DEVELOPMENTS IN ACTUARIAL SCIENCE

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Introduction

Some topics of concern to actuaries worldwide:

- Risk management
- Regulation (e.g. Solvency 2)
- Asset-Liability Management (ALM)
- Dynamic Financial Analysis, Dynamic Solvency Testing
- Catastrophes
- Demographic changes, ageing
- Accounting rules (US/local GAAP, IFRS, IAS, ...)
- Valuation (embedded, fair, market-consistent, ...)
- Embedded options, guarantees
- Business profitability
- The appointed actuary (The Morris Report)

Basic statement: `www.actuaries.org.uk`

> Actuaries are respected professionals whose innovative approach to making business successful is matched by a responsibility to the public interest. Actuaries identify solutions to financial problems. They manage assets and liabilities by analysing past events, assessing the present risk involved and modelling what could happen in the future.

However, do we live up to this definition?

Education / Training: students ought to study issues underlying the "Some topics of concern" list

Actuaries / Companies / Regulators: have to make sure that through CPD (Continuing Professional Development), employees stay up-to-date on relevant new concepts / techniques / tools

Researchers: have to contribute more to the scientific investigation of relevant methodology

Some selected topics

Topic 1: Dynamic Financial Analysis (DFA) as ALM for non-life- and reinsurance

Some references:

- P. Blum: *On some mathematical aspects of Dynamic Financial Analysis*. PhD thesis No. 15907, ETH Zurich, 2005
- P. Blum and M. Dacorogna: DFA – Dynamic Financial Analysis. In J. Teugels and B. Sundt (Eds.): *Encyclopedia of Actuarial Science.* John Wiley & Sons, 2005

Dynamic Financial Analysis (DFA)

"DFA is a systematic approach based on large-scale computer simulations for the integrated financial modelling of non-life insurance and reinsurance companies aimed at assessing the risks and the benefits associated with strategic decisions."

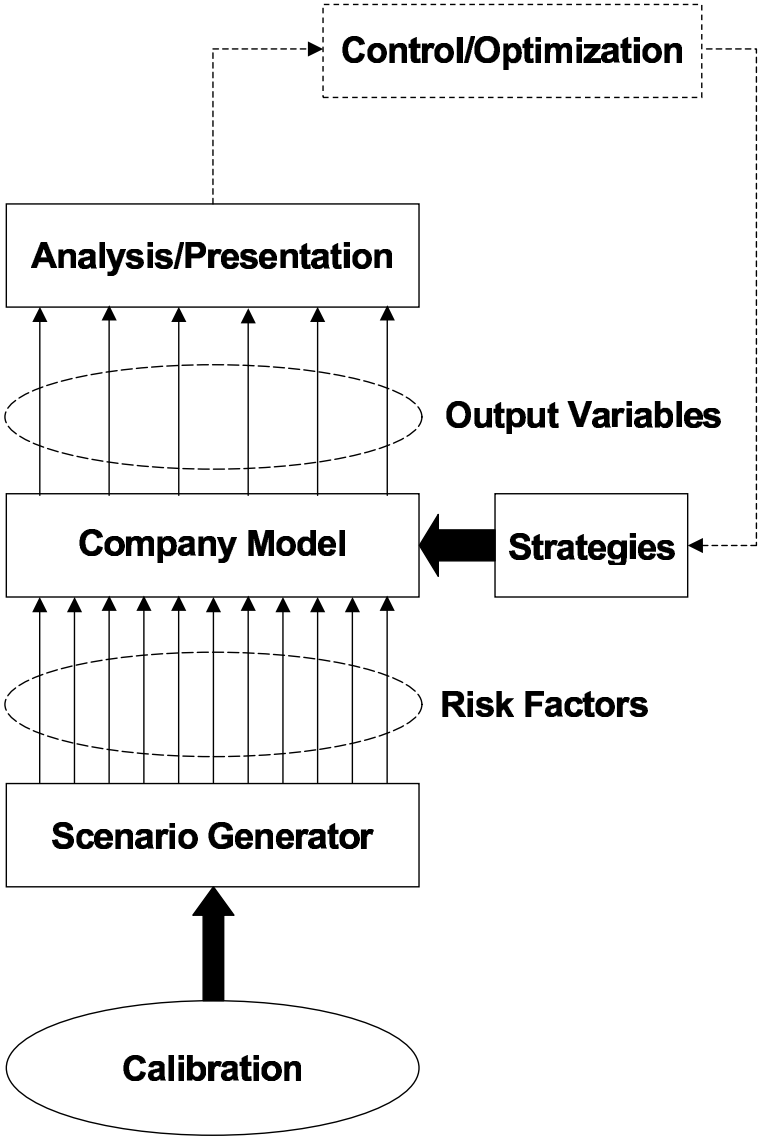
DFA grew out of urgent practical needs of the insurance industry:

- The industry faced a new competitive environment due to deregulation, changing risk landscape, convergence of finance and insurance, ...
- This created the need to design sophisticated strategies that are efficient on company level, i.e. across many risk factors
- This, in turn, requires quantitative methods that encompass all relevant risk factors including their dependencies

DFA with its holistic setup satisfies these requirements

The elements of DFA

A generic DFA system:



Associated techniques:

- Optimization techniques
- Coherent measures of risk
  Multivariate data analysis
  Market-consistent valuation
- Real options, decision rules
- Stochastic modelling: actuarial models, economic models, dependence models ...
- Numerical methods
  Stochastic simulation
- Statistical data analysis, inference, estimation, backtesting

Issues in DFA: scenario generation

- Large number of different risk factors to be modelled over extended time spans, involving complex contemporaneous and intertemporal dependencies
- Actuarial risk factors are generally well understood, due to synergies with pricing
- Modelling of financial risk factors is more problematic: there exist models, but most of them respond to requirements different from the ones posed by DFA
- Moreover, dependencies must be properly modelled so as to avoid spurious diversification opportunities
- **Any model / scanario generator is only acceptable for practical use if all relevant aspects are fully worked out**:
  - Formulation of a model, including exploration of properties
  - Calibration, i.e. selection of model parameters in line with data and problem
  - Solid numerical implementation of model and calibration method
  - Validation of the scenario output

Issues in DFA: company and strategy modelling

- Reflects the internal financial structure of the company:
  - consolidation of various lines of business
  - investment portfolio
  - reinsurance
- Often very detailed: creates projections of company's balance sheet
  - accounting issues must also be reflected
- Model contains parameters that are under management control
  - e.g. reinsurance structures and retentions, investment portfolio weights
- A set of values for these parameters corresponds to a strategy
  - goal of a DFA study: compare different possible strategies
- Given the long time horizons, managerial flexibility must be incorporated
- Consequence: DFA company models are often very complex

Issues in DFA: output and evaluation

- Output = the values resulting from
  - the application of the company model
  - parameterized with some strategy
  - on the risk factor scenarios generated by the scenario generator
- Monte Carlo $\Rightarrow$ large number of result scenarios, requiring appropriate analysis techniques to obtain measures of risk and value
- Coherent risk measures are a must, because of aggregation properties
- Further problem in multi-period setting: time consistency:
  - trajectories implying intermediate ruin require special attention
- Presence of embedded financial options calls for the use of market-consistent actuarial valuation techniques

Some representative DFA studies

- P. Blum, M. Dacorogna, P. Embrechts, T. Neghaiwi, H. Niggli: Using DFA for Modelling the Impact of Foreign Exchange Risks on Reinsurance Decisions. *CAS Forum*, Summer, 2001 (see `www.casact.org`)
- P. Boller, M. Dacorogna, H. Niggli: How much reinsurance do you really need – A case study. *Converium In-depth*, 2002 (see `www.converium.com`)
- M. Cumberworth , A. Hitchcox , W. McConnell, A. Smith: Corporate Decisions in General Insurance: Beyond the Frontier. *Working Paper*, Institute of Actuaries, 1999 (see `www.actuaries.org.uk`)
- J. Burkett, T. McIntyre, S. Sonlin: DFA Insurance Company Case Study, Part I: Reinsurance and Asset Allocation. *CAS Forum*, Spring, 2001 (see `www.casact.org`)
- S. Philbrick, R. Painter: DFA Insurance Company Case Study, Part II: Capital Adequacy and Capital Allocation. *CAS Forum*, Spring, 2001 (see `www.casact.org`)
- R. Kaufmann, A. Gadmer, R. Klett: Introduction to Dynamic Financial Analysis. *ASTIN Bulletin*, 31(1), 2001, pp. 213–249

Topic 2: Issues in life insurance

The background

"In 1980 the life insurance industry was 150 years old. In 1990 ... [it] was 10 years old."

Richard M. Todd and Neil Wallace

FRB-Minneapolis Quarterly Review, 1992

"I am not sure there are any serious issues concerning the life insurance industry these days, unless of course you consider solvency, liquidity, junk bonds, deteriorating mortgage and real estate portfolios, risk-based capital requirements, asset mix, separate accounts, credit risk, congressional inquiries, shrinking surplus and more."

Salvatore R. Curiale

Superintendent of the NY State Insurance Dep't

The background (continued)

- More:
  - interest rate guarantees
  - competition
  - deregulation
  - accounting standards
  - longevity
- Statement: "The late 1980s through the 1990s was a period of quite some turmoil for the life business, and Europe, Japan and the United States can all present their own spectacularly long list of defaulted life insurance companies."
- Some **examples**:
  - US' First Executive Corporation ($ 19 billion in assets)
  - France's Garantie Mutuelle des Fonctionnaires
  - Nissan Mutual Life of Japan (liabilities of $ 2.56 billion)
  - and no doubt more... (to come)

The reasons in a nutshell

- Mismanagement of interest rate guarantees issued with most life insurance policies
- Mismanagement of credit risk stemming from either side of the balance sheet
- Application of poor or inappropriate accounting principles which in many cases have critically delayed or suppressed potentially useful warning signs in relation to company solvency

These issues are of course interrelated!

Below we will look in a bit more detail at some of the above

Interest rate guarantees

- Policy contains explicit rate of return floor (the policy interest rate), r_G, say
- At issuance, typically $r_G \ll r_M$, M standing for market
- Risk of $r_M - r_G < 0$ event ignored, and definitely not priced
- Only recently are premiums for this liability (guarantee) being charged:
  - 1999, Danica introduced an annual premium for the interest rate guarantees issued at the highest level, 4.5 %. Premium amounted to 0.5 % of the life insurance liabilities
  - Skandia Liv introduced annual charges of 0.27 % and 0.17 % for contracts issued with interest rate guarantees of 4.5 % and 2.5 % respectively
- As soon as $r_G > r_M$ dramatic narrowing of safety margins resulted, leading to a major source of problems for some life insurance companies

Interest rate guarantees (continued)

- However: this is kind of ironic since the fundamental function of insurance companies in general is to provide a guarantee of asset value to the customer; see for instance R. Merton (1992): "On the management of financial guarantees", *Financial Management*, 87-109

- Consequently: interest rate guarantees are thus a source of credit risk arising from the liability side of the balance sheet

- In the meantime, regulatory authorities have reacted, e.g. by capping technical rates as for instance in Article 18 of the Third EU Life Insurance Directive (Nov. 10, 1992)

- Also companies have reacted: establishment of sound financial risk management practice in the wake of Solvency 2

Why ALM for life insurance? Current Trends in Europe

- Increasing focus on shareholder / policyholder value:
  - Premium for transparency
  - Emergence of financial ratings
- Market consolidation:
  - Demutualization
  - Domestic and cross-border take-overs
  - Increased competition from pension funds and bank assurance
- European Monetary Union:
  - Loss of currency barrier $\Rightarrow$ Pan-European competition for assets
  - Increasing focus on credit as an asset class
- Implementation of Third EU Life Directive
- Regulator focus on risk management: Solvency 2
- Increasing asset allocation outside the traditional "bond-world"
- Persistent low-yield environment
  - Traditional life products structured for higher interest rate environments
  - Search for yield a priority

Embedded options

- Until recently: prices developed using conservative static assumptions regarding loss distributions and interest rates (by now we know: ill-equipped to accomodate the interest rate volatility that began during the late 1970s)

- However: life insurance policies are replete with options:
  - Settlement option (insured)
  - Policy loan option (insured)
  - Over-depositing privileges (insured)
  - Surrender/renewal privileges (insured)
  - Discretionary dividend (insurer)
  - Crediting rate options (insurer)

- M. Smith (1982): Life insurance policy equals a package of options

- Traditional actuarial methods, which depend on stability, were incapable of correctly resolving these options in times of volatile interest rates

Further issues

- Special product design, e.g interest rate sensitive policies, but also FX protection
- Hedging insurance liabilities:
  - Provide economic protection
  - Structure the solution to be fully admissible under valuation regulations
  - Provide best possible deal via transparency of pricing and efficiency of solution
  - Achieve possible rating agency benefit
  - Release statutory capital to support solvency for investment in new business
- Review use of derivatives in insurance industry (Cummins, Phillips, Smith)
- A statement on VaR: "Now is the time to encourage the BIS and other regulatory bodies to support studies on stress test and concentration methodologies. Planning for crises is more important than VaR analysis." (M. Scholes, P. Embrechts, et al.)

Conclusion

"How did a boring, straightforward business become so difficult to regulate ?"

Salvatore R. Curiale

Superintendent of the NY State Insurance Dep't

Topic 3: Solvency 2

Recall Solvency 1

- **Aim**: revising and updating current EU solvency regime
- Minimum guarantee fund (minimal capital required) = 3 Mio EUR
- Solvency margin = 16% – 18% of premium (non-life), 4% of technical provisions (life)
- **Pros**:
  - simple, robust
  - easy to understand and use
  - inexpensive to administer
- **Cons**: volume-based, not explicitly risk-based (e.g. no difference between investment mixes or asset / liability profiles ...)
  → **Solvency 2**

Background and goals

- Worldwide search for the assessment of solvency for insurance companies
- Who is looking? $\longrightarrow$ Regulators, Rating Agencies, Auditors, Analysts, ...
- Basics:
  - Solvency is linked to risk
  - Traditional systems/tools/rules often failed
  - Insufficient early warning from rating agencies
- **Ansatz:** Actuaries should be key players
- As a consequence, regulators look for actuarial support

Tasks of the IAA WP

IAA forms "Risk Based Capital Solvency Structure Working Party" in the spring of 2002, as requested by the IAIS

- Tasks:
  - Design of a globally applicable risk-based solvency framework for the calculation of capital requirement for non-life, life and health
  - Formulation of methods and principles towards the quantification of solvency
  - Identification of adequate techniques towards the quantification of the risk potentials and the interdependencies between risks
  - Focus on praxis-relevant risk measures and internal risk models
  - Consistency between financial sectors
  - Efficient supervision of insurance groups and financial conglomerates
  - Increased harmonisation and international compatibility

IAA WP: proposed framework

- Three pillar approach for insurance supervision (in line with Basel II):
  - Pillar 1: minimal capital requirements
  - Pillar 2: a supervisory review process
  - Pillar 3: measures to foster market discipline

- Remark: rules for capital adequacy (pillar 1) are necessary but not sufficient towards a solvency judgement

- Which risks are to be analysed/included?
  - all risks relevant for an insurance company

WP chosen risk categories

- Underwriting
- Credit
- Market
- Operational (internal OpRisk Basel II)
- Liquidity (linked to market risk)
- Event (external OpRisk Basel II)

Also note that there are clear interdependencies which need modelling

Stress tests have to be included

- A multitude of actuarial tools enter:
  - collective risk model
  - aggregate risk models
  - diffusion models and other stochastic processes
  - multi-state models
  - cashflow models
- Specific concerns are:
  - time horizon (long-term RM*) and confidence levels
  - combining risks (copulae*)
  - appropriate risk measures (coherence*)
  - extreme event risk (EVT*)
  - and others ...
- But at the end of the day, the proof of the pudding is in the eating!

  Example: The Swiss Solvency Test (`www.bpv.admin.ch`)

* RiskLab projects/contributions: `www.risklab.ch`

Key components of the new regulatory framework

- Summary:
  - principle- rather than rule-based solvency requirement
  - risk-based
  - two tier approach: target versus solvency capital
  - expected shortfall as risk measure (beyond VaR!)
  - modelling of dependencies through "increased correlations" or copula based approach, stress scenarios (EVT)
  - transition from conservative standard-factor-model to a full internal model approach (allowing for intermediate levels)
  - (some) potential issues:
    * time-horizon (life versus non-life)
    * confidence level (per risk category, overall level)
    * mark-to-'market' of liabilities

Basel II $\neq$ Solvency 2

- "The difference between the two prudential regimes goes further in that their actual objectives differ. The prudential objective of the Basel Accord is to reinforce the soundness and stability of the international banking system. To that end, the initial Basel Accord and the draft New Accord are directed primarily at banks that are internationally active. The draft New Accord attaches particular importance to the self-regulating mechanisms of a market where practitioners are dependent on one another. In the insurance sector, the purpose of prudential supervision is to protect policyholders against the risk of (isolated) bankruptcy facing every insurance company. The systematic risk, assuming that it exists in the insurance sector, has not been deemed to be of sufficient concern to warrant minimum harmonisation of prudential supervisory regimes at international level; nor has it been the driving force behind European harmonisation in this field."

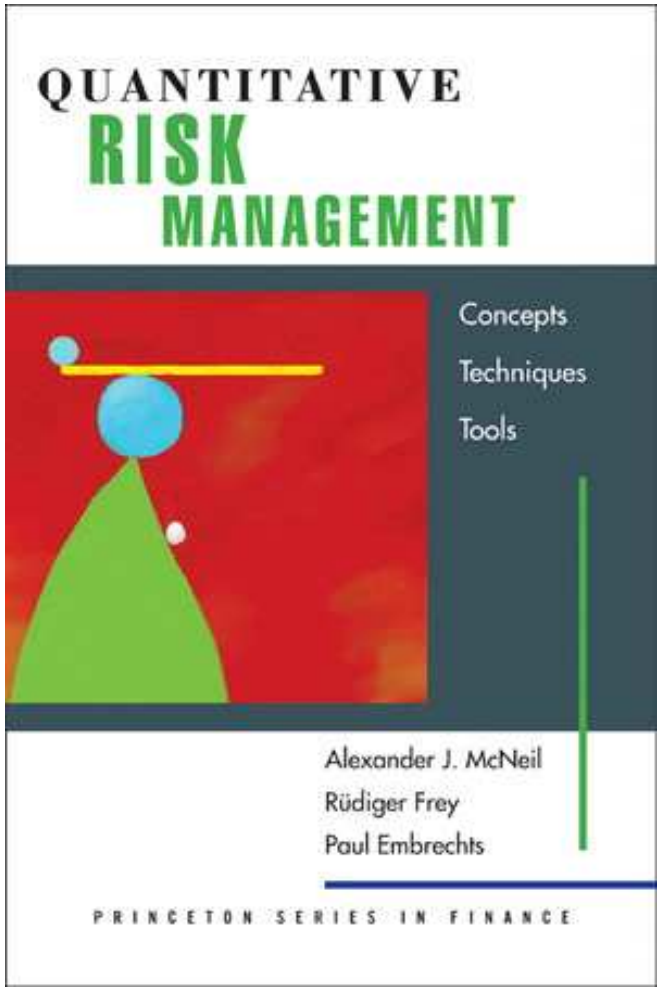
  (EU Insurance Solvency Sub-Committee (2001))

- Also: continued convergence in the supervision of the financial services sector

Research at RiskLab (ETH Zurich)

- Dynamic Financial Analysis (DFA)
- Dependence modelling
- Quantitative risk management
- Risk measures
- Operational Risk
- Lévy process risk models
- Numerics
- Robust statistical methods

Quantitative Risk Management: Concepts, Techniques and Tools



P. Embrechts, R. Frey and A. McNeil:

Quantitative Risk Management: Concepts, Techniques and Tools.

Contents:
- Risk in Perspective
- Basic Concepts in Risk Management
- Multivariate Models
- Financial Time Series
- Copulas and Dependence
- Aggregate Risk
- Extreme Value Theory
- Credit Risk Management
- Dynamic Credit Risk Models
- Operational Risk and Insurance Analytics

Princeton University Press, 2005

Two important events for actuarial research

36th International ASTIN Colloquium

4 – 7 September 2005, Zurich, Switzerland

Actuarial research topics in (non-life) insurance

See `http://www.astin2005.ch/`

15th International AFIR Colloquium

6 – 9 September 2005, Zurich, Switzerland

Research on financial risk in insurance

See `http://www.afir2005.ch/`

Joint ASTIN / AFIR day on 7 September 2005

1905 – 2005: 100 years Swiss Actuarial Association

1855 – 2005: 150 years ETH Zurich

ASTIN / AFIR 2005: invited contributions

David R. Cox Nuffield College, Oxford	Some Challenges Facing Statistical Sciences
Thomas Mack Munich Re	Recent Developments in Claim Reserving
Phelim Boyle University of Waterloo	Incomplete Markets: Some Reflections
Elias S.W. Shiu The University of Iowa	Dynamic Fund Protection
Hans Bühlmann ETH Zurich	On Three Fundamental Issues of Insurance
Robert F. Engle Stern School, NYU	Downside Risk – Econometric Models and Financial Implications
Mary Hardy University of Waterloo	Validation of Investment Models for Actuarial Applications
Damir Filipović University of Munich	Risk-based Solvency Capital Requirements

Conclusion

- Actuarial practice and regulation is undergoing some major changes
- Actuarial teaching must undergo some major changes
- Actuarial research has to follow

Hence one needs an optimal combination of

actuarial

practice – regulation – teaching – research

at

an international level