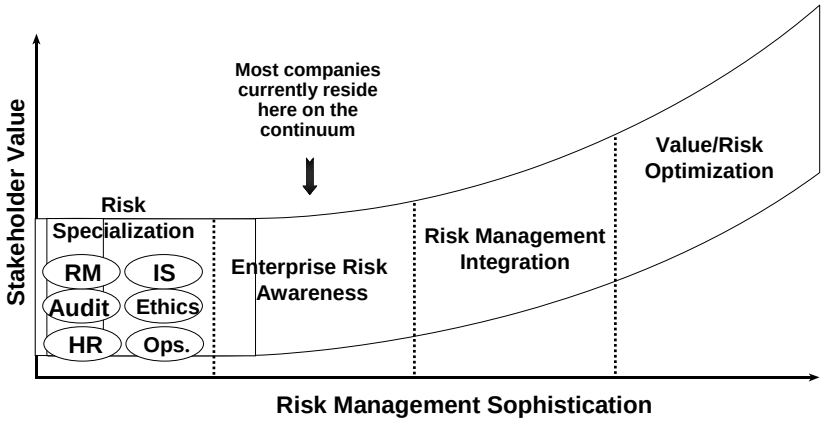
Enterprise Risk Management

Modeling Corporate Risk – An Opportunity

Christopher (Kip) Bohn

The Present State of ERM

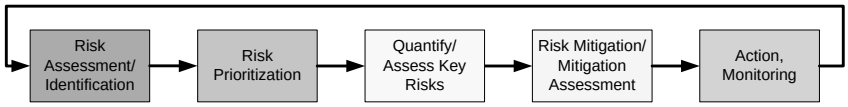


Present State of ERM

- Corporate CRO's, CFO's, RMs, etc. interested in ERM
- Many are looking to COSO for guidance
  - One of the first frameworks on the market
  - Provides transparency
  - Develops framework for meeting financial disclosure requirements
  - Promotes better decision-making, enhances capital allocation
  - Supports regulatory and compliance initiatives
  - Creates a formal link between operational, financial and strategic decision-making within the organization

Present State of ERM

- COSO's key components to ERM (abridged)



- COSO's Application Techniques Document
  - 112 page document, 8 sections
  - 22 pages (20%) dedicated to quantification/assessment of key risks
  - Quantitative methods include probabilistic (3 pages), non-probabilistic, and benchmarking techniques

Present State of ERM

- Probability-based techniques per COSO
  - "Measure the likelihood and impact of a range of outcomes based on distributional assumptions of the behavior of events"
  - "Include "at-risk" models (including value at risk, cash flow at risk, and earnings at risk), assessment of loss events, and back-testing"
  - "Generally non-normal distributions"
  - "Require collection of operational loss data categorized by root cause of the loss"
  - "Preliminary loss distributions developed and refined to take into account the organization's risk responses"

Opportunity for the CAS

- Actuaries are in the business of assessing, measuring and estimating risk
- The added value that actuaries bring is their ability to provide
  - An objective & independent view of risk
  - A view that can incorporate both company specific and industry trends
  - Estimates of risk that are rooted in actuarial science (both science and art)
  - Experience dealing with uncertainty/risk
- Actuaries currently focusing on insurance industry (Nov/Dec Contingencies)
  - Basel operational risk modeling gaining interest
  - Consider expanding scope beyond insurance & banking

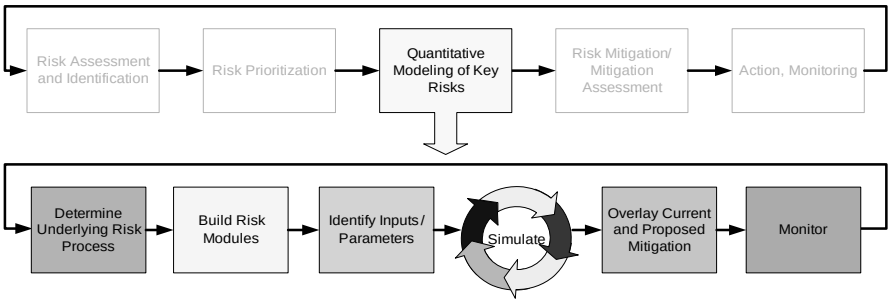
Actuarial Modeling

- Historically casualty risk modeling
  - Focused on standard casualty risks
  - Broke loss process into two components
    - Frequency (# of claims) distribution
    - Severity (size of claim) distribution
  - Benefit of historical loss industry loss data (in general) being readily available
  - Main mitigation under consideration is P&C insurance
    - Easy to model impact
    - Retentions, limits, aggregates, etc.

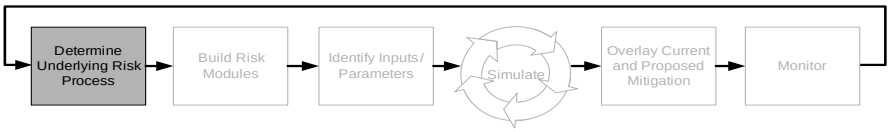
Actuarial Modeling

- Next Generation
  - Considers universe of risks beyond those traditionally insurable
    - Many times, traditional coverage not available
    - Modeling mitigation can be more complex
  - Loss process likely more complicated than frequency & severity
  - Data availability may be limited
    - Creativity in querying universe of available data
    - Need for professional judgment
  - Consideration of upside potential of risk

Quantitative Modeling Methodology

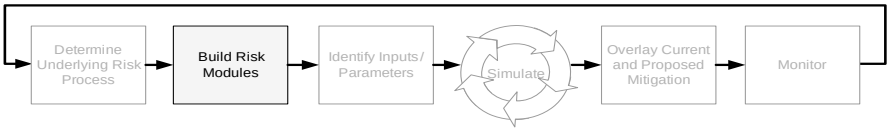


Quantitative Modeling Methodology



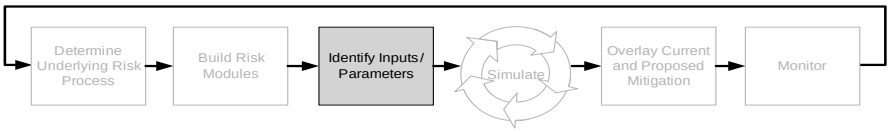
- Determine desired outputs, key performance indicators
- Identify key activities or exposures at risk
- Identify key events that could impact key activities or exposures at risk
- Identify the potential consequences of the events (dollars, time, reputation, etc.)
- Flowchart risk process - modular approach

Quantitative Modeling Methodology



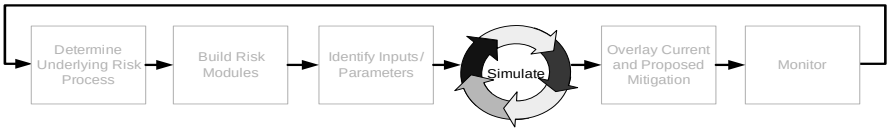
- Convert process flow of key risks into stochastic model (stochastic=dynamic and is the opposite of deterministic/fixed)
- Build in probability distributions associated with events and consequences
- Capture key performance indicators (losses, financial stats, net present values, etc.)
- Consider correlation and causation

Quantitative Modeling Methodology



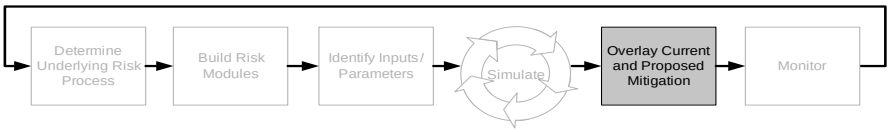
- Required inputs driven by risk process and desired model output
- Identify quantitative internal and external data sources
- Identify qualitative data sources including those personnel who are most familiar with risk process
- Determine appropriate probability distributions for events and consequences
- Investigate correlation where appropriate

Quantitative Modeling Methodology



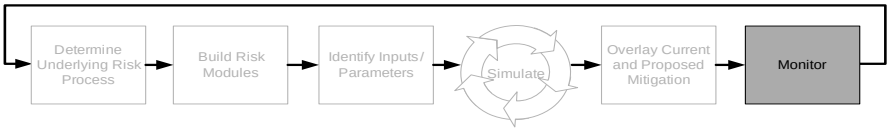
- Combine modules to consider potential correlation (all or subset of identified risks)
- Run Monte Carlo Simulation (e.g. 25K iterations)
- Check results for reasonableness
- Result is a distribution of potential outcomes that can estimate various statistics such as mean, standard deviation, etc.

Quantitative Modeling Methodology



- Build in current and alternative mitigation strategies
- Compare different strategies
- Analyze risk/return (cost/benefit) of competing strategies
- Consider expected value and distribution of modeled key performance indicators
- Results aid in the capital allocation decision process by shedding light on expected cost and associated risk

Quantitative Modeling Methodology



- Risk process, distributions, key performance indicators, etc. can change over time
- As mitigation strategies are implemented, list of key risks that should be modeled may change
- New risks may emerge in the future
- Improvement of risk model through additional modules and refined risk process, inputs, parameters, etc

Case Study

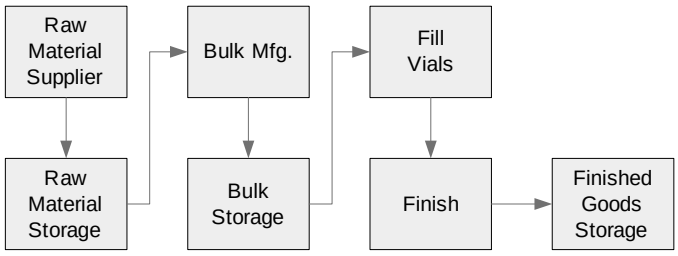
- Biotech firm identifies manufacturing process as a key risk to the company
- Concerned with
  - Impact due to disruptions from sole source suppliers
  - CAT risk to various locations critical to manufacturing process
  - Operational risks such as breakdowns at key steps in manufacturing process
  - Compliance risks

Case Study

- Interested in building a model that could
  - Consider all identified key risks
  - Ability to turn off certain identified risks to understand impacts
  - Ability to measure risk/reward trade-off of various mitigation strategies
    - Diversify locations
    - Pre-qualify additional suppliers
    - Hold more safety stock at various stages
  - Some requests not feasible
    - Black-box
    - Considers all risks (not just identified key risks)
    - Parameters updated daily
    - Can be run by the Treasurer's admin assistant

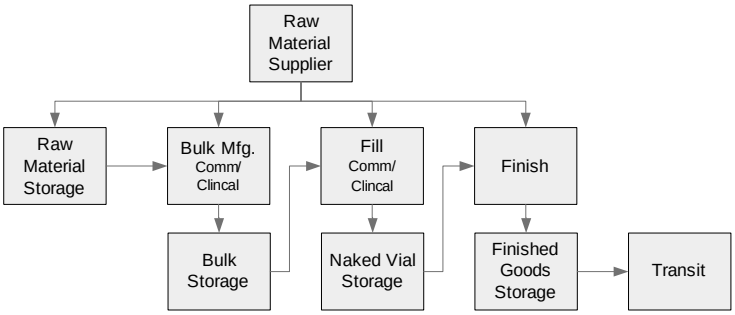
Case Study

- Begin with a high level draft of their operations
  - Based on initial conversations with Risk Management
  - Publicly available information



Case Study

- Conduct interviews with key “risk owners” to refine view of operations
  - Better understanding of manufacturing process
  - Ideas an insights on mechanics of final model



Case Study

- Construct model
  - Used Excel and @Risk as base
  - Due to complexity, need for database software to house results
- Separate module for each step in the process
  - Dependencies between modules
  - Differing units of measure for each module – need for conversion
  - Build in
    - Loss events
    - Consequences
    - Some loss events impacted all operational modules (e.g. CAT)
    - Mitigation

Case Study

- Meet with risk owners again
  - Walk through mechanics
  - Obtain buy-in
- Identify parameters for distributions
  - For some risks, data to back up distributions available
  - For others, proxy parameters and professional judgment of risk owners relied upon
- Run models
  - Do results make sense
  - Sensitivity test parameters

Case Study

- Modeling to understand the companies current risk profile is of interest
  - Does risk fall within risk bearing capacity and appetite constraints
  - What are key drivers of overall risks
- More interesting question is cost/benefit of alternative mitigation strategies
  - Avoid, mitigate, mitigate & transfer or transfer
  - Insurance, captives, safety stock, prequalification, etc.
  - Helps to define management's understanding of risk and their own appetite

Case Study

- 2005 represents the 4th iteration
  - First, second and third versions of the model were not as complex
  - Started with much simpler views of the manufacturing process
  - Every year gained more understanding
    - Able to build on prior year's model
    - Identified prior logic that no longer made sense
  - Always looking forward
    - In 2005, identified a number of items on the wish list for 2006
    - Need to begin investigating alternative modeling platforms

Conclusion

- ERM is gaining interest
  - Insurance companies
  - Financial institutions
  - All industries
- ERM is both quantitative and qualitative process
  - Actuaries understanding of risk can add tremendous value to the quantitative aspects of ERM
  - CAS Centennial goal
- Participation in the quantification of operational, hazard and financial risks will also enable actuaries to develop new mitigation products for the market
- Opportunity for strategic leadership role

GUY CARPENTER

Adapting Banking Models to Insurer ERM

GARY G. VENTER

Guy Carpenter Instrat®
One Madison Avenue
New York New York 10010

Background

- Banks have been doing ERM for a while
  - Based on "economic capital" – capital to meet a risk level
  - Allocate to business unit
  - Ratio of profits to this is a risk-adjusted return by business unit
  - Used in performance measurement and strategic planning
- Insurers have unique issues
  - Bank risk more standardized, so more securitization of risk
  - Insurers' role is to assume risk while banks to finance opportunity
  - Insurers have been modeling hazard risk
  - Accustomed to using several different risk measures

Outline

- Risk Measures
  - Economic capital
  - Tail based measures
  - Transformed probability measures
- Risk adjusted return
  - Capital allocation – marginal decomposition
  - Capital consumption
- Correlation issues
  - How much and where
- Insurance risk assumed
  - Unearned premium reserve – parameter uncertainty
  - Loss reserves
- Asset risk
- Operational risk
- Credit risk

Risk Measures

Economic Capital

- Capital that is needed to meet some risk definition
- E.g., capital that makes probability of ruin = 1/3000
- But focusing on a single risk measure gives an incomplete picture
- Calling it economic capital confuses the fact that it is just one risk measure
- If the actual probability of ruin is 1/3127, that is the more relevant risk measure anyway
  - Usually economic capital measure selected to make economic capital a bit less than actual capital
- Better to have a few measures of actual company risk

Tail-Based Measures

- Probability of default
- Value of default put option
- Value at risk
- Tail value at risk
- Excess tail value at risk
- Weighted excess tail value at risk

Probability of Default

- A long-standing actuarial concept
- Can compare to bond default probability
- But it is beyond the ability of current models to quantify
  - Role of underwriting practices, fraud, mismanagement big in insolvency but hard to measure
  - Loss models themselves not that accurate way out in tail
- Even bond models do not base ratings on default probability
  - They use RBC type factors and compute probabilities historically
- Default put value is market value of the losses beyond default
  - Similar calculation problems as default probability
- Impairment probabilities more practical
  - How much of surplus is lost in 1-in-10, 1-in-100, etc.
  - Probability of drop in surplus and average drop when there is one

Value at Risk

- Fancy name for a percentile of the loss distribution
- Loss is relative to a time-frame
- Tends to focus on a single percentile
  - A very limited look at risk
- Arbitrary – no particular probability stands out
- Hard to analyze into components
  - In a simulation, nearby losses could have very different causes and line breakouts
- Mistakenly thought to represent loss by return period
  - But if 90^{th} percentile loss happened every 10 years, you would never have the 99^{th} percentile loss

Tail Value at Risk = Conditional Tail Expectation

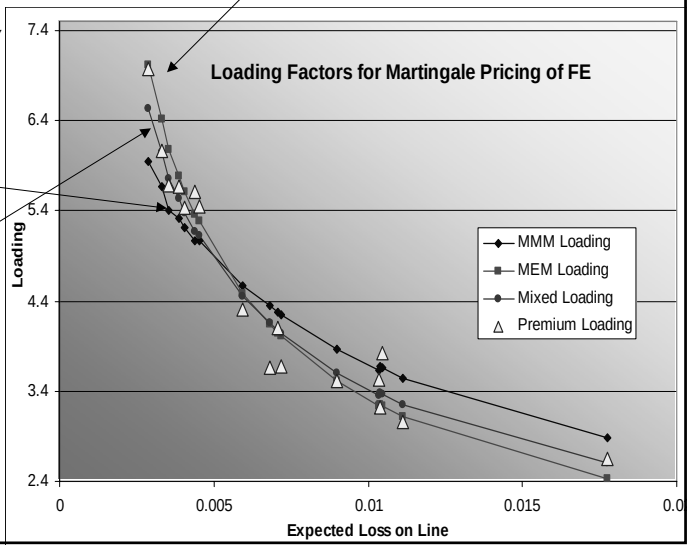
- Average loss at target probability and beyond
- This one does represent the loss at a return period
- More stable breakout into components as not too sensitive to single loss scenarios
- Still arbitrary choice of probabilities
  - Only economically meaningful are probability of default and probability of any surplus loss
  - Latter is perhaps best – possible to measure and includes all larger loss scenarios
  - 99% used a lot but arbitrary and probably too far out
- Problem of linear treatment of all larger losses – contrary to usual ideas of risk preferences
  - Alternative is to take expectation using transformed probabilities – may represent economic value of tail losses
- Excess TVaR is excess of TVaR over mean – so deviation

Transformed Probability Measures

- Risk measure is the mean (but could be TVaR, etc.) after transforming the loss probabilities to give more weight to adverse outcomes
- Prices for risky instruments in practice and theory have been found to be approximated this way
  - Wang transform for bonds and cat bonds
  - Esscher transform for compound Poisson process tested for catastrophe reinsurance
  - Black-Scholes and CAPM are of this form as well
- Using risk measures for risk-adjusted return suggests finding risk measures that are proportional to the market value of the risk

Entropy Transform – Compound Poisson

- $g^*(y) = g(y)e^{cy/EY}/Ee^{cY/EY}$
- $\lambda^* = \lambda Ee^{cY/EY}$
- Quadratic
- Average



Risk Adjusted Return

1. Decomposition of Risk Measure

- For each unit goal is a return on capital that reflects its risk
- Allocating ideally should be marginal and additive:
  - Allocation to a unit is proportional increase in overall company risk from a small growth in the unit
  - Sum of marginal impacts add up to total risk
  - Then growing higher return units will increase overall return
- Even then allocation is arbitrary and artificial
  - Many possible allocation algorithms are additive and marginal
  - Allocation does not actually segregate capital
    - Any unit could use it all
- Alternative methods include pricing that incorporates all risk elements and charging units for their chance of using firm capital

How to Decompose Risk Measures

- Co-measure method looks at contribution of business units to risk measure for company
- TV@R: $\rho_\alpha(Y) = E[Y \mid Y>Y_\alpha]$, co-TV@R: $r_\alpha(X) = E[X \mid Y>Y_\alpha]$
- For scalable risk measures, i.e., $\rho(aY) = a\rho(Y)$, derivative of risk measure wrt X adds up over X's to be the risk measure
  - Assumes change in company is homogeneous – like changing quota share ceded
  - Derivative is a co-measure and gives the marginal impact of a change in the business unit on the company's risk
- E.g., $EPD_\alpha(Y) = (1 - \alpha)E[Y-Y_\alpha \mid Y>Y_\alpha]$
  - $r_\alpha(X) = (1 - \alpha)\{E[X \mid Y>Y_\alpha] - E[X \mid Y=Y_\alpha]\}$
- If company can only change by adding exposure units, risk measures whose margins add up are transformed means of linear functions

2. Alternatives to Capital Allocation (for measuring risk-adjusted profit)

- Figure out price that includes all risk elements
  - Compare actual profits to target from that price
  - Maybe needs more knowledge of market risk pricing than we have
- Charge each business unit for its right to access the capital of the company (capital consumption)
  - Profit should exceed value of this right
  - Essentially an economic value added approach
  - Avoids arbitrary and artificial notions of allocating capital
  - Business unit has option to use capital when premiums plus investment income on premiums run out (stop-loss reinsurance)
  - Company has option on profits of unit if there are any
  - Pricing of these options can determine economic value added

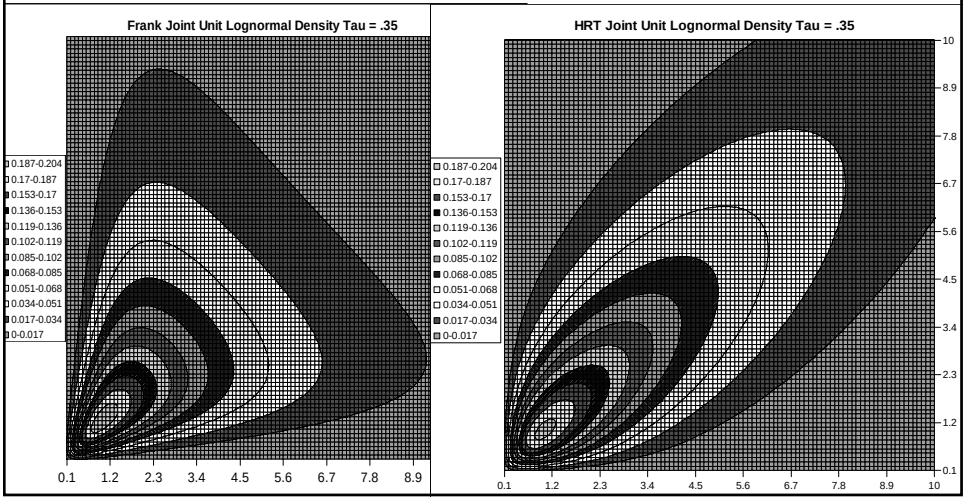
Correlation Issues

Degree and Amount of Correlation

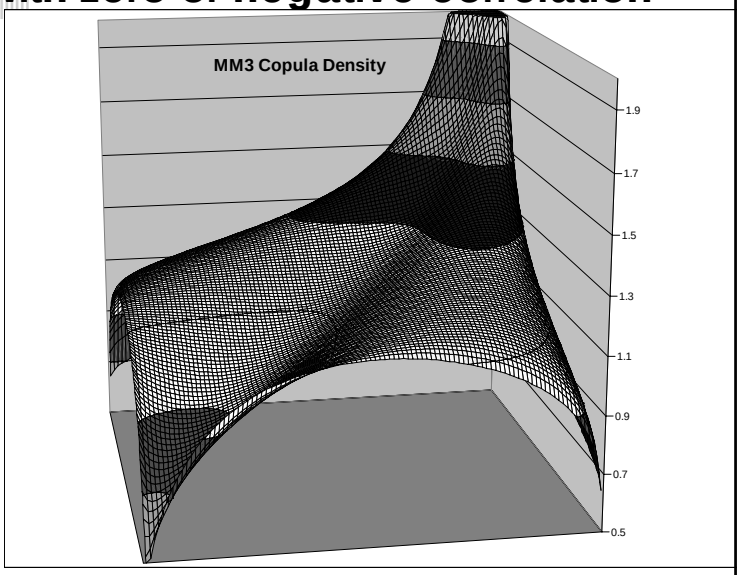
- You can have same overall correlation but differ in how much the tail events are correlated
- Convenient to use copulas to specify both
- Copulas create a dependency in the probabilities of the random variables which then translate to the variables themselves
- Many bivariate copulas are available but for multi-variate only the t and the normal are widely known
- Normal is t with many degrees of freedom
- t has high tail dependency for low dof, low for high

Copulas Differ in Tail Effects

Light Tailed vs. Heavy Tailed Copula
Same Correlation, Joint Unit Lognormal
Frank copula, Heavy right tail copula



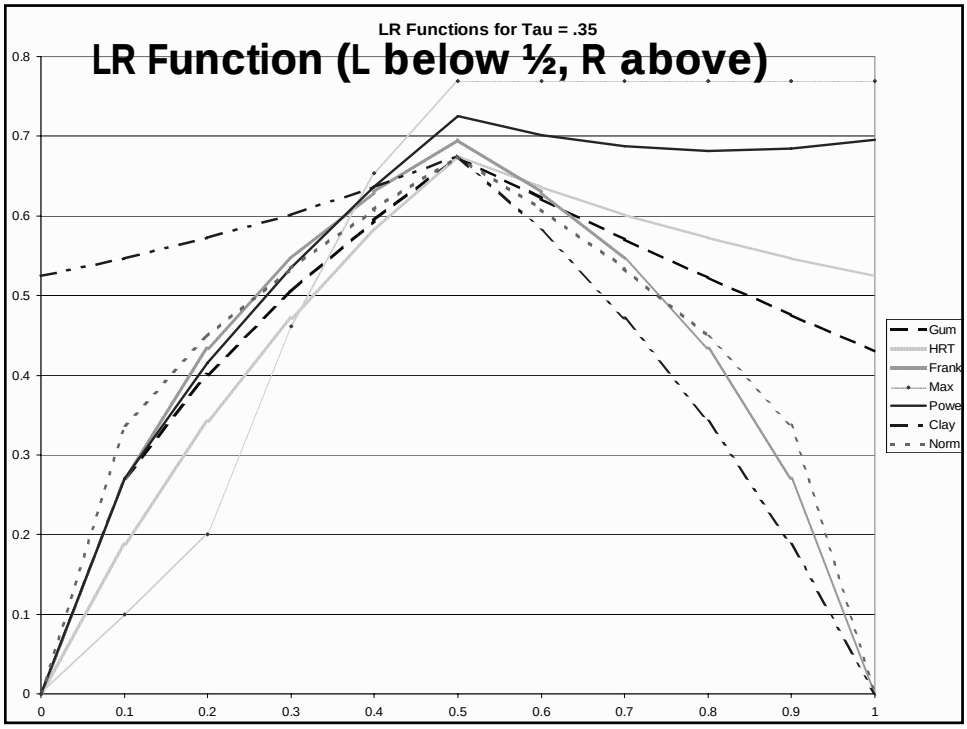
MM3 Copula – High tail dependence even with zero or negative correlation



Tail Concentration Functions

- L(z) = Pr(U<z | V<z) = Pr(U<z & V<z)/z
- R(z) = Pr(U>z | V>z) = Pr(U>z & V>z)/(1 – z)
- L(1) = 1 = R(0)
- Action is in R(z) near 1 and L(z) near 0
- lim R(z), z->1 is R, and lim L(z), z->0 is L
- Generalizes L(z) = Pr(U<z & V<z & W<z)/z

LR Function (L below ½, R above)



Insurance Risk

Unearned Premium Risk

- Liabilities for losses contractually bound but not yet occurred
- Usually actuaries model with frequency and severity distributions
  - Not enough – also need parameter uncertainty
- Banking consultants might model loss reserve risk first then extrapolate backwards
- Most actuaries uncomfortable with this

Parameter Uncertainty

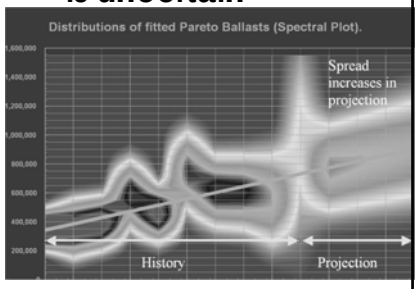
- Projection risk
  - Uncertainty about projected cost level
  - $CV_S^2 = [CV_X^2 + VM]/EN$ from just frequency and severity
  - Multiply by factor J with mean 1:
  - $CV_{JS}^2 = (1+ CV_J^2)CV_S^2 + CV_J^2$
  - No longer inversely proportional to EN
- Estimation risk
  - Uncertainty about parameters of a fitted distribution
  - Inverse of information matrix can quantify this
- Model risk
  - Might be fitting the wrong distributions
  - Could simulate from several and mix

Projection Risk Impact
VM = 1, CV_X=7, E LR = 65% with CV_J = 5%

CV(J) E(N):	2,000	20,000	200,000
0.05	16.6%	7.1%	5.2%
0.03	16.1%	5.8%	3.4%
0.01	15.8%	5.1%	1.9%
0.00	15.8%	5.0%	1.6%

Projection uncertainty is higher for incurred trend because history is uncertain

Uncertainty	Small	Medium	Large
90th	79.2	71.0	69.4
95th	84.1	72.8	70.8
99th	94.1	76.4	73.3
No Uncertainty			
90th	78.5	69.2	66.3
95th	83.1	70.5	66.7
99th	92.5	72.9	67.4



Reserve Runoff Risk

- Losses contribute to risk until they are paid
  - Run off capital needed, but its cost could be present-valued
- Risk of liability lines includes all old years of runoff
- All years could go bad at once – inflation, court cases, etc.
- When evaluating risk of a new accident year, could project its payout and runoff risk– maybe discounting future payments
- May be similar to looking at one year runoff risk of whole book of reserves, depending on what growth has been by line
- Still need to evaluate covariance of that with runoff risk of old years

Asset, Operational and Credit Risk

Asset Risk

- You would think bank analysts would have sophisticated models
  - But they often don't – risk is in loans not stocks and bonds
- Realistic models are available especially for fixed income securities
  - Two or three factor stochastic processes can capture:
    - Stochastic volatility
    - Mean reversion
    - Higher volatility with higher rates
    - High auto-correlation of interest rates
    - No arbitrage
- Importance of no arbitrage
  - Search for strategies would be pulled to arbitrage strategy

Other Assets

- Equity risk models still under development
  - Geometric Brownian motion too light tailed
  - Levy processes hard to calibrate
    - Getting short-term risk right gives too much long-term risk
  - Regime switching models have potential
- Real-estate backed instruments complex to model
- Foreign exchange models have to choose between getting theory right or being empirically right
  - Big question is: Do currencies with lower interest rates tend to move to higher exchange rates over time?

Operational Risk

- Typical insurance categories of risk for ERM
  - Strategic Risk – competition, changes in customer priorities, shifts in brand power, new technology, legal & regulatory changes.
  - Operational Risk – succession planning, HR issues, governance, audit and control, product failure, supply chain, IT.
  - Financial Risk – volatility in interest rates, exchange rates, equity, credit risk and liquidity
  - Hazard Risk - non-financial asset impairment, examples: natural hazards, employee actions, legal liability, product recall and integrity, and business interruption.
- Typical banking definition of operational risk includes risk from other areas
  - the risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events
- Quantifying and adding capital for operational risk often ineffective
  - Identifying and managing this risk should be main emphasis

Operational Risk

- Many aspects can be quantified
  - Probability of pension plan becoming underfunded
    - Mixture of HR and financial issues
  - Probability of IT failure or attack
- Many can't
  - What is the probability that the incentive compensation program will lead to inappropriate management behavior? (Agency Risk)
- Adding capital doesn't always help
  - Reputation risk – could lose reputation from off-hours behavior of key executives
  - Would adding capital have helped?
- ERM role: identifying these risks and managing them to minimize impact

Credit Risk

- For insurers this is largely reinsurance recoverables
- Rating agencies and regulators dock for this
- Big asset class
  - About the same amount as surplus
  - About the same amount as treasury bonds
- Can partially control by getting spread of reinsurers
- Slow paying reinsurers can be more of a problem
  - Companies that are still solvent but in runoff
  - Modeling financials of reinsurers can help predict

In Conclusion

Conclusions

- Economic capital can confuse the issue
- Tail risk measures useful, transformed mean more so
- Allocate by marginal co-measures or don't allocate but risk-adjust profit by cost of carrying business
- Correlate by t-copula
- Don't forget parameter uncertainty and reserve risk for whole book of reserves
- Asset models still developing
- Operational risk especially important to identify and manage
- Reinsurance recoverable risk needs continued focus