FINANCIAL STABILITY INSTITUTE
BANK FOR INTERNATIONAL SETTLEMENTS

ADVANCED
MARKET RISK MODELING

Beatenberg

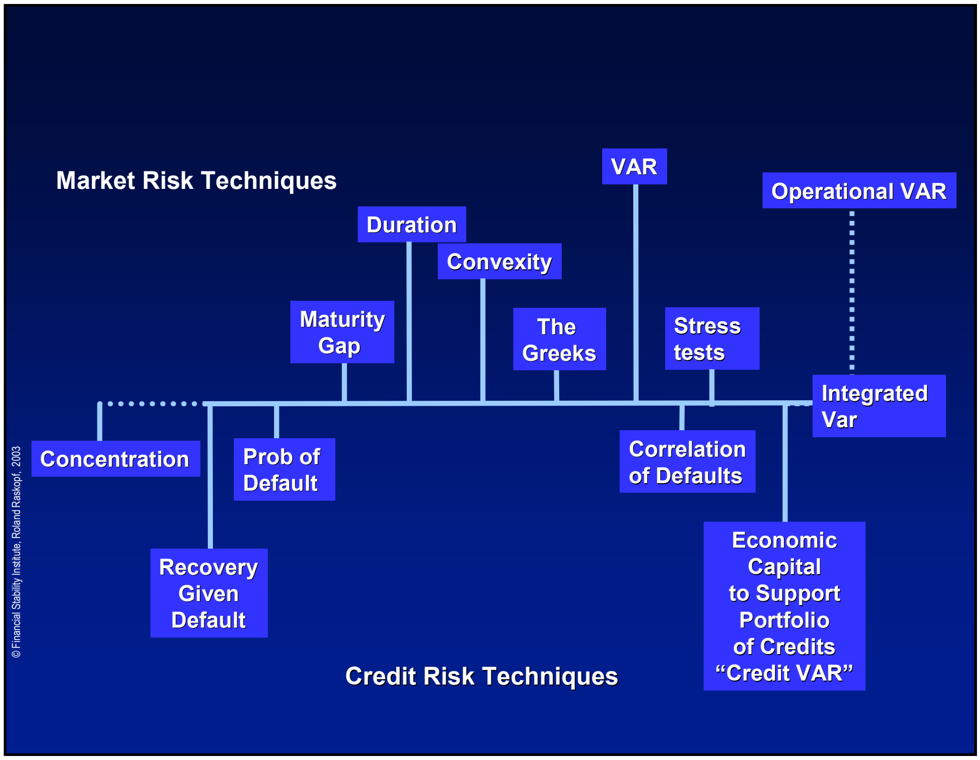
4 September 2003

15.30-17.00

ROLAND RASKOPF
FINANCIAL STABILITY INSTITUTE

Overview

- Integrated Risk Management
- VAR Market Risk Models:
  - Variance Covariance Approach
  - Historical Simulation
  - Monte Carlo Simulation
- Backtesting
- Stress tests
- Regulatory Requirements
- Conclusion


Market Risk Techniques
VAR
Operational VAR
Duration
Convexity
Maturity Gap
The Greeks
Stress tests
Integrated Var
Concentration
Prob of Default
Correlation of Defaults
Recovery Given Default
Economic Capital to Support Portfolio of Credits "Credit VAR"
Credit Risk Techniques
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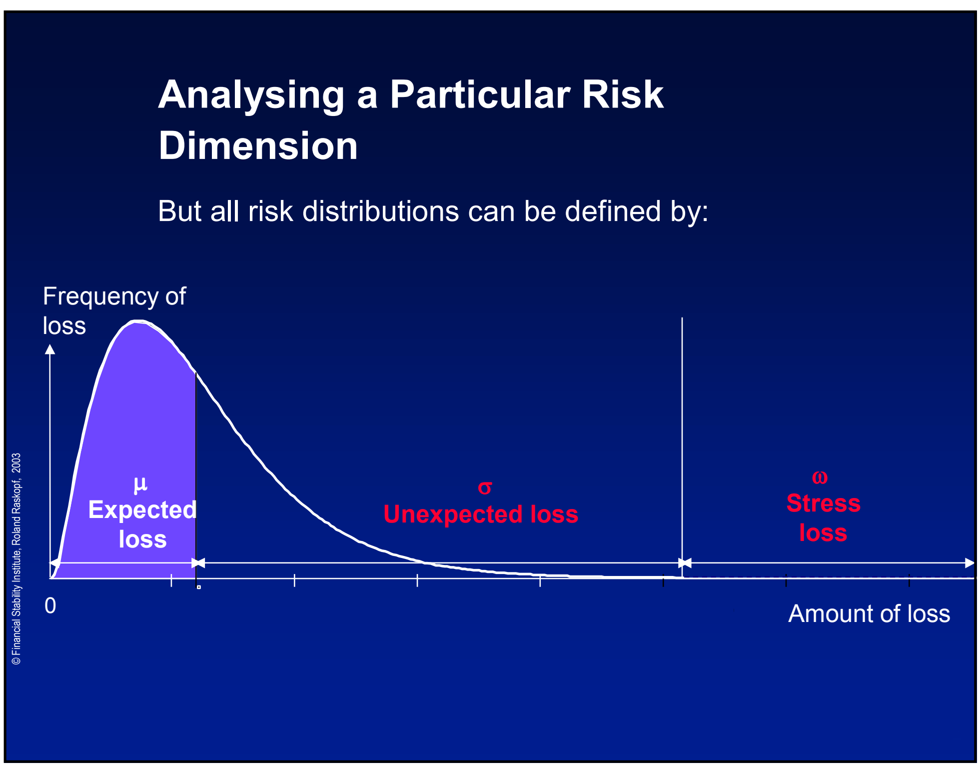
Analysing a Particular Risk Dimension
But all risk distributions can be defined by:
Frequency of loss
μ
Expected loss
σ
Unexpected loss
ω
Stress loss
0
Amount of loss
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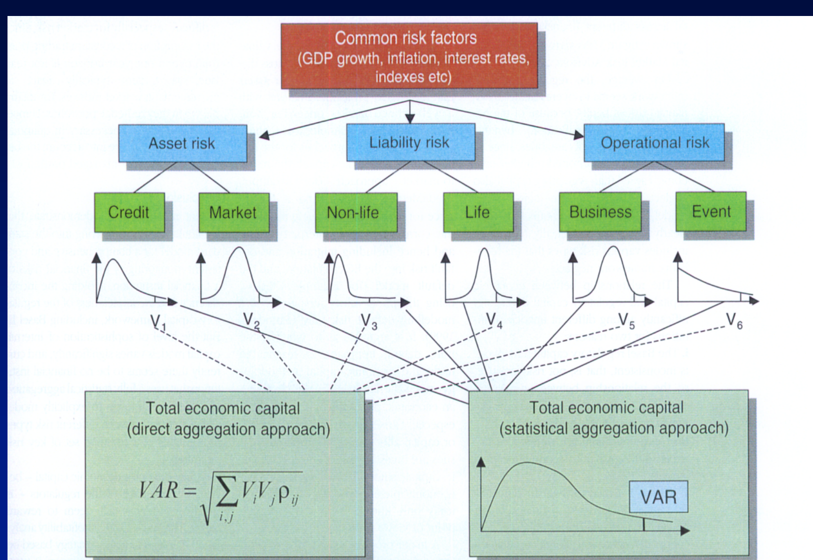
Analysing a Particular Risk Dimension
Market & Credit Risk Compared

- Expected Loss (Mean of distribution)
  Charged to Revenue at Time of Transaction
- Unexpected Loss (Standard Deviation of distribution)
  Covered by Capital Allocation
- Stress Loss (Tail of distribution)
  Prevented by Limits or Reinsured by Underwriters

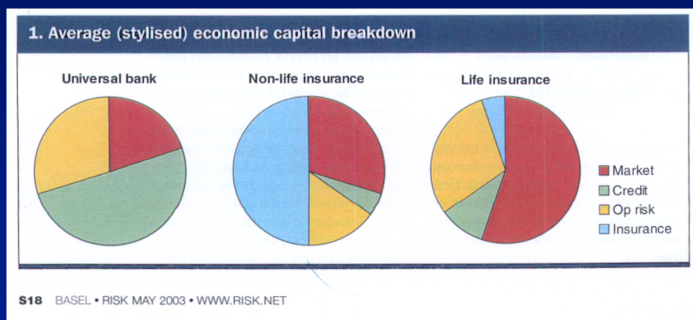
Integrating RISK



Market RISK

Definiton, 1996 Market Risk Amendment:

Market risk is defined as the risk of losses in on and off-balance-sheet positions arising from movements in market prices.



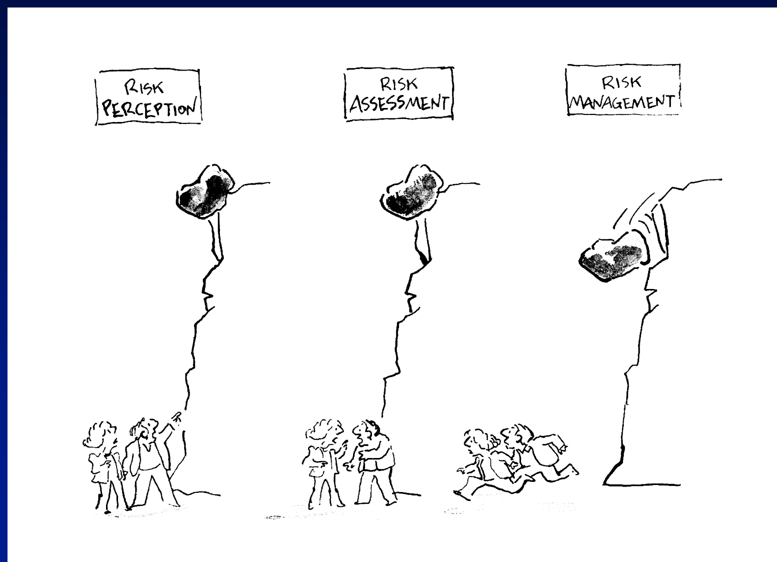
Size of VAR

Taken from Deutsche Bank Risk report 2002

See

Annex 1 Risk Report

Can you manage risk if you can not measure it? Risk factors, sensitivity and volatility



Example: VaR = Euro 73 million
Confidence level: 99%
Holding period: 10 day

For a given portfolio,value-at-risk measures
the potential future loss
(in terms of market value)
that, under normal market conditions,
will not be exceeded in a
defined period
and with a defined confidence level.

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What purpose does value at risk serve?

- **Measurement of the portfolio losses which an institution will ascribe to "unfavourable circumstances"**
- **Standardisation of different risks for the purpose of comparability**
- **Quantification of limits**
- **Optimum allocation of resources**
- **Highly aggregated measure of the risks incurred for the information of management and banking supervisors**

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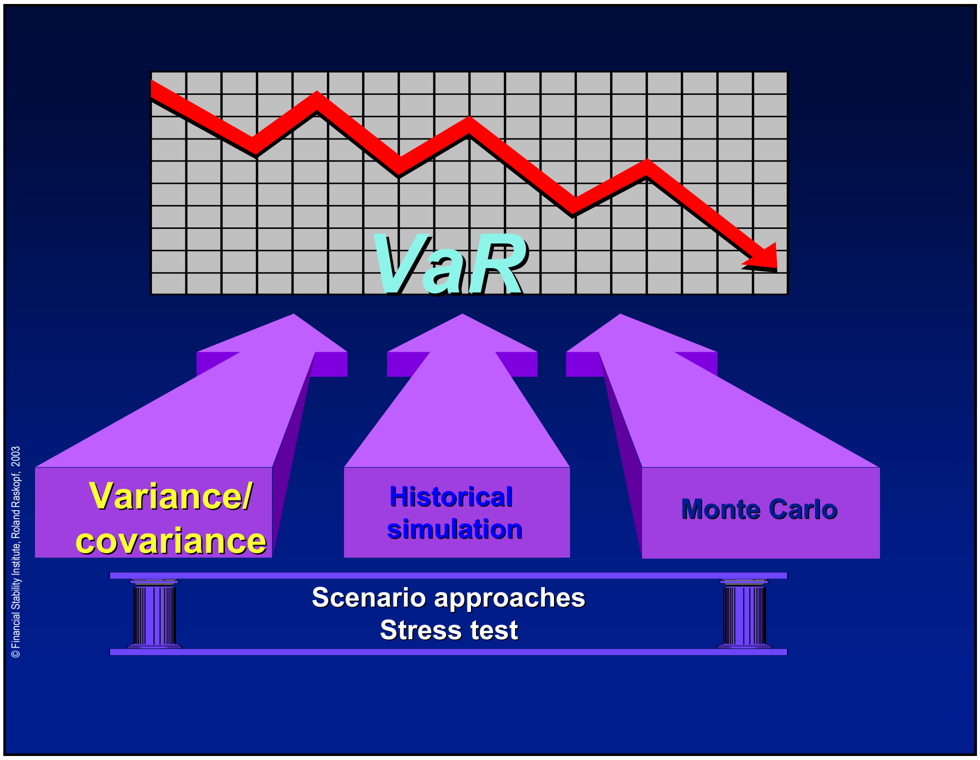


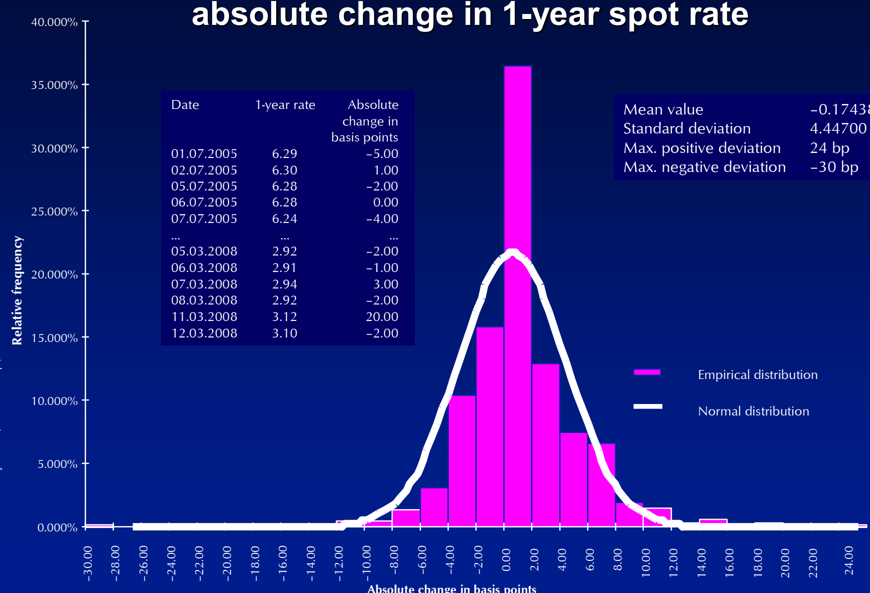
Volatility and value at risk

- Volatilities change over time but often occur in clusters
- As volatility rises, VaR also rises
- Risk can be measured reliably only when volatilities and correlations are determined reliably

Variance/covariance approach

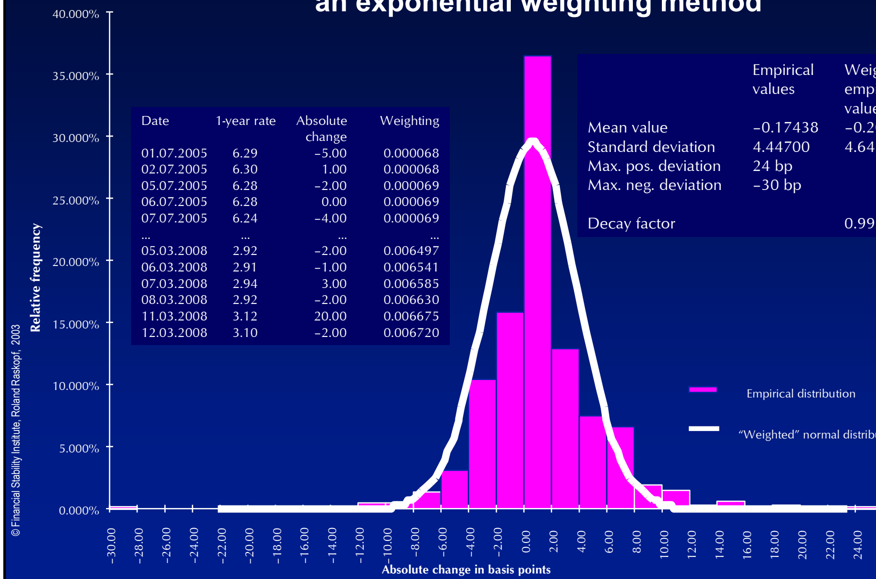
- Calculation of a portfolio's change in value as a function of:
  - the assumed extent of the risk factor changes (volatilities) and risk factor dependencies (correlations)
    (bank-portfolio-independent)
  - the sensitivity of the individual risk factor items (interest rates, exchange rates, shares, volatilities)
    (bank-portfolio-dependent)

Empirical versus normal distribution of daily absolute change in 1-year spot rate



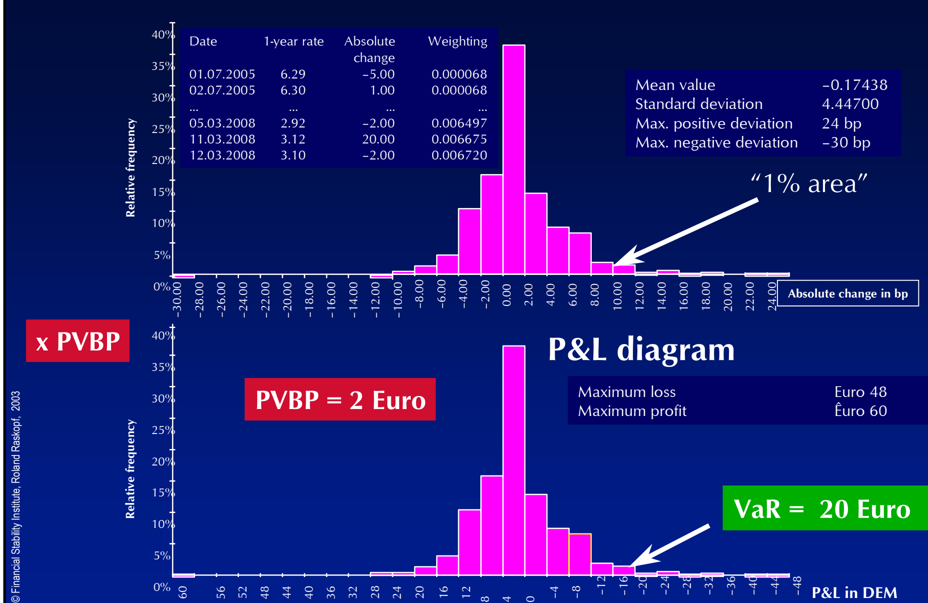
Date	1-year rate	Absolute change in basis points
01.07.2005	6.29	-5.00
02.07.2005	6.30	1.00
05.07.2005	6.28	-2.00
06.07.2005	6.28	0.00
07.07.2005	6.24	-4.00
...	...	...
05.03.2008	2.92	-2.00
06.03.2008	2.91	-1.00
07.03.2008	2.94	3.00
08.03.2008	2.92	-2.00
11.03.2008	3.12	20.00
12.03.2008	3.10	-2.00

Mean value	-0.17438
Standard deviation	4.44700
Max. positive deviation	24 bp
Max. negative deviation	-30 bp



Date	1-year rate	Absolute change	Weighting
01.07.2005	6.29	−5.00	0.000068
02.07.2005	6.30	1.00	0.000068
05.07.2005	6.28	−2.00	0.000069
06.07.2005	6.28	0.00	0.000069
07.07.2005	6.24	−4.00	0.000069
...	...	...	...
05.03.2008	2.92	−2.00	0.006497
06.03.2008	2.91	−1.00	0.006541
07.03.2008	2.94	3.00	0.006585
08.03.2008	2.92	−2.00	0.006630
11.03.2008	3.12	20.00	0.006675
12.03.2008	3.10	−2.00	0.006720

	Empirical values	Weighted empirical values
Mean value	−0.17438	−0.20325
Standard deviation	4.44700	4.64731
Max. pos. deviation	24 bp	
Max. neg. deviation	−30 bp	
Decay factor		0.993280



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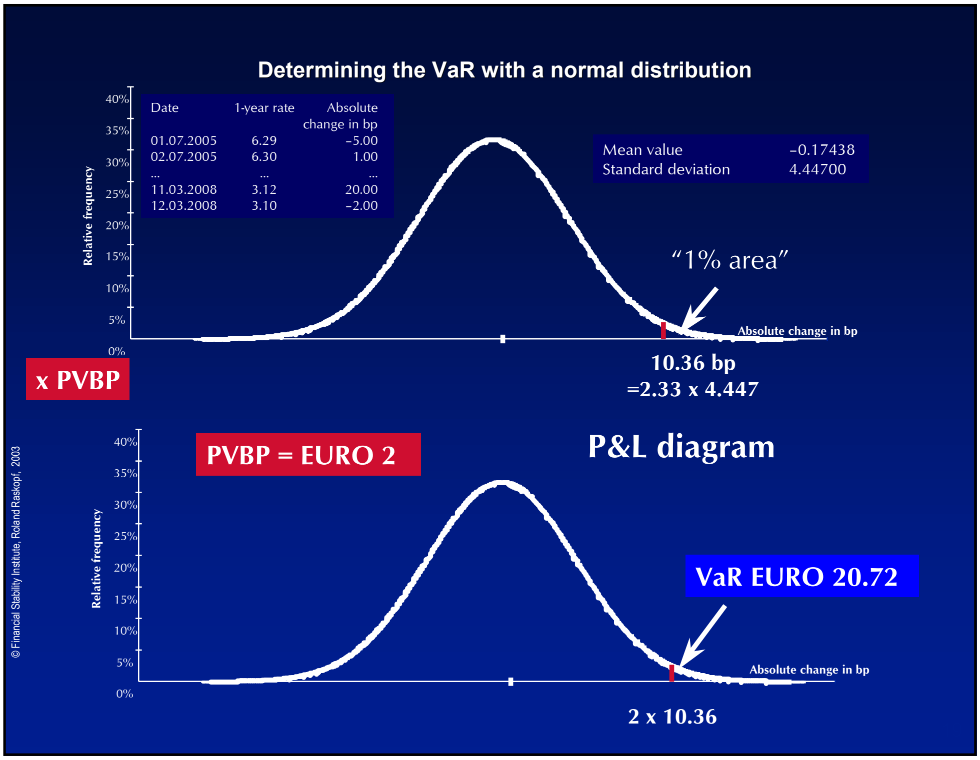
12.03.2008	3.10	−2.00	0.006720

Mean value	−0.17438
Standard deviation	4.44700
Max. positive deviation	24 bp
Max. negative deviation	−30 bp

Maximum loss	Euro 48
Maximum profit	Euro 60

Determining the VaR with the empirical density function



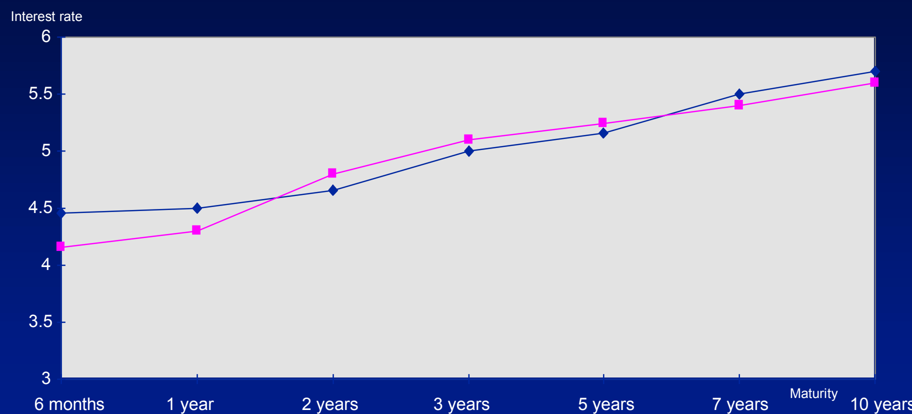
Example: calculating the VaR in a worst-case scenario

Total VaR in the least favourable yield scenario:

VaR = 150+80+45+20+10+100+200 = Euro 605

Maturity	6 m	1 y	2 y	3 y	5 y	7 y	10 y
PVBP	5	4	–3	–2	–1	10	20
Short/long position	short	short	long	long	long	short	short
$\sigma * \theta_{0.99}$	30	20	15	10	10	10	10
Critical rate movement	down	down	up	up	up	down	down
VaR per time bucket	150	80	45	20	10	100	200

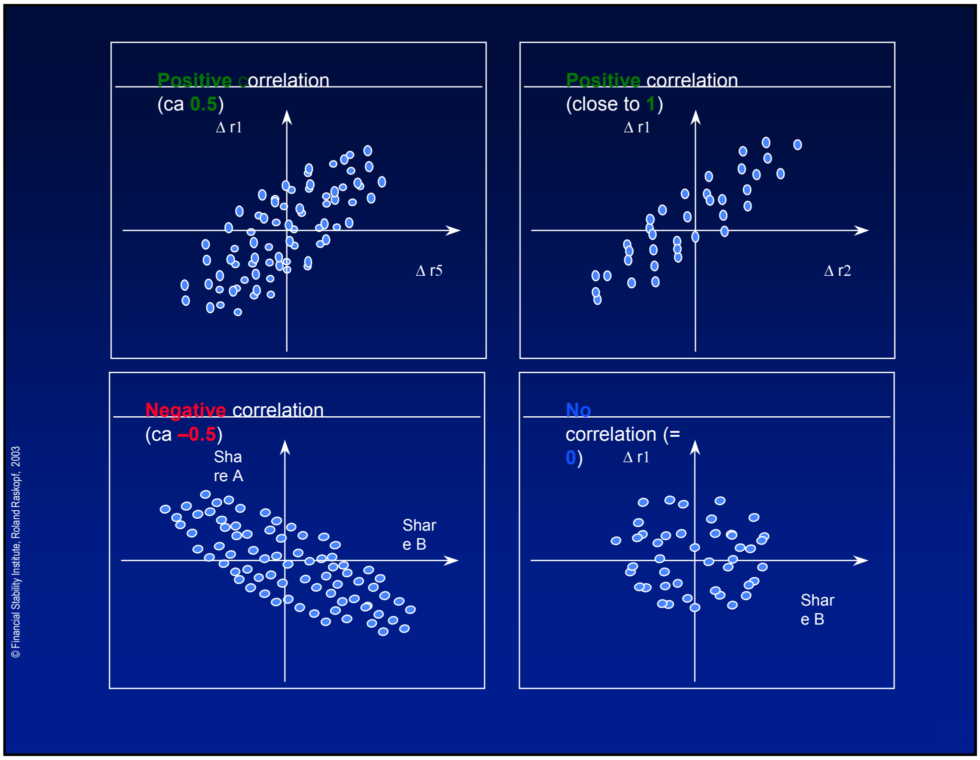
Shift of the yield curve in a worst-case scenario



Case 1: worst case

Time bucket VaRs are perfectly positively correlated:

$$VaR = VaR_1 + VaR_2 + VaR_3$$



Case 2: middle case

Time bucket VaRs are uncorrelated:

$$VaR = \sqrt{VaR_1^2 + VaR_2^2 + VaR_3^2}$$

Case 3: normal case

Time bucket VaRs are correlated:

$$VaR = \sqrt{\begin{array}{l} VaR_1^2 + VaR_2^2 + VaR_3^2 + \\ 2\rho_{1,2}\left(2.33\sigma_1 PVBP_1\right)\left(2.33\sigma_2 PVBP_2\right) + \\ 2\rho_{1,3}\left(2.33\sigma_1 PVBP_1\right)\left(2.33\sigma_3 PVBP_3\right) + \\ 2\rho_{2,3}\left(2.33\sigma_2 PVBP_2\right)\left(2.33\sigma_3 PVBP_3\right) \end{array}}$$

Example:
Three time buckets, confidence level = 99%

Maturity	Net cash flow	Spot rate	Net present value	Sensitivity (PVBP)	Absolute spot volatility (in bp)	Time bucket VaR	Correlation		
1y	–2,000,000	5%	–1,904,762	181	12	5,072	1.0	0.7	0.2
3y	+3,000,000	6%	2,518,858	–713	10	16,607	0.7	1.0	0.8
5y	–1,000,000	7%	–712,986	333	8	6,209	0.2	0.8	1.0

= 2.33 * 12 * 181

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Example:
Three time buckets, confidence level = 99%

Case 1: worst case

5,072 + 16,607 + 6,209 = 27,888

Case 2: middle case

$$\sqrt{5{,}072^2 + 16{,}607^2 + 6{,}209^2} = 18{,}441$$

Case 3: normal case

$$\sqrt{\begin{array}{l} 5{,}072^2 + 16{,}607^2 + 6{,}209^2 + \\ 2 * 0.7 * (5{,}072)(-16{,}607) + \\ 2 * 0.2 * (5{,}072)(6{,}209) + \\ 2 * 0.8 * (-16{,}607)(6{,}209) \end{array}} = 8{,}352$$

STABILITY OF CORRELATIONS

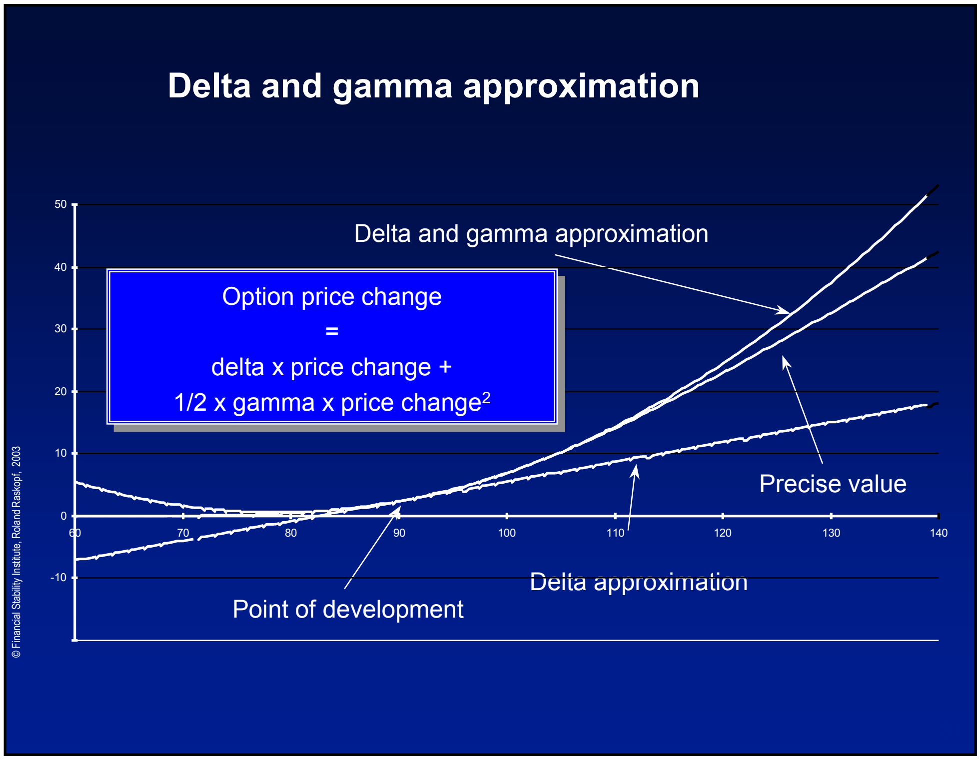
- Correlations in key risk factors in developed markets are fairly stable.
- Some market risk factors can be assumed to be independent i.e. correlations are zero.
- In stress szenarios correlations tend towards 1 not towards 0.
- The estimation of volatilities and correlations requires historical data.
- Volatilities and correlations can be made variable with a GARCH approach.

Advantages of the variance/covariance approach

- Most common VaR approach
- Comparatively few calculations to make if:
  – second-order risks are disregarded
  – restricted to a few risk factors
- Possible to isolate individual risk factors (direct access to risk factor sensitivities: marginal value at risk)
- Input data (variances, correlation matrix) can be obtained externally (J P Morgan's RiskMetrics)

Problems/criticisms regarding variance/covariance approach

- Second-order risks of options (convexity risks) are disregarded
- Limited to a small number of specified risk factors
- A specific distribution assumption (inter alia, normal distribution) is taken as a basis
- Fat tails are disregarded
- Stability assumed for volatilities and correlations


Delta and gamma approximation
Delta and gamma approximation
Option price change
=
delta x price change +
1/2 x gamma x price change²
Precise value
Delta approximation
Point of development
50
40
30
20
10
0
-10
60
70
80
90
100
110
120
130
140
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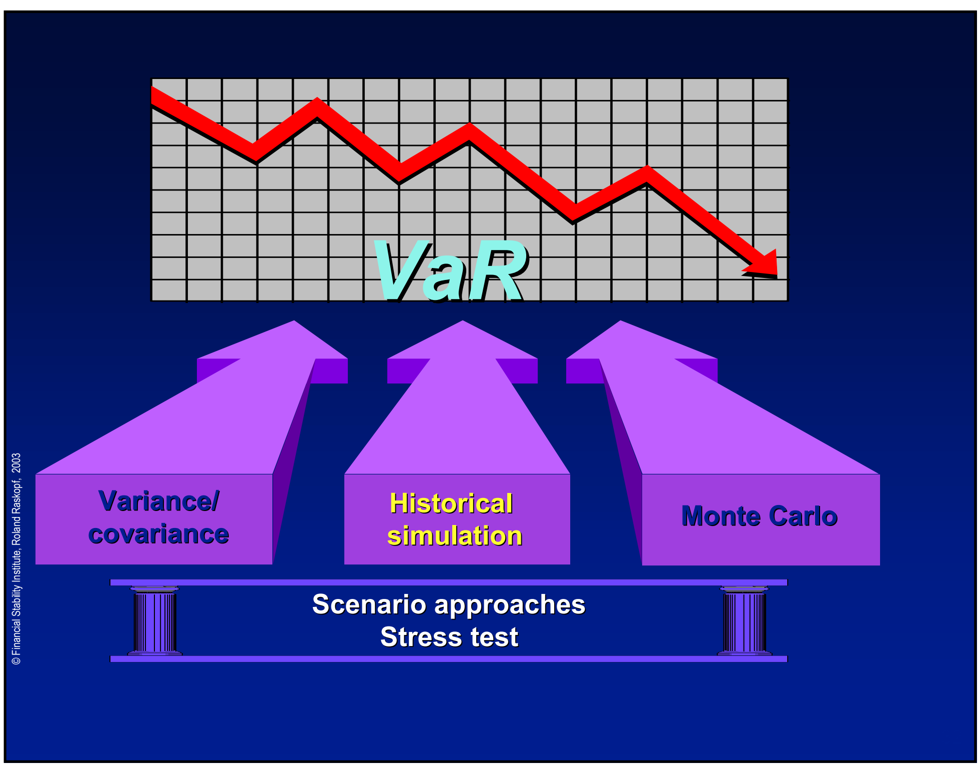
VaR
Variance/
covariance
Historical
simulation
Monte Carlo
Scenario approaches
Stress test
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Example: historical simulation

- Determination of 10-day changes on the basis of historical risk parameters
- Arrangement of changes in ascending order and elimination of the five lowest values
- VaR = sixth-lowest value

Example: historical simulation

10-day change

–90
–70
–60
–55
–50
–45 = VaR
–40
…

99% confidence interval, i.e. the sixth value of 500 values.

Historical simulation

- Valuation of current portfolio on the basis of historical risk parameters:
  $PV_1, PV_2, \ldots, PV_{510}$

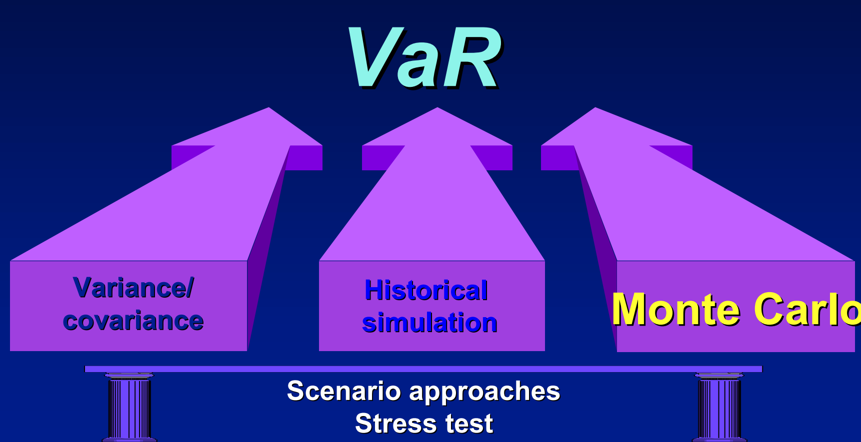
- Determination of portfolio changes for a defined holding period (here: 10 days):
  $\Delta \Pi\varsigma_1 = PV_{11} - PV_1$
  $\Delta \Pi\varsigma_2 = PV_{12} - PV_2$
  …
  $\Delta \Pi\varsigma_{500} = PV_{510} - PV_{500}$

Advantages of historical simulation

- Exact reproduction of historical reality
- Independent of any distribution assumption
- Historical correlations, variances implicitly taken into account
- Capture of second-order risks

Problems / criticisms

- Extremely resource-intensive storage and calculation process
- Purely past-oriented
- No sensitivities recognisable



Monte Carlo simulation

- The variance/covariance approach and historical simulation are purely past-oriented
- Monte Carlo simulation offers the possibility of determining random paths for risk factors on the basis of historically calculated or impliedly determined statistical quantities
- In addition to VaR estimates, Monte Carlo methods are used for valuing complex derivatives (e.g. path-dependent options) for which there is no analytical solution

Monte Carlo simulation procedure

- Determining input data (historical or implied variances and correlations)
- Generating random-event-dependent risk factor paths
- Determining P&L for each path status
- Eliminating 1% to remove worst cases
- VaR = worst value left over

Generating random paths with geometrical Brownian motion

- The risk factor (e.g. periodical yield, share price, exchange rate, volatility) changes over time as follows:

$$\Delta \ln S = \mu \Delta t + \varepsilon \sigma \sqrt{\Delta t}$$

Example: creating a risk factor path for the DAX

Given $\mu_{daily} = 0.00046$
$\sigma_{daily} = 0.00962$
DAX = 2,700

$$\Delta \ln DAX = \mu_{daily} + \varepsilon \times \sigma_{daily} = 0.00046 + \varepsilon \times 0.00962$$

$$t = 0: \; DAX_0 = 2700$$

Carrying out a (normally distributed) random experiment: ε = 0.52

$$t = 1: \; \Delta \ln DAX = \ln DAX_1 - \ln DAX_0 = 0.00046 + 0.52 \times 0.00962 = 0.0055$$

$$\Rightarrow \ln DAX_1 = \ln DAX_0 + 0.0055$$

$$\Rightarrow \; DAX_1 = DAX_0 \times e^{0.0055} = 2,715$$

Creating a risk factor path

Carrying out a (normally distributed) random experiment: ε = -0.11

$$t = 2:\ \Delta \ln DAX = \ln DAX_2 - \ln DAX_1 = 0.00046 - 0.11 \times 0.00962 = -0.0006$$

$$\Rightarrow \ln DAX_2 = \ln DAX_1 - 0.0006$$

$$\Rightarrow DAX_2 = DAX_1 \times e^{-0.0006} = 2{,}713$$

Thus a two-step Monte Carlo path is created for the DAX, with:

$DAX_1 = 2{,}715$
$DAX_2 = 2{,}713$

Monte Carlo Simulation

Basic ideas:

- Produce numerous changes in portfolio value with the help of a random generator
- assumption:
  the probability distribution of risk factors is known
- common approach:
  the daily logarithmic risk factor changes are multivariate normally distributed

Monte Carlo simulation

- distribution assumption:
  multivariate normal distribution:

$$\left(X_{t+1}^{1},\ldots,X_{t+1}^{n}\right) \sim N(\mu,\Sigma)$$

$$\mu = \left(\mu_1,\ldots,\mu_n\right)$$

$$\Sigma = \begin{pmatrix} \sigma_1^2 & \cdots & \rho_{1,n}\sigma_1\sigma_n \\ \vdots & \ddots & \vdots \\ \rho_{1,n}\sigma_1\sigma_n & \cdots & \sigma_n^2 \end{pmatrix}$$

Monte Carlo simulation

- Problem:
  the parameters μ and Σ are unknown:
  - ➡ estimation of the parameters μ_i , σ_i and $\rho_{i,j}$ from historical data
  - ➡ additional assumption:
    $\mu_i = 0$ for i = 1,...,n
- After estimation of the parameters the normal distribution is completely known

Monte Carlo simulation

Cholesky decomposition:

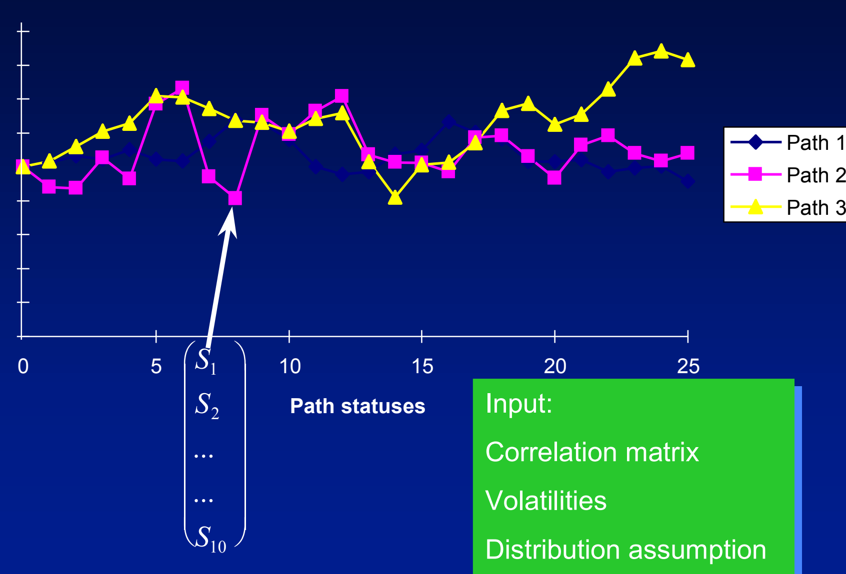
$$C = AA^T$$

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1i} \\ a_{21} & a_{22} & \cdots & a_{2i} \\ \vdots & \vdots & \ddots & \vdots \\ a_{j1} & a_{j2} & \cdots & a_{ji} \end{bmatrix}$$

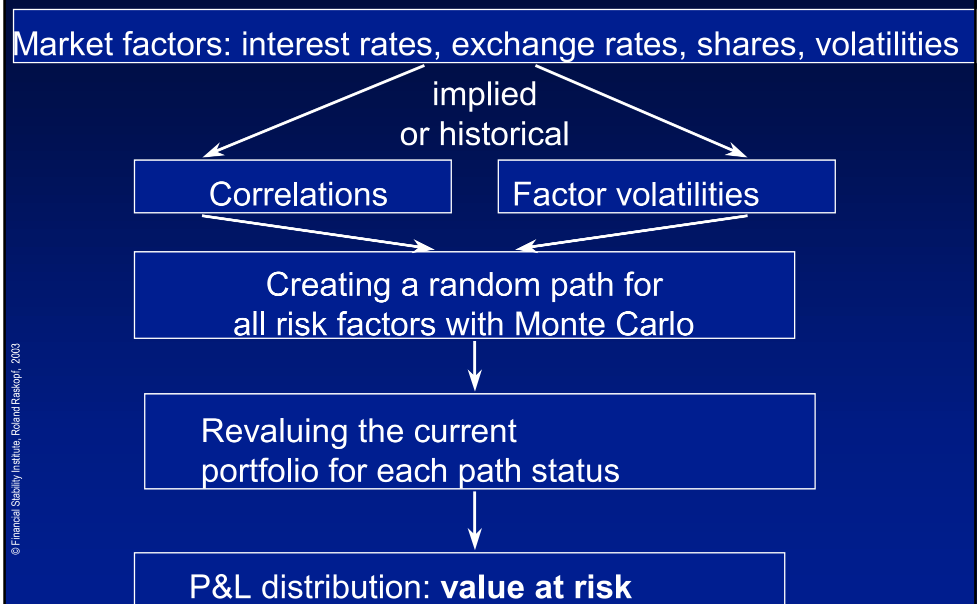
$$a_{ji} = \begin{cases} 0 & \text{for } j < i \\ \sqrt{c_{ii} - \sum_{k=1}^{i-1} a_{ik}^2} & \text{for } j = i \\ \frac{1}{a_{ii}} \sqrt{c_{ji} - \sum_{k=1}^{i-1} a_{ik} a_{jk}} & \text{for } j > i \end{cases}$$

$$c_{ij} = \text{cov}(i, j)$$

Creating random paths with Monte Carlo



Calculating VaR under Monte Carlo approach



Advantages

- Although the input data are usually past-oriented, random-event-dependent risk factor paths can be generated
- Very flexible to handle. Different distribution assumptions can be made for different risk factors (e.g. fat tails are taken into account, leptokurtosis is possible)
- Capture of second-order risks

Problems/criticisms

- Extensive calculation involved; entire portfolio has to be revalued for each path status
- No stable solution with short Monte Carlo path
- Distribution assumption of disturbance term
- Usefulness of random generator questionable

Summary: Comparison of VAR approaches

	Variance-Covariance	Historical simulation		Monte Carlo simulation
		Partial	Full	
Position valuation	Delta	Delta-gamma-vega	Full revaluation	Full revaluation
Distribution assumption	Normal	Non-normal (historical)	Non-normal (historical)	Non-normal (implied)
Cost	Low	Medium	High	High
Drawbacks	Reliance on history; linearity	Reliance on history; extreme events	Reliance on history	Reliance on historical correlations

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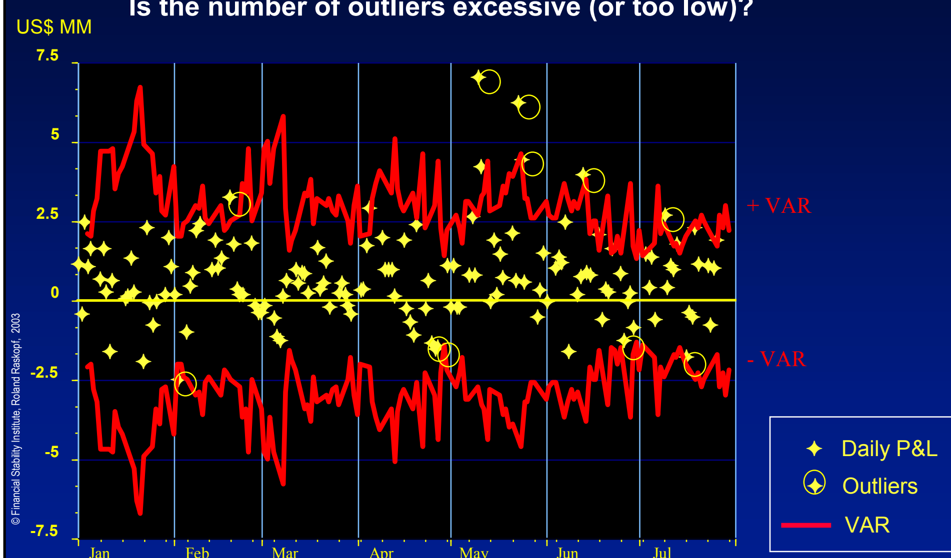
Backtesting VAR against realized P&L

Is the number of outliers excessive (or too low)?



1997

Establishing the increase factor

Zone	Number of outliers	Increase factor	Cumulative probability
Green	0	0.00	8.11%
	1	0.00	28.58%
	2	0.00	54.32%
	3	0.00	75.81%
	4	0.00	89.22%
Yellow	5	0.40	95.88%
	6	0.50	98.63%
	7	0.65	99.60%
	8	0.75	99.89%
	9	0.85	99.97%
Red	10 or more	1.00	99.99%

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Stress tests

Standard risk measures (e.g. VaR) do not take into account stress events sufficiently, therefore...

- A routine and rigorous programme of stress testing should be in place
- Results should be reviewed periodically by senior management
- If vulnerabilities are revealed prompt steps must be taken to manage those risks appropriately

⇒ **“Stress testing“ as generic term describing various techniques used by financial firms to gauge their potential vulnerability to exceptional, but plausible, events**

⇒ **See CGFS publications from April 2001 and April 2000**

Stress testing - some conclusions beforehand

- Sound risk management makes extensive use of stress tests
- If you have to make the choice: rather rely on expert judgement than on the model

“The discipline of concentration in the essential elements is the secret of success.” Reinhold Messner

Positive aspects...

- Stress tests are **easy to understand** for management (no assumptions like at VaR, ...)
- Stress tests **supplement Value at Risk** (VaR) as VaR is of limited use in measuring firms' exposures to extreme market events
- Stress Testing calls on the judgement of risk managers and senior executives to assess whether, and to what degree, the firm should handle an exposure ...

but also challenges ...

- **What** is a stress scenario, i.e. how much should risk factors be changed for a stress scenario to be given?
- Crashes in market prices are rare events. Can one estimate a crash in future relying on **crashes experienced in the past** ?
- For a stress scenario to be defined, the portfolio itself needs a thorough analysis beforehand: Where are the loop holes? What are the most important risk factors?
- As portfolios change, there is a need for **updating**
- Valuation with approximation is not fully satisfactory, even a full revaluation on grid points can be problematic

and limitations...

- A Stress test estimates the exposure to a specified event, but not the probability of such an event occurring.
- Numerous decisions in the specification of a stress test must be made that rely on the judgement and experience of the risk manager.
- No guarantee that the risk manager will chose the "right" scenarios or interpret the results effectively.
- Stress tests impose significant computational cost (collecting data from diverse business units, need to revalue complex options-based positions).
- At present firms cannot integrate market and credit risks in a systematic way in their stress tests.

How to derive stress tests

- Historic scenarios (crash, crisis)
  - equity crash 1987
  - emerging market crisis (SE Asia) 1997
  - russian debt problems 1998
- Historic market movements
- Makro-research
  - expert-scenorios
- Correlation breakdown, correlation setting
- Portfolio scenarios

Stress testing techniques

Technique	Stress test result:
Simple sensitivity test	Change in portfolio value for one or more shocks to **a single risk factor**
Scenario analysis	Change in portfolio value if the **scenario** were to occur
Maximum loss	**Sum** of individual trading units' worst case scenarios
Extreme value	**Probability distribution** of extreme losses

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Supervisory Quantitative Requirements

The Quantitative Part of the Model :

- 10 days Holding Period
- 99% Confidence Level
- Full Usage of Risk Factor Correlations
- Observation Period

But ...

Supervisory Qualitative Requirements

… the qualitative aspects on how a model is implemented are most important:

- Ensure that risks are measured accurately and with integrity
- The standards include the following:
  - Independent risk control unit
  - Regular back testing
  - Senior management must be actively involved
  - Model must be closely integrated into day-to-day risk management process
  - Independent review of overall risk management process regular part of internal audit

Supervisory Review Process
Scoring - Setting the Scaling Factor for Regulatory Capital

Organisation of Trading Activities / Organisational Environment	**0.30**
Front Office, Middle Office, Back Office	x
Risk Controlling	x
Internal Audit	x
Model Input	**0.20**
Trade / Position Data (Timeliness)	x
Market Data (Quality)	x

Supervisory Review Process
Scoring - Setting the Scaling Factor for Regulatory Capital

Model	**0.20**
Instrument Models	x
Adequacy of Risk Factors, Stripping and Mapping	x
Adequacy of Stochastic Modeling	x
Model Use in Risk Control	**0.30**
Limit System	x
Management Information and Reporting	x
Stress Tests	x

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Models useful in difficult markets?

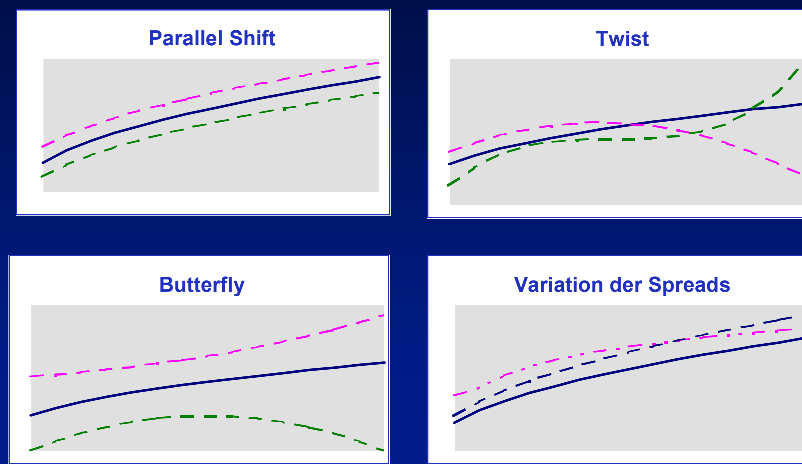
- Limited information
- Limited access to the market
- High volatility
- Concentration of instruments/players
- Poor settlement procedures
- Regulation
- High sensitivity to political considerations & commodity cycle

Conclusion

- MR Models are just tools but no “crystal balls”
- Capital allocation and models
- Black boxes are useless
- Main Problem: DATA
- Improved the risk culture and EDP environment
- Event risk approach
  - stress-testing
  - contingency plans
- Integrated approaches are key in difficult markets

ANNEX Stresstests

Interest rate scenarios



DPG Stress Testing Standards

- Parallel yield curve shifts of 100 basis points up and down;
- Steepening and flattening of the yield curves (2s to 10s) by 25 basis points;
- Each of the 4 permutations of a parallel yield curve shift of 100 basis points concurrent with a tilting of the yield curve (2s and 10s) by 25 basis points;
- Increase and decrease in all 3-month yield volatilities by 20% of prevailing levels;
- Increase and decrease in equity index values by 10%;
- Increase and decrease in equity index volatilities by 20% of prevailing levels;
- Increase and decrease in the exchange value (relative to the US dollar) of foreign currencies by 6%, in the case of major currencies, and 20%, in the case of other currencies;
- Increase and decrease in foreign exchange rate volatilities by 20% of prevailing levels; and
- Increase and decrease in swap spreads by 20 basis points.

Source: DPG, *A Framework for Voluntary Oversight*, February 1995, p.30.

DPG Stress Testing Example

Country	Risk Factors	Move Size	P&L ($ Millions) Up	P&L ($ Millions) Down
US	Parallel yield shift	100bp	<2.2>	3.4
US	Curve steepening	25bp (2s to 10s)	2.0	<1.8>
US	Interest rate volatility	20%	<1.5>	2.4
US	Equity index shift	10%	0.2	<0.1>
US	Equity index volatility	20%	0.0	0.0
US	Swap spreads	20bp	0.5	0.5

Stress Scenario: Credit Spread

Desk	Market Exposure (in $mill)	1bp Spread Widening (in $thous)	Shock Widening (basis point)	Loss Impact (in $mill)	Impact Limit	% of Limit
Corporate Bonds						
Corporate Bond Rating						
AAA	125	88	20	(1.75)		
AA	75	53	30	(1.58)		
A	(5)	(4)	45	0.16		
BBB	25	18	70	(1.23)		
Portfolio Hedges						
Swap (Corporate Bond Index)	(15)	(11)	50	0.53		
Swap (Interest Rate)	(5)	(4)	30	0.11		
Total Corporates:				(3.76)	**10**	38%
Global Emerging Debt Markets						
High 2-4yrs	-10	(7)	2,400	5.50 *		
High 4+yrs	12	8	2,100	(6.00) *		
Medium	11	8	500	(3.85)		
Low	15	11	250	(2.63)		
Total Emerging Markets:				(6.98)	**10**	70%

* adjusted for convexity

Default Scenario

	Par	Price	Mkt Val (US$ in MM)	Recovery	IMPACT (US$ in MM)
Hard Currency Bonds:					
IANs	USD10MM	60%	6.0	10%	<5.4>
PRINs	USD 6MM	60%	3.6	10%	<3.2>
MinFin3s	USD 5MM	70%	3.5	15%	<3.0>
Russia 10.0% Jun'07s	USD15MM	70%	10.5	15%	<8.9>
Local Mkts: Bonds & Bills					
GKOs/OFZs (RUR/$ = 6)	RUR90MM	50%	7.5	10%	<6.8>
Local Mkts: Foreign Exchange					
FX Deposits with Russian banks	RUR12MM	6.0	2.0	0.0	<2.0>
FX Deposits with Western banks	RUR24MM	6.0	4.0	12.0*	<2.0>
Equity:					
Equity (Various)			5.0	20%	<4.0>
TOTAL					**35.3**

Hypothetical Economic Scenario

- The Modest Recession Case: (12 month horizon)
  - *the following changes will gradually occur in the first six months and the conditions will remain unchanged for the remaining six months*
    - Inflation expectations rise one percent
    - Bond yields rise 150 basis points
    - Equity market valuations decline 20%
    - Credit spreads widen approximately one-third the move observed in Fall 98
- The Severe Recession Case: (18 month horizon)
  - *the following changes will gradually occur in the first twelve months and the conditions will remain unchanged for the remaining six months*
    - Inflation expectations rise two percent
    - Bond yields rise 300 basis points
    - Equity market valuations decline 35%
    - Credit spreads widen approximately two-thirds the move observed in Fall 98

Economic Scenario

Projected Revenue Impact

	Modest Case	**Severe Case**
Investment Banking	<25MM>	<40MM>
Merchant Banking	<5MM>	<10MM>
Fixed Income	<10MM>	<15MM>
Currency	<5MM>	<5MM>
Commodity	<0MM>	<0MM>
Equity	<20MM>	<30MM>
Asset Management	<5MM>	<10MM>
TOTAL	**<70MM>**	**<110MM>**

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Equity Market Analysis

S&P 500 Volatility \ **S&P 500 Level**	**-25%**	**-10%**	**0%**	**10%**	**25%**
-40%	(2.2)	(2.8)	(4.3)	**(5.1)**	3.6
-20%	1.1	(1.3)	(2.6)	(1.9)	7.4
0	4.7	1.2	0.0	1.6	11.3
20%	8.5	4.4	3.3	5.3	15.3
40%	**12.4**	7.9	7.0	9.3	19.4

'87 US Market Crash

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ROLAND RASKOPF

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