Economic valuation in life insurance
market-(in)consistency

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Market inconsistencies of the market-consistent European life insurance economic valuations: pitfalls and practical solutions – N. EL KAROUI, S. LOISEL, J-L. PRIGENT, J. VEDANI

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Introduction

- Since the early 2000s, numerous regulatory changes for life insurance (Solvency 1, Solvency 2) leading practitioners to consider new issues when valuating liabilities

- Orientations deeply linked to the accounting fair-valuation tendency from Anglo-Saxons countries - IFRS (2002)

- Issues mainly induced by two complex finance-driven notions
  → Risk Neutral (RN) valuation
  → Market-consistency

Content

Introduction

- Insurance regulatory developments
- Risk-Neutral practice in finance
- Risk-Neutral in insurance
- Zoom on the interest rates simulation problems
- Conclusion and recommendations

RN valuation in life insurance

- **2002** – IFRS 2005: *fair-value* in accounting (stockholders-oriented)

- **2009** – Market Consistent Embedded Value, « market-consistency » to value EV (EEV 2005, notion of TVFOG)

- Insurance regulation: Risk-Neutral scheme to specify solvency
  - **2002** – Solvency I: required capital calculated as a MR Cook ratio
  - **2009** – Solvency II: calculation of the TVFOG → stochastic scenarios, Risk-Neutral, inspired from Basel II, IFRS

  → **Economic value based scheme**

Risk-Neutral practice in finance

A deep link between model and objective

The RN valuation practice in bank is limited to a specific activity, **derivatives:**

- Products which underlying risk must be hedged dynamically, contract by contract
- **The variable of interest is the hedging cost**
- **The RN value is used to estimate the perfect hedging (that neutralizes the underlying return impact) cost**
- The portfolio management activity is not concerned → no RN because prices are estimated to price the return (not only the risk-free rate)

Derivatives → RN because only volatility (pure risk) is priced not the return

Risk-Neutral practice in finance
Everyday use

Problems induced by the RN valuation

- In practice, **the calibration instruments are very important**
- Generally, **one model by class of product**

Day-to-day use = continuous update

- The market being incomplete, **non-unicity of prices and of probability measures**

In practice a RN price is necessarily linked to a trade (one buyer/one seller)

- The Bid-Ask range is not considered

Conclusion: for this type of activity

Constantly changing prices

Models are only useful because they are updated continuously

A model is useful for its objective only

If simulations are used it is necessary to link the processes to the objects simulated and priced in the end

Risk-Neutral in insurance

The balance-sheet's valuation -:what the directive says

Solvency 2 (FR):

"liabilities shall be valued at the amount for which they could be transferred, or settled, between knowledgeable willing parties in an arm's length transaction."
➔ **fair-value (IFRS)**

"the calculation of technical provisions shall make use of and be consistent with information provided by the financial markets and generally available data on underwriting risks (market consistency)"
➔ **Market valuation**
➔ **Market-consistency**

Risk-Neutral in insurance
Adaptation of the finance theory and practice

The use of the RN valuation for life insurance is linked to regulation and to a formalism choice to assess solvency

- A scheme structurally non-adapted to financial practice
  - No trade of the valuated objects
  - Complex hedging
  - Very long term simulations
  - Practical impossibility to update the models and prices day after day

Conclusion:

- Various implementation issues to valuate such products

➔ **Only financial risks are simulated**

➔ **<u>Criterion</u> required to choose among the RN probability measures available**

A will to get option pricing and insurance liabilities valuation closer

No closed formula ➔ «Risk-Neutral scenarios »
Problem: which criterion to choose the valuation measure…

➔ **market-consistency**

"A market consistent value of an asset or liability is its market value, if it is readily traded on a market at the point in time that the valuation is struck, and, for any other asset or liability, **a reasoned best estimate of what its market value would have been had it been readily traded at the relevant valuation point.**" (Kemp M., 2009)

Standard algorithm to calculate Own Funde / Best Estimate of Liabilities

1. **Choice of the financial models** to use in the Economic Scenarios Table (EST)
2. Extraction of the **economical assumptions** at the calculation date
3. **Market-consistent calibration** of the models
4. Simulation of the EST through **+/- 30-60 years**
5. Use of the table as an input in the company **ALM model**

Zoom on the interest rates simulation problems

Standard calibration of an interest rate (IR) model as of 31/12/N

Maturity	Nominal rates (EIOPA)
1	0.9871
2	0.9634
3	0.9351
4	0.9032
5	0.8691
6	0.8336
7	0.7977
8	0.7636
9	0.7284
10	0.6963
11	0.6619
12	0.6301
13	0.6004
14	0.5706
15	0.5448
16	0.5204
17	0.4973
18	0.4763
19	0.4550
20	0.4366
21	0.4196
22	0.4039
23	0.3895
24	0.3764

Maturity \Tenor	1	2	3	4	5	6	7	8	9	10
1	65%	62%	60%	58%	57%	56%	54%	53%	52%	51%
2	63%	60%	59%	57%	56%	54%	53%	52%	51%	50%
3	60%	59%	57%	56%	54%	53%	52%	51%	50%	49%
4	58%	57%	55%	54%	53%	51%	50%	49%	49%	48%
5	56%	55%	54%	52%	51%	50%	49%	48%	47%	47%
6	55%	53%	52%	51%	50%	49%	48%	47%	46%	45%
7	53%	52%	50%	49%	48%	47%	47%	46%	45%	44%
8	51%	50%	49%	48%	47%	46%	45%	45%	44%	43%
9	50%	49%	48%	47%	46%	45%	44%	43%	43%	42%
10	48%	47%	46%	45%	45%	44%	43%	42%	42%	41%

Swaption « market » prices (Black formula)

Optimization $\rightarrow \hat{\theta}$

RN « market » model Ex: Hull-White

Parameters

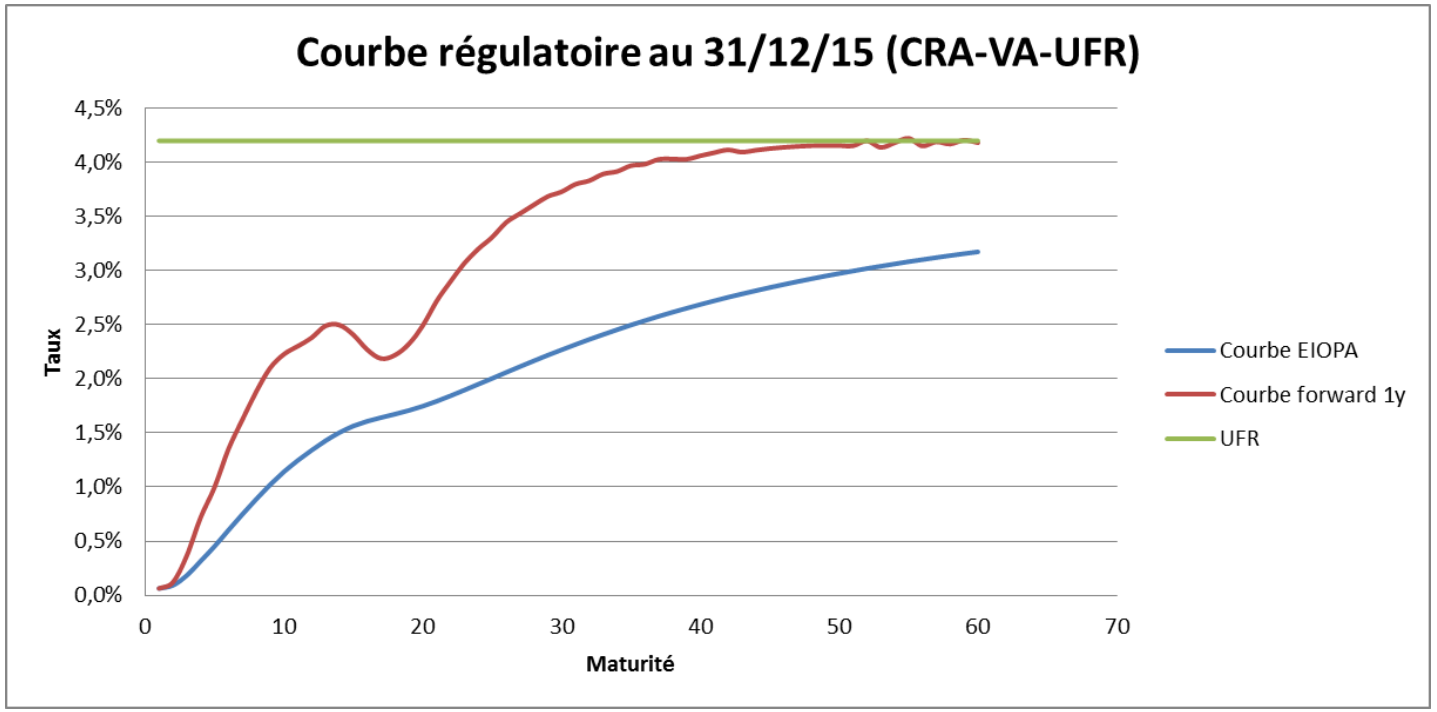
$$\theta = \begin{pmatrix} a \\ \sigma \end{pmatrix}$$

Swaption « theoretical » prices (depending on θ)

Zoom on the interest rates simulation problems
The regulatory curve

EIOPA - Technical documentation of the methodology to derive EIOPA's risk-free interest rate term structures (05/16)

"The starting point in Solvency II is the economic valuation of the whole balance sheet, where all assets and liabilities are valued according to **market consistent** principles.
The risk-free interest rate term structure […] underpins the calculation of liabilities by insurance and reinsurance undertakings. **EIOPA is required to publish the risk-free interest rate.** "

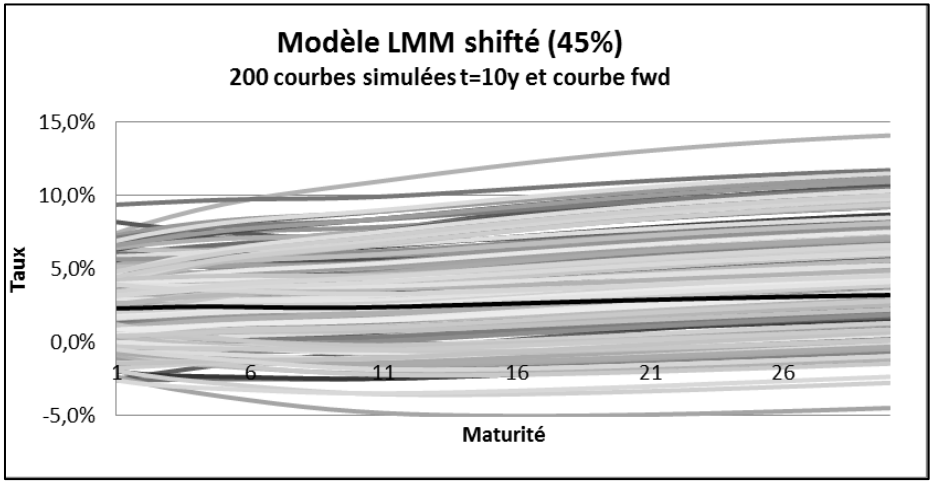


Zoom on the interest rates simulation problems
The regulatory curve

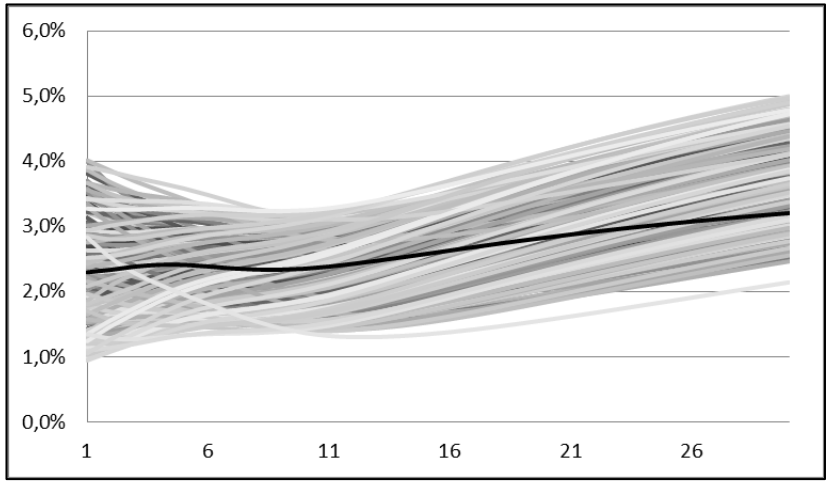
Two problems introduced by this disturbing link between market-consistency and regulatory curve:

1. No link with the market swap curve
   - Impossible to get market prices
   - → **Models are calibrated on EIOPA prices**
   - **Arbitrage opportunities probable**

2. The forward curve deeply impacts the generated curves
   - The curve provided by EIOPA **strongly conditions the estimated values**



Displaced Diffusion LMM t=10y
200 random simulations vs. Forward curve



DDLMM t=10y
20% chosen simulations vs. Forward curve

Zoom on the interest rates simulation problems
Model calibration 1

EIOPA - Annexes to the QIS5 Technical Specifications (07/10)

"The use of implied volatilities has the following advantages:

- Implied volatilities are based on current information derived from financial markets.
- Historical volatilities may not be relevant to current market conditions.

- **Where an insurer is holding a hedging instrument for which there is a price, using historical rather than implied volatilities will lead to unnecessary balance sheet volatility.**

- **The derivation of implied volatilities based on financial models such as the Black-Scholes is consistent with the way in which market participants analyze the prices of traded financial instruments and price over-the-counter financial instruments .**

[…]

Implied volatilities seem to be more appropriate [than historical volatilities] for the purpose of a market consistent valuation."

The Solvency Capital Requirement: A yearly valuation based on market data as of 12/31

The Turn-of-the-Year effect

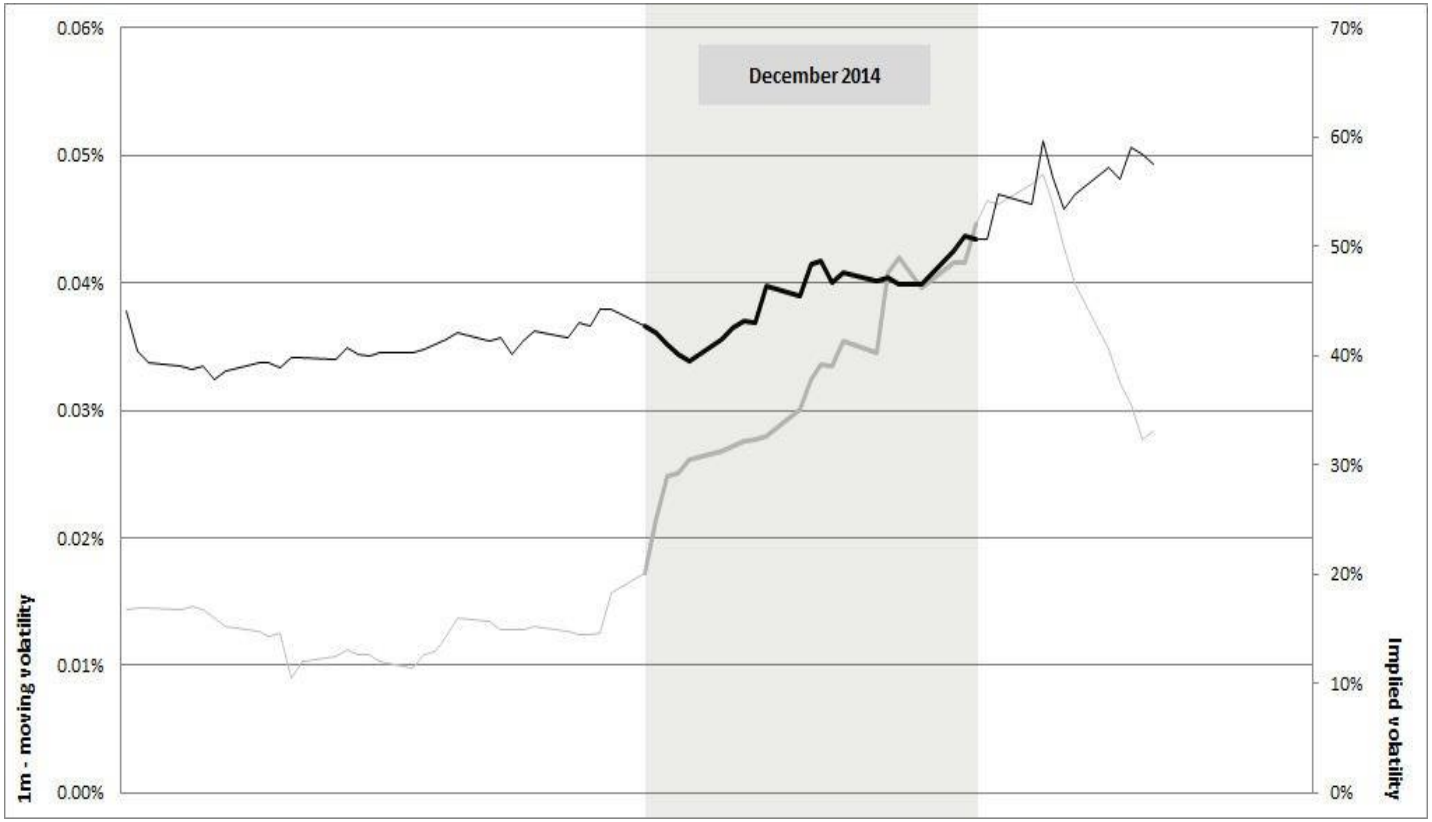
This effect depicts a rising tendency of trading volumes and stock prices between the last week of December and the first of January.

Historical data	Turn-of-the-year	Other days
1950-2004	+0,144%	+0,039%

Returns
Source: Fundamentals of Investments, McGraw Hill, 2006

→ Strong volatility of data
→ Due to accounting adjustments of big companies → biased values
→ **Traders watch out for market data as of 12/31**

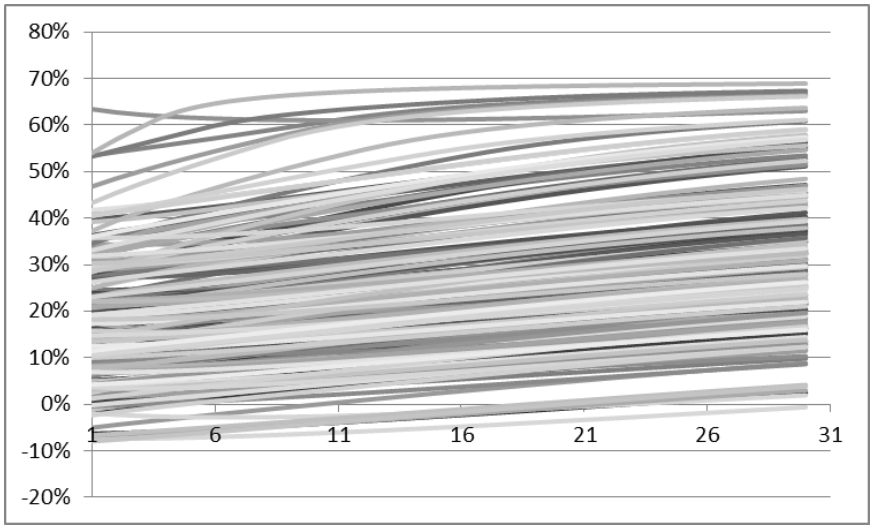
Zoom on the interest rates simulation problems
Model calibration 2



Evolution of the 5x5 swaption implied volatility and of this indicator volatility
Horizon October 14' – January 15'

Zoom on the interest rates simulation problems
Model simulation: DDLMM

Variability of the simulations



DDLMM, t=40y – 200 random scenarios

Other important comparison

Finance – IR options valuation

Short term simulations: 10’000 to 50’000 scenarios

Assurance – Regulatory economic valuation (BEL, OF)

Long term simulations, explosive volatility, ~1’000-5’000 scenarios

→ What kind of confidence intervals, quantiles (VaR) of the simulated NPV?

Implementation of 4 market-consistent valuations

- We have tested 4 approaches to calibrate the IR models on swaption implied volatilities
  - As of 12/31/14, on the “5,5 cross” (v2)
  - As of 12/31/14, on the “10,10 cross” (v1)
  - Averaged v2 on October data
  - Averaged v2 on October and November

- On 3 distinct savings products « French market like»
  - Standard ALM rules (dynamic lapse, assets management, MRG,…)

v2

M\T	1	2	3	4	5	6	7	8	9	10
1	65%	62%	60%	58%	57%	56%	54%	53%	52%	51%
2	63%	60%	59%	57%	56%	54%	53%	52%	51%	50%
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4	58%	57%	55%	54%	53%	51%	50%	49%	49%	48%
5	56%	55%	54%	52%	51%	50%	49%	48%	47%	47%
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9	50%	49%	48%	47%	46%	45%	44%	43%	43%	42%
10	48%	47%	46%	45%	45%	44%	43%	42%	42%	41%

v1

Results:

	Octobre 14’	Oct. & Nov. 14’	12/31/14 v1	12/31/14 v2
Portfolio nb 1	16’898	15’614	7’046	10’000
Portfolio nb 2	12’826	12’283	9’517	10’000
Portfolio nb 3	12’553	12’073	6’050	10’000

Conclusion and recommendation

Keep in mind the link between model and objective

→ An insurance product optionality is very specific and cannot be replicated by market assets optionality

→ In addition, prices are not unique

→ **No single fair value**

An arbitrage-free valuation means a seller and a buyer agree on a price

→ This leads to comparable values

→ In insurance, these values cannot be comparable

- → Neither among them
- → Nor with any other financial value

Conclusion and recommendation

Extremely complex models…

➔ Should not provide legitimacy in themselves

…and very approximative implementation

➔ Simplicity? (Factor model, realism, shorter term modelling – 5/10y)

Necessity to define processes to **homogenize** practices and estimate **more comparable** values

→ Limit manipulations

→ Calculation robustness

The link between solvency, accounting and reality is not clear

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RN in financial theory

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RN IR models long term simulation (explosion/null)

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Thanks!
Questions?