Joint Colloquium of the IACA, PBSS and IAAHS Sections of the International Actuarial Association

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Enterprise Risk Management:

An Introduction

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ASSOCIATION INTERNATIONALE DES ACTUAIRES-CONSEILS
INTERNATIONAL ASSOCIATION OF CONSULTING ACTUARIES
IACA

SECTION SUR LES PENSIONS, AVANTAGES SOCIAUX ET SÉCURITÉ SOCIALE DE L'AAI
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Frank Redington

'I have often regretted the casual way the (actuarial) profession compresses the varied complexity of its affairs into a colourless present value.'

'The briefest glance at the past tells us one fundamental actuarial lesson, that our strength lies in no way at all in the infallibility of our forecasts; it lies in our power to measure and deal with our own fallibility, to face and assess our own uncertainty.'

Motivation for expansion

- Move to variable insurance contracts
- More complex benefits, options
- Increased complexity of valuation and regulation
- Insurance/investment focus for life insurance
- Intellectual advances in the modelling of risk
- Recognition of risk beyond product risk
- Increased computational power
- Expansion of actuarial practice to new areas beyond insurance

Important Trends in Insurance

- Deterministic to stochastic methodologies in insurance:
  - Stochastic dynamic financial analysis
  - Risk measure calculations
  - Stochastic cash flow projections for pensions
  - Fair value accounting
  - Economic capital calculation

Important trends (cont'd)

- From diversifiable to non-diversifiable risk:
  - Variable Annuities, EIAs
  - Universal life
  - Hybrid pension plans
- Equity risk and interest rate risk are critical to analysis
- Longevity risk
- Recognition of other risk types: operational, credit, etc leads to …..

Expansion to ERM

Definition of ERM

"ERM is the discipline by which an organization in any industry assesses, controls, exploits, finances and monitors risks from all sources for the purpose of increasing the organization's short- and long-term value to its stakeholders"

(Casualty Actuarial Society)

Enterprise Risk Management for Financial Institutions

What is it?

- A framework for identifying, measuring and management of risk exposure for the enterprise as a whole. It includes:
  - Process controls to avoid losses
    - e.g. Leeson/Barings
  - Mechanisms to transfer risk
    - e.g. insurance
    - Alternate Risk Transfer mechanisms; e.g. securitization
  - Mechanisms to report and manage risk
  - Methods to assess risk/return tradeoffs
  - Tools to measure capital needs to support risk exposure

Key Elements

- ERM is an ongoing process that involves
  1. Identification – to identify hazards
  2. Measurement – to assess risk exposure
  3. Management – to achieve objectives
  4. Value creation – through meeting firm objectives

  These parallel what insurers have always done for assumed risk –
  1. underwrite,
  2. price and reserve,
  3. reinsure,
  4. profit

Who are the players interested in ERM?

- Banks' and insurers' management and boards
- Bank and insurer regulators
  - BIS, BCBS
  - IAIS
  - national regulators of banks and insurers
- Professional groups
  - Auditors, actuaries, other risk professionals
- Rating agencies
  - Fitch, Moody, S&P, etc

Acknowledging Risk: Development of the CRO

- Recognition of enterprise-wide risk has become an increasing part of governance of financial institutions.
- The senior management person: the CRO.
- Recognition of ERM by rating agencies has caused managements of traded companies to focus on risk exposure.

Measuring Risk: Economic Capital

- ERM adds value by exploiting risk by recognizing interdependencies
- This must be translated into a more efficient decision-making about capital usage
- EC – a common metric that attaches the cost of risk to strategic initiatives
- EC – the amount of capital required to sustain losses at a given risk tolerance level over some horizon

Communicating Risk: ERM Dashboard

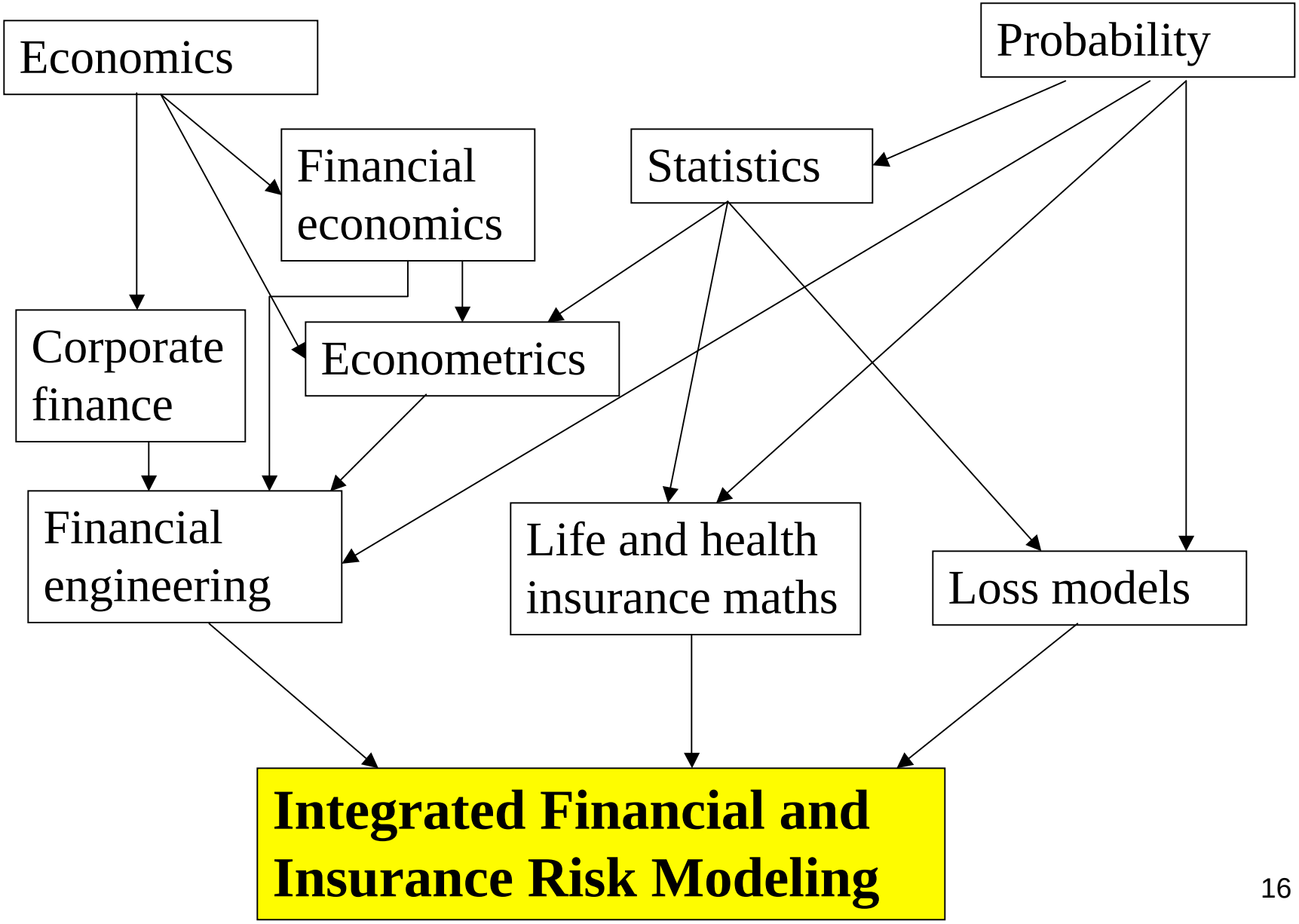
- Key communication tool to management
- Highly customized
- Increases transparency
- Leverages existing infrastructures
- Integrates disjoint data
- Drills into details on a click
- Allows real-time assessment

Actuaries' response to ERM

- Historical actuarial expertise is on exploiting product risk
- There is a growing actuarial knowledge base in the areas of
  - External risks, the occurrence of which is not under control of management
  - Interdependent risks
  - Co-ordination of risk management within entity
  - Transparency of risk management system
  - Reputation risk
  - Quantification of risk: especially low frequency, limited data
  - Long term risk: scenario testing, stress testing

Actuarial Education Growth

- Deeper study of risk types
  - Market risk,credit risk, operational risk, etc
- Deeper study of risk analysis methods
  - Many are already <u>very</u> actuarial
- Deeper study of financial markets
  - Asset side, including all types of derivatives, without reference to insurance products
- Deeper study of financial economic theory
  - This provides the language for addressing challenging problems such as valuation in incomplete markets


Economics
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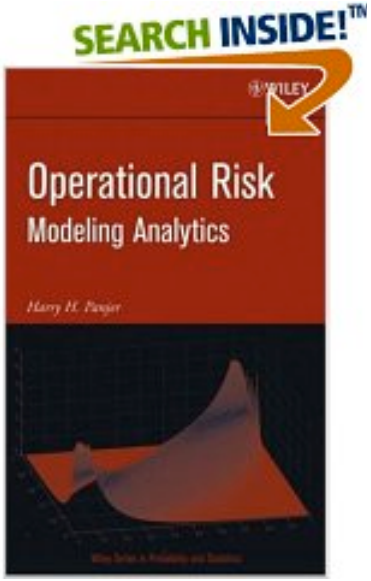
Financial economics
Statistics
Corporate finance
Econometrics
Financial engineering
Life and health insurance maths
Loss models
Integrated Financial and Insurance Risk Modeling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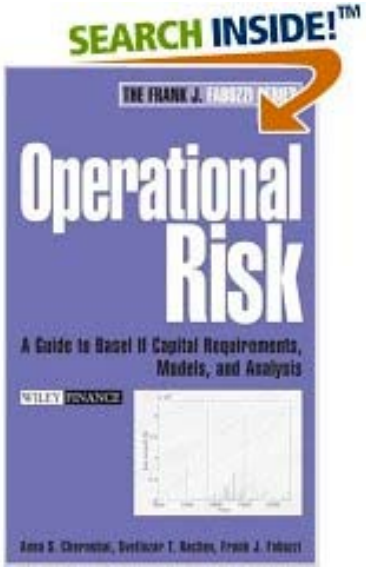
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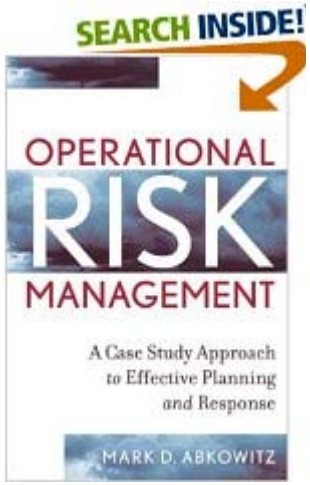
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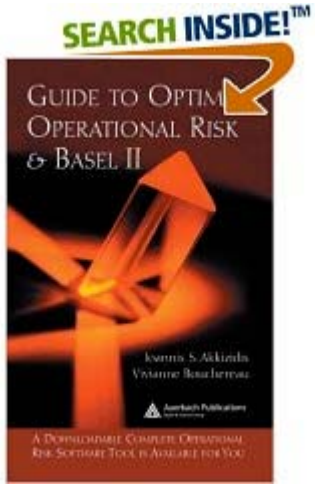
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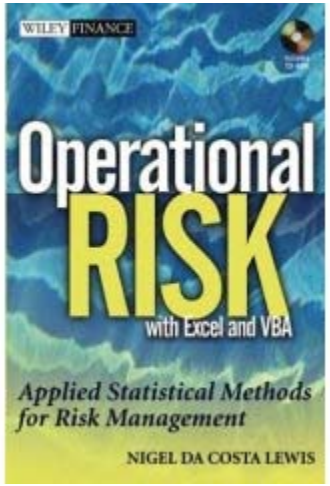
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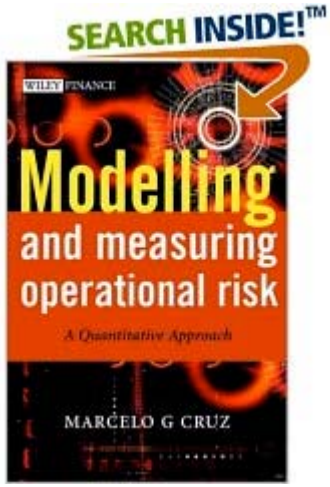
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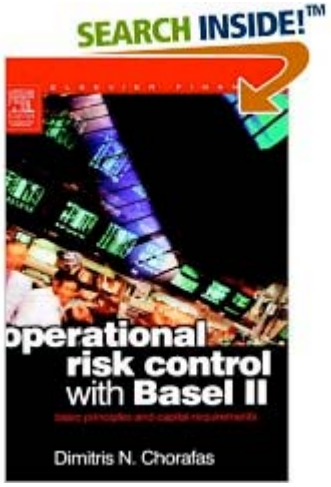
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operational
risk control
with Basel II
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Risk Management – traditional "silos" …

	Strategic Risk	Business Risk	Financial Risk	Operational Risk	Insurance/ Underwriting Risk
Who	• Board of Directors • CEO	• Business Managers • Project Managers	• CFO • Treasurer	• Internal Audit • Compliance • IT	• Actuaries • Underwriters • Brokers/ Agents
How	• Strategic planning • EVA • Balanced scorecard	• Product plans • Business reviews • Project management	• Country and credit limits • Trading and ALM Limits • Financial derivatives	• Controls • Audits • Contingency planning • Insurance	• Reserving and modeling • Underwriting guidelines • Profitability-based commissions

What is the difference between Risk Management and ERM?

- *An ERM Program comprehensively applies Risk Management…*

  - **across ALL of the significant risks of the Enterprise**
  - **Consistently across the risks**
  - **Consistently with the fundamental objectives of the enterprise**

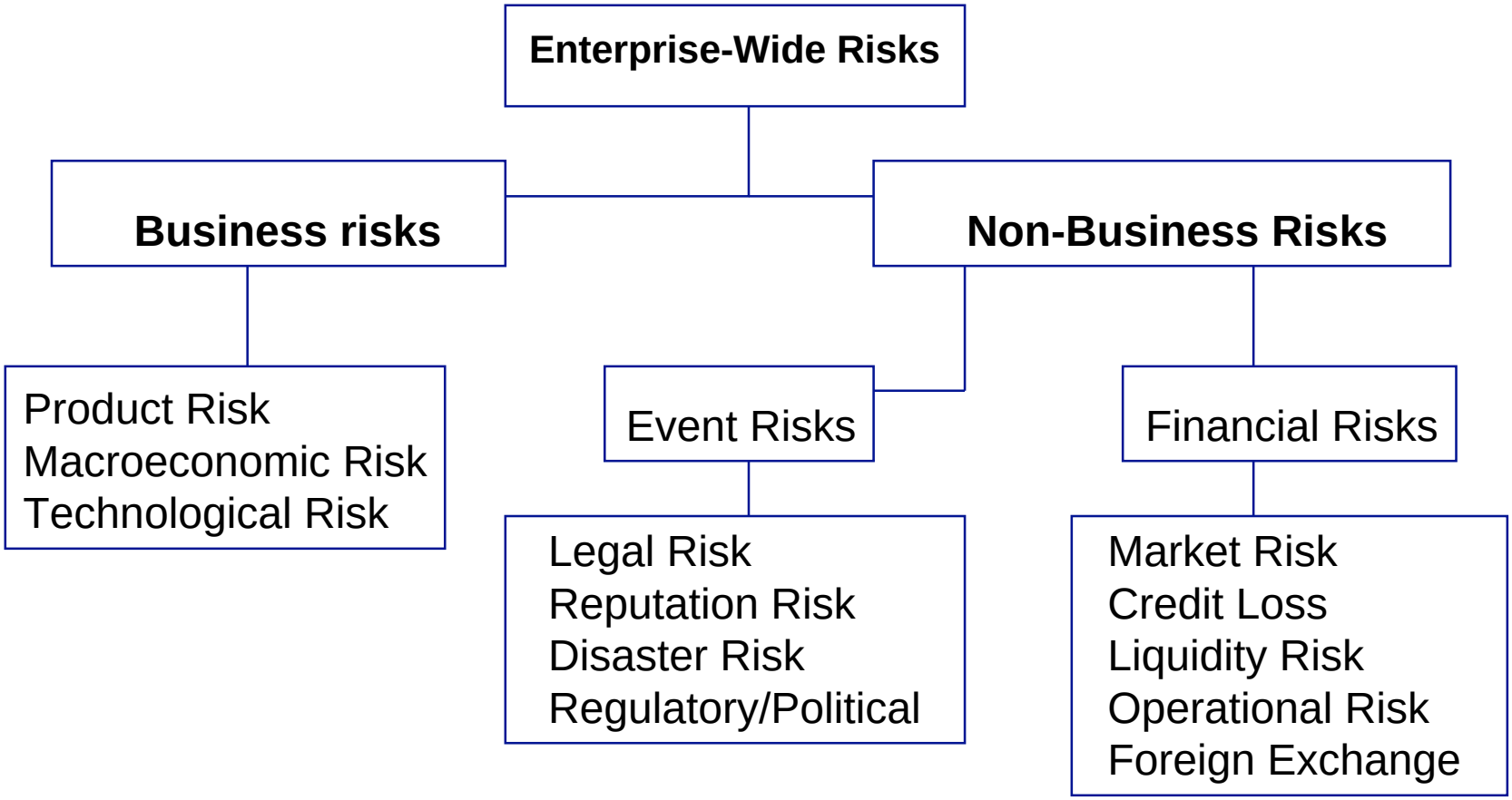
Benefits of an ERM Program

Once a firm's enterprise wide risks are identified and objectives are set, an ERM Program should…

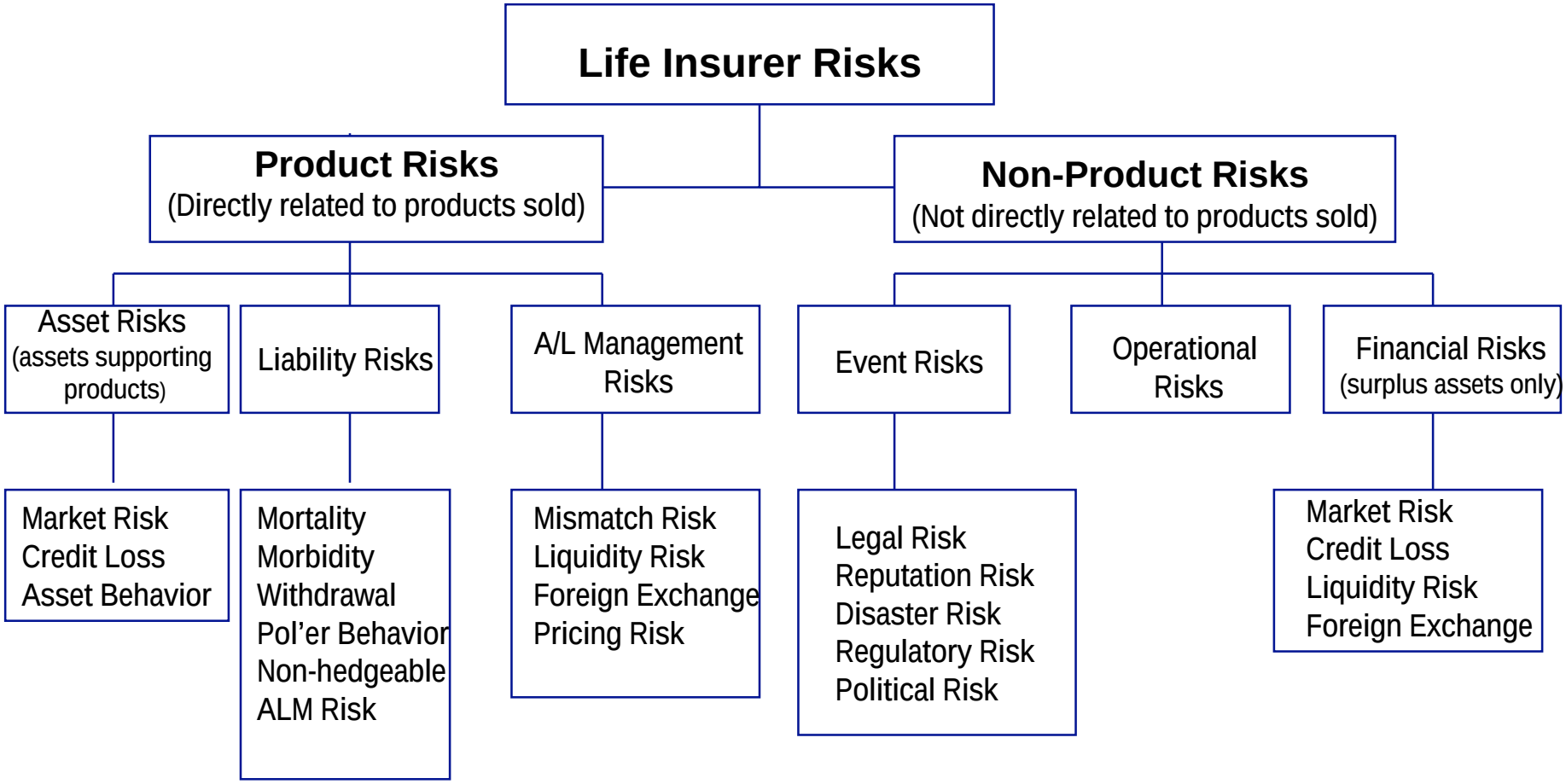
- **Develop and maintain systems to periodically measure the <u>capital</u> needed to support the retained risks of the company**
- **Reflect the risk capital in:**
  - strategic decision making,
  - product design and pricing,
  - strategic and tactical investment selection
  - financial performance evaluation

The product of a fully-realized ERM Program is the
<u>optimization of enterprise risk adjusted return</u>

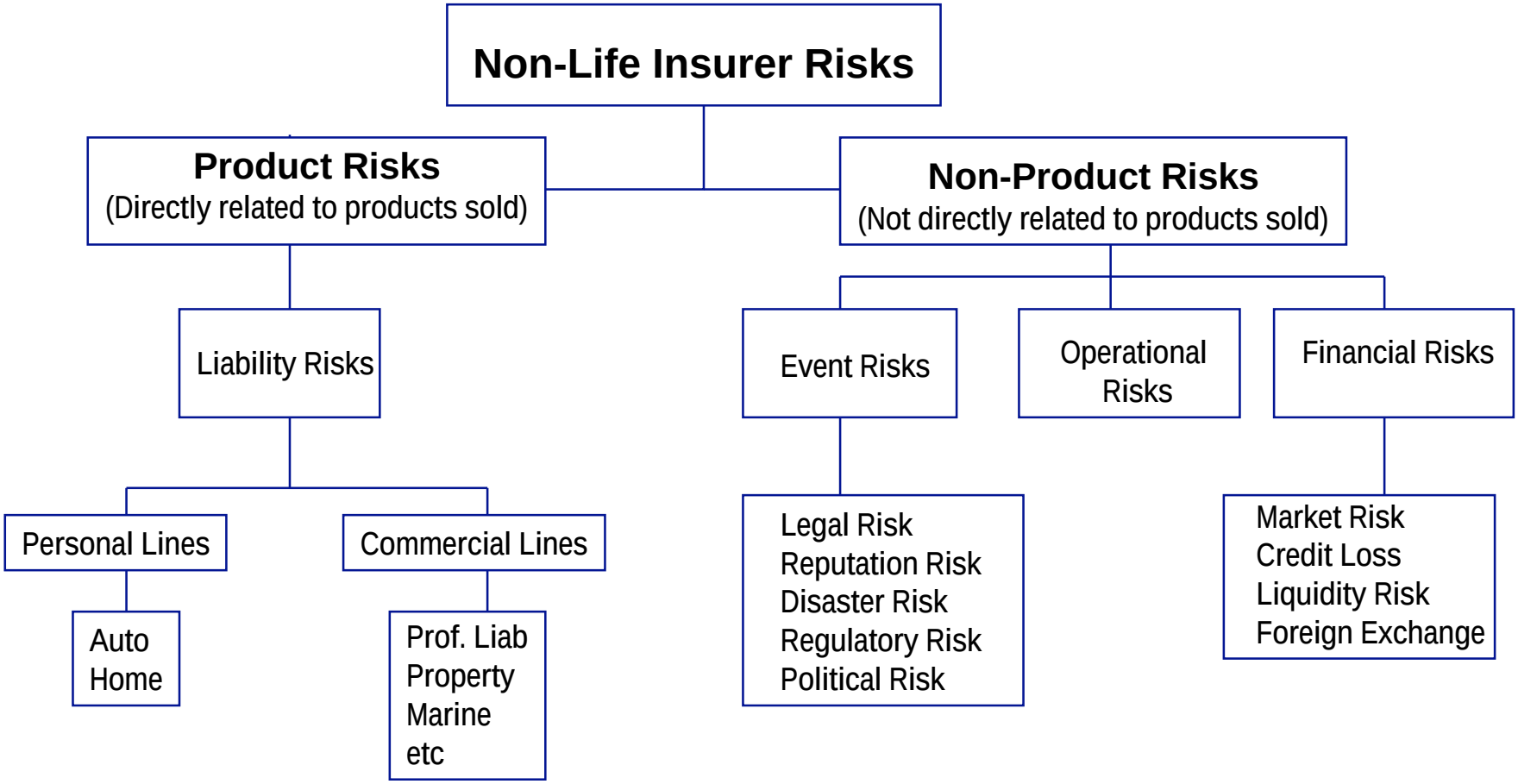
Taxonomy of Risk (any enterprise)



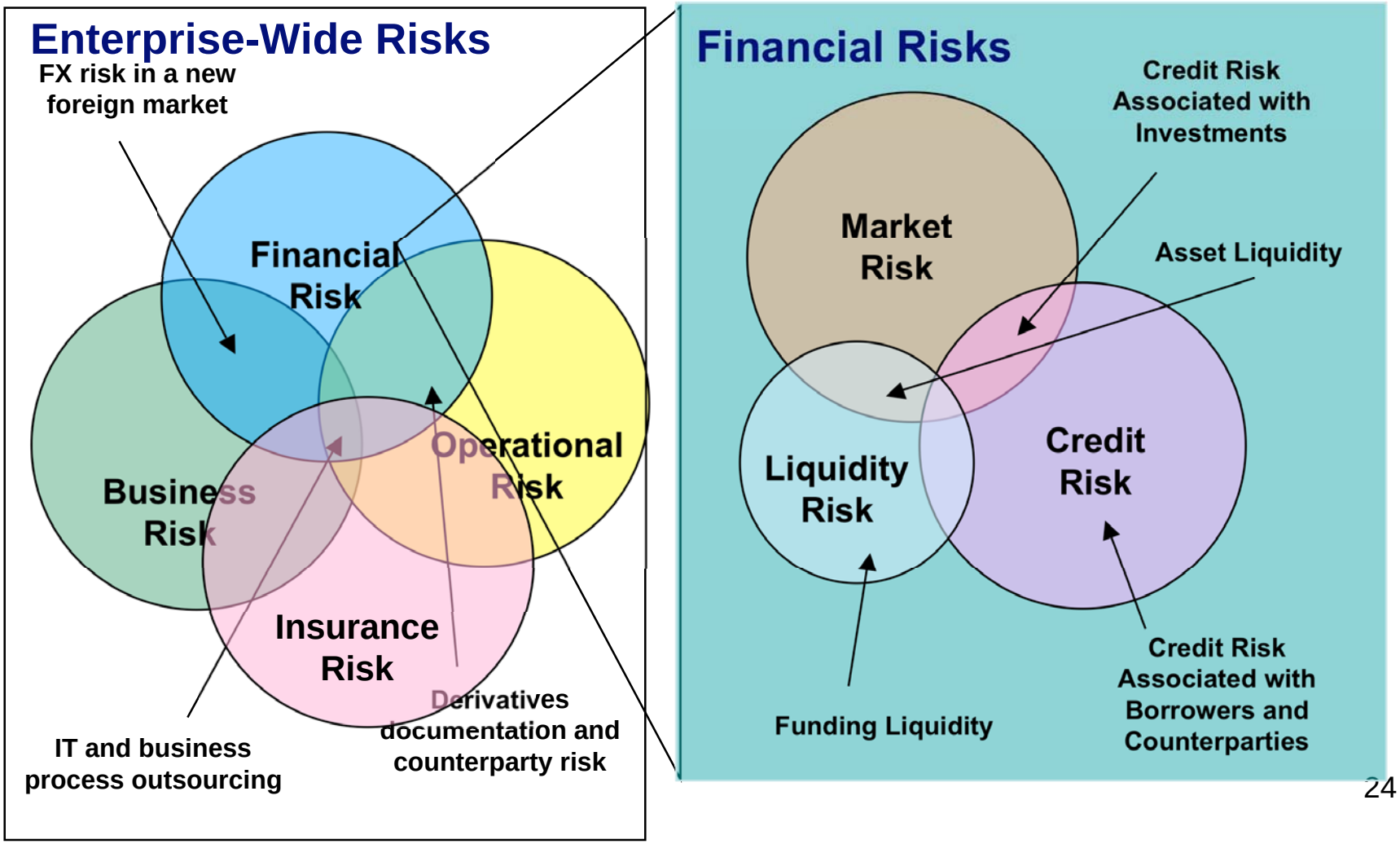
Taxonomy of Risk (life insurer)



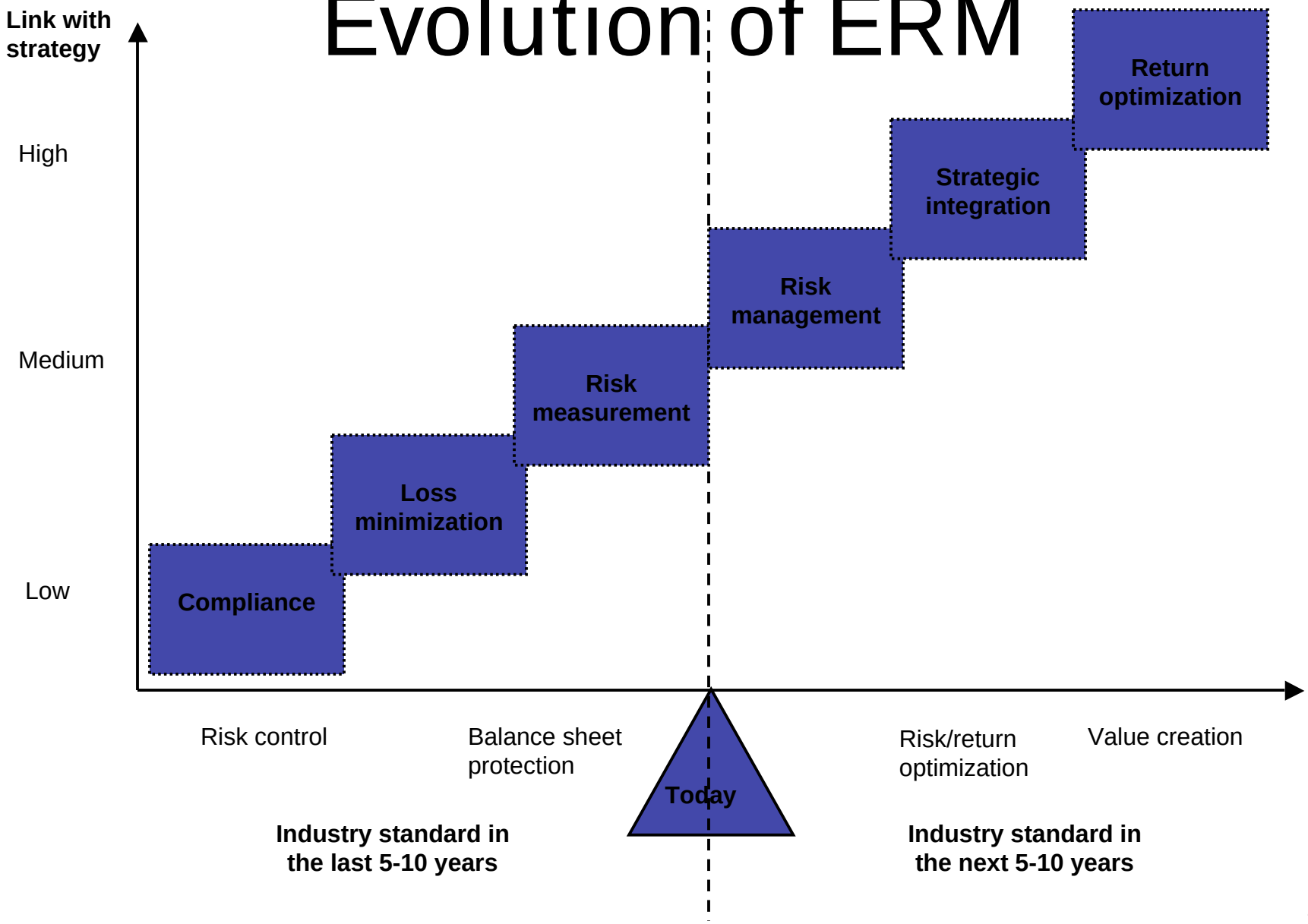
Taxonomy of Risk (non-life insurer)



...but risks faced by companies are highly interdependent



Evolution of ERM



Some Current Challenges

- Internal models
- Economic scenario generators
- Risk measures
- Risk aggregation
  - Copulas

Internal models

- To assess the impact of risk, companies are building large scale computer models of all elements of the company's operation.
- By adding probabilities, measures of economic capital can be obtained from the model.
- In addition, the sources of the need for economic capital can be better understood.
- The impact on economic capital of any initiative can be assessed.

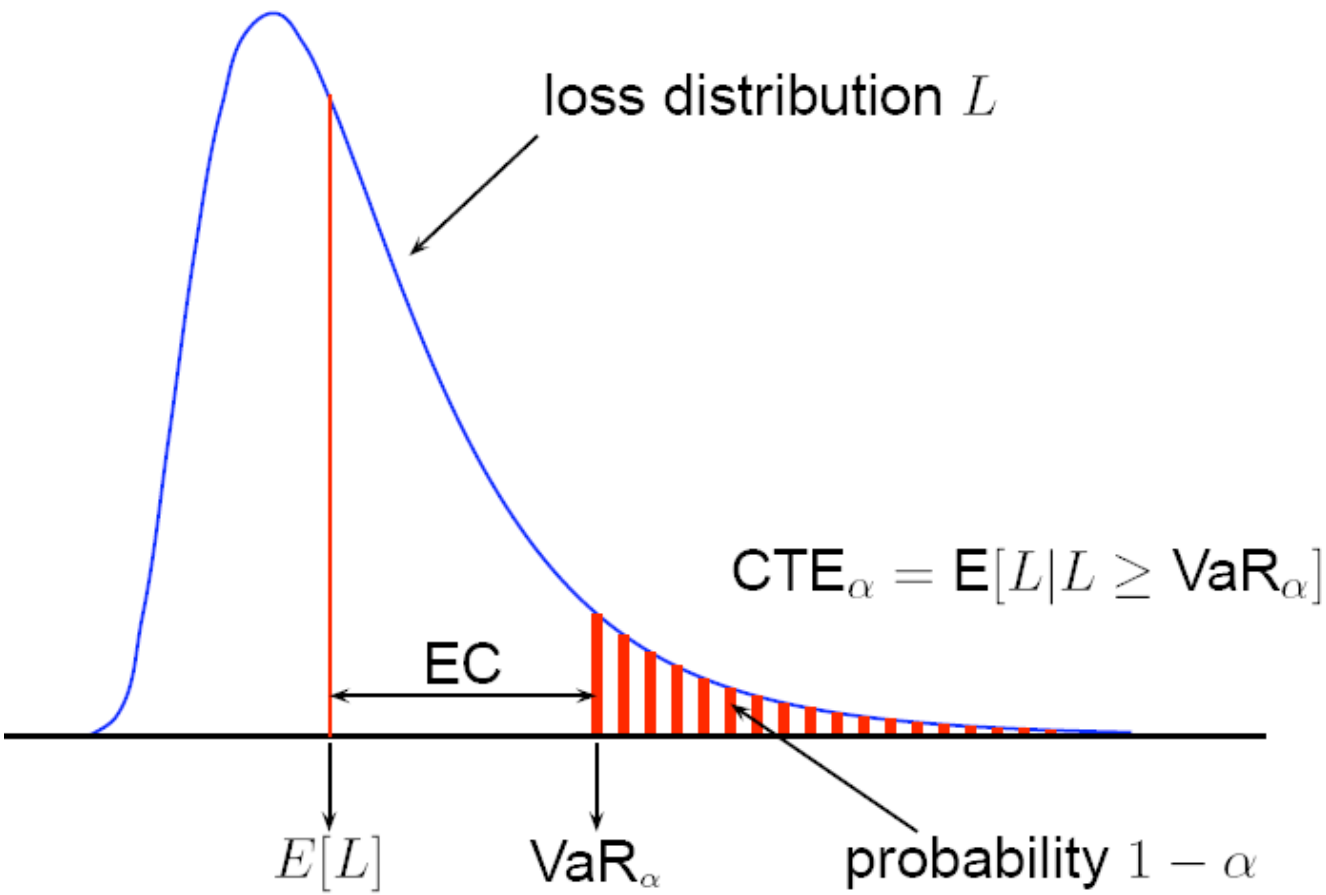
Economic Scenario Generators

- A probability-based model of the economy in which the company operates.
- ESG captures dependencies amongst economic variables.
- ESG is external to the company; it does not depend on the structure or actions of the company.
- The ESG provides input into the company's internal model.

Risk Measures

- Risk measures attempt to quantify the riskiness of a portfolio or an entire company.
- Popular risk measures are
  - Value at Risk (VaR)
  - Conditional Tail Expectation (CTE,TCE, TVaR, CVaR) or Expected Shortfall (ES)

VaR, CTE, Economic Capital (EC)

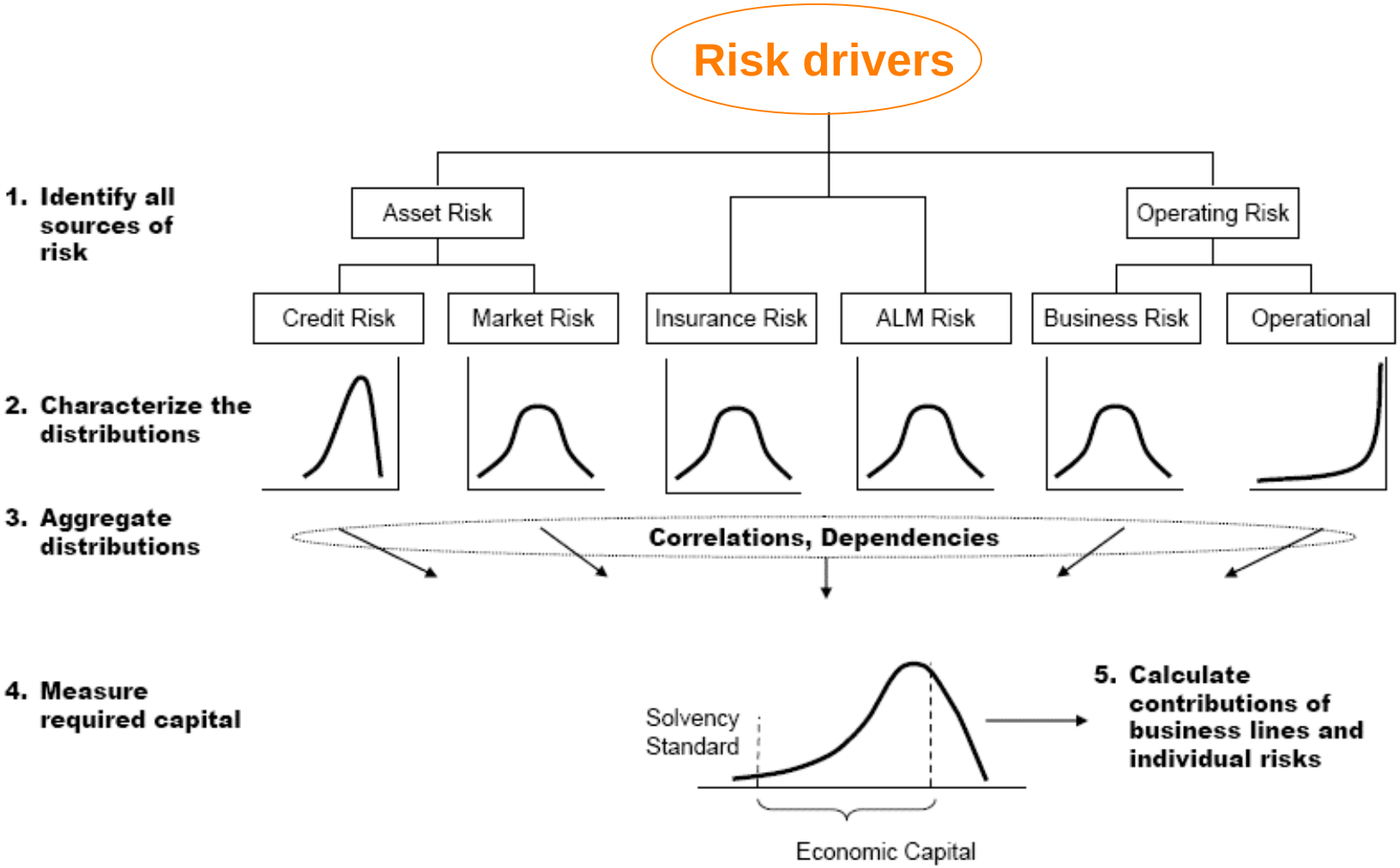


Uses of Risk Measures

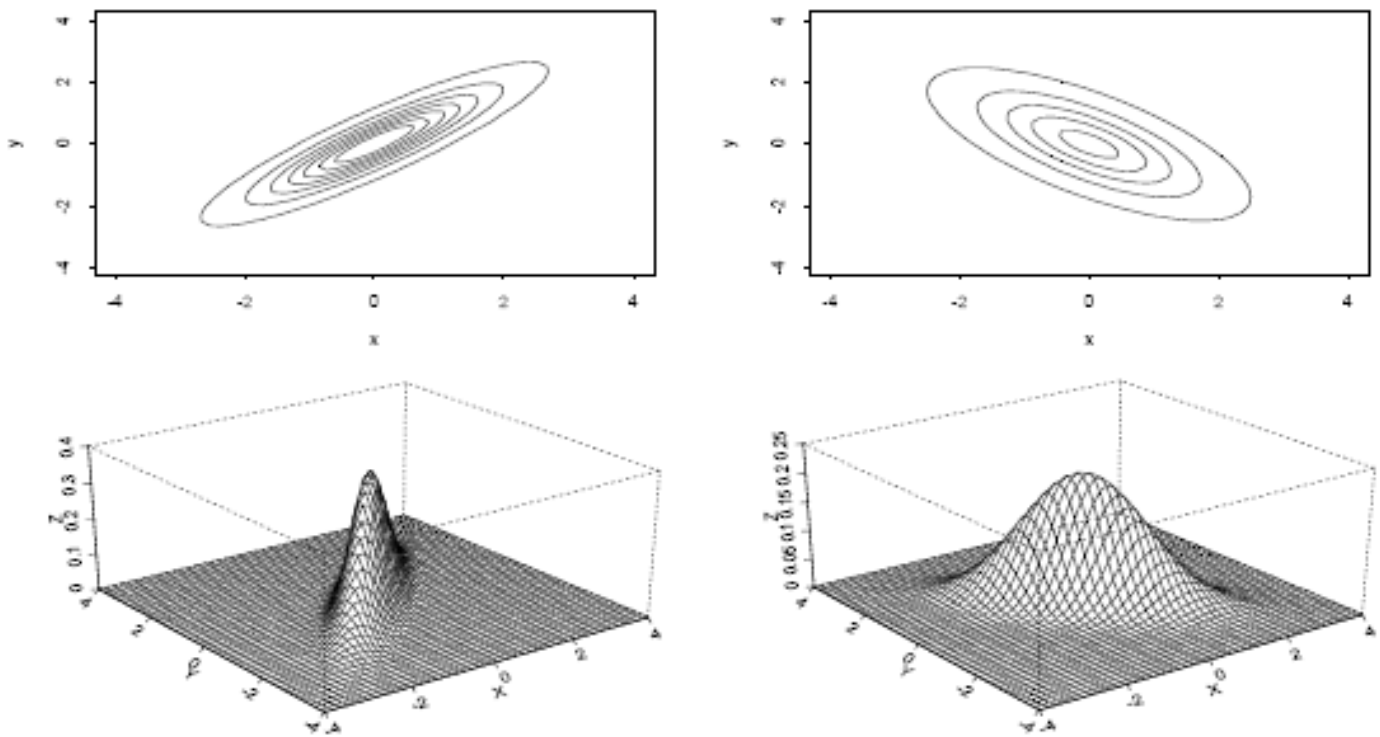
- Management tool.
  - Risk measures are used in internal limit systems.

- Determination of risk capital
  - Risk measure gives amount of capital that needs to be added to a position with loss L, so that the position becomes acceptable.

Risk Aggregation

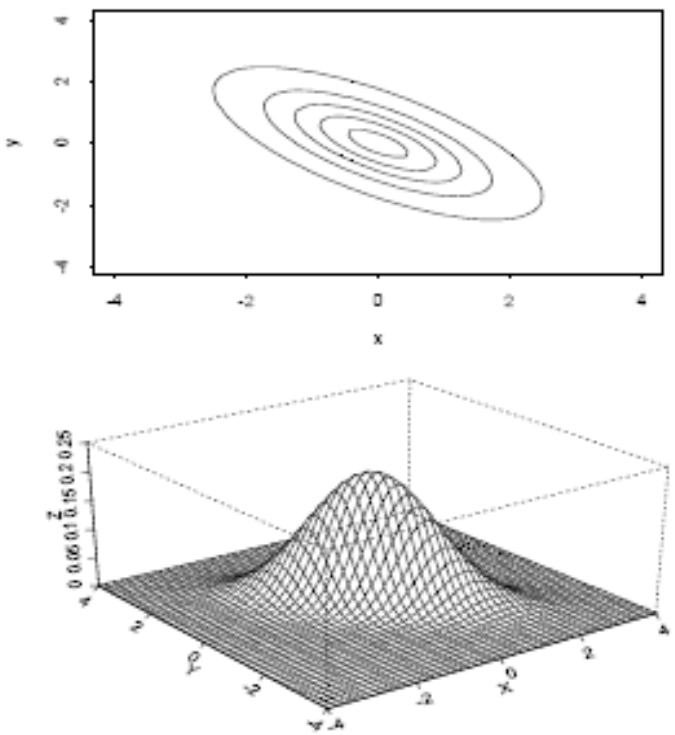


Bivariate Standard Normals

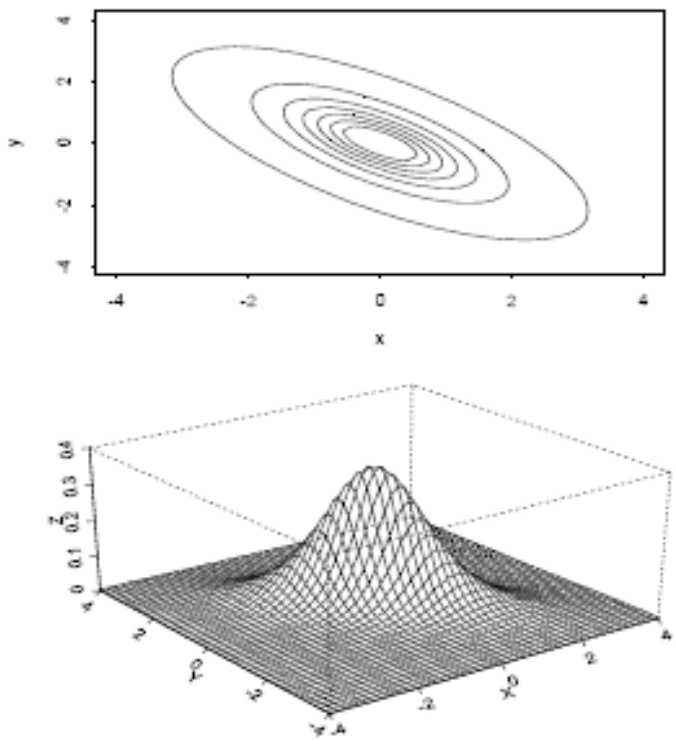


ρ=0.9 ρ=-0.7

Bivariate distributions: Normal vs *t*



ρ=-0.7



ρ=-0.7, d.f. 3

Copulas

- Suppose X and Y have continuous d.f. F_X & F_Y and joint d.f. $F_{X,Y}$, then:

$$F_{X,Y}(x,y) = C\left(F_X(x), F_Y(y)\right) \qquad (*)$$

- Key result: Decomposition of multivariate d.f.
  - Copula function models the interdependence

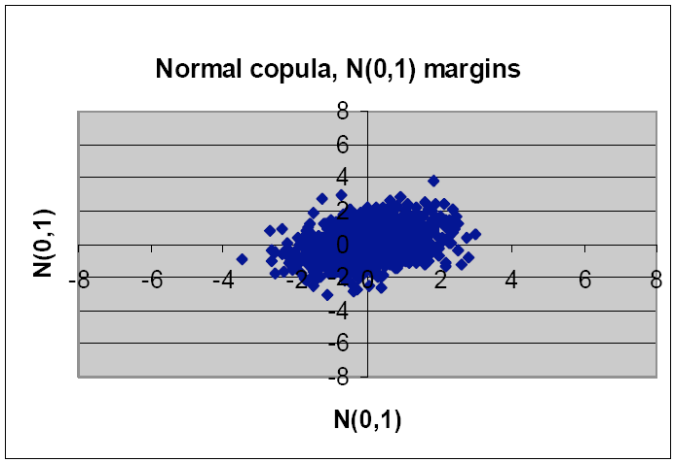
Examples of Copulas

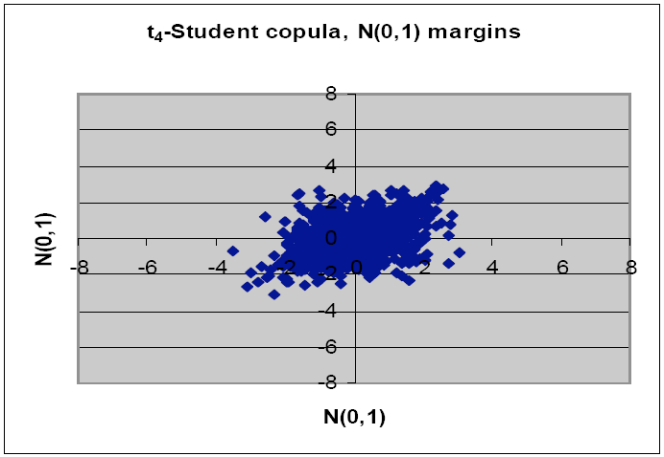
- Independence copula

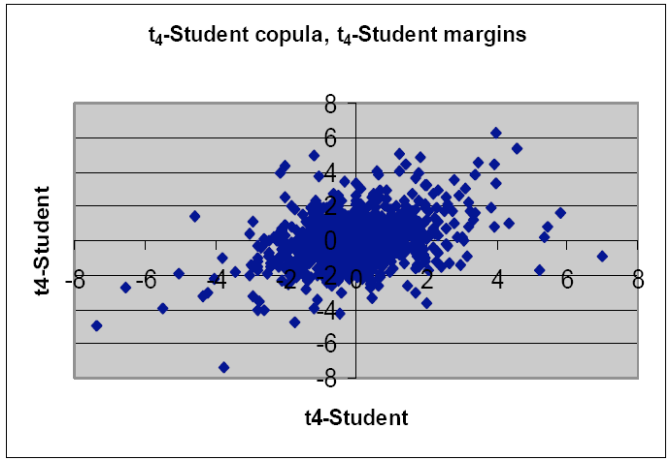
$$C(u,v) = u \cdot v \quad \Rightarrow \quad C\left(F_X(x), F_Y(y)\right) = F_X(x) \cdot F_Y(y) = F_{X,Y}(x,y)$$

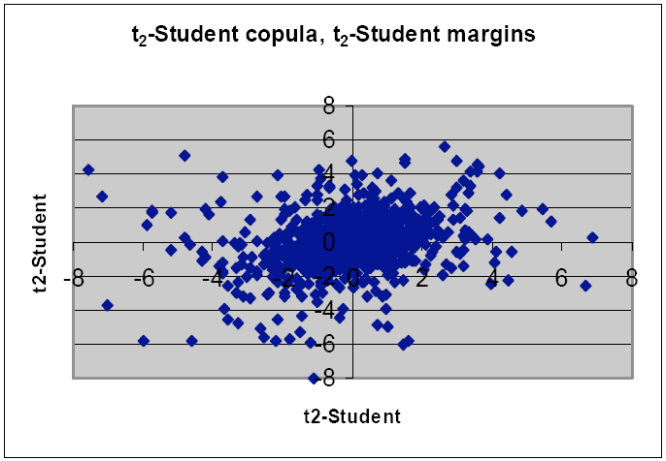
- Gaussian (or Normal) copula
- Student *t* copula
- Gumbel copula
- Clayton copula
- Frank copula
- etc.

Copulas: Gaussian vs Student *t*









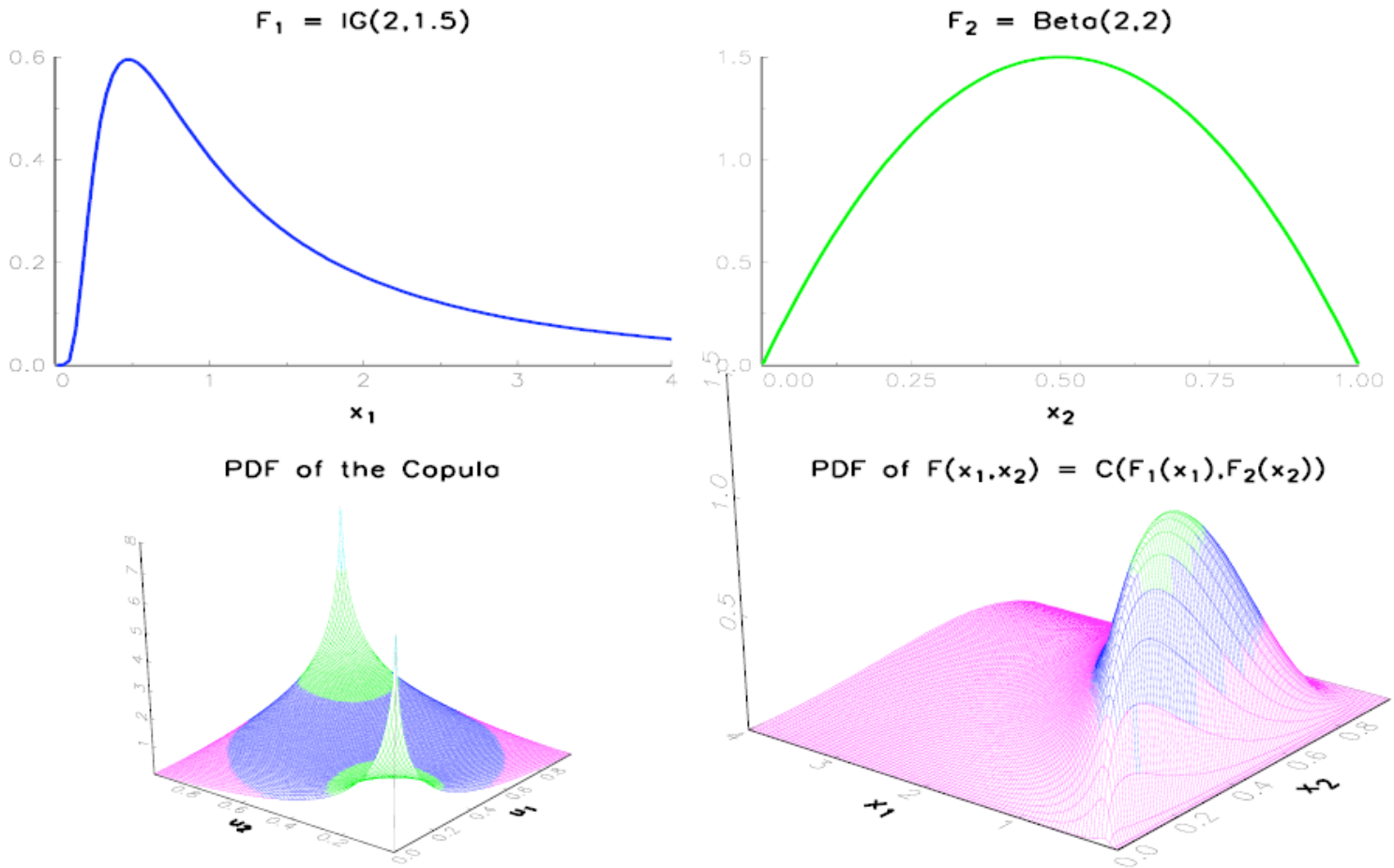
Flexibility of Copula

- It should be emphasized that the power of copula lies in its flexibility in creating multivariate d.f. via marginals
- Question: What is the bivariate distribution of X_1 & X_2 if

$$X_1 \sim \text{Inverse Gaussian} \ \ \& \ \ X_2 \sim \text{Beta}$$

  – Example: in credit risk modeling, X_1 may be a default time and X_2 a recovery rate
  – see Jouanin, Riboulet and Roncalli (2004)

Gaussian Copula with marginals Inverse Gaussian & Beta

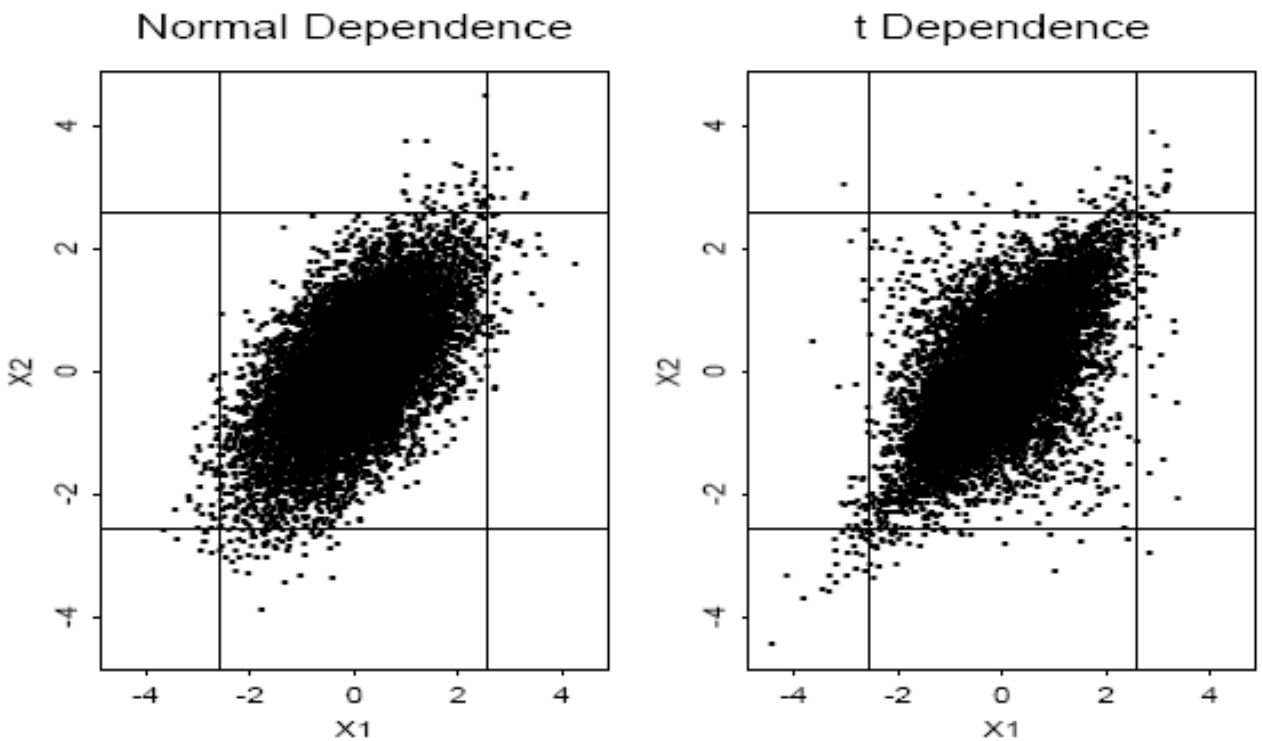


Coefficients of Tail Dependence

- In risk management, we are often concerned with extreme values, particularly their dependence in the tail

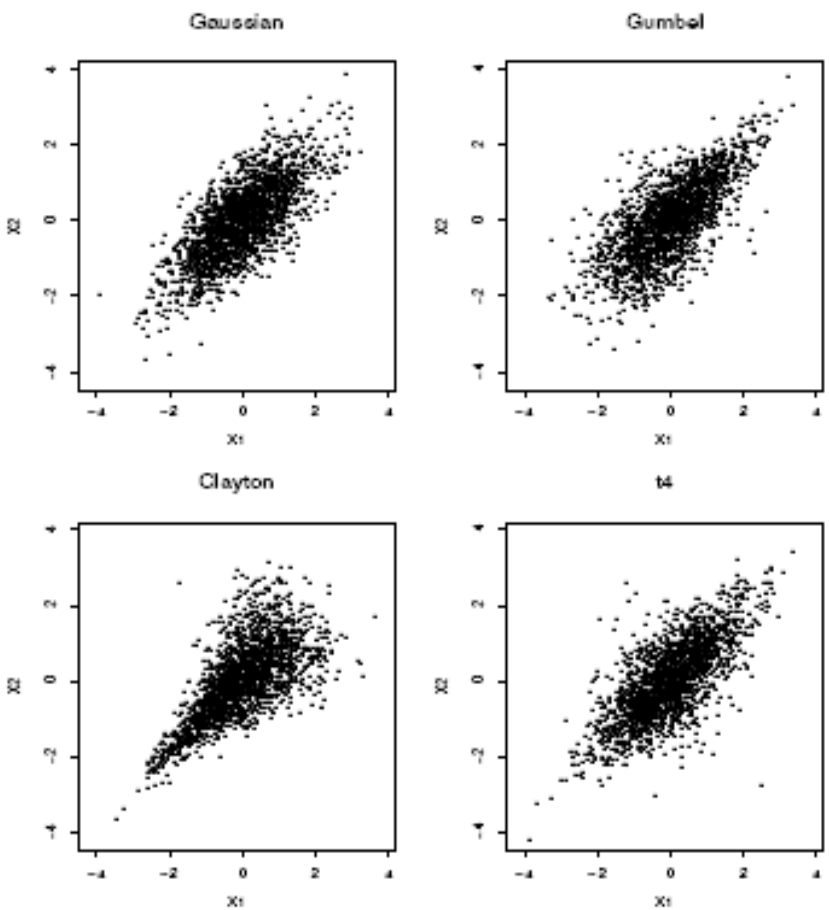
- Coefficient of tail dependence provides a measure of extremal dependence
  - It measures the strength of dependence in the (upper or lower) tails of a bivariate distribution

Tail dependence: Gaussian vs t copulas (std normal margins)



- copula parameters: ρ=0.7, ν=3
- quantiles lines (vertical and horizontal): 0.5% and 99.5%

Simulated Copulas
- Normal Marginals



- In all cases, linear correlation is around 0.7
- Gumbel copula:
  - $\theta = 2.0$
- Clayton copula:
  - $\theta = 2.2$
- t copula:
  - $v = 4$ $\rho = 0.71$

Example on Operational Risk: Dalla Valle et al. (2005)

- They examine operational loss data from a bank
- The data set consists of monthly observations collected over Jan 1999 to Dec 2004
- There are 407 loss events classified into two business lines and four event types, forming a total of eight business line/event type combinations.
- Frequency data:
  - Poisson and negative binomial
- Severity data:
  - exponential, gamma, Pareto

Operational Risk Example (cont'd)

		VaR 95%	VaR 99%	ES 95%	ES 99%
Poisson Exponential	*Perfect Dep.*	925,218	1,940,229	1,557,315	2,577,085
	Normal Copula	656,068	1,086,725	920,446	1,340,626
	T copula (9 d.o.f.)	673,896	1,124,606	955,371	1,414,868
Poisson Gamma	*Perfect Dep.*	861,342	3,694,768	2,640,874	6,253,221
	Normal Copula	767,074	2,246,150	1,719,463	3,522,009
	T copula (9 d.o.f.)	789,160	2,366,876	1,810,302	3,798,321
Poisson Pareto	*Perfect Dep.*	860,066	2,388,649	2,016,241	4,661,986
	Normal Copula	663,600	1,506,466	1,294,654	2,785,706
	T copula (9 d.o.f.)	672,942	1,591,337	1,329,130	2,814,176
Negative Bin. Exponential	*Perfect Dep.*	965,401	2,120,145	1,676,324	2,810,394
	Normal Copula	672,356	1,109,768	942,311	1,359,876
	T copula (9 d.o.f.)	686,724	1,136,445	975,721	1,458,298
Negative Bin. Gamma	*Perfect Dep.*	907,066	3,832,311	2,766,384	6,506,154
	Normal Copula	784,175	2,338,642	1,769,653	3,643,691
	T copula (9 d.o.f.)	805,747	2,451,994	1,848,483	3,845,292
Negative Bin. Pareto	*Perfect Dep.*	859,507	2,486,971	2,027,962	4,540,441
	Normal Copula	672,826	1,547,267	1,311,610	2,732,197
	T copula (9 d.o.f.)	694,038	1,567,208	1,329,281	2,750,097

Rosenberg and Schuermann (2006)

- A comprehensive study of banks' returns driven by credit , market, and operational risks
- They propose a copula-based methodology to integrate a bank's distributions of credit market, and operational risk-driven returns,
- Finally they compare VaR and CTE measures for a bank's aggregate returns.

Rosenberg and Schuermann (cont'd)

- They consider four cases for a bank's return based VaR:
  - Normal VaR, risk distribution is multivariate normal
  - Additive VaR: perfect correlation
  - Hybrid VaR
  - Copula VaR: Gaussian and t copula
- They show that the additive approach overestimates risk by more than 40%.
- A typical alternative, assuming joint normality of the risks, underestimates risk by a similar amount

Conclusions

- ERM is here to stay
- There is still lots to learn about modeling
- Capital measurement is key
- ERM can be applied to any business
- Insurers and banks are at the forefront

Thank you

Acknowledgements:

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