ACTEX Learning

Study Manual for Enterprise Risk Management Exam

12th Edition

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An SOA Exam

Actuarial & Financial Risk Resource Materials
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Thank you for purchasing the ACTEX ERM Study Manual.

Actuaries have practiced risk management for centuries. Yet it was not until recently that the actuarial profession (and indeed, the financial services industry) began to focus on risk in the context of the entire enterprise. Commercial banks started the shift a decade or so before the insurance industry, although some of their early efforts would be more aptly described as management of portfolio risk rather than enterprise risk.

The Society of Actuaries introduced the ERM exam into its syllabus in 2012. The syllabus has undergone considerable change over the last few years. This is reflective of the changes in the practice and new emerging research in what is a relatively young field. In addition, the financial crisis of 2008-2009 has spurred numerous changes in the regulatory and rating agencies perspective on risk management. The SOA has endeavored to include current publications and research in place of older papers as appropriate.

One consequence of the dynamic state of the practice and the multitude of papers included in the syllabus is a considerable amount of overlap and duplication in content. In some cases the duplication serves to fill in background for the principle subject of the paper, and in other cases it is simply the result of a different author offering his or her own perspective. In producing these study guides we have reduced some duplication but more often tended towards keeping close to the content as presented by each author.

These study guides attempt to capture the key essence of the syllabus in a considerably compressed form. They are not, however, a substitute for the original syllabus material. We recommend you start with a thorough reading of the each syllabus resource before reading the corresponding guide. Our intent is for the guides serve as an efficient means of subsequent review and overview of the entire syllabus.

Finally, I welcome any comments, observations or recommendations for improvement to this Manual.

Godspeed with your preparation for the exam.

Zafar Rashid

FSA, MAAA, CERA

ERM Exam – Core Readings – Fall 2023

Table of Contents

Section A: Enterprise Risk Management Framework and Process

Learning Objectives

The candidate will understand the ERM framework and process and be able to apply them to organizations.

Learning Outcomes

The Candidate will be able to:

a) Recommend an appropriate framework for an organization's enterprise risk management and an acceptable governance structure.

b) Demonstrate an understanding of the perspectives of regulators, rating agencies, stock analysts, auditors, and company stakeholders and how they evaluate the risks and the risk management of an organization.

c) Demonstrate how to articulate an organization's risk appetite, desired risk profile, quantified risk tolerances, risk philosophy and risk objectives.

d) Assess the overall risk exposure arising from an organization's current and emerging risks.

e) Propose ERM solutions or strategies that effectively manage risk under different real (case study) and hypothetical situations facing financial and non-financial organizations.

Resources

Section B: Risk Categories and Identification

Learning Objectives

The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.

Learning Outcomes

The Candidate will be able to:

a) Describe different definitions and concepts of risk

b) Discuss risk taxonomy, including an awareness of how individual risks might be categorized in different ways

c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational, and strategic risks

Resources

Section C: Risk Modeling and Aggregation of Risks

Learning Objectives

The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

Learning Outcomes

The Candidate will be able to:

a) Demonstrate how each of the financial and non-financial risks faced by an organization can be amenable to quantitative analysis

b) Demonstrate organization-wide risk aggregation techniques that illustrate the concept of risk diversification by incorporating the use of correlation

c) Evaluate and select appropriate copulas as part of the process of modelling multivariate risks

d) Demonstrate the use of scenario analysis and stress testing in the measurement of current and emerging risks

e) Demonstrate the importance of the tails of distributions, tail correlations, and low frequency / high severity events, and the use of extreme value theory to analyze these situations

f) Demonstrate an understanding of model and parameter risk

g) Evaluate and select appropriate models to handle diverse risks, including models that use a stochastic approach

Resources

Section D: Risk Measures

Learning Objectives

The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

Learning Outcomes

The Candidate will be able to:

a) Determine risk exposures using common risk measures (e.g., VaR and TVaR) and compare the properties and limitations of such measures

b) Analyze quantitative financial and non-financial data using appropriate statistical methods to assist in quantifying risk

c) Analyze risks that are not easily quantifiable, such as liquidity, operational, and environmental risks.

Resources

Section E: Risk Management Tools and Techniques

Learning Objectives

The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes

The Candidate will be able to:

a) Demonstrate risk optimization and analyze the risk and return trade-offs that result from changes in the organization's risk profile

b) Demonstrate application of the following responses to risk, including consideration of their costs and benefits: avoidance, acceptance, reduction without transfer, and transfer to a third party

c) Demonstrate the use of controls for retained and residual risks

d) Demonstrate how derivatives, synthetic securities, and financial contracting may be used to reduce risk within a static or dynamic hedging program

e) Determine an appropriate choice of mitigation strategy for a given situation, which balances benefits with inherent costs (including exposure to moral hazard, credit, basis and other risks)

f) Demonstrate the use of tools and techniques for identifying and managing credit and counterparty risk

g) Analyze how ALM and other risk management principles can be used to establish investment policy and strategy, including asset allocation

h) Demonstrate possible risk management strategies for non-financial risks

i) Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization

Resources

- Financial Enterprise Risk Management, Sweeting, Paul, 2nd Edition, 2017
  - Ch. 16: Responses to Risk E-1
- Value at Risk: The New Benchmark for Managing Financial Risk, Jorion, Philippe, 3rd Edition, 2007
  - Ch. 7: Portfolio Risk: Analytical Methods..... C-1
  - Ch. 18: Credit Risk Management (excluding Appendices) B-3
- ERM-107-12: Strategic Risk Management Practice, Andersen and Schroder, 2010, Ch. 7: Strategic Risk Analyses A-39
- ERM-120-14: IAA Note on Stress Testing and Scenario Analysis (pp. 1-6, 14-17 & 19-25) C-27

Section F: Capital Management

Learning Objectives

The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes

The Candidate will be able to:

a) Demonstrate a conceptual understanding of economic measures of value and capital requirements (e.g., EVA, embedded value, economic capital, regulatory measures, and accounting measures) and their uses in decision-making processes

b) Apply risk measures and demonstrate how to use them in value and capital assessment

c) Propose techniques of attributing the "cost" of risk/capital/hedge strategies to business units in order to gauge performance (e.g., returns on marginal capital)

d) Demonstrate the ability to develop a capital model for a hypothetical organization

Resources

Jorion – *Value at Risk – The New Benchmark for Measuring Financial Risk*
Chapter 13 – Liquidity Risk

Reviewer's note: *Well-organized and complete, this reference provides both background and detailed information.*

I. Intro - Liquidity Risk

A. VAR models assume a frozen portfolio that will transact at market price – which is adequate in assessing risk but not if you want the worst possible loss in a liquidation

B. Liquidity risk – funding liquidity risk (financing collapses due to creditor demands) and asset liquidity risk (forced liquidation creates unfavorable prices)

II. 13.1 DEFINING LIQUIDITY RISK

A. LR arises from the assets side of the BS through large positions in times of forced liquidations and the liability side when investors/creditors demand redemption/refuse to refinance existing positions and/or mark to market haircuts
   1. Must understand ALM, market microstructure that affects clearings and optimal trade execution to minimize trading costs

B. 13.1.1 Asset Liquidity Risk – aka market/product liability risk
   1. Risk that liquidation value differs from current mark to market – function of size/ price
   2. Asset liquidity is measured by a price-quantity function – aka market-impact effect
      a. Deep markets – positions can be sold with little market price impact
      b. Thin markets – any transactions quickly affect prices
      c. Figure 13-1 illustrates that p-q function
         i. Tight markets have narrow bid-ask spread
         ii. This spread is constant to a point – the normal market size or depth
            - Transaction cost is half the spread
         iii. As q increases from normal, bid-ask widens, net price decreases and transaction costs increase as a %; could be linear or another shape
   3. Liquidity also depends on prevailing market conditions, e.g. when fear of default pushes traders into treasuries and out of corporates
   4. Traditional control mechanism for liquidity risk is limits on position size

C. 13.1.2 Funding Liquidity Risk
   1. Cash flow/funding liquidity risk is the inability to meet payment obligations to creditors/investors, which could force unwanted liquidation of the portfolio
   2. FLR arises from the liability side of the BS due to common practice of leveraging/borrowing with assets pledged as collateral
      a. More assets pledged than the liability (haircut) to provide lenders a buffer
      b. Collateral is constantly being marked to market and if value falls below the liability, lender will require an additional variation margin to be advanced by borrower
         i. If borrower doesn't have cash to cover margin call, they must liquidate other assets

ii. Lender can raise margin requirements as well, which happens in times of crisis

3. Also get FLR if timing of payments is mismatched – owe before you receive proceeds
4. Cash on hand is first defense against FLR, then a line of credit
   a. Raising new equity or debt is next, but hard in hard times
5. Need to anticipate that lenders will raise margin requirements or call debt at the time when the institution appears vulnerable
   a. Liquidity issues affect assets too as some assets (hedge funds) impose a minimum time period for fund to hold a client's assets (lockup period) or longer redemption notice before withdrawing funds
      i. Also, commercial banks borrow short (deposits) and lend long (mortgages), necessitating deposit insurance to prevent a run on the bank

III. 13.2 ASSESSING ASSET LIQUIDITY RISK

A. Mid-market trading values do not reflect the value of assets in a large portfolio liquidation scenario, but to manage risk, we must be able to assess this potential
   1. One way is to ensure in VAR measures that the liquidation horizon is stretched beyond the time required for orderly liquidation
      a. Could also increase volatility assumption in the VAR calculation

B. 13.2.1 Effect of Bid-Ask Spreads
   1. Bid-ask reflects three costs:
      a. Order processing costs – should decrease with volume
      b. Asymmetric information costs – informed traders may know more than market makers, who increase the spread to protect themselves
      c. Inventory carrying costs – cost of maintaining open positions, this increases directly with price volatility/interest rates and inversely with trading activity
   2. If it were fixed, could derive a liquidity-adjusted VAR by adding a term
      a. $LVAR = VAR + L_1 = (W\alpha\sigma) + 1/2(WS)$; W is initial wealth, S is spread
   3. If spread is uncertain:
      a. $LVAR = VAR + L_2 = (W\alpha\sigma) + 1/2[W(\bar{S} + \alpha'\sigma_S)]$, $\bar{S}/\sigma_S$ is mean/std. dev. of the distribution of spread
      b. Assumes worst market loss and spread increase happens simultaneously as volatility and spreads are positively correlated

C. 13.2.2 Incorporating Liquidity in Valuation
   1. If position is to be sold, the second term above is a certain loss (bid price is less than mid-market price
      a. Can also mark to bid/ask for long/short positions
      b. Could also add a reserve to reflect illiquidity and/or model risk

D. 13.2.3 Effect of Price Impact
   1. Not enough to focus on bid-ask to capture all transactions costs since quantity traded also affects prices
      a. If the price quantity function is linear, then can lower impact by 4/5 by spreading sales uniformly over 5 days vs. immediately over 1 day
      b. But leaves the company exposed to price variation for longer period, increasing volatility so that must also be accounted for

i. $LVAR = \alpha\sqrt{V(W)} + C(W)$; V is portfolio variance

E. 13.2.4 Trading Strategies
1. Execution strategies are not limited to immediate vs. uniform liquidation
2. Because of increased volatility of taking more time, an optimized strategy (by Almgren and Chriss) of algorithmic trading involves selling more than the uniform strategy on day one
3. Optimal half life (the time to liquidate half the portfolio) depends on price impact and volatility
4. Tradeoff is between price impact of dumping shares too quickly and being exposed longer to normal price fluctuations

IV. 13.3 ASSESSING FUNDING LIQUIDITY RISK

A. Involves examining asset-liability structure and potential demands on cash and other liquidity sources

B. Counterparty Risk Management Policy Group (established in the wake of Long Term Capital Management crisis) provides guidance in managing market, counterparty credit and liquidity risk
1. Evaluate funding risk by comparing cash at hand with what it could need meet obligations
   a. Cash liquidity is the ratio of cash equivalent over potential decline in the value of relevant positions – those that create cash-flow needs
2. Example shows the difference in VAR from two way vs. one way MTM swaps
   a. Two way means positive MTMs can used to offset negatives, while one way, only the negatives are settled, increasing VAR

C. Box 13.2 How Rating Agencies Assess Liquidity Risk
1. S&P uses a stress scenario where the subject's rating is lowered and collateral calls take place
2. Size of worst collateral is estimated by the sum of all positions with negative market values since positives on one position cannot be applied to protect negatives from other positions

V. 13.4 LESSONS FROM LTCM – which was a hedge fund created to take advantage of relative value or convergence arbitrage trades

A. 13.4.1 LTCM's Leverage – because these strategies generate tiny profits, leverage is needed to get high returns – 25:1 on the balance sheet of 125 billion with another 1.25 trillion gross off balance sheet
1. LTCM represented over 2% of global swap market, even though positions netted to much less

B. 13.4.2 LTCM's "Bulletproofing"
1. LTCM leveraged its balance sheet through sale – repurchase agreements (repos) with banks
   a. Repo agreements involve selling assets in exchange for cash (loan) and a promise to repurchase them at a fixed price in the future
   b. typically value of the assets exceeds the cash – haircut
2. LTCM was able to obtain financing with near zero haircuts because it was viewed as safe – also it swaps were two way mark to market
3. LTCM protect itself against liquidity squeeze by requiring a three-year lockup from its investors; it also secured a 900 million credit line from Chase and other banks
4. LTC M add funding liquidity covered, but was still exposed to market and asset liquidity risks

C. 13.4.3 LTCM's Downfall
1. Strategy worked well early on (40+ percent returns)

2. In 2Q 1998, Russia restructured its bomb payments – i.e. defaulted – and immediately credit spreads, risk premiums and liquidity spreads jumped up sharply while stock markets dove
   a. By August, fund lost half its value, increasing leverage from 28:1 to 55:1
   b. Capital was needed but was not forthcoming and further losses occurred in September
   c. Bear Stearns, LTCM's prime broker, was subject to a margin call and they passed on increased collateral requirements to LTCM, depleting its liquid resources
3. The squeeze was between funding risk, as reserves dwindled, and asset risk, as its large positions prohibited liquidation
   a. lenders faced significant potential exposure because the small haircuts they required or more than offset for potential losses due to liquidating collateral
4. This potential disruption led the New York Federal Reserve to organize a bailout wears 14 banks invested 3.6 billion in return for 90% of the firm, costing original investors 92% of their investment

D. 13.4.4 LTCM's Liquidity
1. LTCM fail because it could not manage its risks – its trades were undiversified and portfolio optimization did not manage risk
   a. All its trade types were subject to increased liquidity risk and many were exposed to increased default risk
   b. In fact, a single risk factor – changes in credit spreads – explained most of its return volatility, suggesting little diversification across risk factors
   c. Additionally LTCM suffered both asset and funding liquidity risk – it protected itself against withdrawal but did not foresee inability to raise new capital or organize an orderly liquidation of the portfolio
2. The situation raise questions about the soundness of brokers' risk management systems, which led to acceleration of the integration of credit and market risk management

VI. 13.5 CONCLUSIONS

A. Traditional VAR measures account for the worse change in Mark to market values over the horizon but not the cost of liquidation, which depend on price – impact function and the size of the positions – so a liquidity-adjusted VAR hybrid can be calculated that combines price volatility with liquidation costs

B. Bid ask spreads are less important than traditional VAR measures – what matters more are large price drops when liquidating large positions

C. An alternative to LVAR is to value positions at the conservative did ask quote and add a reserve for liquidity

D. Funding liquidity risk by contrast arises when financing for the portfolio cannot be maintained – again VAR can be altered to estimate the risk of running out of cash

E. Both sides of the balance sheet affect liquidity risk

F. LVAR may be difficult to measure but we know the following:
1. Bid ask spreads are positively correlated with volatility
2. Illiquid assets will generate greater execution costs as volatility increases
3. Can mitigate liquidity risk by taking offsetting positions in assets that benefit from increased volatility – those with positive vega

Shaw, Smith, Spivak – Measurement and Modeling of Dependencies in Economic Capital
Chapters 4-5

Reviewer's note: *This paper, presented to the Institute of Actuaries in 2010 is wide-ranging in scope.*

I. 4. CORRELATION AS THE SIMPLEST TYPE OF DEPENDENCE

A. 4.1 Dependency Structures

1. Economic drivers are the risks – interest rates, mortality, etc.
2. Monetary effects are the functions of these drivers
   a. So we have a multivariate joint probability distribution and must calculate marginal distributions for each risk before we can even consider how to link them in a dependency structure
      i. Which is information in the joint distribution, not in the marginal distribution
3. Very difficult to assess dependency accurately – and errors in doing so can offset the most accurate individual capital components
4. Dependencies and Causation
   a. Dependencies – information about one risk can provide information about another
      i. Example: catastrophe damages a property and that causes the stock price of the company that owns that property to fall
      ii. More often, dependence reflects complex impact of macroeconomic conditions on many risks
         - Inflation, interest rates, equity prices and foreign exchange rates are interrelated and affect values on both sides of the BS
      iii. When the dependencies in risk factors are assessed using expert judgment, causal impacts can be taken into account
      iv. Statistical approaches, on the other hand, describe correlation or dependency without determining causation
5. Dependency as a Mathematical Representation – most often described as a single number – the Pearson correlation coefficient, which is linear
   a. If one variable depends on another in a non-linear way, correlation does not adequately capture the relationship
   b. Dependency structure includes linear and non-linear dependence – so don't use "correlation" and "dependency" interchangeably

B. 4.2 What Do We Mean by Dependency?

1. Dependency means there is a link between two random variables
   a. Perfect dependence means if you know one value, you know the other
   b. On the other extreme is the case where the value of one RV tells you nothing of the other
   c. Dependency does not imply a linear relationship – although it is convenient to assume so
      i. Modern Portfolio Theory uses variance-covariance matrices, based on a normal distribution
         - These assumptions have been tested by recent economic events and found to be lacking
            ◊ Correlation is linear and does not reveal the whole dependency structure
            ◊ Possible values of correlation depend on the marginal distribution of risks
            ◊ Perfectly positively/negatively dependent risks do not necessarily have a correlation of 1/-1
            ◊ Zero correlation does not imply independence

- ◊ Monotonic transformation – like the log function, change the correlation
- ◊ Correlation is only defined when variances of the risks are finite (note that heavy-tailed risks seem to have infinite variances)

C. Detailed explanations of the Pearson, Spearman and Kendall Tau correlation statistics – See pages 17 through 20 of the paper

II. 5. RISK AGGREGATION

A. 5.1 Risk Aggregation Framework

1. Dependency modeling helps us find the overall EC level
2. Assess individual risk components and then figure out how to best aggregate them
3. Multivariate distribution is useful and brings copulas into play to combine marginal distributions of single risks into a multivariate distribution

B. 5.2 Risk Aggregation Methodologies – broadly

1. Simple summation – no diversification benefits, equivalent to perfect correlation
2. Fixed diversification % - Overall EC is reduced by a fixed %
3. Variance-covariance Matrix – Stand-alone capital for each risk is aggregated using a correlation matrix
4. Copulas – Monte Carlo simulation with full marginal risk distributions are joined together by a copula function to produce an aggregate distribution
5. Causal Modeling – may be used in conjunction with other methods
   a. Common risk drivers which impact risks, often non-linearly
      i. Used to capture dependencies within economic scenario generators
   b. Causal Loops
      i. A diagram that is used to understand how interrelated variables impact each other
         - Positive feedback means the two change in the same direction, negative means they change in opposite directions
         - Can be open (outputs respond to , but do not influence their inputs) or closed (outputs both respond to and influence their inputs)
         - Complexity of these diagrams means some Monte Carlo simulation is necessary

C. Best Approach – balances the following criteria:

1. Model accuracy
2. Consistent methodology
3. Numerical accuracy
4. Data availability
5. Communication ease and intuitiveness
6. Flexibility
7. Resources needed

D. Solvency II (and IMAP)– increases the importance of some criteria – like intuitiveness and communication ease of the risk aggregation framework

E. 5.8 Natural Catastrophe vs. Reinsurance Credit Risk Aggregation

1. Companies use different methods or combinations
2. Example: catastrophe underwriting risk vs. reinsurance credit risk
   a. Cat UW and RI Credit risks used as separate entries in a variance-covariance matrix
      i. The correlation coefficient in the correlation matrix would reflect the dependencies between the two
   b. Could try to capture the reinsurance credit risk associated with the Cat UW risk in the Cat UW marginal distribution by adjusting the reinsurance recoveries with an appropriate dependency function
      i. May still leave some default risk unaccounted for
   c. Or perhaps more complex causal modeling

Milliman – Economic Capital Modeling: Practical Considerations

Reviewer's note*: Very practical guide, although it is difficult to teach this material, which is better learned through hands-on experience. Pay particular attention to the examples at the end of the paper. The appendix contains a detailed recitation of risks.*

I. Introduction

A. Interpretation of economic capital varies – used to value a business or manage risk in a business
   1. Measure/optimize capital resources already existent in a business
   2. Determine capital required by a business to meet risks inherent in its liabilities and operations
      a. Required EC – what you need; available EC – what you have

B. EC analysis being used more to facilitate strategic management decisions
   1. Basel II requirements in banking, Solvency II in insurance, IAIS
   2. Used to calculate cost of capital for embedded capital calcs

C. Methods of EC calculation still differ among companies – decisions to be made
   1. What type and scope of risks to consider?
   2. How to measure risks and what is the right probability of ruin to accept?
   3. What decisions should be involved in developing an EC model?

II. What is EC?

A. Required EC – capital required (by economics not regulation) to support a business assuming a certain probability of default

B. Available EC – Assets less liabilities on a realistic (mark-to-market) basis
   1. Closely related to European Embedded Value (see below)

C. Can relate EC to statutory capital and market value
   1. Market capitalization =statutory assets less statutory liabilities plus value of in force plus value of goodwill
   2. Market cap also = market value of assets less (MV of liabilities plus allowance for cost of capital) plus economic franchise value
      a. MV less value in parenthesis is available EC

D. Questions to consider
   1. Scope of risks should include all material risks
   2. Probability of ruin could be tied to a certain credit rating
   3. Proper time period for assessing probability of ruin – 1 year or many years?
   4. Current in force or future business (going concern approach?

E. It is now accepted that financial strength is related not only to the value of capital but to the basis on which those values are calculated

F. IASB is moving toward fair value – market consistent values
   1. Easier to calculate for assets than liabilities

G. Makes sense to use an economic (fair value) model vs. a statutory model, but this is not universally done

III. What are the benefits of EC analysis?

A. Because capital is necessary to insulate companies against performance fluctuations and take on risk, calculating the proper figure balances the need to have enough capital to avoid insolvency but not too much capital, upon which investors require a risk return, which would drive COIs up too high

B. Ratings agencies often approach capital requirements by setting formulas based on net amount at risk, asset types, etc.
   1. Arguably, this may not appropriately reflect a company's processes and procedures for managing risk or managements strategic decisions on capital deployment

C. Shareholders and other users of financial statements need to understand a company's capital position and measure effective returns on capital

D. Regulators need to understand on a realistic basis, the level of capitalization as one of their goals is to prevent insolvencies

IV. How can EC analysis be applied?

A. International Regulatory Trends
   1. Regulators have recognized weaknesses in formulaic approaches to assessing solvency levels, to wit:
      a. No link between capital required and the effectiveness of a company's risk management/mitigation strategies
      b. Formulas do not deal with all risks
      c. Mistaking prudent management with capital requirements obscures the actual level of solvency
      d. Formulaic approaches do not handle well changes in the environment – new product introductions, for example
      e. Benefits of diversification are not recognized
   2. The European Commission began Solvency II in 2000, hoping to correct the above
      a. So far, a draft Framework Directive has been published and is being evaluated
         i. Two levels of solvency capital defined
            - Solvency Capital Requirement (SCR) – level so that there is a 0.5% probability that assets will not be sufficient
            - Minimum Capital Requirement (MCR) – absolute minimum level of capital, below which urgent regulatory action is required
         ii. SCR could be calculated with internal models that have been validated and approved by regulator
            - Internal models will encourage insurers to measure/manage risks, be more flexible and better represent the insurer's business than rules-based standards

iii. SCR is closely related to economic capital, so Solvency II is a convergence between economic and regulatory management of insurance companies

3. US regulators use risk-based capital (RBC), a formulaic measure, and use of internal models is progressing slowly
   a. NAIC adopted an RBC provision for VAs with MGDB, MGWD, MGAB, etc. that included internally developed stochastic models but also a deterministic projection set by regulators
   b. Internal models for UL are being considered under principles-based valuation but regulatory capital requirements are still formulaic
4. Canada allows internal models under a principles-based approach
5. Switzerland's Swiss Solvency Test is based on stochastic models based on principles defined by regulators
6. IAIS – international body of insurance supervisors – has developed a solvency regulatory framework
   a. Will be consistent with international financial reporting standards of IAA and IASB

B. European Embedded Value – almost all leading European life insurers have disclosed embedded value information, the weaknesses of which were uncovered by extreme market conditions of recent years
   1. CFO Forum launched European Embedded Value (EEV) principles in 2004
      a. Extends traditional embedded value techniques to include explicit valuation of options and guarantees as well as standardizing reporting standards
         i. Historical practices left wide divergence in these approaches
   2. Some companies use economic capital as the basis for the cost of capital
      a. Since economic capital considers all risks, they claim this process makes allowance for all risks even if there is no explicit margin added for non-financial risks

C. Risk-Adjusted Return on Equity or Capital (RAROE/RAROC)
   1. Different products have different risks and hence, different levels of economic capital
   2. Makes sense to measure ROE in a way that recognizes economic capital

V. What Type of Risks Should Be Considered?

A. We are dealing mainly with downside risk, not the traditional standard deviation of returns under CAPM

B. Important to consider all risks in determining economic capital – see IAA 2004 paper – A Global Framework For Insurer Solvency
   1. IAA Risk Categories
      a. Underwriting – pricing, product design, claims, policyholder behavior
      b. Credit – default, downgrade, concentration, counterparty
      c. Market – interest rate, equity & property, currency, reinvestment, concentration, ALM, off-balance sheet
      d. Operational – operational failure, strategic, catastrophes
      e. Liquidity – insufficient liquid funds to meet cash flow requirements

A. Three Key Components for Modeling – each risk type can be further broken
   1. Volatility Risk – random fluctuations in frequency/severity of contingent events
      a. Investors can diversify this away if markets are efficient, but insurance markets aren't (Reviewer's note: really?)
         i. Companies may wish to recognize their exposure to volatility regardless of whether it is diversifiable – issue becomes whether investors will accept this approach
   2. Uncertainty Risk – use of the wrong model or bad assumptions – not diversifiable
   3. Extreme Events – calamity – tail risk

VII. How Should Each of Those Risks Be Measured?

A. Total risk is calculated by measuring the effect of each specific risk to a company's earnings/surplus, generally as a function of the probability distribution of losses and then aggregating individual risks as shown in VII
   1. Scenario-based model – deterministic or stochastic
      a. Risk capital is calculated by measuring the impact of specific scenarios to the distribution of loss
         i. Not stress test as scenarios cover multiple risk drivers, not a single shock
   2. Static factor model – linear combination of a static risk factor times a company-specific amount
      a. RBC in the US is an example (except for C3, phase I and II)
   3. Stochastic factor model
      a. Identify relevant risk drivers
      b. Find Delta (proxy for 1^{st} derivative), Gamma (2^{nd} derivative) or a scenario vector by doing sensitivity analysis
      c. Model joint distribution of risk drivers
      d. Resulting loss is aggregated across all risk types, leading to its stochastic distribution
         i. Find risk capital by applying a risk measure such as VaR or CTE
      e. Covariance model is a special case of stochastic factor model

B. CRO Forum study in 2004 found 8 of 13 companies surveyed used stochastic factor models while 5 used covariance models

C. Measuring risk – a brief exposition
   1. Underwriting risk – mortality, morbidity and lapse
      a. Split into diversifiable (which decreases with increasing policy count) and non-diversifiable (mortality level risk and mortality trend risk) components
         i. Use binomial model to estimate volatility risk
         ii. Use methods based on company or industry experience to estimate mortality level risk
            - Do not forget catastrophe risk
      b. Surrender and lapse risk can be handled as mortality risk
      c. Risks associated with policyholder's options are dependent on economic conditions and can be measured with stochastic analysis or stress test
         i. Build model where the interaction is defined

1. Credit Risk – modeled consistent with banking standards – default, credit migration, spread and spread volatility
   a. Tools available include CreditRisk + (Credit Suisse), CreditMetrics and KMV
      i. Explicitly model default and recovery
      ii. KMV is widely used
   b. Don't forget reinsurance default risk
2. Market Risk – can be modeled consistently with banking standards, but need to include liabilities of the insurer as well– an ALM approach
   a. Price volatility of assets also impacts liabilities
   b. Liabilities do not have a real market so MV of liabilities need to be technically derived
3. Operational Risk – not well-developed methods for this risk, but include
   a. Add-on model
   b. Stochastic frequency-severity model

IX. What Modeling Decisions Should Inform the Analysis? Issues

A. VaR vs. Tail-VaR – the two most suitable risk measures
   1. VaR assess probability of ruin at a given quantile of the probability distribution
   2. Tail VaR measures both the probability and severity of losses exceeding a given quantile and is the arithmetic average of losses exceeding the quantile
      a. VaR is adequate for shareholders as once the company is bankrupted, their investment is worthless
         i. Tail VaR better for regulators because it provides info on losses to policyholder
      b. Tail VaR is better for low frequency, high severity events
         i. IAA likes it better than VaR
         ii. Conditional tail expectation (CTE) is similar to Tail VaR
            - Set at the x% level, the average cost of the worst (100-x%) scenarios

B. Stochastic Analysis vs. Stress Test
   1. Stochastic analysis is projecting future cash flows based on multiple scenarios for which a probability distribution is defined – it is necessary to calculate EC
   2. Stress test is projecting future cash flows based on a particular scenario that could occur in an extreme environment for which the probability of the scenario is not specified
   3. It follows that a stress test is indicated if no meaningful probability distribution can be determined
      a. But if the task is to calculate EC to cover losses with a certain %-tile confidence, an assumption must be made as to the probability of occurrence
         i. Just realize it is a judgment call

C. Real World (preferred) vs. Risk Neutral
   1. Risk neutral technique calculates the PV of cash flows by discounting risk-adjusted future CF with risk-free rates based on multiple scenarios
      a. No arbitrage assumed and no arb opportunity assumed to exist
      b. Assumes any derivative security can be perfectly reproduced by combining other securities

a. Theory says that the expected value of the PV of future CF based on risk-free rates and a transformed probability distribution (q-measure) = expected value of the PV of future CF based on adequate discount rates and real-world probability distribution (p-measure)
   i. Risk-adjusted cash flow then becomes the cash flow multiplied by the ratio of occurrence probability under q-measure to that under p-measure
      - It is easier to find discount rates under q-measure so that is why this is done

2. Real world technique is to calculate the PV of CF by discounting projected CF with risk discount rates based on multiple scenarios
   a. CF are not adjusted for uncertainty risk, instead the discount rate is increased above the RFR
      i. Judgment is in setting that rate
      ii. If done adequately real world and risk neutral results are the same
3. Risk neutral approach is superior because adjustments for uncertainty can be made consistent with observable market prices of securities
   a. However, there are major shortcomings to the risk-neutral approach - when calculating EC:
      i. Need to define EC as the expected value of CF – if EC is defined as a certain loss at 95% confidence, then the probability distribution should be converted to have the expected value at the 95^{th} %-tile
         - Hard to figure how to use market prices to construct a risk-neutral probability distribution
      ii. Since loss is an expected value under an adequate risk-neutral probability distribution instead of the 95^{th} %-tile under a real-world probability distribution, it is hard to interpret the results
   b. For those reasons, the real-world technique is widely used

B. Diversification Effect

1. It is accepted that the total capital required could be less than the sum of the required capital for individual risks to the extent that these risks are independent
   a. Keep in mind that risk correlations may behave differently in extreme scenarios
      i. For example, mortality rates and interest rates are thought to be uncorrelated, but in the time of a terror attack or earthquake, they may be correlated
         - Can use copulas – a multivariate probability distribution function with uniform marginal distributions – to introduce dependency among risks
            ◊ Difficult to apply in practice
2. Ratings agencies have been skeptical about giving full credit for diversification and the issue of tail dependencies seems to support this stance
3. If different lines of business have non-correlated risks, then insurance groups with diverse businesses will benefit from diversification
   a. European companies have argued this point, but investors may wish to diversify their own portfolios
   b. But for capital management purposes, diversification seems reasonable
      i. Unless each entity is viewed as standalone by regulators or if there are cash flow restrictions should problems occur
      ii. CFO Forum suggested a solo entry test and a group test to sort this out

A. Time Horizon to Consider
   1. Insurers tend to use either a one-year (covariance model) or multiyear (balance sheet run off) horizon
      a. One-year horizon tests for shocks but does not look beyond that time or measure tail loss
         i. Not adequate for VaR or CTE
         ii. But less complex and time-consuming
      b. Multiyear horizon (stochastic scenarios) can look for adequate capital throughout the period or just at the end (see f. below)
         i. Gives better sense of long-term risks but does not allow for managerial action to correct issues that emerge
      c. Regulators should not take more than a year to respond to the analysis so perhaps one-year horizon is preferable (10 of 13 in the CRO Forum)

B. Whether to Allow Negative Cumulative Surplus in the Middle of the Time Horizon
   1. If so, recognize that REC may be understated
   2. If not, is borrowing allowed and at what rate?
   3. US specifies CTE(90) with no negative cumulative surplus in the middle, while Canada requires CTE(95) measured only at the end
      a. Since CTE is defined differently, no telling which is more conservative

C. Whether to Account for Future New Business
   1. Yes, according to the CRO Forum - new business must not jeopardize the sufficiency of current assets
      a. Profitable business lowers the PV of liabilities, but increases required economic capital
         i. All 13 CRO benchmark companies include new business, but 11 include at most one year and none more than 4 years

XII. Illustrative Examples

A. Deterministic Stress Test
   1. What if an instantaneous shock hit – where management did not have time to respond?
   2. This is very similar to tests run in UK and Switzerland
   3. Business is VAs with financial guarantees and the shock is a 20% decline in equities, 5% nominal increase in volatility and a 1% decrease in short term interest rates
      a. Company is bankrupted
      b. Also test the impact of a hedge program, which protects the company at a small cost relative to holding enough capital to stave off bankruptcy

B. P&L Projection
   1. Business is a VA with GMAB, 25-year horizon, supported by a 40/60 mix of stocks/bonds
   2. Using stochastic projections and the Greeks – delta, rho, vega, quarterly P&L volatility is measured on a hedged and unhedged basis
   3. CTE and VaR are calculated
   4. Hedging seems effective
   5. CTE requires more EC at a given confidence interval than VaR

C. Holistic VaR Aggregation

1. The two preceding examples dealt with market risk, but we can assess all risks using the same framework – market, credit, liquidity, insurance, operational and group
   a. Underwriting can be further split into mortality/longevity/morbidity, lapse, policyholder behavior and expense
2. Correlation of risks (more properly, lack of perfect correlation) is recognized and reduces required capital

Anderson & Schroder – *Strategic Risk Management Practice*
Chapter 7 - Strategic Risk Analysis

Reviewer's note: *This reference is quite laborious. The authors provide illustrative examples to bring theory into practice. Each section adds a layer of complexity on the existing foundation.*

I. Introduction

A. A look at the variety of analytical tools that can be adapted for RM purposes
   1. Start with simple trend analytics and then add the spectrum of uncertainty

II. 7.1 Environmental Scanning in a Predictable World

A. Since 90% of drops in shareholder value are attributed to strategic and operational risks, it is critical that a firm be observant and sensitive to changes in the risk environment
   1. Difficult to see and interpret future events, e.g. the PC was a major technology change, but not appreciated or understood long after its initial use
   2. No one foresaw the mortgage meltdown from the weak signals (reviewer's note: except the one guy in that Michael Lewis book)
      a. But signals were there – excess liquidity, low interest rates, big deficits, (reviewer adds, relaxed lending standards, record cash out re-financings)

B. Environmental scanning involves:
   1. Formal search – firm is structured to seek information as part of normal processes
   2. Conditional viewing – firm tracks **pre-selected information** to identify evolving issues
   3. Informal search – the corporation actively looks for information through unfocused and unstructured efforts to understand **specific developments**
   4. Undirected viewing – the firm scans diverse sources of information **without specific informational needs in mind** to sense new trends

C. Company must balance these four modes – e.g. too much undirected viewing is costly and unfocused; too much formal search and conditional viewing is too narrow
   1. Generally, complexity and volatility suggest more undirected viewing
   2. Formal search and conditional viewing are part of centralized planning
   3. Informal search and undirected viewing often occur at decentralized functions, close to operations, suppliers, and customers
   4. Both centralized and decentralized approaches are necessary

D. No standardized way to do this, but it makes sense to begin with the general environment and then the industry and finally, the company
   1. General environmental risks
      a. Exogenous factors completely outside the control of management that affect all players across industries and sectors, albeit differently
         i. Organized into categories (Box 7.1 Drivers of change in non-life insurance)
            (a) Political
            (b) Economic
            (c) Social

(d) Technology

(e) Environmental

(f) Legal

b. Industry risks

i. Factors identified at the industry level where competitive conditions may influence corporate exposures, while corporate actions may affect industry developments

(a) Typical frameworks include Porter's 5 forces model and national diamond model, competitive analyses, and mapping of strategic groups

(b) Conventional industry analysis considers conditions that are specific to the particular business environment

(i) New product development

(ii) Process innovation

(iii) Changing customer needs

(iv) Industry regulation

ii. Competitor analysis is often used to determine possible strategic moves and their expected consequences (Box 7.2 Industry threats and opportunities in non-life insurance)

(a) Porter's 5-forces analyzes profitability of an industry based on:

(i) Threat of new entrants

(ii) Power of buyers

(iii) Power of suppliers

(iv) Threat of substitute products

(v) Intensity of competition

c. Company risks

i. Risk factors that are endogenous to the organization as they are caused by internal processes, technological systems, and actions

(a) Includes things like operational disruption, technological breakdown, misreporting, fraud, inability to observe and react to market changes

(b) Common tools include the McKinsey 7S model, value chain analysis, VRIO and analysis of core competencies (Box 7.3 Assessing company risks)

(i) Lays out strengths and weaknesses

d. The above tools are used to assess the strategic position of the company in terms of developments in external market conditions and internal organizational capabilities - focus is on current perceptions

i. Going a step further requires developing a common risk vocabulary to help emphasize RM and facilitate internal communication in handling risk

(a) Many ways to handle this – breakdowns of broad categories and finer sub-categories

(b) Analogous to developing a strategic management vocabulary to help facilitate a common understanding of strategy

(i) Strategic analysis is typically SWOT – strengths, weaknesses, opportunities, threats – note first two are internal, last two are external

[a] SWOT can identify risk factors

[b] But SWOT does not explicitly state their relative importance

(ii) Risk map is the RM equivalent of SWOT; SWOT is an input to the RM initial assessment process – supplemented by assessments of operational risk factors and hazards

[a] After identifying all risk factors, the exposures should be evaluated based on two dimensions, likelihood, and economic impact to determine which risks are most economically material

[b] Often these dimensions are determined through qualitative judgment

[c] Risk map is a two-dimensional representation (impact/likelihood) of these judgments – increasing severity risks are located in the top right of the graph – i.e. high impact, high likelihood

[d] Further analyze those high severity risks by breaking them down into immediate vs. longer term timing

[e] Immediate risks are handled tactically and operationally – they need ongoing attention

[f] Longer term risks are handled strategically – they need lesser but regular attention

(iii) The foregoing assumes independence of risks

[a] Next level of granularity is the influence matrix, where each risk is listed vertically and the relative impact of the risk on other risks is then listed horizontally

[i] Scale of 0-2

[ii] Totaling across indicates how influential each risk factor is on the other risk factors – tells you which risks to prioritize and which will affect others as they are handled

[iii] Totaling down indicates how each risk factor is impacted by the other risk factors – tells you which risks must be dealt with alone (low score) because they are not influenced by handling other risks

III. 7.2 Scenario Planning – A Simple Technique in an Unpredictable World

A. The above tools and approaches are static in nature – and that is problematic in today's world – narrow focus leads to blind spots

1. Examples:

a. Brent Spar: Shell Oil wanted to sink an offshore oil container to dispose of it and despite receiving government approval, environmentalists caused a huge public relations issue which forced the company to abandon those plans – at great economic and reputational cost

b. Nokia: Nokia made a deal to produce phones in Romania in exchange for government concessions, but then closed a plant in Germany, for which they had received concessions years earlier, angering the Germans, who demanded paybacks, and worrying Romanians, who were concerned they might be victims of the strategy in the future

B. Corporations should therefore acknowledge uncertainty and explore the important uncertainties to challenge conventional wisdom about the future business environment

1. Most predictable surprises escape notice due to insufficient attention or lack of resources committed

a. Information gathering is too narrowly focused

b. Not enough challenging of what is known, perceived or unknown

C. Scenario planning can help evaluate weak signals and challenge current beliefs
   1. Analogous to financial deterministic scenarios and Monte Carlo techniques
   2. However, it is a qualitative tool in the strategic RM context
      a. Difficult to estimate strategic risks due to lack of data
      b. Statistical models are built on very restrictive assumptions
      c. Sophisticated models may suggest precision that doesn't really exist
   3. But also consider that qualitative scenario analysis may be seen as pure guesswork
      a. But getting folks to think about these situations, organize them and discuss their implications on the effectiveness of current strategies, while exploring new ones may be beneficial

D. Five steps in the SP process:
   1. Identify key environmental risk factors
      a. From SWOT, risk mapping or influence matrix
         i. Adding further uncertainties
      b. Typically deals with exogenous factors
   2. Elaborate some of the major themes that may characterize plausible alternative developments in future competitive market conditions
   3. Elaborate on major themes outlined previously and describe a few alternative environmental scenarios that arise as the consequence of different assumptions about the risk factors and the relevant underpinning themes
   4. Evaluate the consequences of key strategic risk factors within the themes that shape the alternative scenarios in view of essential strategic concerns and assess the capacity for corporate responsiveness
   5. Formulate new strategic alternatives, if required, and evaluate them given the different scenarios
      a. They should be flexible to allow the firm to react no matter how the future unfolds

E. SP is nothing but plausible stories based on competing assumptions about the future
   1. It can be a powerful tool that helps managers evaluate the robustness of strategic alternatives
      a. Gives management a way to evaluate strategic alternatives when operating in an uncertain business environment
      b. Provides needed structure when thinking about the appropriate corporate response capabilities in the event of unexpected events

IV. 7.3 Adding Complexity and Uncertainty

A. The foregoing assumes that it is possible to identify important risk factors and extrapolate them

B. Sometimes, the interactions between various risk events are so complex and unpredictable that the outcomes are literally unknown
   1. Company cannot expect to be capable of designing a foolproof set of contingency plans
      a. Existence of contingency plans may lead to false sense of security and an inability to consider anything outside the plan
   2. Planned responses to anticipated risks are insufficient in complex environments
      a. Organization must be able to handle the unexpected in a flexible manner
         i. Success depends on alertness and adaptable mindsets of management
            (a) Examples of organizations that successfully deal with unexpected include fire & rescue, nuclear power plants and submarines – high reliability organizations

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