the **historical volatility** of the respective risk factor. Besides the historical volatility there is also the **implied volatility**. In contrast to the historical volatility that is calculated from historical data the implied volatility is derived from current market data (e.g. option prices)

StdDev

Mean

date	Dax	r_{log}
24. Sep 10	6.298,30	0,0182
23. Sep 10	6.184,71	-0,00381
22. Sep 10	6.208,33	-0,01084
21. Sep 10	6.275,98	-0,00296
20. Sep 10	6.294,58	0,013567
17. Sep 10	6.209,76	-0,0064
16. Sep 10	6.249,65	-0,00195
15. Sep 10	6.261,87	-0,00216
14. Sep 10	6.275,41	?
13. Sep 10	?	?
10. Sep 10	6.214,77	-0,00109
09. Sep 10	6.221,52	0,009217
08. Sep 10	6.164,44	0,00758
...	...	...

Practical Difficulties – Data Quality

- **Missing data**
  - small gaps: constant/linear interpolation; proxy time series return
  - larger gaps: Brownian Bridge or Expectation Maximization (EM) algorithm
- **Products without available data history**
  - map on suitable existing time series (related product)
  - create synthetic time series with desired volatility and correlation

Market risk calculations are based on historical data.

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Risk Factors – Risk Factor Categories

Risk factors can be divided into groups according to their market risk category:

Interest Rate	(Credit) Spread	FX
Commodity	Equity	Volatility

Within these categories there are still different kinds of risk factors:

- 0-dimensional structures: prices, indices, FX rates
- 1-dimensional structures: interest rate curves, spread curves, commodity forward curves
- 2- or 3-dimensional structures: equity volatility surfaces, FX volatility surfaces, interest rate volatility surfaces (cap/floor 2-dim, swaption 3-dim)

There are different categories and types of risk factors.

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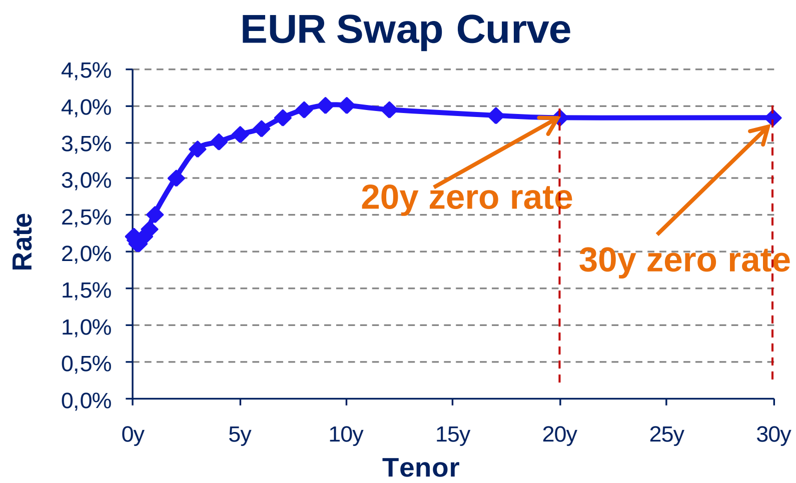
Risk Factors – Interest Rate Curves

The interest rate determines the interest one receives when depositing money in a bank. The rate depends on the time the money is deposited, therefore interest rates have a **term structure**. Another way to look at it is the **time value of money**. One euro today has a different value than one euro received in a year.



Specification requires:

» **Interpolation method**: e.g., linear on discount factors, ...

» **Day count convention**: A/360, Act/Act, ...

» **Business Day Convention**: preceding, ...

» **Compounding**: continuous, 3m, 6m, ...

There are different kinds of interest rate curves depending on the referenced entity:

» **Government curves**: Germany, France, UK, US, …

» **Swap curves**: EUR, USD, GBP, JPY, …

Depending on the properties of the financial instruments they are constructed from Government and Swap curves can be further differentiated (see next slide).

Risk factors

Interest rate curves are usually defined as array of zero rates (marker on diagram curve) for a fixed grid of tenors. The zero rates per tenor can be used as risk factors for the rate curve (generate time series for each tenor from daily observation).

Interest rate curve: simple concept, complex in practice.

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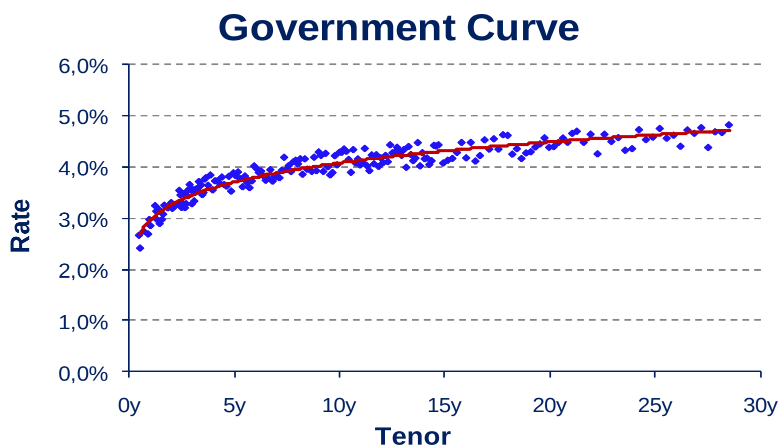
Risk Factors – Interest Rate Curves

Construction of Interest Rate Curves

Government curves

A government curve is constructed from the prices of government bonds. It can be calculated as regression curve through the available data but often also parametric forms are used.



There are also special government curves that are constructed from government bond futures (Germany: Bund, Bobl, Schatz) only.

Swap curves

During the recent financial crisis the classification of swap curves has been further differentiated. Now banks use several swap curves for the same currency depending on the instruments they are constructed from.

Swap curves are constructed via **bootstrapping** from different instruments:

- » short end: deposits, FRAs, futures, EONIAs
- » long end: swaps

Today the **different degree of credit risk and liquidity** of the different instruments can no longer be neglected in the construction of rate curves. The same holds for basis risks between swap tenors.

Interest rate curve construction has become more complex during the financial crisis.

Risk Factors – Spread Curves

Spread

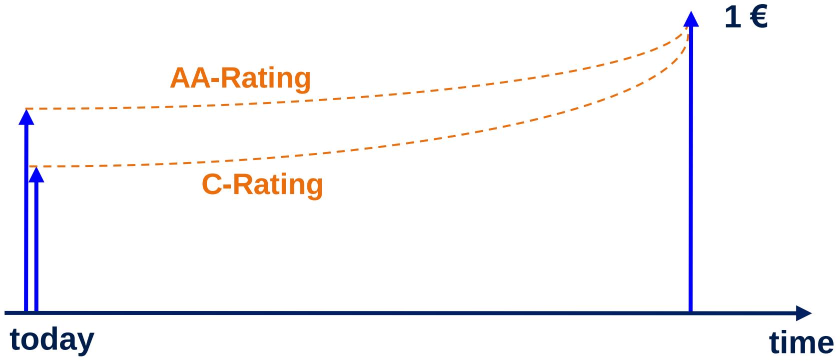
Creditworthiness and Spread Curves

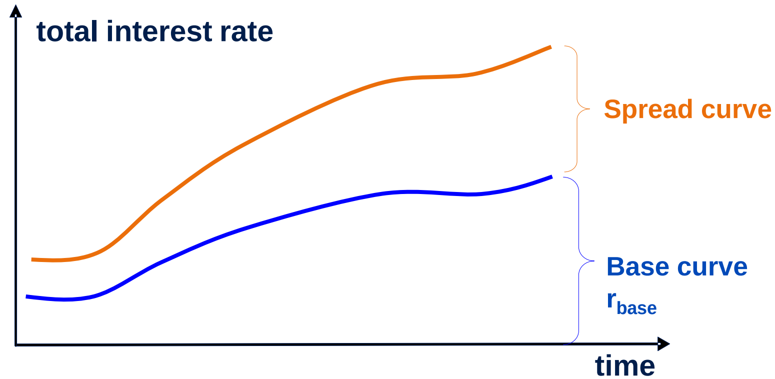
The value of financial instruments and contracts depends on the **creditworthiness** of the issuer or counterparty. This is reflected in the time value of money. 1 euro due in one year from a AA-rated company is worth more than 1 euro due in one year from a C-rated company.

To reflect the creditworthiness of issuers and counterparties in valuation and risk measurement of financial instruments **individual rate curves** are necessary. On the other hand risk management usually wants to **separate risk contributions** of interest and creditworthiness.

Therefore one introduces so called **spread curves** that measure the spread between a common base curve (e.g. swap curve) and the issuer/counterparty specific curve.

Market risk accounts only for the **change in spread levels** but **not for defaults or rating migrations**!



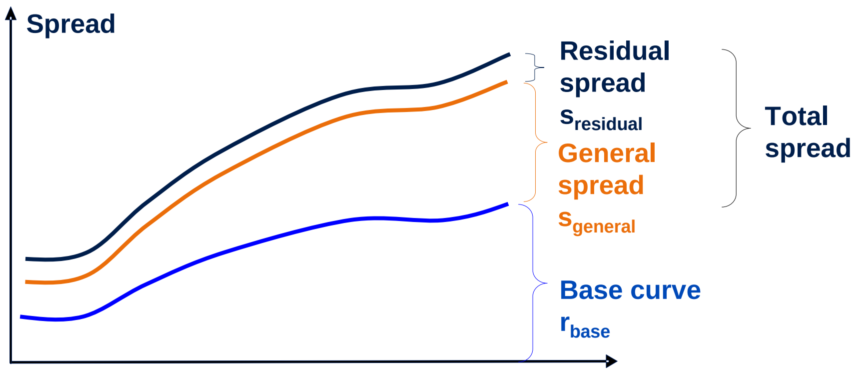


Spread curves reflect the creditworthiness of the issuer/counterparty.

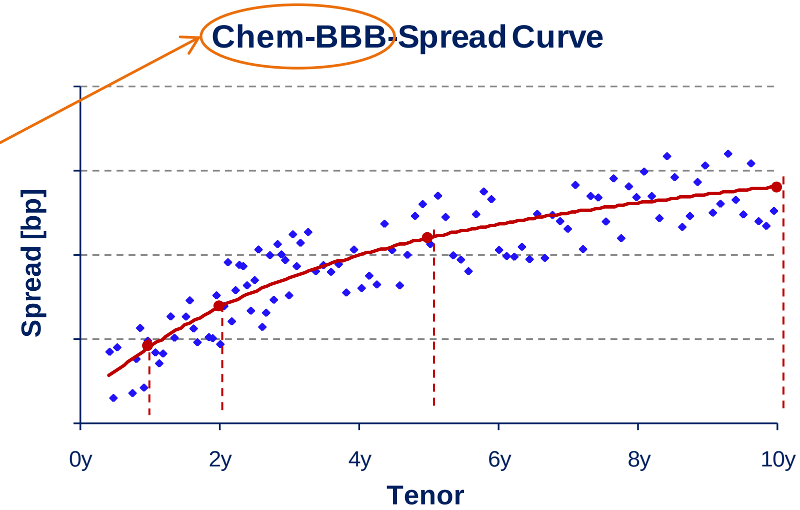
Risk Factors – Spread Curves

Spread Curve Construction (Bonds)

In **practice** one often **lacks** the **data** to generate individual spread curves for each address. Instead general spread curves (per sector/rating) with a residual spread are used.



$$r_{total} = \underbrace{r_{base} + s_{general}}_{\text{systematic}} + \underbrace{s_{residual}}_{\text{idiosyncratic}}$$



Spread Curve Risk Factors

- In analogy to the case of interest rate curves spreads for individual tenors are used as risk factors for the general (sector/rating) spread curves.
- The residual spreads are usually modelled as single risk factor.
- For CDS often issuer specific spread curves are used.

Spread curves can be separated into systematic and idiosyncratic parts.

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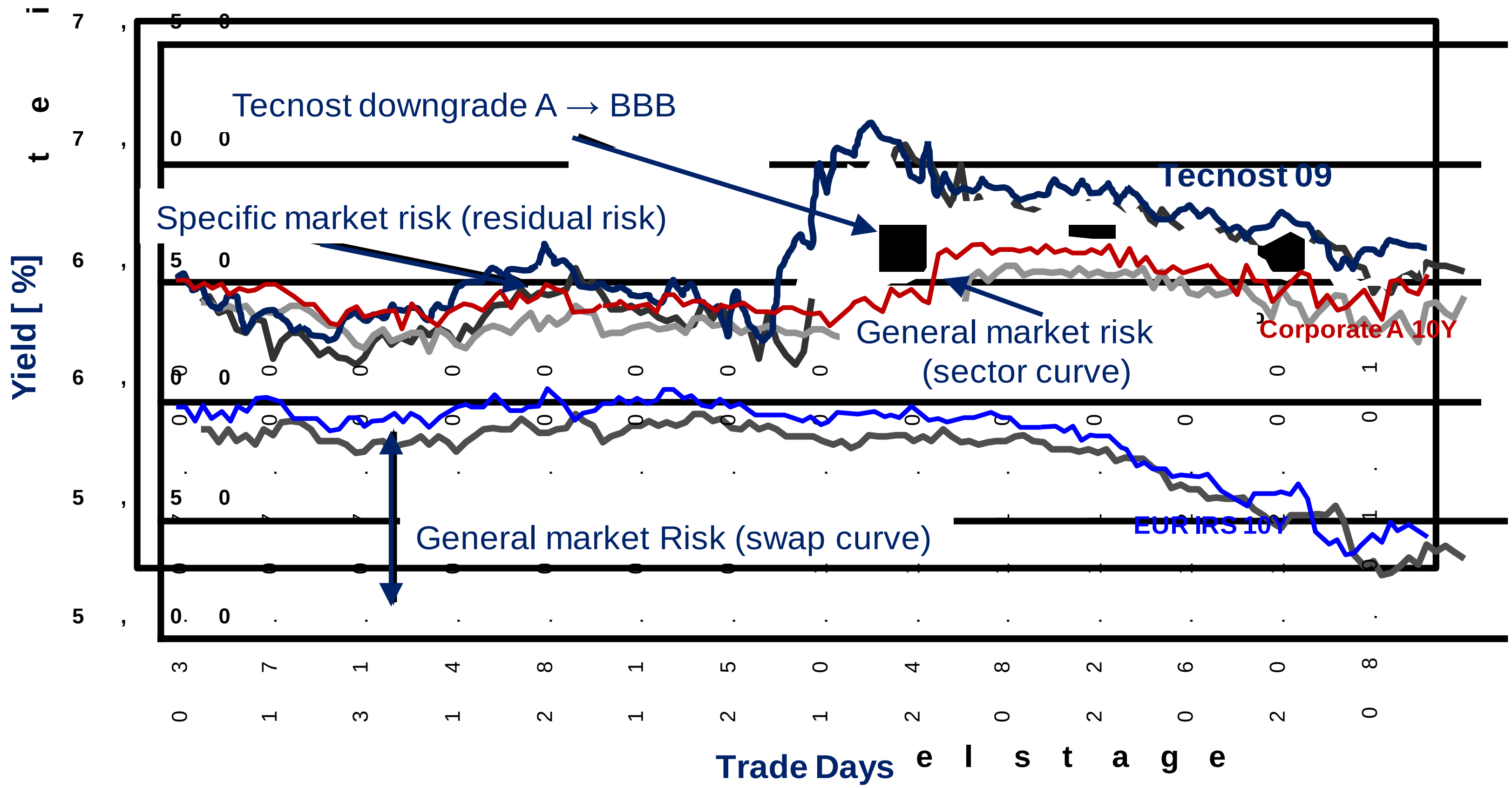
Risk Factors – Spread Curves

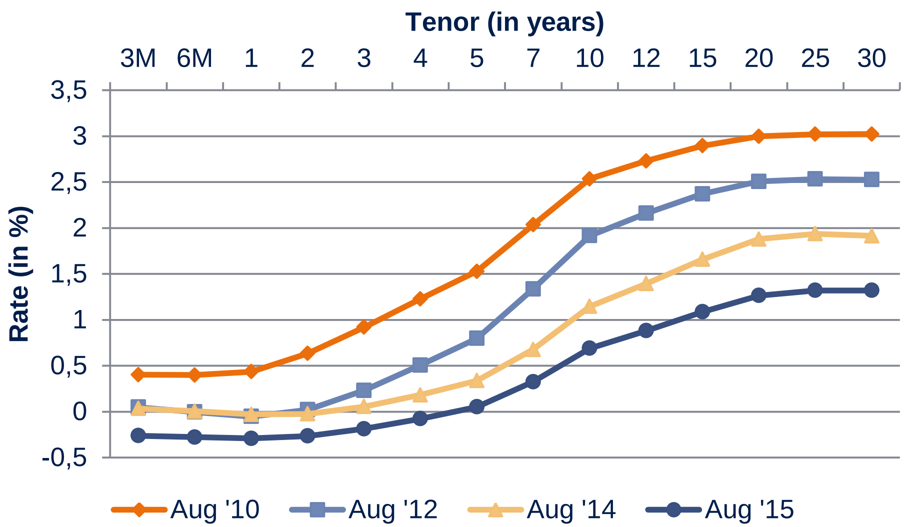
Example of Spread Curve Risk



Market risk (spreads) does not account for defaults or rating migrations.

Risk Factors – Interest Rate Curves – The new Era

Since the financial crisis, due to massive interventions of central banks, interest rates have been dropping.

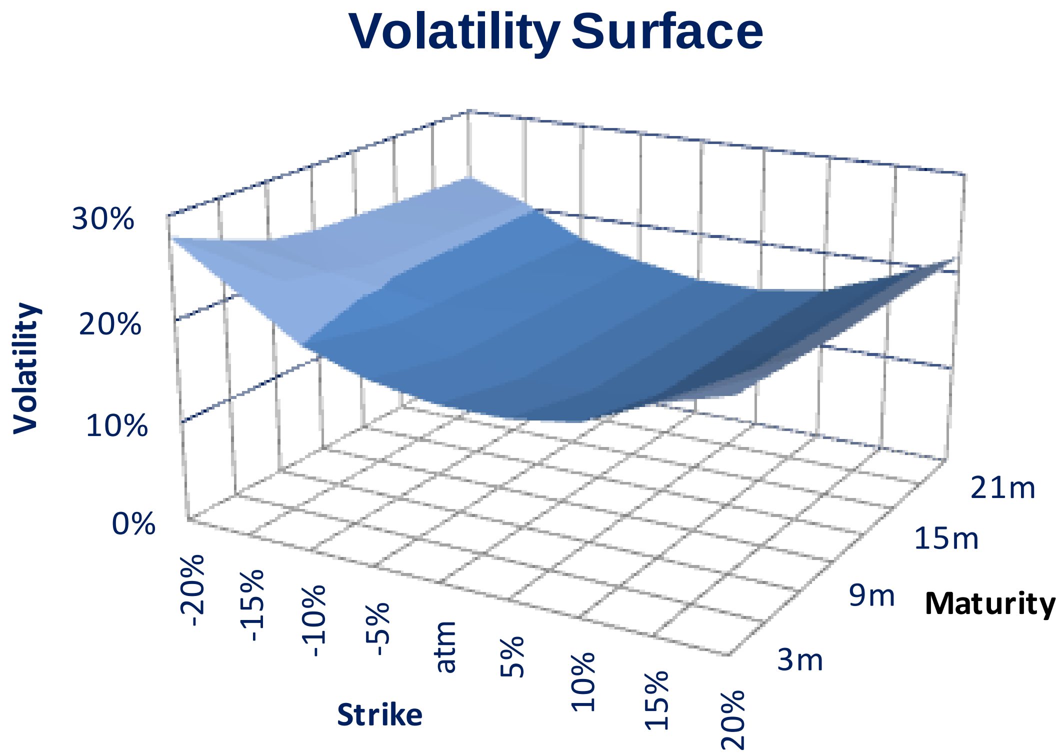


Interest rate curve construction has become more complex during the financial crisis.

Risk Factors – Volatility Surfaces

Volatility Surfaces (implied volatilities)

Volatility as function of
time to maturity and strike



Implied volatilities are used as risk factors.

Risk Factors – Portfolio Level

Market Risk Factors on Portfolio Level

- The trading book of big banks contains all kinds of risk factors that easily amount to **several thousand risk factors**. Risk measurement has to take all (relevant) risk factors into account.
- Risk factors usually are not independent of each other but are **correlated**. Risk measurements must take these correlations into account.
- Risk factors continuously vary while markets are open. Therefore risk factor **observations** to generate time series for risk measurement **must be simultaneous** to preserve correlations.
- Portfolios are often hedged to eliminate risks. This might result in risks that can be neglected on instrument level to be dominant on portfolio level.

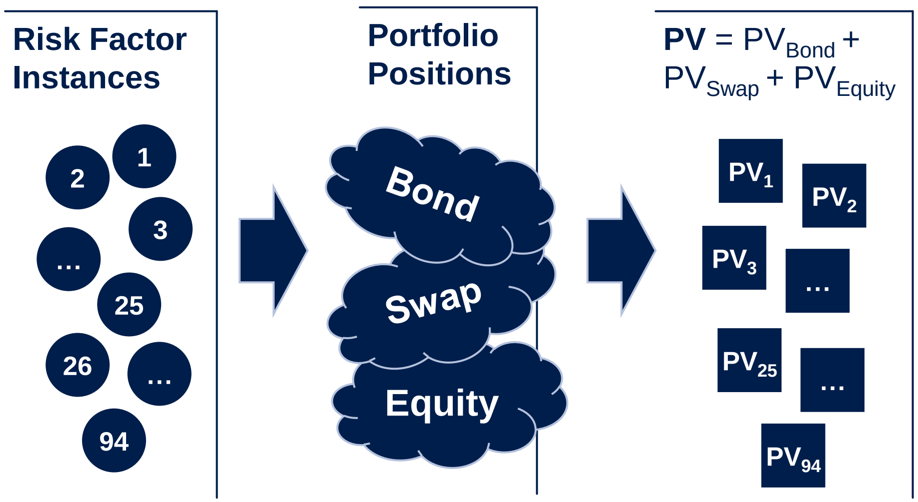
Adequate risk measures, tools and processes are needed to manage market risk.

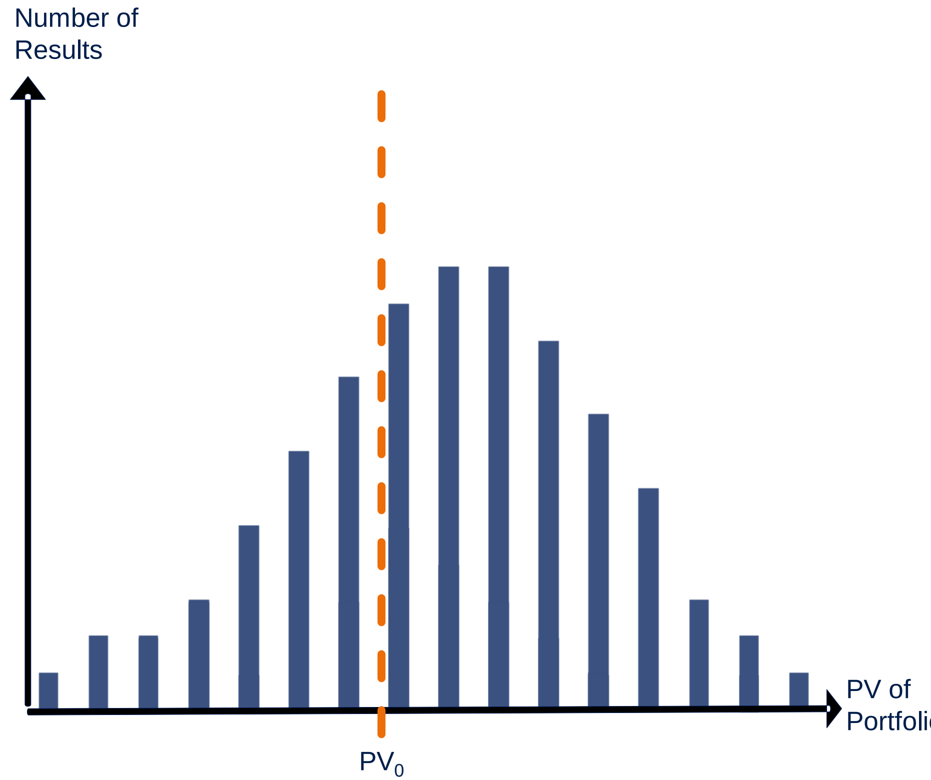
Measurement of Market Risk – Value at Risk as a central tool

Market Risk Valuation – Portfolio Level

Random Change of Risk Factors

Going forward in time risk factors change. The Profit-and-Loss (P&L) is derived as the difference between the new (PV_i) and old present values (PV_0), first for single portfolio positions and subsequently for the portfolio.





The Profit-and-Loss distribution derives from the (common) distributions of risk factor changes.

Introduction of Market Risk Measures – Value-at-Risk (VaR)

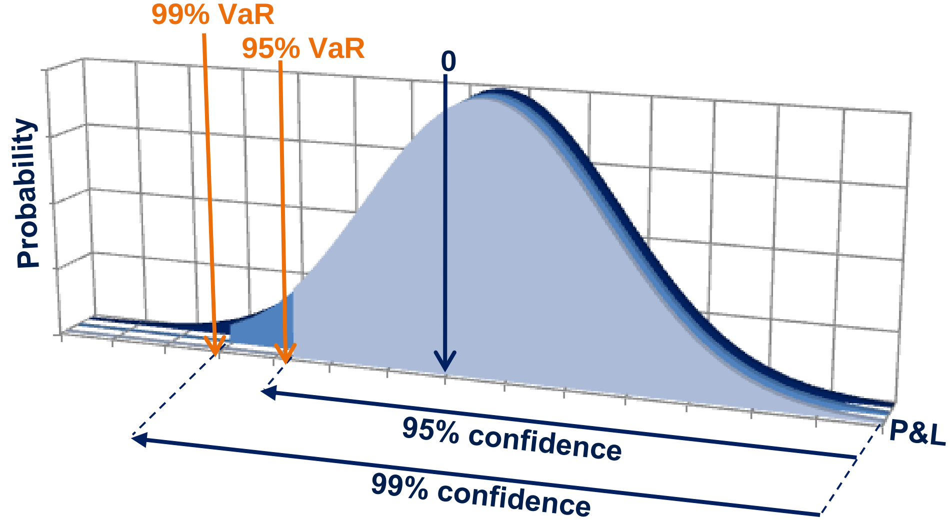
The quantification of Market Risk of a portfolio is based on its P&L-distribution

Most frequently used quantity:

Value-at-Risk (VaR)

The maximum loss which will not be exceeded with a given probability over a certain time horizon T.

Estimated Portfolio P&L Distribution



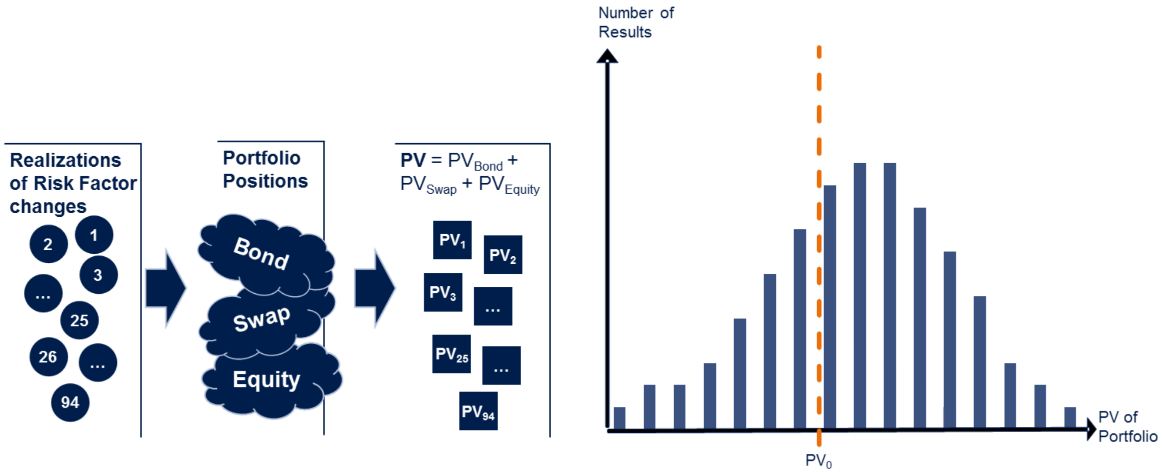
- VaR is measured in monetary units (e.g. €).
- VaR can be calculated for arbitrary quantiles.
- VaR is usually calculated on short time horizons (e.g. 1 or 10 days).

VaR quantifies potential portfolio loss based on an estimated portfolio P&L distribution.

VaR Models – Overview of VaR Models

Calculating the P&L Distribution

The estimation of the **P&L distribution** on the **risk horizon** (usually 1 or 10 days) is the key element of each VaR model.



Three different methods to estimate the P&L distribution, leading to three VaR models:

- **Monte Carlo Simulation VaR**
- **Historical Simulation VaR.**
- **Parametric VaR / Delta Normal VaR**

Standard VaR models: Parametric, Monte Carlo, Historical Simulation.

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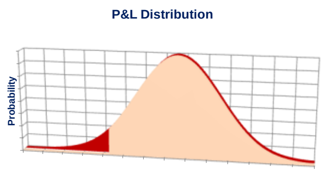
VaR Models – Monte Carlo VaR (1/3)

The calculation of the Portfolio P&L distribution on the risk horizon is the basis of each VaR model.



» **Monte Carlo Simulation – Idea**

- The P&L distribution is generated by revaluation of the portfolio under a large number of simulated risk factor scenarios.
- The risk factor scenarios are generated from the assumed risk factors distributions / stochastic processes.

Basic idea: generate P&L distribution from large number of scenarios.

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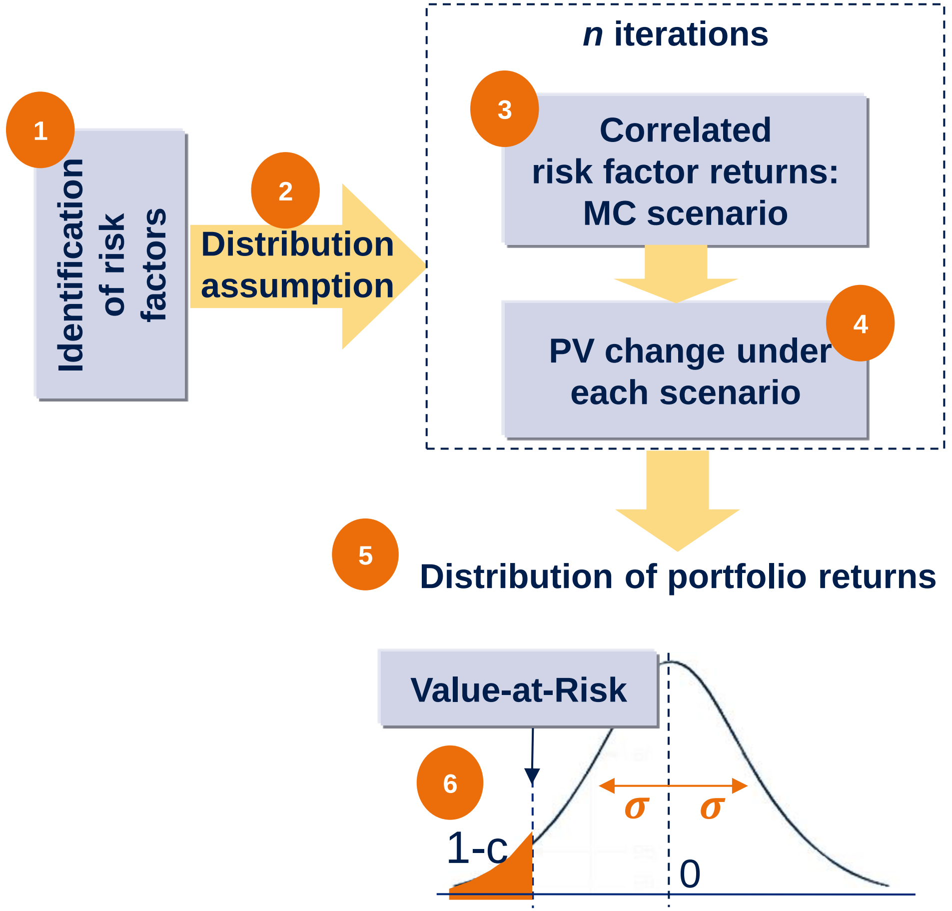
VaR Models – Monte Carlo VaR (2/3)

Illustration of main Calculation Steps

- **(1)** Identification of all relevant risk factors
- **(2)** Distribution assumption(s) for risk factor returns over the time horizon from time series analyses
- **(3)** Generate correlated risk factors returns form a Monte Carlo scenario.
- **(4)** Full (or sensitivity based) revaluation of portfolio under the generated scenario
- **(5)** Generation of a large number of scenarios leads to P&L distribution
- **(6)** Estimation of VaR as the desired quantile of this distribution



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VaR Models – Monte Carlo VaR (3/3)

Scenario Generation for one Risk Factor (e.g., Intel stock)

Model & Parameter

- Return model: $d\ln(S_t) = \mu \cdot dt + \sigma \cdot X\sqrt{dt}$
- Parameters: **μ = 3%** **σ = 21%** **dt=10 days**

Risk Factor Return

- Random number (normally distributed) ***X* = -1,45457645**
- **Relative change of risk factor**:
  d ln(*S*) = 3%*10/250 + 21% * -1,45457645*0,2 = -5,989 %

Scenario

- Old value of risk factor: ***S(t)*** **= 20,00 €**
- New value of risk factor: ***S(t+1)*** = *S(t)* exp(-5,989%) **= 18,84 €**
- PV change of the portfolio (of 10 Intel stocks): **10 * (18,84 € - 20,00 €)** **= -11,63 €**

n **iterations**

3 **Correlated risk factor returns: MC scenario**

4 **PV change under each scenario**

iterations

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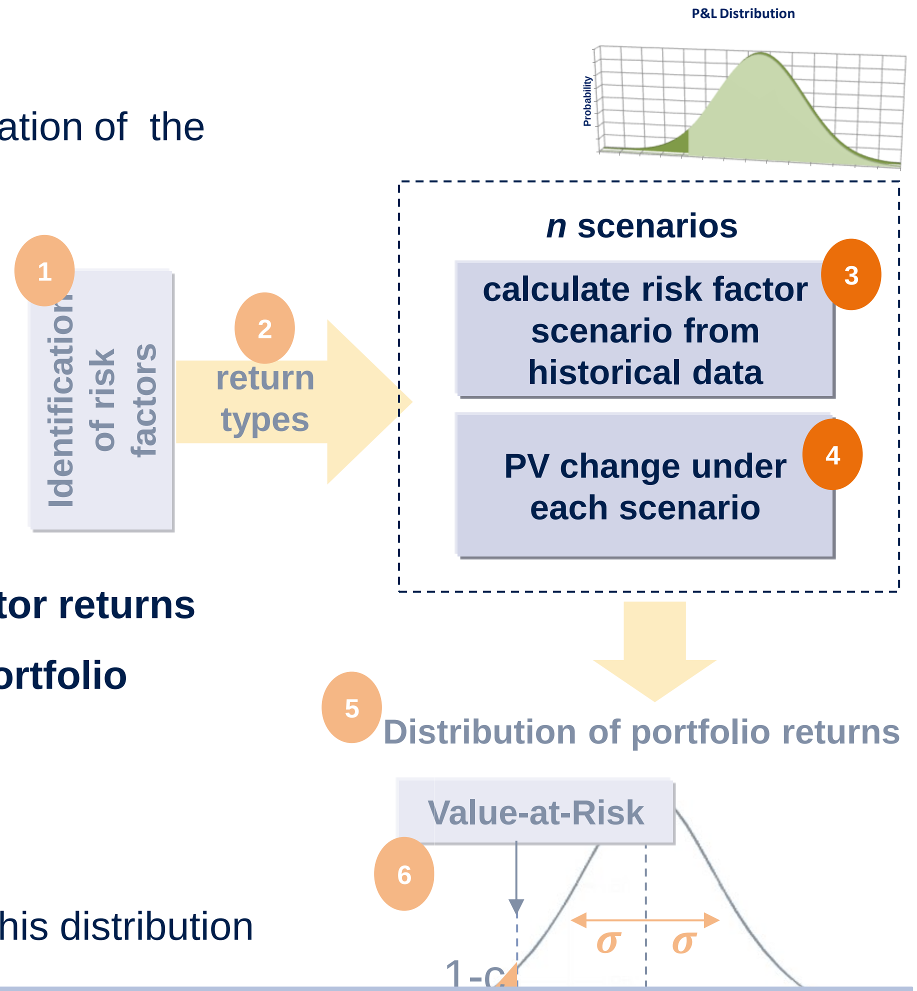
VaR Models – Historical Simulation VaR (1/2)

Historical Simulation – Idea

- Use real historical risk factor scenarios for generation of the Portfolio P&L distribution.
- Similar to the Monte Carlo Simulation

Illustration of main Calculation Steps

- **(1)** Identification of all relevant risk factors
- **(2)** Specification of return type for each risk factor
- **(3) Calculate scenario from observed risk factor returns**
- **(4) Full (or sensitivity based) revaluation of portfolio under historical risk factor scenario.**
- **(5)** Repeat **(3)** and **(4)** for all historical scenarios (typically 250 or 500)
- **(6)** Estimation of VaR as the desired quantile of this distribution



Basic idea: generate P&L distribution from large number of historical scenarios.

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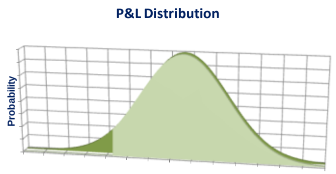
VaR Models – Historical Simulation VaR (2/2)



Historical Simulation – Pro and Contra

Advantages

- No assumption about risk factor return distribution necessary (esp. no assumption of normal distribution)
- Non-linear risk is considered
- No approximations necessary
- VaR can be attributed to a certain scenario (incl. date)

Disadvantages

- Depends on quality of time series
- Difficult to calculate VaR for long time horizons
- Only small number of scenarios available

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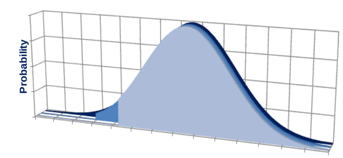
VaR Models – Parametric VaR / Delta-Normal VaR (1/3)

Delta-Normal VaR



» **Assumption 1**: risk factor (log-)returns are normally distributed:

$$\ln(S(t+1)/S(t)) \sim N(0,\Sigma)$$

» **Assumption 2:**

Difference in present value of any position is a linear function of the (log) returns of all risk factors.

$$\Delta_{S_i} = \partial \mathrm{PV} / \partial S_i \Rightarrow \delta \mathrm{PV} \approx \sum_i \Delta_{S_i} \cdot \delta S_i$$

» The variance of the sum of normal distributed random numbers can be calculated:

$$\begin{aligned} \mathrm{var}[\delta V] &\approx \sum_{i,j=1}^{n} \Delta_{S_i} \Delta_{S_j} \mathrm{cov}[\delta S_i, \delta S_j] \\ &= \sum_{i,j=1}^{n} \Delta_{S_i} \delta\Sigma_{ij} \Delta_{S_j} \\ &= \sum_{i,j=1}^{n} \Delta_{S_i} S_i \sigma_i \rho_{ij} \sigma_j \Delta_{S_j} S_j \end{aligned}$$

$$VaR \approx Q_{1-c}^{N(0,1)} \sqrt{dt} \sqrt{\sum_{i,j=1}^{n} \Delta_{S_i} S_i \sigma_i \rho_{ij} \sigma_j \Delta_{S_j} S_j}$$

Value at Risk can be written in an analytically closed form.

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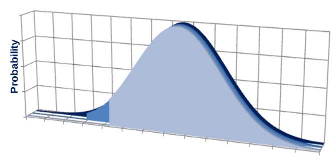
VaR Models – Parametric VaR / Delta-Normal VaR (2/3)

Delta-Normal VaR – Example of one Position with one Risk Factor



- Position with 10 units of one instruments, e.g. 10 equity shares, dependent on one risk factor (underlying share price) with sensitivity $\Delta_S = 0{,}52$
- Risk factor with spot price S = 3000 € and annual volatility $\sigma_S = 32\%$
- Liquidation period or time horizon T = 10 days =10/250 years
- Confidence interval 99%, i.e. 2,326 standard deviations
- Value at Risk = price change caused by risk factor change

Quantile of risk factor change

Position sensitivity

$$VaR = Q_{1-c}^{N(0,1)} \cdot \sqrt{t} \cdot \sigma \cdot S \cdot \Delta_s \cdot 10$$
$$= 2{,}326 \cdot \sqrt{10/250} \cdot 0{,}32 \cdot 3000\,EUR \cdot 0{,}52 \cdot 10$$
$$= 2322\,EUR$$

Delta normal VaR: simple and fast to calculate.

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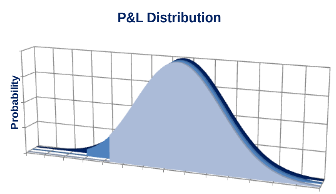
VaR Models – Parametric VaR / Delta-Normal VaR (3/3)

Parametric VaR – Pro and Contra



Advantages

- » Simple
- » Fast
- » Reproducible (analytical formula)

Disadvantages

- » Non-linear effects not captured
- » Assumption of normal distribution
- » Covariance matrix as necessary input

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VaR Models – Comparison of VaR Methods

Comparison of VaR Methods

	Parametric VaR	Monte Carlo Simulation	Historical Simulation
Coverage of non-linear risks	–	+	+
Assumption of distribution of risk factors	–	–	+
Speed / time consumption	++	–	+
Size of statistical samples	+	+	–
VaR attributable to scenario	–	+	++
Need for explicit volatilities and correlations	–	–	+
Dependence on time series quality	+	+	– –
Decomposition of VaR	+	–	–
Extension by new risk factors	+	+	–

Each VaR method has its advantages and disadvantages.

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Negative Interest Rates – Challenges for Market Risk measurement

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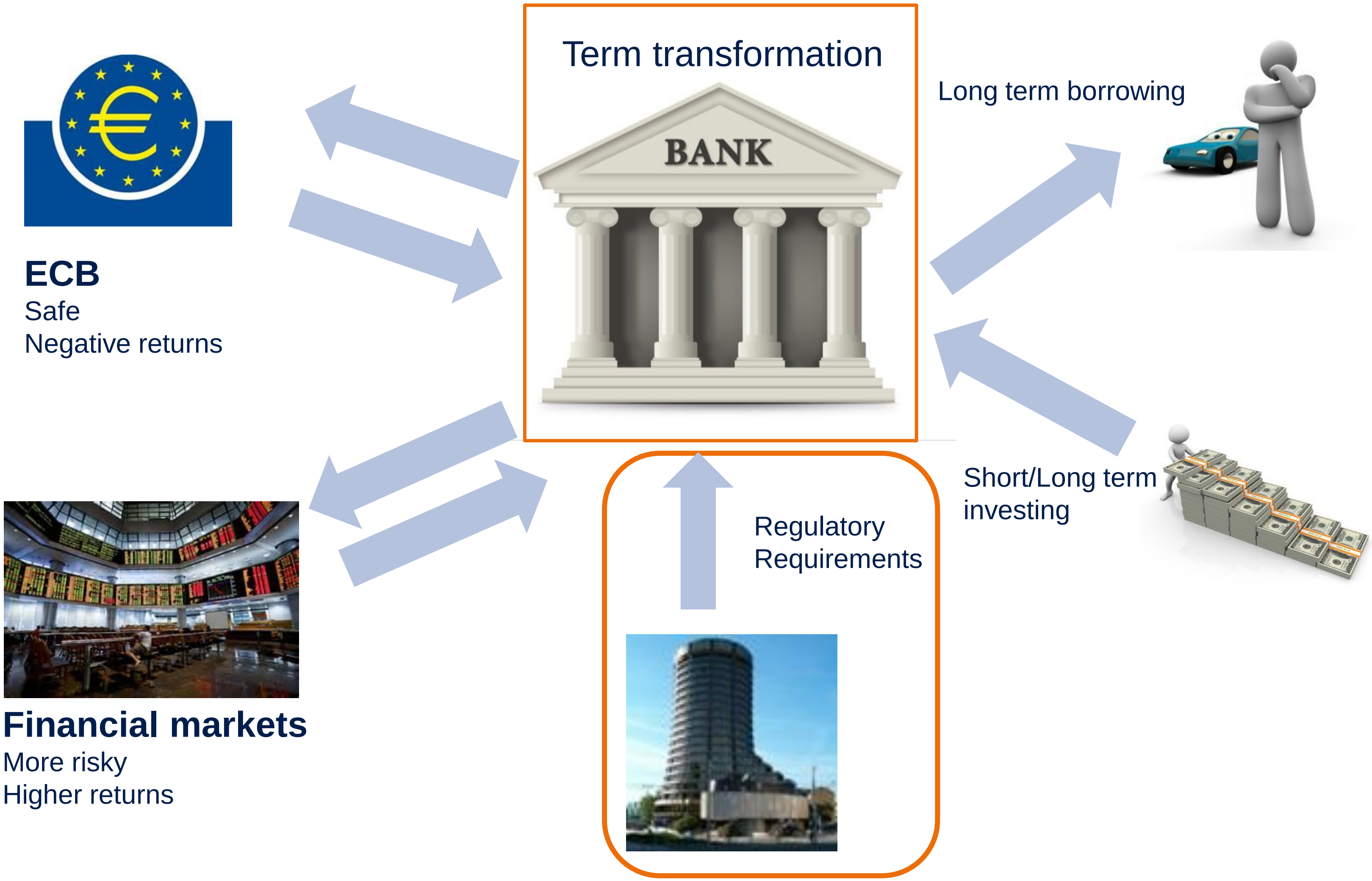
Operating Model of a “usual” bank



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Excurse – Regulatory requirements for Market Risk Measurement

Rational Arguments on Measuring (Market) Risk – Management Impulses

Managing (Market) Risk

Financial instruments and portfolios of them are subject to (market) risk.

- How much risk?
  - Quantify risk of a portfolio and compare risk and return
    => Management impulses: Which business should be increased/reduced?
  - Quantify total risk and compare to risk capacity
    => Determine economic capital requirement
  - Limit utilisation
    => Generates direct management impulses
- Understanding business-related risk
  - Find (unknown) risk concentrations
  - Analyse risk sensitivities
  - Do hedges generate the desired risk reduction?

Business and Risk Strategies

... Seems like a good idea ...

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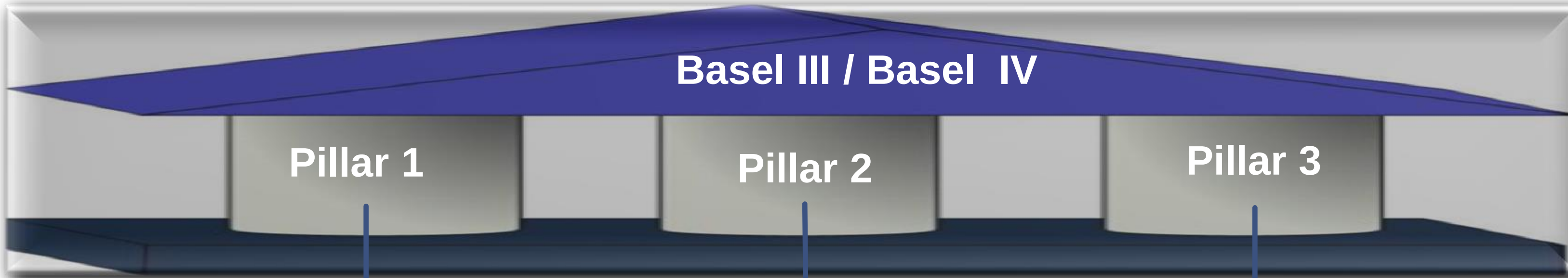
Regulatory Requirements – German Regulatory Documents



CRR: Capital Requirements Regulation

directly applies to national institutes

CRD IV: Capital Requirements Directive

directly applies to national institutes

Kreditwesengesetz (KWG) + CRD IV Umsetzungsgesetz

KWG § 24
KWG § 25a

BaFin 10/2012: MaRisk

Basel III is incorporated into German regulations by CRR and MaRisk 2012.

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Why Measuring Market Risk? – Regulatory Requirements

Main goals of Regulatory Requirements

Pillar 1	Pillar 2	Pillar 3
Ensure minimum capital buffers to balance risks.	Banks shall analyse, understand and manage risks inherent in their business.	Market disclosure and discipline no capital requirements
Regulatory Capital	**Economic Capital**	

different implications

Bank Portfolio

Banking Book:
- » long term investments
- » "held to maturity"

Trading Book:
- » positions held for trading
- » short term horizon

Regulation takes into account the different nature of banking book and trading book.

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CRR contains Requirements for Regulatory Capital (pillar 1)

Managing Market Risk – Regulatory Capital Requirements

» Regulation requires capital buffers for positions subject to **market risk (CRR)**:

Bank Portfolio

Banking Book:
- » Credit — Credit Risk
- » FX
- » Commod. — Market Risk

Trading Book:
- » IR
- » Spread
- » Equity
- » FX
- » Commodity — Market Risk

Operational Risk

» IR risk not required due to HTM idea

» Prevailing risk in trading book is market risk

For both books, either a standard approach or an Internal Model approach can be used:

Standard Approach

» weighted exposures

» “god-given” weight factors

Internal Model Approach

» usually based on a VaR-model

» one-sided confidence interval of 99%; 10 day holding period

Banks must use the standard approach or an internal model approach to calculate regulatory capital.

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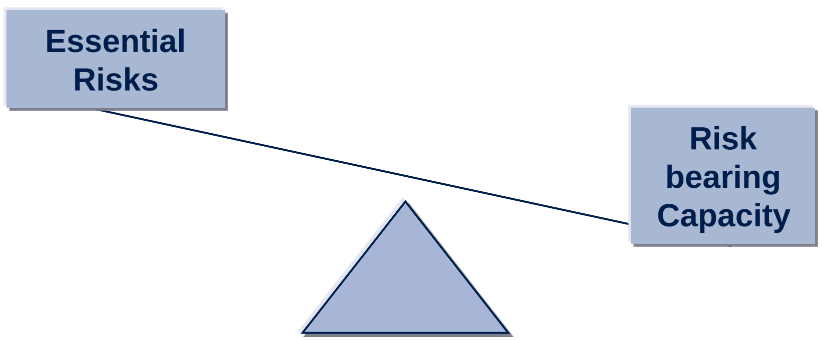
MaRisk (2012) contains requirements for Economic Capital (pillar 2)

Internal Capital Adequacy Assessment Process (ICAAP)
Idea: compare essential risks to economic capital (risk bearing capacity) over a long time horizon (1y)



Methodological freedom for calculation of Risks and Risk bearing capacity

Proportionality Principle: regulations are adjusted based on the size and complexity of the institute

Bank Portfolio

Banking Book and Trading Book:

- Credit Risk
- FX
- Commodity
- IR (IRRBB)
- Spread
- Equity

Market Risk (FX, Commodity, IR (IRRBB), Spread, Equity)

Operational Risk

- all relevant (essential) types of risk need to be considered
- particularly for the Gone concern perspective: IR risk in the banking book

Both requirements need to be fulfilled for regulatory compliance.

Different Measures for different Purposes

	Pillar I	Pillar II	Internal Steering	…
	Regulatory Capital	Economic Capital	Internal Limit System	
Idea	**Short term steering:** Measurement and steering of „current“ risk	**Risk bearing capacity:** Stable risk measure / stable capital requirements based on complete economic cycle	**Allocation of risk budgets** to departments and desks **Meeting the risk appetite**	…
Risk Measurement	**Standardised approach:** » Exposure based measure **Internal model approach:** » Risk based measure like VaR or ES	**Internal (Model) Approach:** » VaR / ES or Stressed VaR » Stress Tests » Going concern /gone concern approach (or both) » Balance sheet or Value based	**Sensitivity based** **Internal (Model) Approach:** » VaR or ES	…
Model Parameterisation	Regulatory risk horizon of 10 days for internal model » Time series used in model: typically 1-2 years » Backtesting of 1 day model » Confidence level: 99%	Risk bearing capacity » Risk horizon: 1 year » Time series: several years » Confidence level › Gone Concern: 99.9x% › Going Concern: 95%+	Management of market risks usually short term (trading book) » Risk horizon: usually 1 day » Time series: typically 0.5-2 years, weighted	…

There are different purposes in a bank that require market risk measurements

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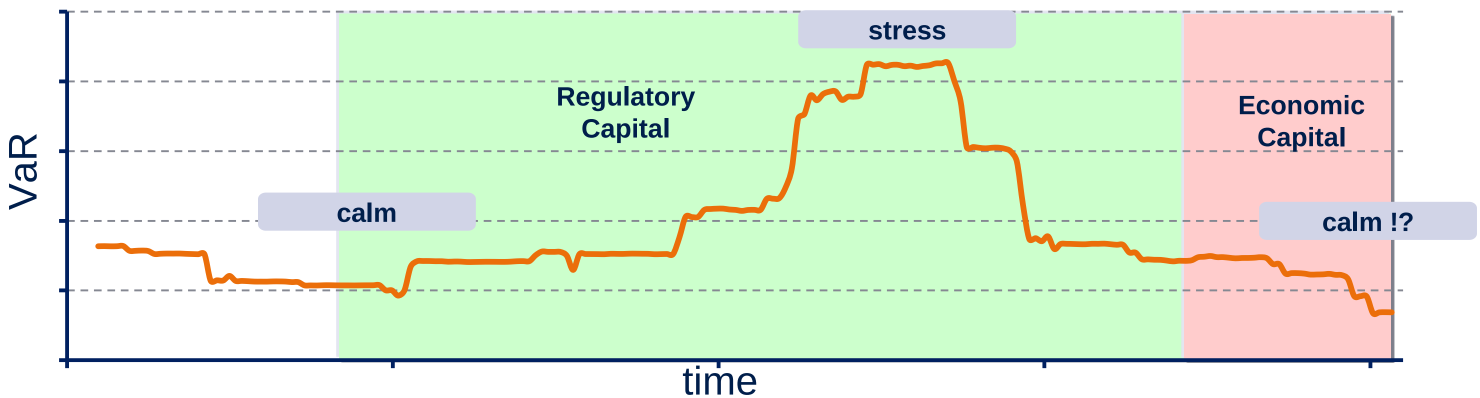
Different Measures for different Purposes

There are different purposes in a bank that require market risk measurements:

Pillar I / Regulatory Capital	Pillar II / Risk bearing capacity
Short term steering via VaR like models » Measurement and steering of „current“ risk: possibly exp. weighted time series » Implies stationarity of current market phase » pro-cyclical risk measure	**Risk bearing capacity** » Stable risk measure / stable capital requirements based on complete economic cycle » Avoiding pro-cyclical capital requirements



Market risk depends on risk horizon and steering purpose.

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Regulation goes Europe – European System of Financial Supervision (ESFS)

European Supervisory Authorities

- European Banking Authority (EBA, London)
- European Insurance and Occupational Pensions Authority (EIOPA, Frankfurt)
- European Securities and Markets Authority (ESMA, Paris)

European regulatory publications

- EBA publications concretise requirements defined in CRR and CRD IV
- Publications divided into Regulatory Technical Standard and Implementation Technical Standard (RTS / ITS)

Regulations EU 1092-1095/2010
of European Parliament and Council

Recent selected publications

- Guidelines on the management of interest rate risk arising from non-trading activities (EBA/GL/2015/08)
- Consultation paper on RTS on prudent valuation (EBA/CP/2013/28)
- Consultation paper on draft RTS on Capital Requirements for CCPs (EBA/CP/2012/08)
- EBA consultation papers on guidelines to the Stressed Value At Risk (Stressed VaR)

A lot of national regulatory authority is now carried out by central authorities on European level under governance of the European Systemic Risk Board (ESRB), a sub-agency of the ECB.

External Challenges of negative Interest Rates

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External Challenges of negative Interest Rates

Negative Interest Rates

E1 Hedging

- Certain loans are capped at zero interest rates while their hedges are not
- Contracts need to be revised legally

E2 Investment Challenge

- Margins for banks are falling while regulatory requirements for capital are increasing

E3 Refinancing challenge

- Negative rates increase the need for good liquidity management, i.e. negative deposit rates may lead to a bank run.

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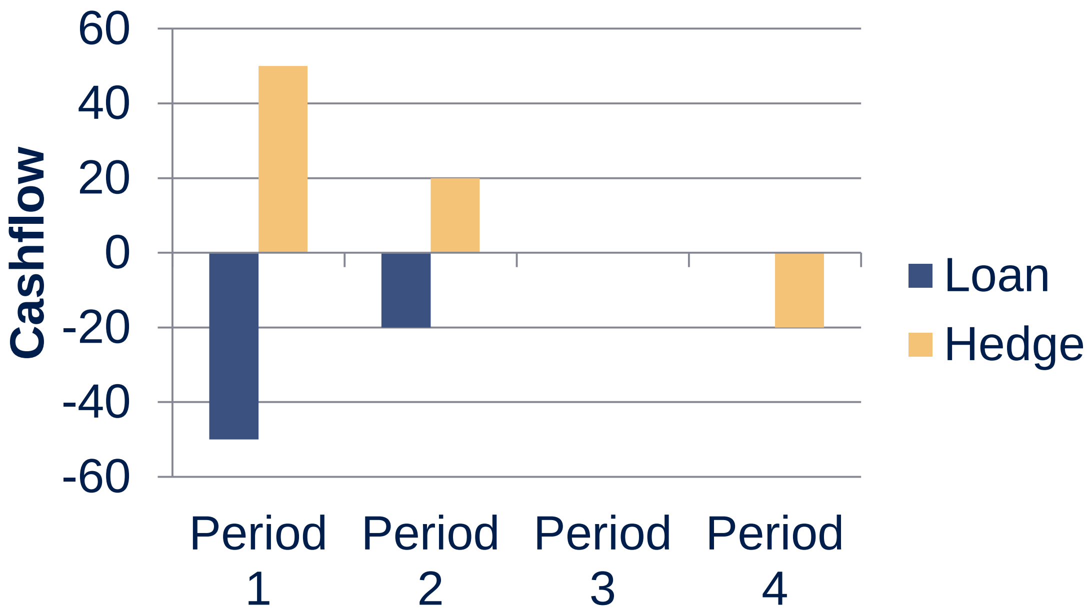
Hedging challenge

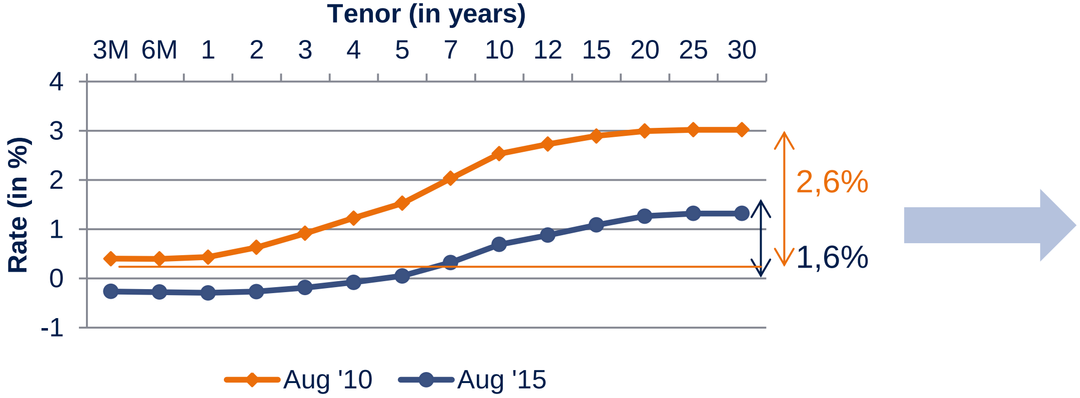
» Floating rate loans are normally capped at zero, while Interest Rate Swaps, that are used for hedging, are not



Investment Challenge

» With dropping interest rates, it is harder and harder for insurance companies to earn the guaranteed rates with low risk investments

» Since banks cannot (or will not charge) customers on their checking accounts, their margins are decreasing



Profit margin decreases by 40%

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Internal Challenges of negative Interest Rates

Internal Challenges of negative Interest Rates

Negative Interest Rates

I1 System / technical challenges

- Many system can not process negative values for interest rates

I2 Pricing / model challenges

- Log-Normal returns can not be calculated out of negative values
- Certain pricing models can not work with negative rates (SABR model)

I3 Payments and balances challenges

- Many banks could not handle negative deposit rates
- Stream of cash flow inverts (problem with payment processing)

Pricing / model Challenge

» Most risk calculations work with log-returns, which does not work with negative numbers

$$\lim_{x \to 0} \ln(x) \to -\infty$$

» Some pricing formula (e.g. the Black 76 model) do not work with negative interest rates

» Some pricing models, e.g. the SABR model can not be calibrated to negative interest rates

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