

# **Auditing Value at Risk models in the context of banking – a practitioner's framework**

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Zagreb, June 2014

# OBJECTIVE

❑ Illustrate why YOU (“Quants”) must have a vested interest that a strong control environment supports and protects your models

❑ Inform discussions YOU are likely to have with Risk Managers, Internal Auditors, External Auditors and Regulators (“Non Quants”)

❑ Help YOU to understand

- ✓ the way in which risk models are embedded into the day to day risk management
- ✓ the challenges model users face from a technical and operational perspective
- ✓ the lessons learned from the financial crisis and the latest developments

❑ Value at Risk models as case in point

- ✓ proliferation and multi-purpose usage
- ✓ criticism during financial crisis 2007/2008
- ✓ criticism following JP Morgan incident 2012



# AGENDA

1. Definition – What is VaR?
2. Methods – How to calculate VaR?
3. Audit approach – How to audit VaR?
  - (Regulatory) Compliance
  - General management control and organisation
  - Completeness
  - Accuracy
  - Model validation
  - Stress testing
  - Limit system, limit monitoring, reporting

## 4. Summary

## Appendix



“A slight mistake on the part of the doctor”

# DEFINITION

- ❑ Value at Risk is the **monetary**
  - ✓ negative change of value (**loss**) of a portfolio
  - ✓ during a pre-determined **holding period**
  - ✓ with a particular pre-determined probability (**confidence level**)

which will normally **not** be **exceeded**.

## ❑ Example

- ✓ With a probability of **99%** the market value of a bond portfolio will not decrease by more than **£100,000** within the next **ten days**.

VaR added two new dimensions (holding period and confidence level) and allowed the (bankwide) aggregation of risks across products and desks!

# METHODS

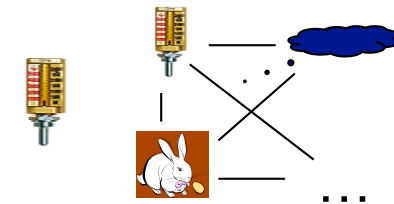
## □ VaR parameter

- ✓ Confidence level
- ✓ Holding period

VaR models: four key building blocks, three methods, numerous calibrations!

## □ Input: Scenario generation

- ✓ Identification of (all material) risk factors
- ✓ Observation period for (historical) risk factor changes
- ✓ Definition of risk factor changes between two dates
- ✓ Distribution assumption for risk factor changes
- ✓ Correlations between risk factors



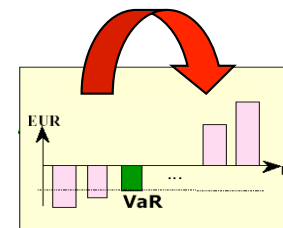
## □ Processing: (Re)Valuation

- ✓ Full model vs. approximations



## □ Output: Generation of profit and loss distribution

- ✓ With or w/o consideration of the signage.
- ✓ VaR reading (e.g. nth highest loss)



# METHODS

Regulators accept systematic differences between VaR models (even for one and the same portfolio)!

## □ Three methods, three VaR figures ...

- ✓ Long Straight Bonds (£ 100 m notional, 10% coupon, maturity 3 years, PV £112.442 m)
- ✓ Long Zero Bonds (£ 50m notional, maturity 3 years, PV £ 41.6618 m)

Variance Covariance	Historical Simulation	Monte Carlo Simulation
£ 0.3722 m	£ 0.7654 m	£ 0.3378 m

source: B. Jendruschewitz, 1999

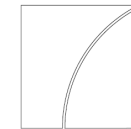
UK regulator (2014): “The PRA accepts that the scope and nature of VaR models varies across firms. This means that different firms are likely to calculate different estimates of market risk for the same portfolio. Systematic differences are due to length of data series, choice of methodology (historical or Monte Carlo simulation or variance-covariance method or a hybrid of these) differences in aggregating risks within and across broad risk factors, the treatment of options and other non-linear products and the specification of risk factors.”

# I. Audit stream: (Regulatory) Compliance

Myriad of constraints - Management and regulators are further strengthening the control requirements!

## VaR model specific requirements

- ✓ Internal requirements (e.g. trading book policies)
- ✓ Bank specific VaR internal model recognition letter
- ✓ Generic VaR model requirements (Basel 2.5, CRD, PRA handbook)



Consultative Document

Fundamental review of the trading book: A revised market risk framework

Issued for comment by 31 January 2014  
October 2013

Basel Committee  
on Banking Supervision

## Non VaR model specific requirements

- ✓ Market Risk department not fully incorporated into operational risk (pillar 1)
- ✓ Public disclosure (pillar 3)
- ✓ Sarbanes Oxley Act (SOx)
- ✓ Investment Management Agreement
- ✓ ...

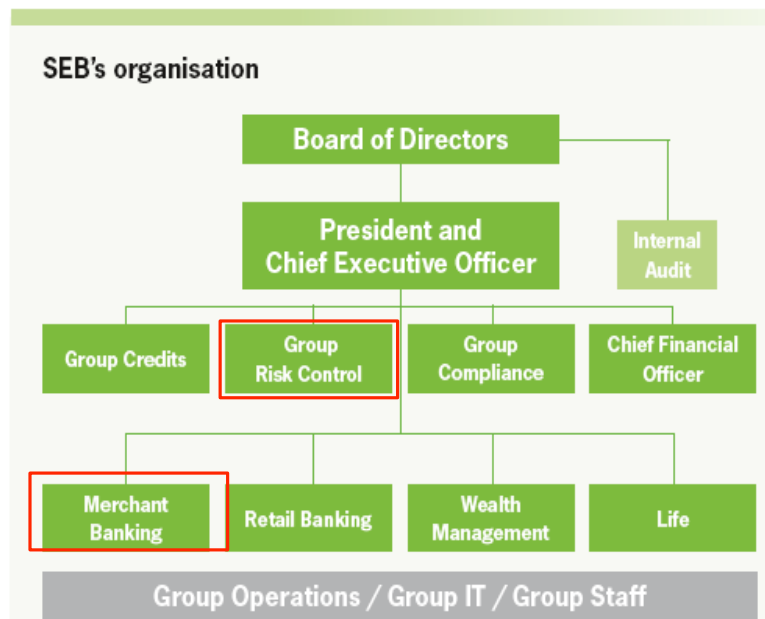


Frequently asked  
questions on Basel III  
monitoring

21 February 2014

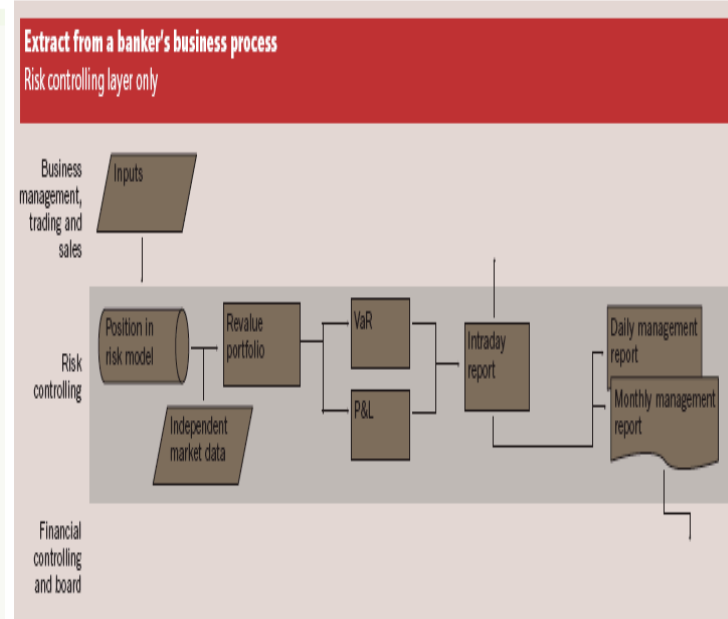
## II. Audit stream: General management control and organisation

Models are not a substitute for market experience – Model governance AND Risk governance are key!



source: SEB: Annual Report 2007, p.46

- ✓ Model governance (independent review function?) **AND** Risk governance



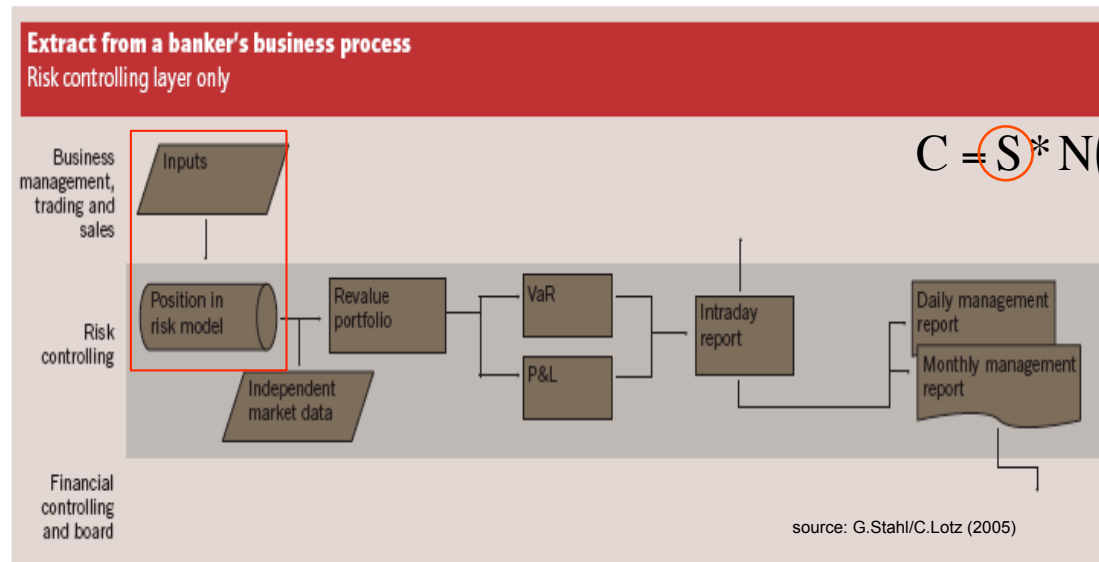
source: G. Stahl/C. Lotz, 2005

- ✓ Adequate and effective overall process and control framework?



### III. Audit stream: Completeness

Missing positions, missing risk factors and late feeds may materially misrepresent the risk!



$$C = S * N(d_1) - Ke^{-rt} * N(d_2)$$

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right) \cdot t}{\sigma\sqrt{t}}$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

- position data feeds into risk engine incomplete or not timely
  - ✓ no control that positions are correctly booked (e.g. dummy trades)
  - ✓ no control that risk analytics are generated
  - ✓ no evidence of the reconciliations or inadequate set up of the reconciliations
  - ✓ no delivery statistics on late front office trade data feeds into risk engine and rolled data (timeliness)
- trades outside core application (e.g. non standard trades)

# III. Audit stream: Completeness

Hierarchy and hierarchy specifications may cause a misrepresentation!

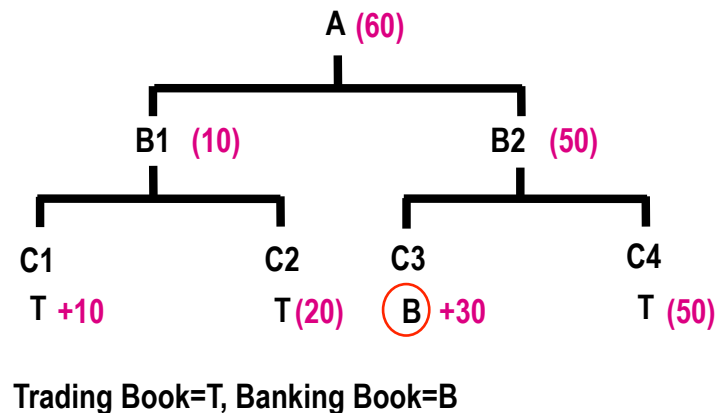
## ❑ Risk Aggregation

✓ **Hierarchies** incomplete or not regularly reconciled

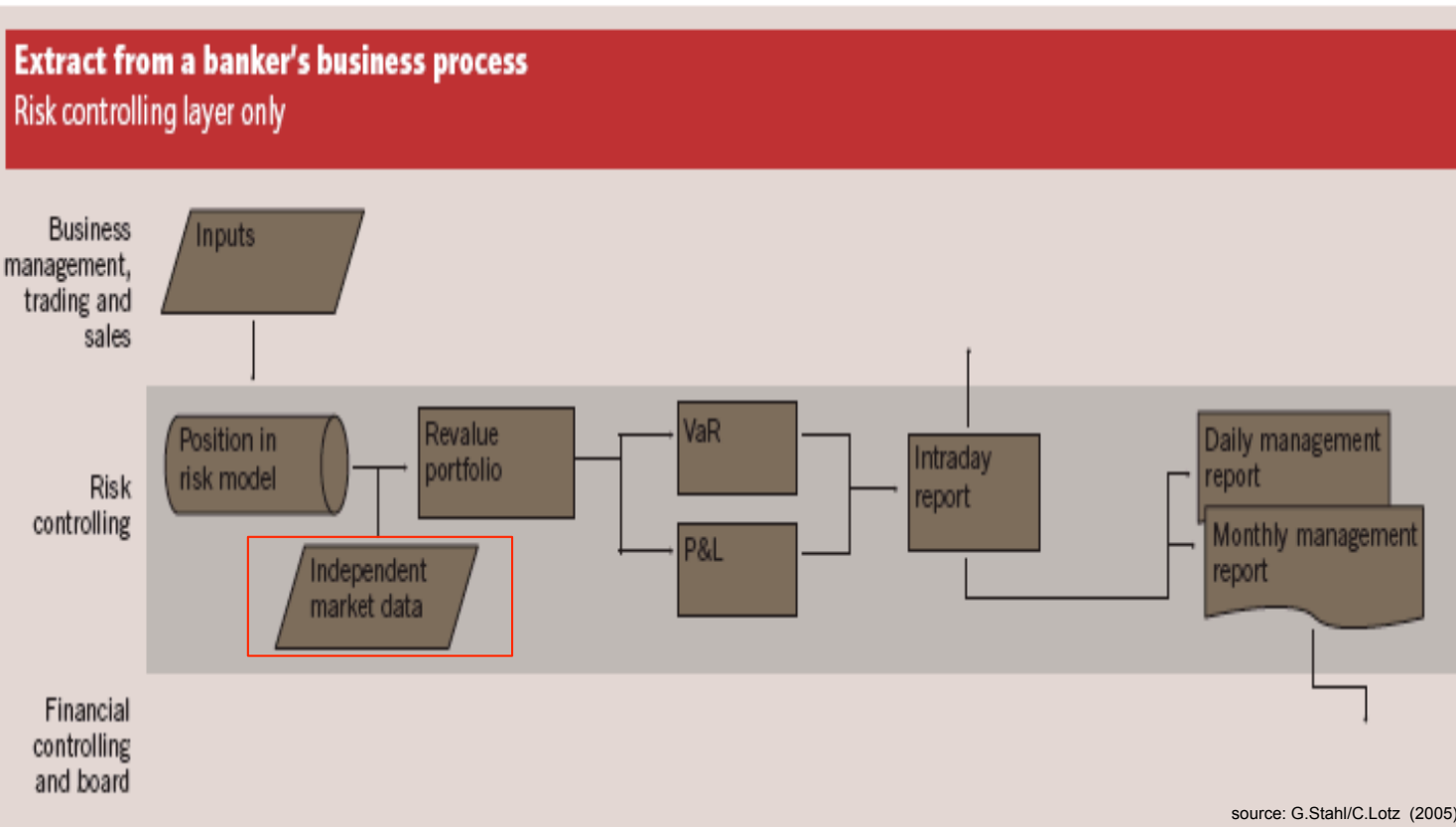
- No adherence to periodic review processes via Risk Manager
- Risk Management hierarchy inconsistent with Finance hierarchy

✓ **Flags and filters** incorrect or not regularly monitored

- Risk by legal entity
- Risk by banking book and trading book
- Risk by PRA approved internal VaR model
  - » Trading book vs. scope of PRA approved internal VaR model



## IV. Audit stream: Accuracy



## IV. Audit stream: Accuracy

It is crucial to understand which market data the risk engine uses (“rubbish in, rubbish out”)!

- Inadequate process to identify unmapped codes
- Inadequate market data used
- Inadequate and ineffective process to maintain mapping tables regularly

Code	Mapped Code
BOND_GBP_14Y	BOND_GBP_15Y
FXOPTION_AUDUSD_2Y	FXOPTION_AUDUSD_1Y
FXOPTION_NLGJPY_3M	FXOPTION_DEMJPY_3M
SWAP_ATS_12Y	SWAP_ATS_10Y
CAP_BEF_6Y	CAP_DEM_5Y
ZERO_CAD_10Y	SWAP_CAD_10Y

- No alternatives than to map positions to other ‘similar’ securities
  - e.g. exponentially weighted schemes, pseudo-historical series generation, antithetics, volatility-scaling, creation of risk add-ons to provide buffers

## IV. Audit stream: Accuracy

Sudden market changes and processing errors may contribute to a misrepresentation!

- ❑ FSA (2008): “We encourage firms ... to use their judgement to adjust their models in ways which are demonstrably **prudent** relative to core requirements of BIPRU 7.10...”
- ❑ FSA (2008): “.... we would like to **support** firms that are taking **tangible measures** to improve the resilience of their VaR models **in volatile market conditions** ....”

### ❑ Processing errors

- ✓ Missing or irregular update of time series in risk engine
- ✓ Incorrect download of market data
- ✓ Data cleansing process inadequate and ineffective
- ✓ Incorrect upload

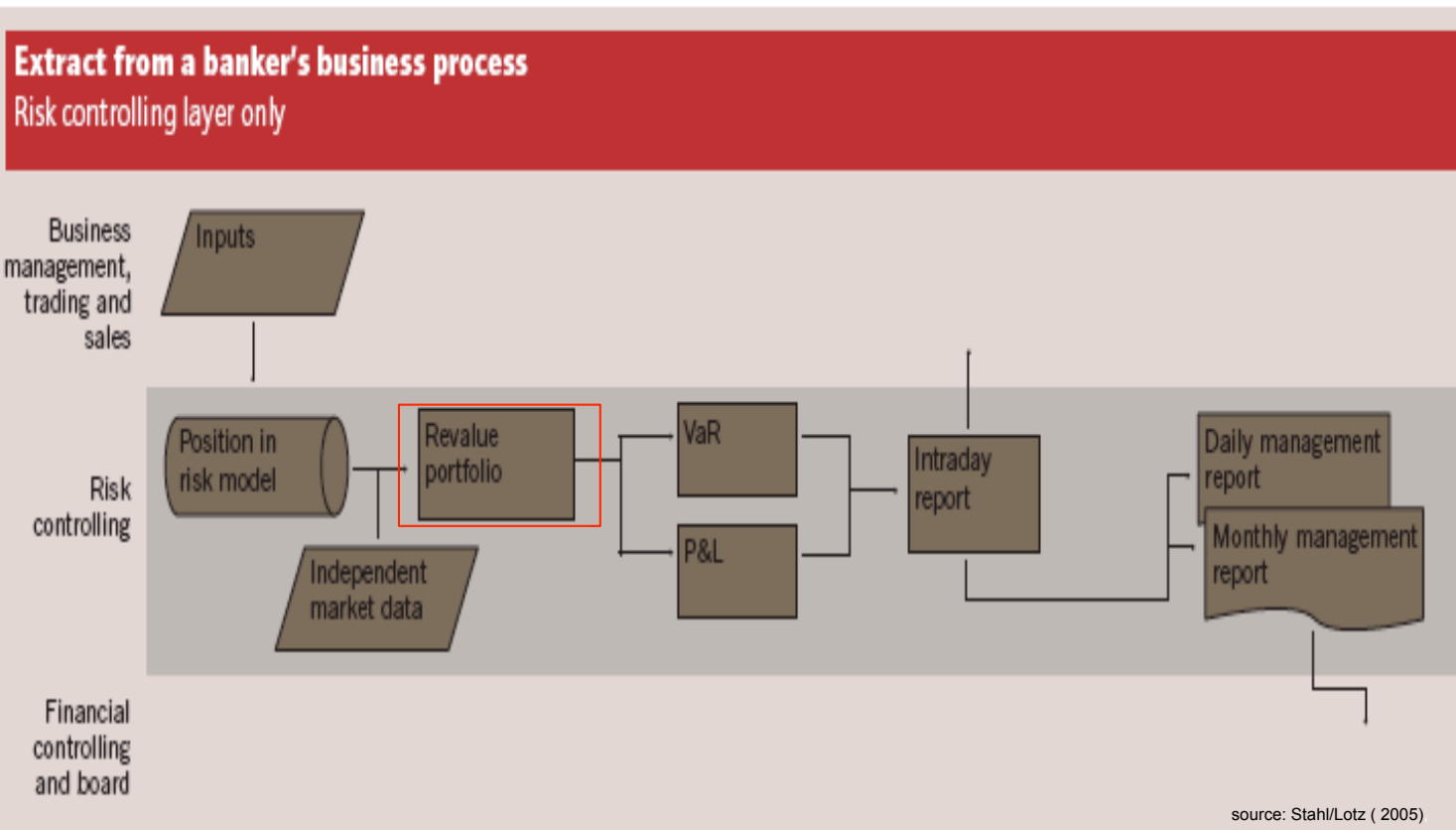
Basel Committee  
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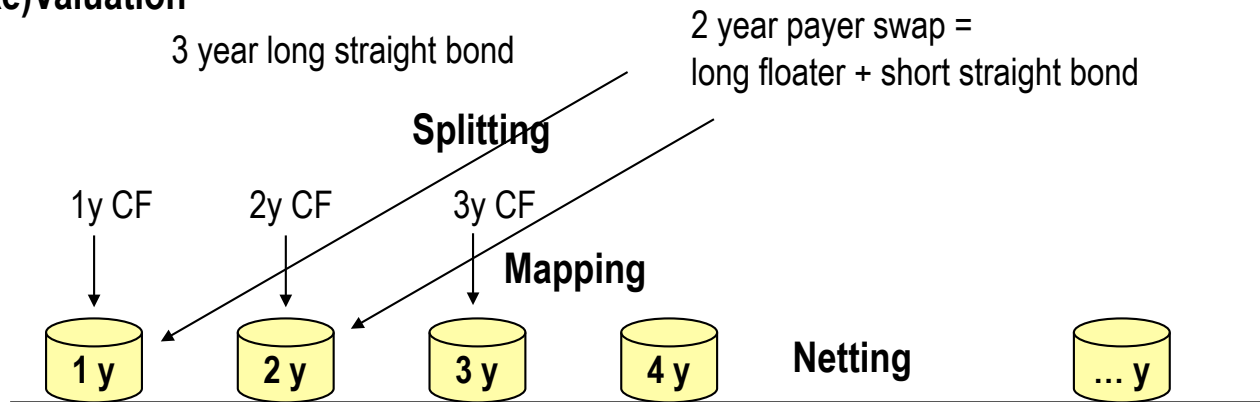
## IV. Audit stream: Accuracy



# IV. Audit stream: Accuracy

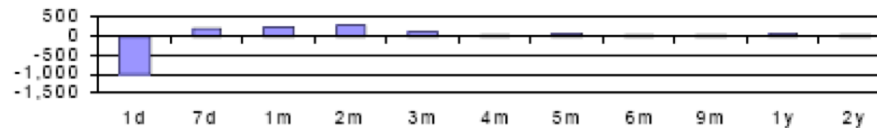
The way the revaluation happens is key – trade by trade valuation is impractical!

## □ (Re)Valuation



## Bucketing

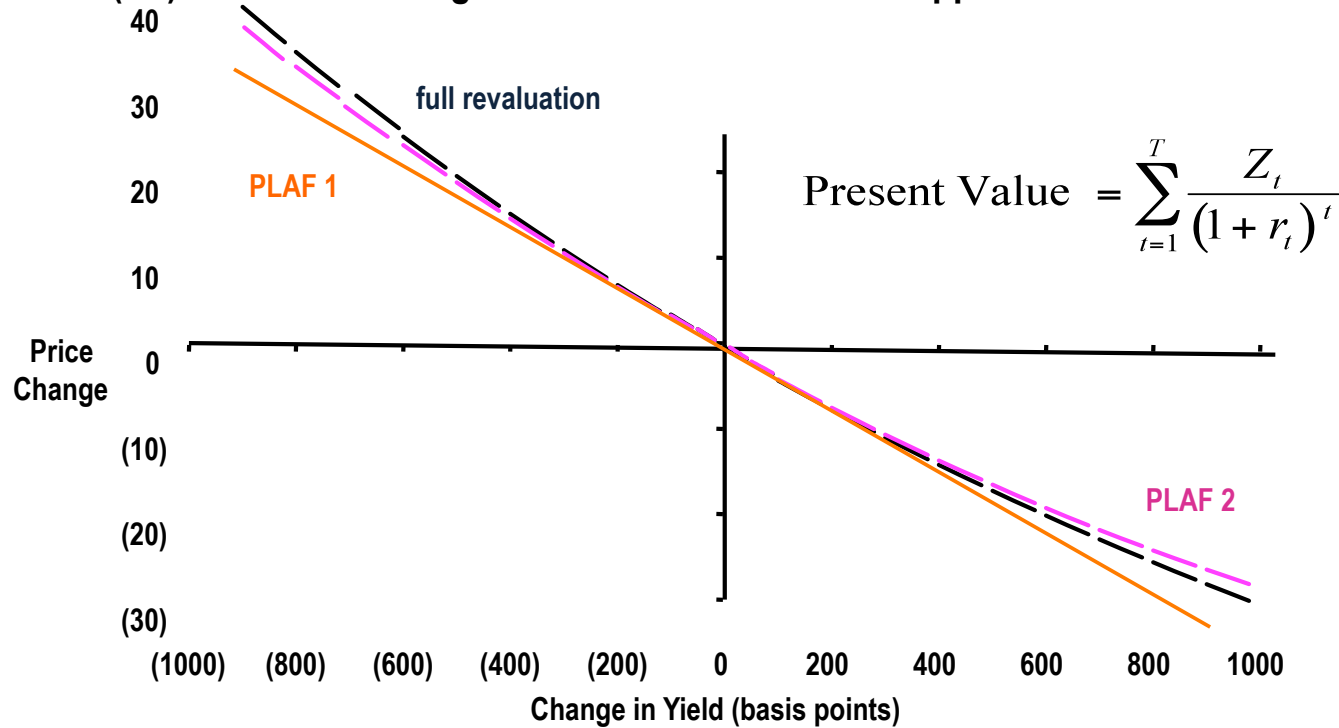
- ✓ **SEB**: The model maps positions onto **risk buckets** for **market rates** and other key risk drivers. (SEB, Capital Adequacy and Risk Management report (Pillar 3) 2007, p.12)
- ✓ BIPRU 7.10.40 R: “ ... **yield curves** ... minimum, the major currencies and markets ... **minimum of six maturity segments.**”



# IV. Audit stream: Accuracy

Full revaluation is often impractical – banks use approximations!

## □ (Re)Valuation: Pricing models and Profit & Loss Approximation Functions (PLAFs)



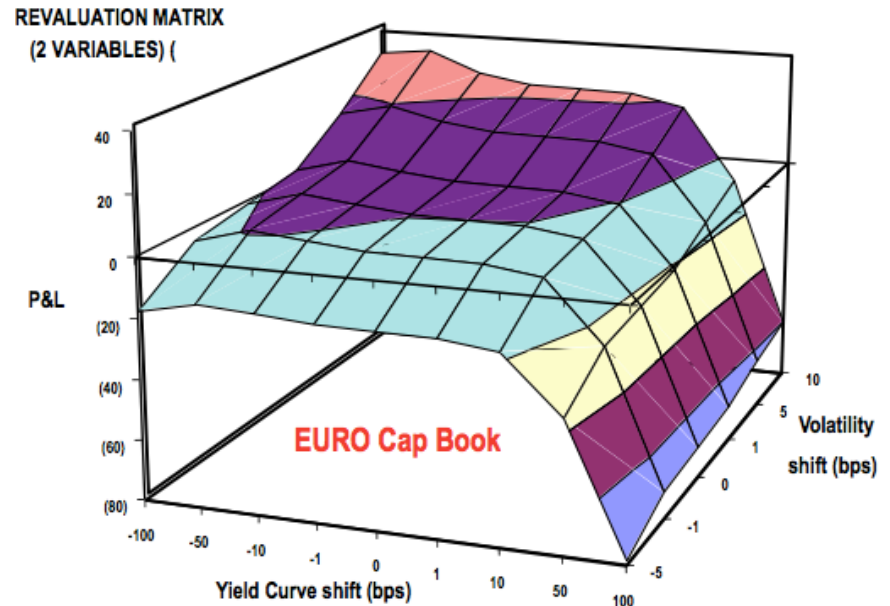
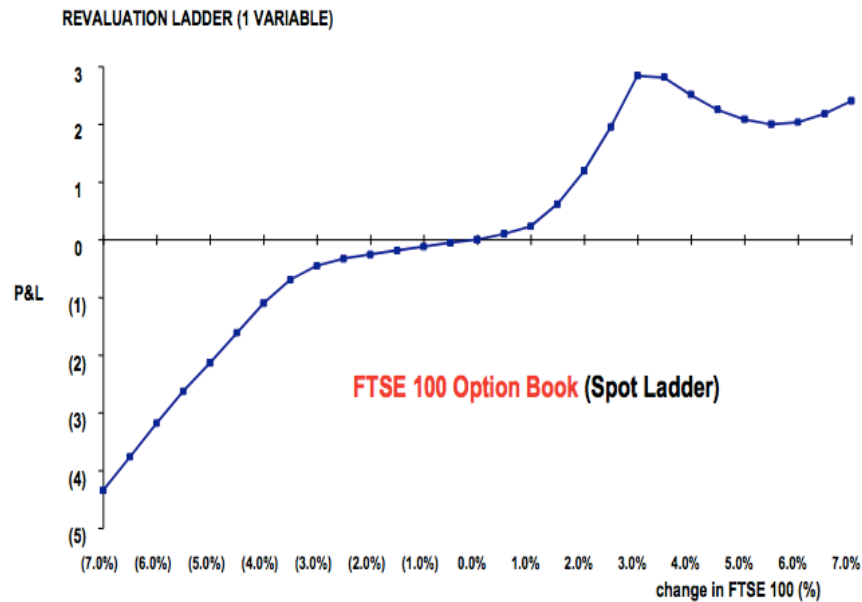
✓ Interest delta (PV01), Credit spread sensitivity (CR01), Equity delta, FX delta etc.



# IV. Audit stream: Accuracy

Full revaluation is often impractical – banks use PnL approximations!

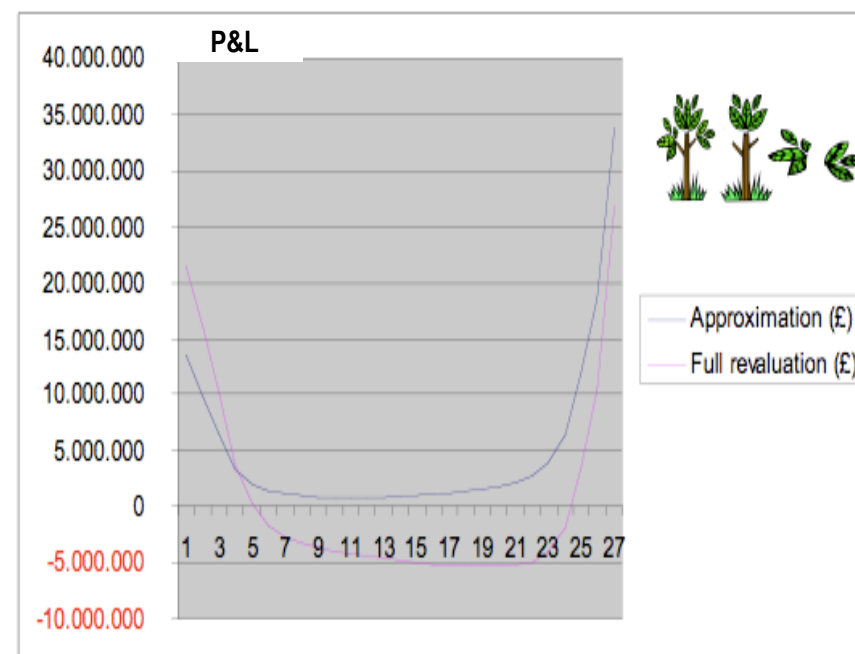
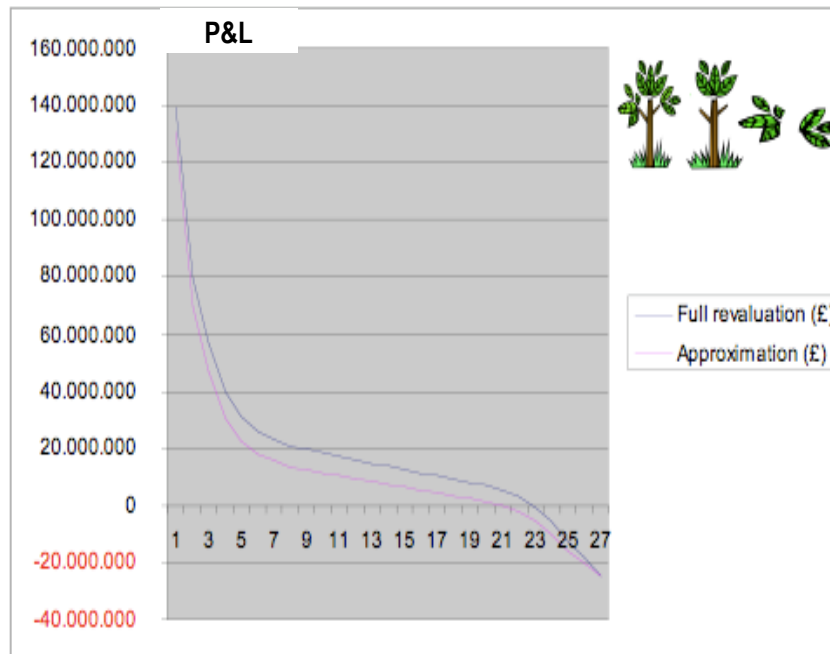
## □ (Re)Valuation: Pricing models and PLAFs



## IV. Audit stream: Accuracy

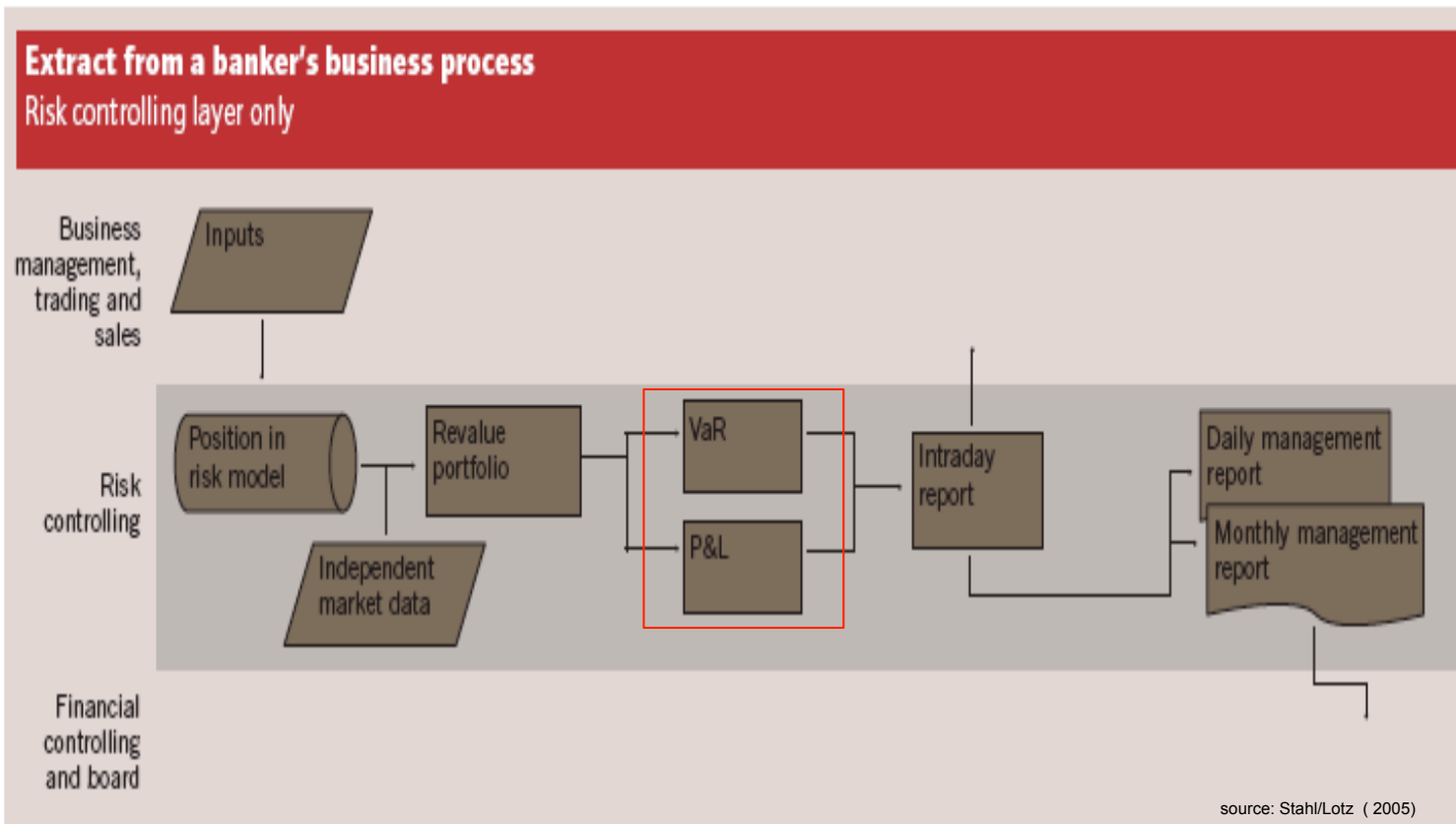
- Pricing model inadequate or not tested
- Approximations not tested (e.g. higher order approximations)
- Process to test approximations not adequate or effective
- Findings not followed up sufficiently

PnL approximations must be (re)tested!





## V. Audit stream: VaR model validation

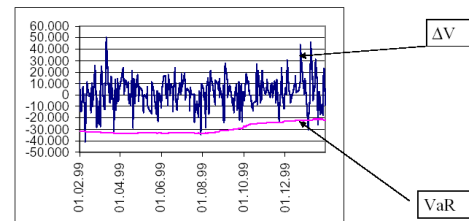


## V. Audit stream: VaR model validation

“All models are wrong – some of them are useful!”

### □ Backtesting (BIPRU 7.10.91 G – BIPRU 7.10.126 G)

- ✓ BIPRU 7.10.91 G „Backtesting is the process of **comparing VaR to portfolio performance**. It is intended to act as **one of the mechanisms** for the ongoing validation of a firm's VaR model and to provide incentives for firms to improve their VaR measures.“



### □ Exceptions

- ✓ BIPRU 7.10.103 R „A backtesting **exception** is deemed to have occurred for any business day if the **hypothetical profit and loss figure** for that business day shows a loss, which in absolute magnitude, **exceeds the one-day VaR** measure for that business day.“

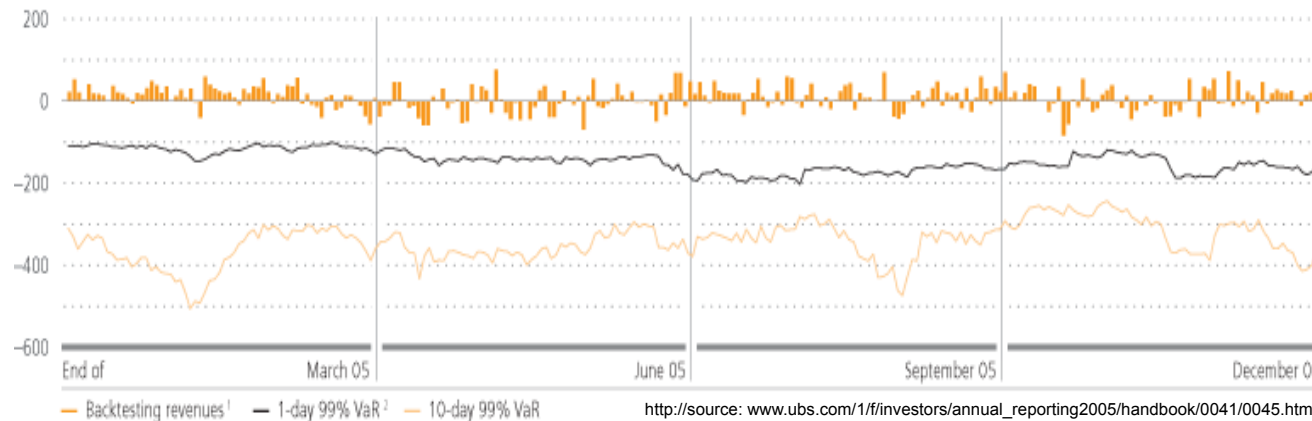
# V. Audit stream: VaR model validation

No backtesting exception may not equate to good model fit!

## UBS Investment Bank: backtesting revenues<sup>1</sup> and VaR

CHF million

1 January 2005 – 31 December 2005



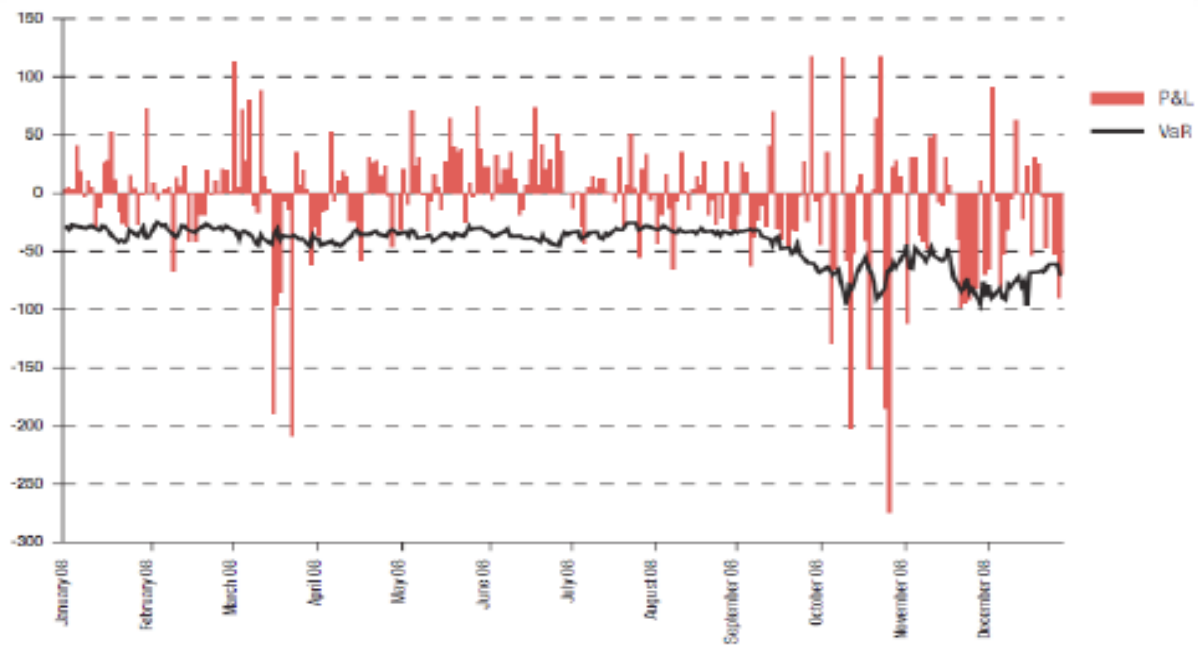
<sup>1</sup> Backtesting revenues exclude non-trading revenues such as commissions and fees, and revenues from intraday trading. <sup>2</sup> 1-day 99% VaR includes only positions subject to market risk regulatory capital.

- C. Jeffery (2006): “The reported number of value-at-risk exceptions at the world's largest financial institutions appears to be far lower than statistically expected. Are dealer VaR models faulty? And are regulatory standards vigorous enough?”

## V. Audit stream: VaR model validation

Models that perform well for years may produce series of material exceptions in a crisis!

### Backtesting Results for SOCIETE GENERALE



source: Frésard/Pérignon/Wilhelmsson (2012)

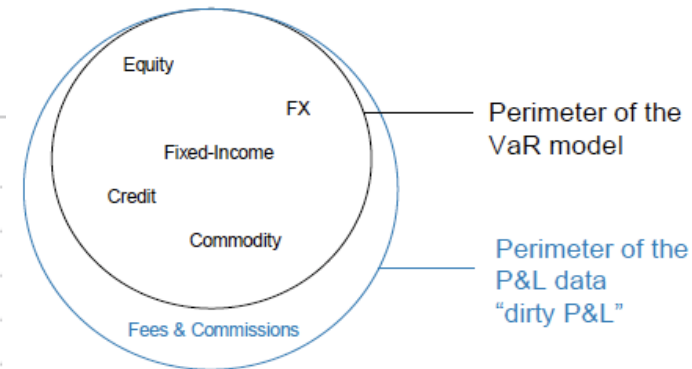
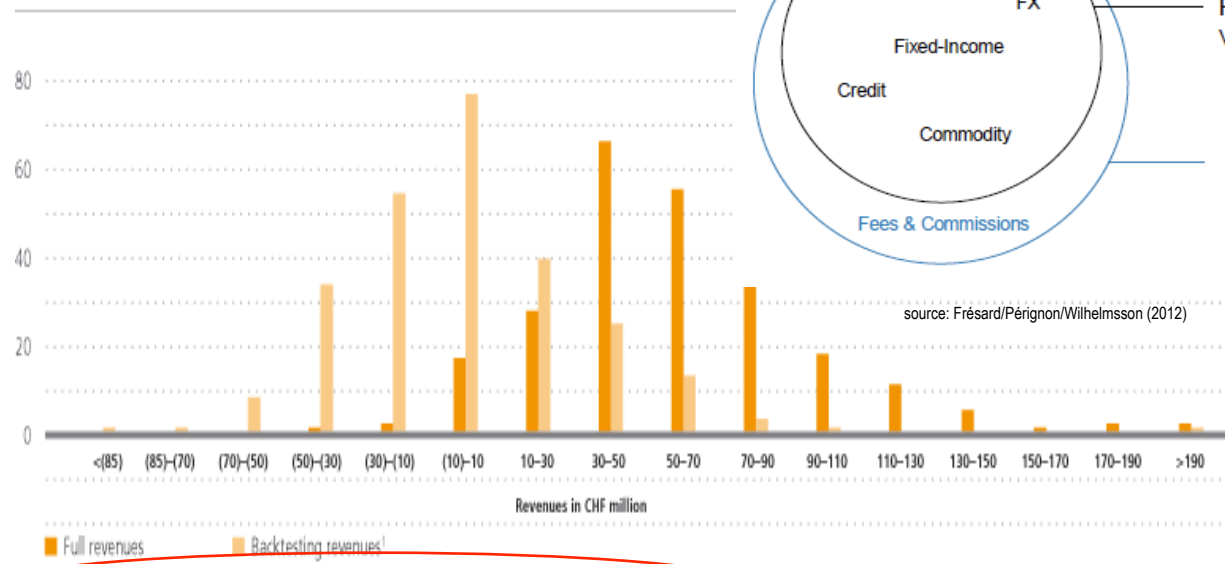
# V. Audit stream: VaR model validation

Backtesting must support “like for like” comparison!

- Backtesting against clean and dirty PnL
- Backtesting against actual or “frozen” portfolio

Investment Bank: distribution of daily revenues, 2005

Frequency in number of days



source: Frésard/Pérignon/Wilhelmsson (2012)

<sup>1</sup> Excluding non-trading revenues such as commissions and fees, and revenues from intraday trading.



# V. Audit stream: VaR model validation

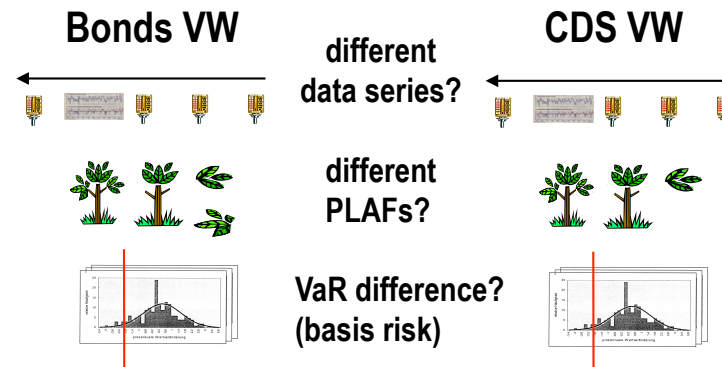
Model validation must be more than “just” backtesting!

## □ further model validation (example)

- ✓ The VaR model must **capture name-related basis risk**.
  - The firm must be able to demonstrate that the VaR model is sensitive to material idiosyncratic differences between similar but not identical positions.

### ✓ Proposed Test:

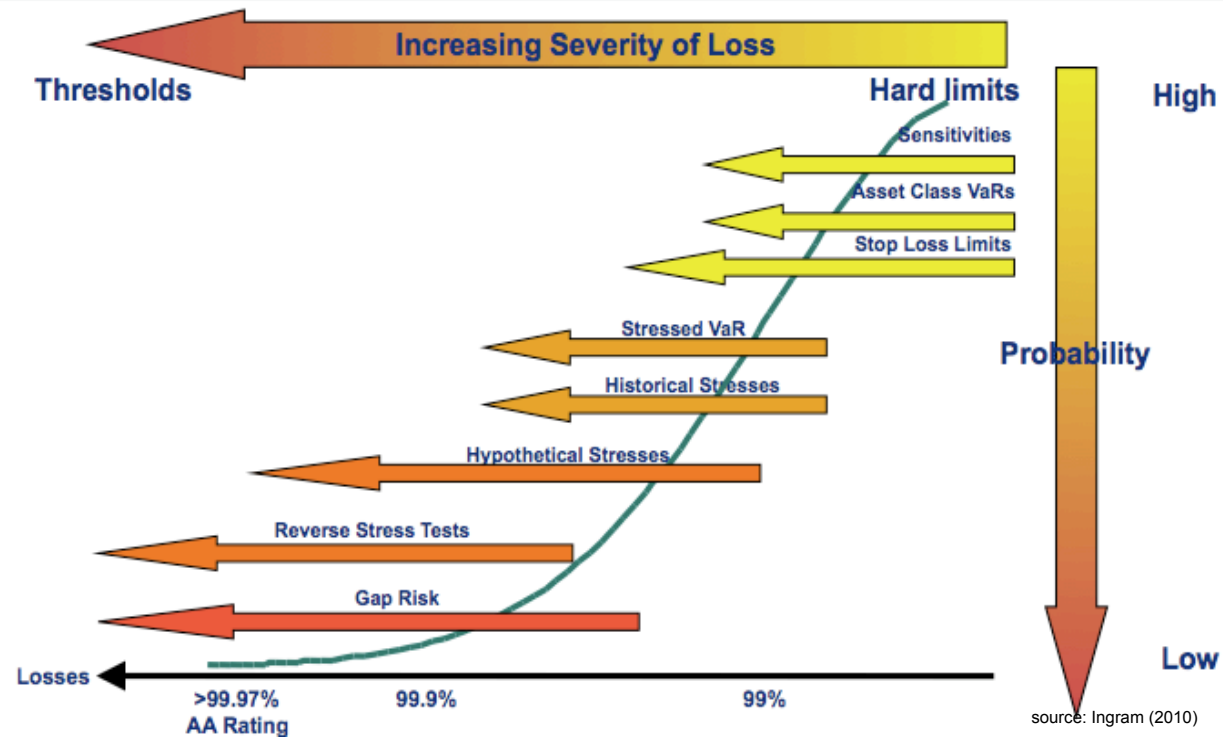
- Model captures bond CDS basis for the same issuer: Show there is a difference in VaR for bond and CDS positions in the same issuer. Show that a **CDS hedged with a bond will generate some risk**.



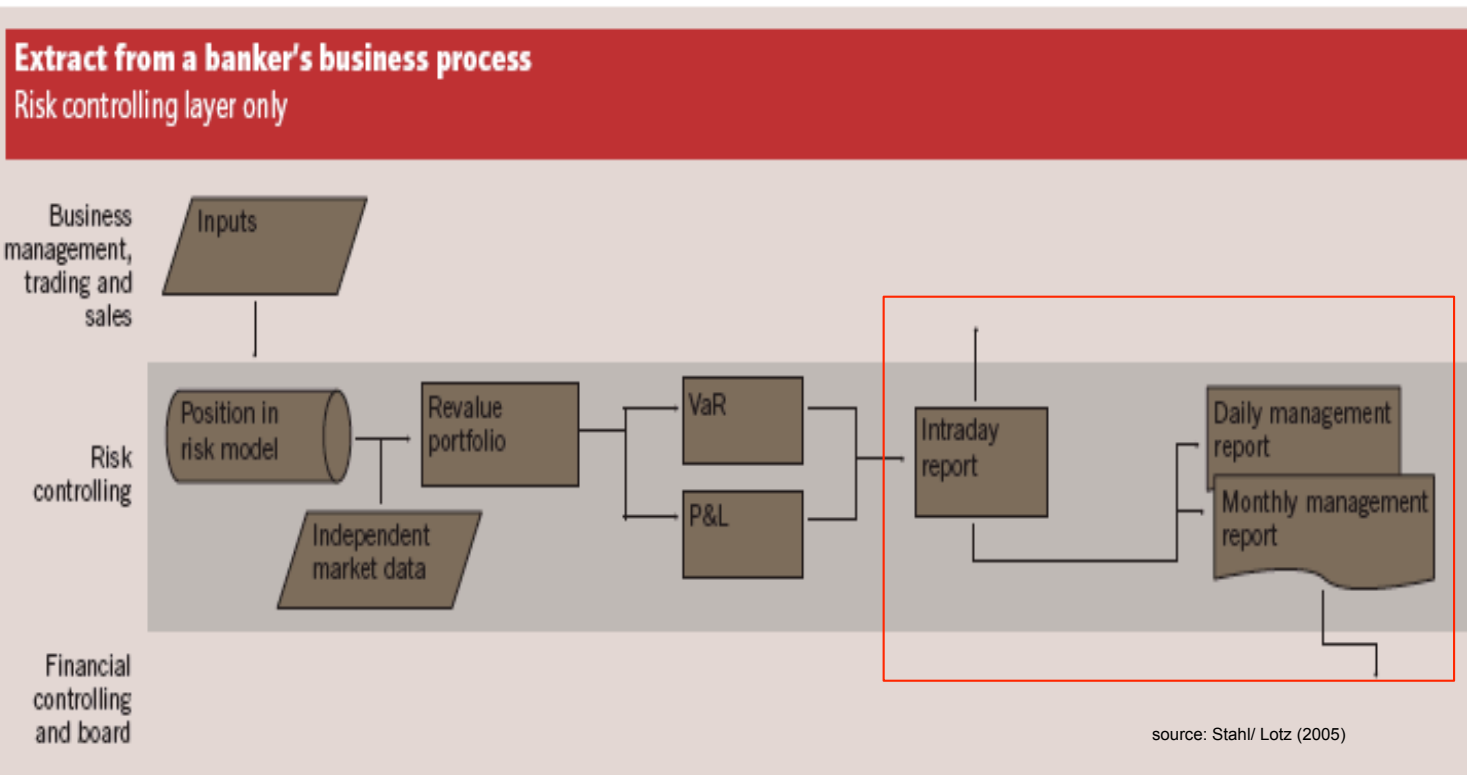
# VI. Audit stream: Stress testing

No risk model fits all markets – VaR must be complemented with other (tail) measures!

## Measuring the appetite for loss



## VII. Audit stream: Limit system, limit monitoring, reporting



## VII. Audit stream: Limit system, limit monitoring, reporting

### ❑ Limit framework

- ✓ Risk bearing capacity
- ✓ Risk appetite
- ✓ Limit allocation

Limit framework and monitoring must ensure risk exposures do not compromise the existence or other objectives of the bank!

### ❑ Reporting

- ✓ Frequency and completeness
  - VaR calculation not performed for all positions
  - Exclusion of books due to incorrect hierarchy filters
- ✓ Timeliness and rolled data
- ✓ Manual overwrites
- ✓ Reporting on tail risks



### ❑ Processes to calculate the regulatory capital not adequate and effective

## VII. Audit stream: Limit system, limit monitoring, reporting

Dealing room controls should support compliance!

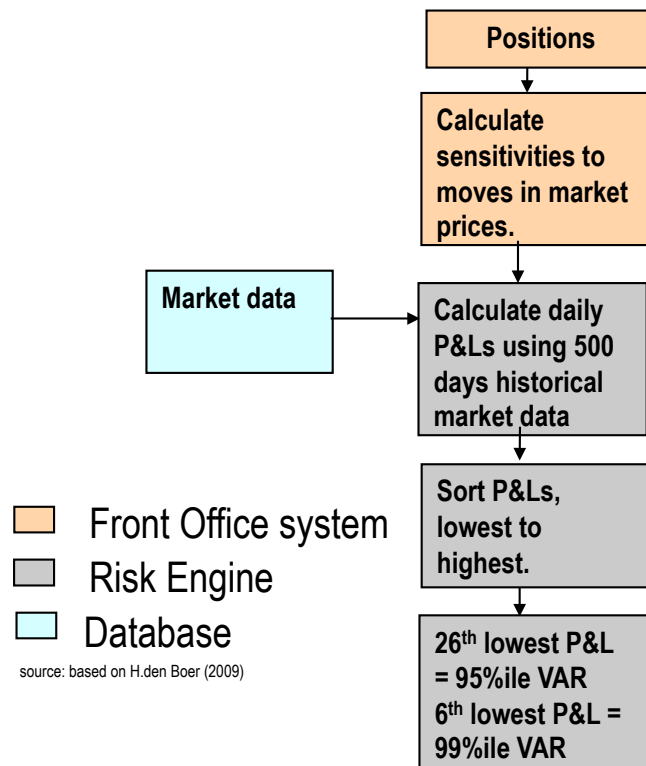
### ❑ Dealing room controls

- ✓ **Escalation of limit breaches not in line with internal policies** (level, timeliness)
- ✓ No monitoring of internal **approval requirements** (e.g. products that need market risk pre-approval)
- ✓ Breach of constraints set out in VaR model recognition letter etc.
- ✓ VaR based limits not recalibrated following model changes
- ✓ **Missing limits and incomplete dealing authorities** (e.g. missing risk factor, limits inadequate for portfolios with complex derivatives)
- ✓ No annual or ad hoc update of dealing authorities (e.g. joiners and leavers)
- ✓ Weaknesses in intra-day controls
- ✓ Stop loss limit stated in dealing authority but not captured in the loss trigger report that Finance produce daily



# Closing thought

- ❑ In practice, risk modelling is not only about building the best possible model. It is equally about having adequate and effective control points around the decisions taken on what market data, what valuation models, what methodologies etc. are used for such models.



## Key questions

- ❑ Are positions correctly booked and books are correctly mapped?
- ❑ Are valuation models correct?
- ❑ Are approximations a good measure for P&L?
- ❑ Are all relevant risk factors captured?
- ❑ Are (historical) data sets available for risk factors?
- ❑ Are these data sets representative of how the markets behave?

# Appendix

- **Links to slideshows**
- **<http://www.nsph.gr/files/FileManager/Pdf/safetyatwork.pdf>**
- **<http://www.slideshare.net/guest6067361/football-1719788>**