

# Audit, Finance & Control of the Future

TopQuants 2013 Autumn Event

7 November 2013



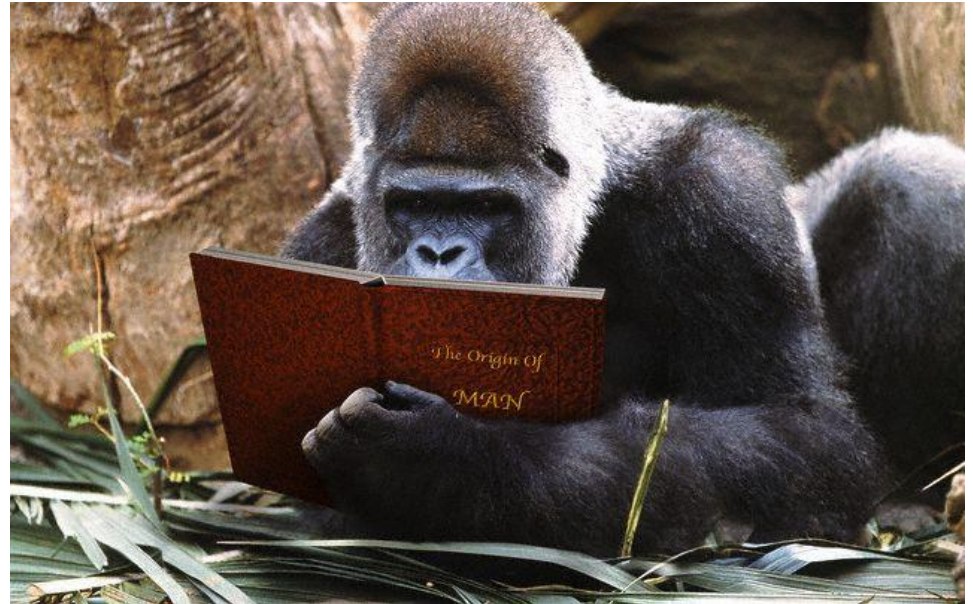
Building a better  
working world

# Audit, Finance & Control of the Future and 'Model Materiality' using DVOC

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## Auditing the Future – a revolution or an evolution?

'The Origin of Solvency II  
Audit by Means of  
Natural Risk Selection,  
Or the Preservation  
of Favored Cooperation  
between Auditors and  
Actuaries in the Struggle  
for Life'



# Agenda

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- ▶ Introduction
  - ▶ Developments
  - ▶ Ingredients
- ▶ Model Risk Management
- ▶ Concept of DVOC
  
- ▶ Examples
  - ▶ Life Risk
  - ▶ Non-life Risk
  - ▶ Market Risk
  
- ▶ Appendix: Using DVOC in Analysis of Change





# Introduction, Developments and Ingredients

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# Introduction

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For assessing the reasonableness of a model outcome, we want to find a positive answer on the question: **‘Does the model do what it has to do?’**

To be able to answer this question we indirectly split up this question into two questions

- ▶ **‘Does the model do what it can?’** and
- ▶ **‘Can the model do what it has to do?’**

by dealing with the following criteria:

1. Arithmetical correctness
2. Objective Measurability
3. Fit for Purpose

# Ingredients

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Judgment for a stand-alone model in consideration to materiality per legal entity.

Avoidable versus unavoidable risk.

Distinction in Tolerable Error between risk models (e.g. for  $x\%$  of SCR) and Market Value models (e.g. for  $y\%$  of MVL/MVA; AFR) – define 'Tolerable Range'

Define in Tolerable Range boundaries  $x$  and  $y$  for valid and invalid for certain error levels, to be determined based on risk appetite for model risk and approved by senior management.





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# Discussion statements

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On the figures: Quality + Acceptance = Effectiveness.

Stochastic modeling: number of runs to be increased to the level that the resulting uncertainty range falls in the financial statement reporting materiality levels (so this could cost a lot of time and money).

Different materiality metrics per model, per risk driver, per usage, per disclosure.

There is need for new materiality measures for audit, finance & control in the future.

**And should be aligned to risk appetite.**



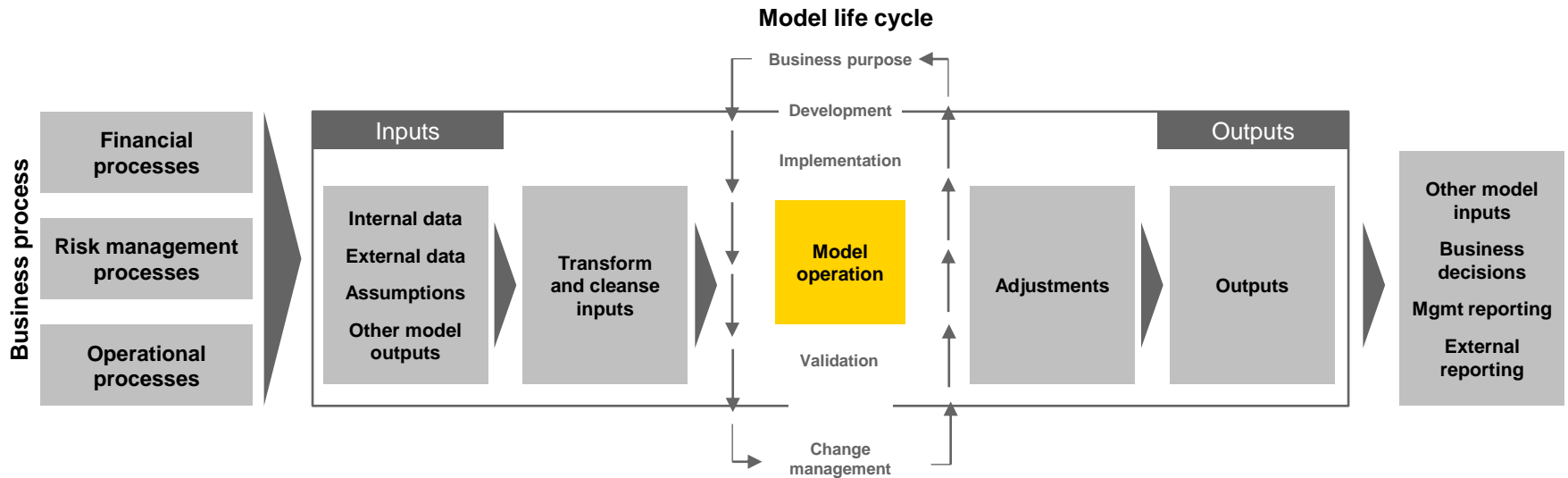
# Model Risk Management

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# Effective MRM balances process risks with risks associated with the model lifecycle



*Many organizations have traditionally concentrated on risks associated with processes themselves and have attached less significance those risks associated with the various stages of the model life cycle, although the latter may represent more serious threats.*

Model risk management achieves the rebalancing of risk management activity between both sets of risks (process / model ) through bringing the assessment of model risk into the insurer's risk management framework.

Similar approaches are used as for other sources of risk but recognising that there are specific considerations given the complexity of this area and the potential mitigation steps.



Concept of DVOC

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# When is a model ‘good’?

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The concept lies in assessing the sensitivities of the outcome of the model relative to the key choices and parameters that drive the (economic or risk) value.

If those choices and parameters are volatile in their own right, it provides the range of possible and/or reasonable outcomes the value should be in.



# When is a model 'good'?

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## ▶ DVOC

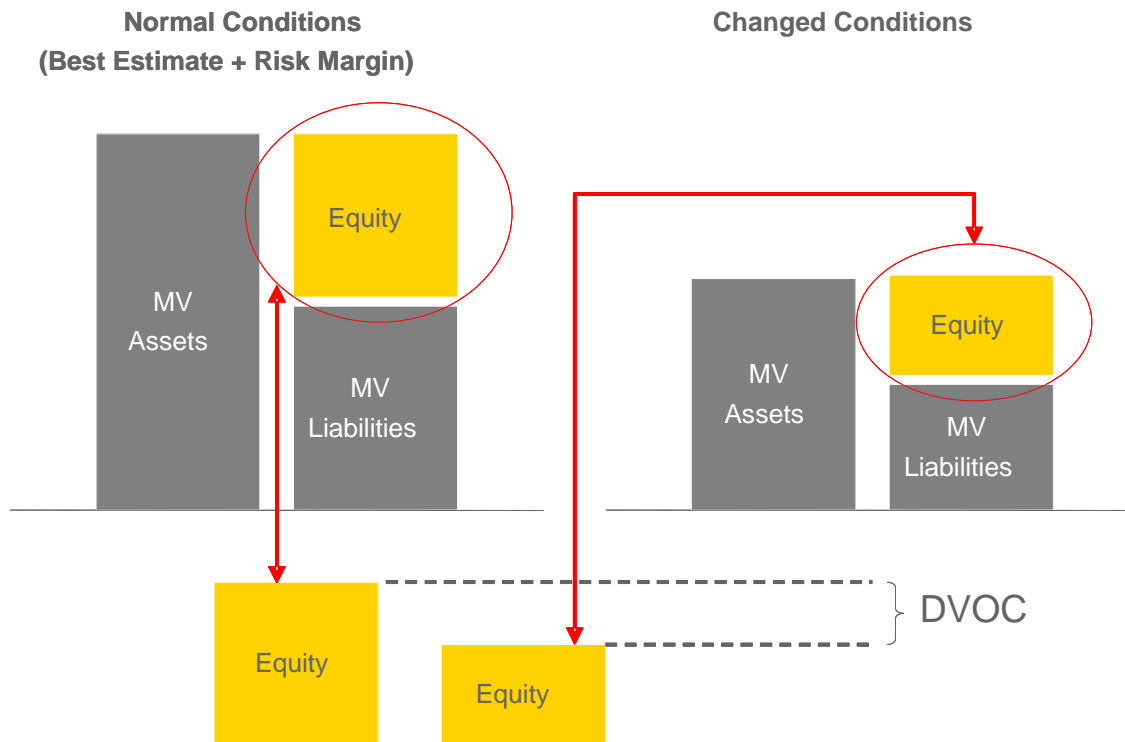
- ▶ Delta Value of Change ('partial derivative of the valuation/risk function').
- ▶ **Generalization of DVO1** – Dollar Value of 1 basis point change in interest rate
  - ▶ Used in the Asset Management sector.
  - ▶ Deviations are not material when e.g.  $<3DV01$ .
  - ▶ Already expanded in audits for other risk drivers in auditing derivatives (volatility, dividend yield, inflation, FX etcetera).
- ▶ **Assess the 'first partial derivative of the valuation/risk function'**
  - ▶ Key risk drivers – market and non-market related (those that explain eg 95% of EC).
  - ▶ 'normal' expected fluctuations (e.g. opening vs closing quotes, choice of data vendor, statistical noise, model choices; overall and per parameter).
  - ▶ Effect on stand alone valuations and impact on consolidated level.

# Assess the key risk drivers

Consider the value of (entries on) the balance sheet in normal and changed situation

Valuation:  $MV = f(R_1, \dots, R_n)$

With  $MV$  the market value of an asset, liability, or full surplus, and  $R_i$  the  $i$ -th risk driver.



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# DVOC: Delta Value of Change (1/2)

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Both assets and liabilities are sensitive to changes in key-risk drivers.

First partial derivatives of valuation/risk function are used to evaluate the impact of potential fluctuations on the value.

For assets the DVO1 method is used to calculate the sensitivity of the asset towards a small shock in the underlying market parameters.

For instance, the DVO1 is calculated by applying a 1 basis point shock to the underlying curve (commonly used for interest rate swaps) or the 'volatility DVO1' (also known as vega) is calculated by shocking the underlying volatility with 1% (swaptions, equity options).

For liabilities these parameters include not only financial market parameters such as interest rates and volatilities but also include, amongst others, mortality rates and lapse rates.



# DVOC: Delta Value of Change (2/2)

For liabilities the key-risk drivers are not only financial input parameters, but also include:

- ▶ Shocks in mortality tables.
- ▶ Shocks in lapse rates.
- ▶ Shocks in expense rates.
- ▶ Insurance liabilities can be more sensitive to changes in non-financial parameters than changes in financial parameters.
- ▶ Assess inherent fluctuations or uncertainties in non-financial parameters to identify the level to change these.



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## Short Examples: Derivates and Life Insurance Liabilities

# DV01 – example IRS

90) Actions		91) Products		93) Data & Settings		94) Help		Swap Manager	
3) Main		4) Curves		5) Cashflow		7) Details		10) Resets	
11) Risk		13) Scenario		15) CVA		17) Matrix			
Fixed Float Swap		Cpty SWAP CNTRPARTY		CCP OTC		TKR / SWAP		Series	
Deal ID		30) Properties							
31) Load		32) Save		34) Send		36) Share		37) Ticket	
38) Trade Activit									
Leg 1		Receive Fixed				Leg 2		Pay Float	
Notional	250MM	Leg ID		Notional	250MM	Leg ID			
Currency	EUR	Coupon	2.140000 %	Currency	EUR	Index	EUR006M		
Effective	12/31/2012	Calc Basis	Money Mkt	Effective	12/31/2012	Latest Index	0.19152		
Maturity	04/02/2032	Day Count	300/360	Maturity	04/02/2032	Tenor	6 Month		
Pay Freq	Annual	Unwind Cpn	0.000000 %	Reset Freq	SemiAnnual	Leverage	1.00000		
				Pay Freq	SemiAnnual	Spread	0.00 bp		
						Day Count	ACT/360		
		a) Detail				b) Detail			
MV	249,834,203.09	Accrued	0.00	MV	-249,847,838.19	Accrued	0.00		
Premium	99.93	DV01	417,582.43	Premium	-99.94	DV01	-6,378.40		
Market		CSA No		OIS DC Stripping OFF					
Discont Curve	45 Mid	EUR Bloomberg Curve (I)		Discont Curve	45 Mid	EUR Bloomberg Curve (I)			
				Fwd Curve	45 Mid	EUR Bloomberg Curve (I)			
Curve Date	12/31/2012	Valuation	12/31/2012						
Valuation									
Par Cpn	2.140336	Calculate		Premium					
Principal	-13,635.10	Unwind Annuity		2.140000	PW01	405,319.98			
Accrued	0.00	Unwind PV		86,738,475.28	DV01	411,204.03			
Market Value	-13,635.10	Premium		-0.00545	Gamma (1bp)	811.39			



# DV01 – example swaption

90) Actions 91) Products 93) Data & Settings 94) Help Swap Manager

3) Main 4) Curves 5) Cashflow 6) Option 7) Details 10) Resets 11) Risk 13) Scenario 17) Matrix

Swaption Cpty IRS CNTRPARTY CCP OTC TKR / IRS Series Deal ID 20) Properties

31) Load 32) Save 34) Send 36) Share 37) Ticket

Leg 1	Receive Fixed	Leg 2	Pay Float
Notional	250MM	Notional	250MM
Currency	EUR	Currency	EUR
Effective	04/02/2014	Index	EUR006M
Maturity	03/31/2034	Latest Index	0.42420
Pay Freq	Annual	Tenor	6 Month
Coupon	2.300000 %	Leverage	1.00000
Calc Basis	Money Mkt	Spread	0.00 bp
Day Count	30U/360	Day Count	ACT/360

MV -738,046.34 Accrued 0.00 MV 0.00 Accrued 0.00

Option Premium Paid At Expiry

Type	Exercise Into	Style	European
Position	Long Receiver	Expiration	03/31/2014
1 YR X 20 YR	Exercise For Cash	Notification Days	2 B
Market	Settlement	04/02/2014	

Curve Date 12/31/2012 Valuation 12/31/2012

Discount Curve 45 Mid EUR Bloomberg Curve (ICV) Fwd Curve 45 Mid EUR Bloomberg Curve (IC)

Vol Cube VCUB Mid EUR Bloomberg Cube Model Black-Scholes

Valuation Convention Spot Premium

Par Cpn	2.318208	Calculate	Premium
Implied Vol	29.50	Yield Value	29.305
Principal	11,878,460.02	Forward Prem	4.77140
Accrued	0.00	Underlying Prem	-0.29522
Market Value	11,878,460.02	Premium	4.75138

DV01	194,182.49
Delta (Hedge)	0.45956
Vega (1%)	411,146.39
Theta (1-day)	-13,170.71

# DV01 – inflation swap

3 Main 4 Curves 5 Cashflow 7 Details 10 Resets 13 Scenario

Inflation Swap Cpty SWAP CNTRPARTY CCP OTC TKR / ZC Series Deal ID 30) Properties

31) Load 32) Save 34) Send 36) Share 37) Ticket

Leg 1				Leg 2			
Receive Inflation	Zero Coupon	Pay Fixed	Zero Coupon				
Notional	250MM	Index	CPTFEMU	Notional	250MM		
Country	EU EUR	Lag	3 Months	Currency	EUR	Coupon	1.771657 %
Effective	12/31/2012	Interpolation	Monthly	Effective	12/31/2012	Calc Basis	Bond Eqv
Maturity	04/02/2022	Leverage	1.00000	Maturity	04/02/2022	Day Count	ACT/ACT
Base Index	115.97000	Spread	0.00 bp	Comp Freq	Annual	Unwind Cpn	2.521000 %
		Day Count	ACT/ACT				
6) Detail				6) Detail			
MV	255,782,002.21	*Accrued	-1,810,813.14	MV	-255,782,004.30	*Accrued	-1,109,032.41
Premium	102.31	DV01	245,083.28	Premium	-102.31	DV01	-245,083.28

Market Seasonality OIS DC Stripping OFF

Dscent Curve 45 Mid EUR Bloomberg Curve (I) Dscent Curve 45 Mid EUR Bloomberg Curve (I)

Fwd Curve IL Mid CPTFEMU

Curve Date 03/27/2013 Valuation 04/02/2013

Valuation

Par Cpn	1.771657	Calculate	Premium	
Principal	-2.09	Unwind Annuity		-0.749343
*Accrued	-2,919,845.55	Unwind PV		17,963,440.16
Market Value	-2.09	Premium		0.00000
			DV01	0.00
			Inflation DV01	-225,904.65

Australia 61 2 3777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000  
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# DVOC – Example Insurance Liability

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In this example we show the impact of the shocks of different key-risk drivers for different insurance products. Consider the following products:

- ▶ Immediate annuity
- ▶ Deferred annuity
- ▶ Term assurance ('overlijdens risico verzekering')
- ▶ Endowment ('gemengde verzekering')

The scenario's are:

- ▶ 1 bps shock of the interest rate curve.
- ▶ Calculation based on the exclusion of the CCP (1%).
- ▶ A relative longevity shock of 10% on the mortality table.
- ▶ A relative shock on the expenses of 10%.
- ▶ An increase in the assumed lapse rate from 4% to 5%.



# DVOC – Output Example

Overview				
	Immediate annuity	Deferred annuity	Term insurance	Endowment
BE	€ 394.867.057	€ 305.577.521	€ 59.218.810	€ 33.604.987
IR shock	€ 394.510.153	€ 305.033.334	€ 59.146.805	€ 33.522.610
CCP shock	€ 429.914.651	€ 351.980.880	€ 66.672.258	€ 41.268.535
Longevity shock	€ 399.710.363	€ 307.116.212	€ 56.131.280	€ 33.662.456
Expense shock	€ 395.207.529	€ 306.049.947	€ 59.392.264	€ 33.850.495
Lapse shock	€ 394.867.057	€ 305.577.521	€ 59.218.810	€ 37.847.669
Impact				
	Immediate annuity	Deferred annuity	Term insurance	Endowment
IR shock	-€ 356.903	-€ 544.188	-€ 72.005	-€ 82.377
CCP shock	€ 35.047.595	€ 46.403.358	€ 7.453.448	€ 7.663.547
Longevity shock	€ 4.843.306	€ 1.538.690	-€ 3.087.529	€ 57.469
Expense shock	€ 340.472	€ 472.425	€ 173.454	€ 245.508
Lapse shock	€ 0	€ 0	€ 0	€ 4.242.682



Examples

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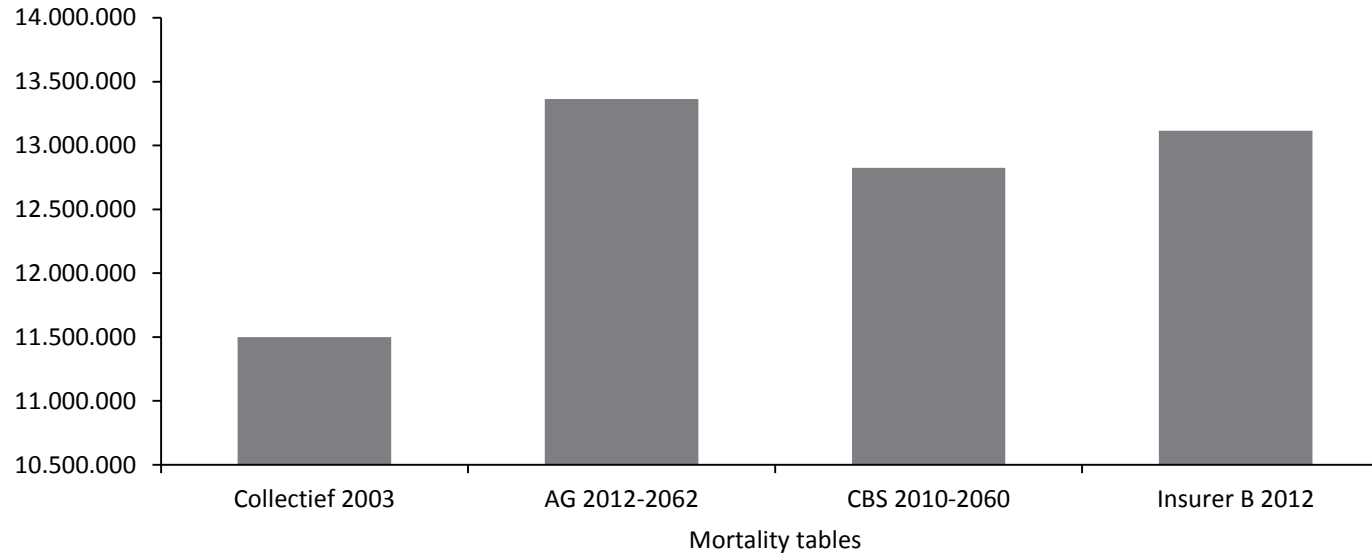
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## Example: Life Insurance

# Annuity Insurance – Results

## Best Estimate provisions annuity insurance



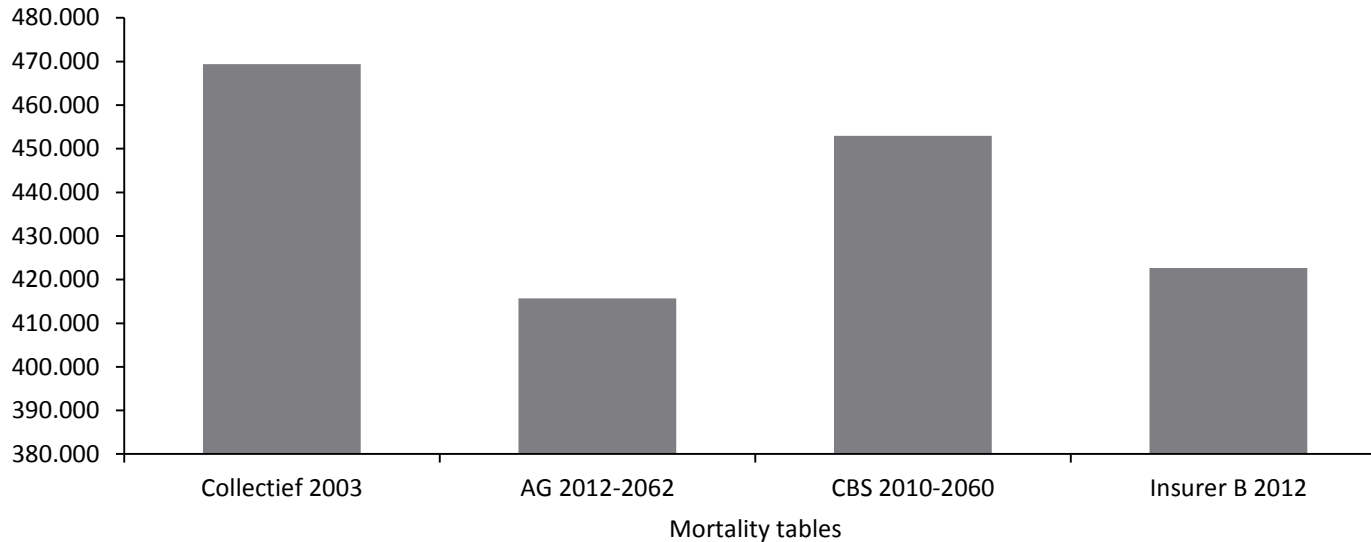
Impact of using different mortality tables on provisions compared to Collectief 2003:

- ▶ AG 2012-2062: +16%
- ▶ CBS 2010-2060: +12%
- ▶ Insurer B specific mortality table 2012: +14%



# Term Insurance – Results

## Best Estimate provisions term insurance



Impact of using different mortality tables on provisions compared to Collectief 2003:

- ▶ AG 2012-2062: -11%
- ▶ CBS 2010-2060: -3%
- ▶ Insurer B specific mortality table 2012: -9%

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## Example: Non-life insurance

# Arithmetical correctness (1/2)

## 1. Arithmetical correctness

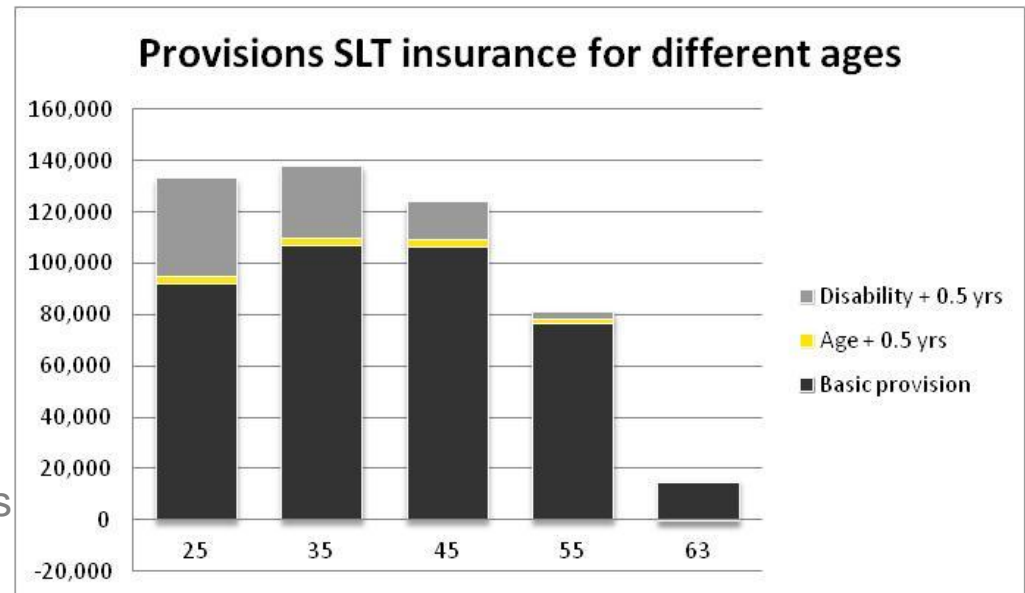
“Valid” modeling result differences can be caused by:

- ▶ Approximation of current age, retirement age and disability inception date to full months or full years
- ▶ Use of recovery rate assumptions which are constant per full year
- ▶ Rounding or approximation of yield curves

### What is a valid deviation?

- ▶ 0.5 yrs deviation in age
- ▶ 0.5 yrs deviation in disability history
- ▶ 1 week of data timelag

**Individual** results show deviations up to 43% for young individuals



# Arithmetical correctness

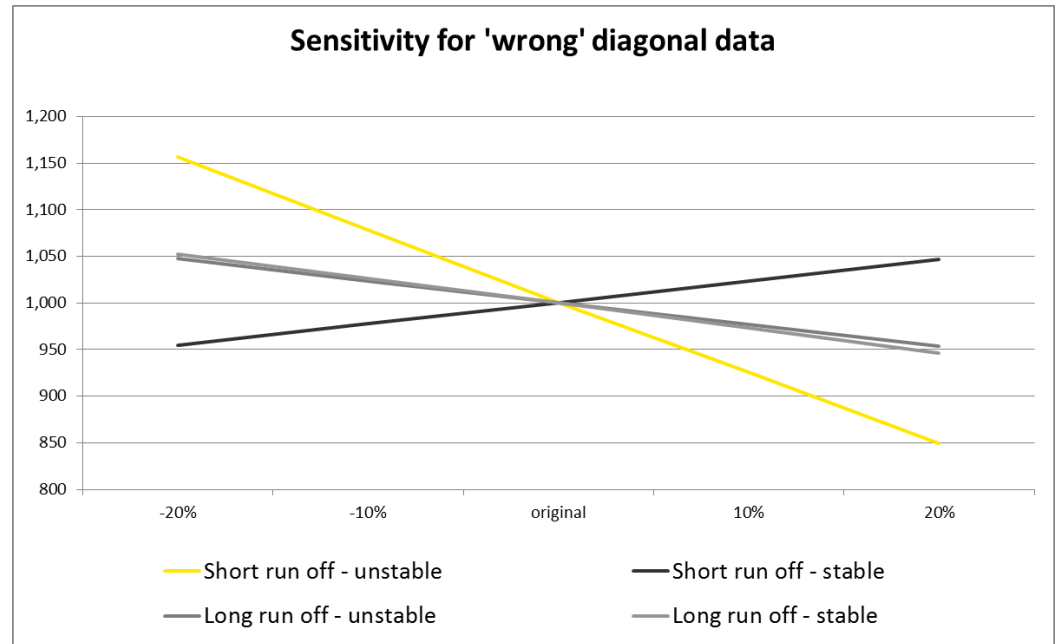
## 1. Arithmetical correctness

Quantitative modeling result differences can be caused by:

- ▶ Data issues: we see this as the largest cause of deviations

We have tested the sensitivity for data errors:

- ▶ X % of deviation in new diagonal data
- ▶ Crude results given in graph
- ▶ Results move linearly with deviations
- ▶ Materiality depends on Line of Business characteristics



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# Asset Examples



# Market data, derivatives and fixed income instruments

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## ▶ Market data

- ▶ Interest rates
- ▶ Interest rate volatility
- ▶ Equity prices
- ▶ Equity volatilities
- ▶ FX rates
- ▶ Inflation rates
- ▶ Credit spreads

## ▶ Derivatives

- ▶ Interest rate swaps
- ▶ Swaptions
- ▶ Equity options
- ▶ FX forwards / swaps
- ▶ Inflation-linked swaps
- ▶ Credit default swaps
- ▶ Fixed income
  - ▶ Private loans
  - ▶ Asset-backed securities
- ▶ Other similar products...

- ▶ Note: focus is on level 2 and level 3 valuations

# Market data – objective measurability

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## Examples

- ▶ Interest rates: measure of 3 bps for interest rates reasonable to test objective measurability
- ▶ Interest rate volatility: measure strongly depends on option expiry and swap tenor to test objective measurability
- ▶ Equity volatilities: measure of 350 bps – 500 bps for equity volatility reasonable to test objective measurability
- ▶ FX rates: Rate of client must be between high and low rate for that specific day
- ▶ Inflation rates: measure of 3 bps inflation movement to test objective measurability. Note that seasonality can have a large impact on the inflation rates.
- ▶ Credit spreads: measure of daily change in credit spread to test objective measurability

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# Derivatives – objective measureability

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- ▶ For every derivative, evaluate the difference between the ‘parallel model’ value and the ‘audit object’ value to the applicable DVOC measure.



## Using DVOC in Analysis of Change

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# Example – case study

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*At January 1, 2013 the portfolio “value” includes 50,000 death benefit contracts with the following characteristics:*

- ▶ *Maturity: December 31, 2022*
- ▶ *Annual premium, payable January 1, per contract: € 1,250*
- ▶ *Acquisition costs per contract, paid January 1, 2013: € 1,000*
- ▶ *Death benefit (on occurrence of death), payable December 31, per contract: € 100,000*
- ▶ *Required capital for risk margin purposes: € 12,500,000. (The risk margin is calculated by determining the cost of providing an amount of eligible own funds equal to the Solvency Capital Requirement necessary to support the insurance obligations over their lifetime.)*
  
- ▶ *Assume Cost of Capital rate of 6%*
- ▶ *Assume (flat) Risk Free rate (curve) of 3%*
- ▶ *Assume Best Estimate Mortality Rate: 1% for all future years*



# Example – qualitative insights

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At  $t=0$  the Basic Own Funds (BOF \* € 1.000) for this portfolio equals € 61.219

After one year, the BOF equals € 58.498. Analyze the change between year  $t=0$  and  $t=1$ .

We can make a movement analysis by using the knowledge of the portfolio at  $t=0$ :

1. BOF will make a return in the best estimate assumption equal to the risk free return
2. BOF will increase with the release of the risk margin (+risk free interest)

*Variances in period (0,1)*

3. BOF will change due to difference between best estimate mortality and realized mortality
4. BOF will change due to delta in investment return

*Assumption changes after  $t=1$*

5. BOF will change due to change in mortality assumption
6. BOF will change due to change in interest rate curve

**1 and 2 are fixed, 3-6 can be estimated by using DVOC's on  $t=0$  and apply parameter changes known on  $t=1$ . No additional 'full B/S and/or P&L' calculations are needed!**

# Example – quantitative insights

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At  $t=0$  the Basic Own Funds for this portfolio equals € 61.219. at  $t=1$ : BOF equals € 58.498

1. BOF will make a return in the best estimate assumption equal to the risk free return:  
€ 1.836,57
2. BOF will increase with the release of the risk margin for Y0 (+risk free interest):  
€ 772,50
3. DVOC death benefits: € 100,00 per individual
4. DVOC investment return: € 1,25 per basis point increase in return
5. DVOC mortality assumption: € 3.747,52- per basis point increase in mortality rate
6. DVOC interest rate: € 0,60- per basis point increase in interest rate

## Changes (variances and assumption changes) known on $t=1$ :

20 more individuals died in year 1

Investment return 3% above risk free

Mortality assumption increased by 1bp (hence: 1,01% per year instead of 1,00%)

Interest rate (curve) increased by 50bp (hence: 3,5% flat rate as of year 1 onwards)

# Analyses of Change - results

At  $t=0$  the Basic Own Funds for this portfolio equals € 61.219. At  $t=1$ : BOF equals € 58.498

<b>t=0 calculated BOF</b>	<b>€ 61.219,07</b>	<b>% delta BOF</b>
20 additional deaths	€ 2.000,00-	72%
0,50% change interest rate	€ 30,00-	1%
3% additional investment return	€ 375,00	13%
1 bp increase mortality rates	€ 3.747,52-	134%
risk free change BOF	€ 1.836,57	66%
release risk margin Y1	€ 772,50	28%
<b>t=1 estimated BOF</b>	<b>€ 58.425,62</b>	<b>estimation using the DVOC's</b>
<b>calculated BOF</b>	<b>€ 58.497,88</b>	
unexplained	<b>€ 72,26</b>	<b>3%</b>

The unexplained is due interest rate convexity and to the non-linear effect between change in both mortality rates and interest rate movement.

# Thank you

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