EDUCATION COMMITTEE

OF THE

SOCIETY OF ACTUARIES

ENTERPRISE RISK MANAGEMENT STUDY NOTE

COURSEWARE—A GUIDE TO THE ERM CORE READINGS

The Education Committee provides study notes to persons preparing for the examinations of the Society of Actuaries. They are intended to acquaint candidates with some of the theoretical and practical considerations involved in the various subjects. While varying opinions are presented where appropriate, limits on the length of the material and other considerations sometimes prevent the inclusion of all possible opinions. These study notes do not, however, represent any official opinion, interpretations or endorsement of the Society of Actuaries or its Education Committee. The Society is grateful to the authors for their contributions in preparing the study notes.

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SOCIETY OF ACTUARIES

Courseware – A Guide to the ERM Core Readings

Welcome to the Society of Actuaries ERM exam. This study note is designed to help you master the syllabus material by providing additional commentary. It will guide you through the stated learning objectives using the required reading material; suggest an order of reading and provide context. It does not replace the original material and is not a shortcut. It is designed to make your study path clearer and provides a bridge between the required readings. Candidates are accountable for this material and it is testable.

The SOA's Enterprise Risk Management (ERM) exam is unique because, in addition to leading to an FSA designation, it is a required component of the Chartered Enterprise Risk Analyst credential. The CERA is an international credential, recognized by many actuarial bodies around the world. You can read more about the Pathway to Membership in the SOA at http://www.soa.org/Education/Exam-Req/default.aspx and about the global CERA initiative at http://www.ceraglobal.org. The learning objectives for the ERM exam have gone through a rigorous review within the SOA and have been reviewed by a committee representing the CERA treaty members.

My goal in writing this courseware is to provide information that ties together the material so you can use it for practical applications in addition to helping you study for the ERM exam. I wish you luck in your studies and your career, and encourage you to comment on the usefulness of this product so it can be improved for this and other exams going forward.

Max J. Rudolph, FSA CERA MAAA

To report errors or make comments about this study note, please contact the Society of Actuaries at education@soa.org.

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Preface to the 2015 Edition

This edition covers the Fall 2015/Spring 2016 syllabus. This edition replaces all previous versions.

Introduction

The ERM exam syllabus consists of texts, readings and study notes. To help you better prepare for the written exams the SOA released the *Guide to SOA Written Exams*, which I strongly encourage you to read before proceeding. Pay particular attention to discussions of cognitive levels and verb use. The *Guide* can save you a lot of time and make your limited study time more efficient. You can find the *Guide* at http://www.soa.org/education/general-info/edu-new-guide.aspx.

Candidates should understand how Marzano's Taxonomy is applied to SOA exams. Verbs representing levels of learning like analyze and justify appear in the learning objectives and might be tested during the exam even though the syllabus material is more applicable to a verb such as identify. You are expected to apply what you learn, including how material from different sources might interrelate, and give recommendations. This will help you prepare for practical projects and make better decisions during your career.

The syllabus has core material for which every candidate is responsible and six practice-area reading extensions. The syllabus includes a case study that will form the basis for a portion of the questions on the exam. At registration for the exam you will be required to choose one of the extensions and at the exam will receive questions related to those extensions and the related part of the case study. The reading extension is intended to be studied in conjunction with the case study. The candidate should read the exam syllabus (at http://www.soa.org/education/exam-req/edu-exam-erm-detail.aspx) and documents referenced within, such as the Introductory Study Note, and also regularly check for updates. Note that you will not be allowed to use your own copy of the case study on exam day.

You should become familiar with the case study prior to the day of your exam. The case study can be a valuable tool in helping you understand how ERM might be applied in a real-world situation. Read the portion of the case study that relates to your chosen extension, and then continue to refer back to it while you go through the syllabus readings. Think about how the principles included in the readings are evidenced, or perhaps not evidenced, in the case study. Make a critical evaluation of the entities in the case study. Pay particular attention to the case study as you go through the readings that are specific to your extension.

ERM Syllabus

The syllabus contains two text books in the core readings (practice-specific extensions are in addition to this core material). Make sure you have access to:

- *Financial Enterprise Risk Management*, Sweeting, 2011
- *Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk*, Jorion, 2007

The syllabus also includes a study note package that contains many of the required readings. In this document they will carry the study note code number (ERM – xxx – xx) and other identifying information. You are also required to secure several readings through links in the syllabus document.

The text *Financial Enterprise Risk Management* was written by Paul Sweeting, an actuary in the UK. The chapters making up the required reading provide a brief introduction to the ERM process as well as some of the modeling tools used in quantitative analysis. As this is a first edition book, errata have been identified. Note that some errata have been updated in later printings of the text's first edition. The current errata can be found on the exam Updates page. While most are minor typos, you should spend a few minutes going through the book and updating it for these changes.

At the end of each chapter, Sweeting lists material for further reading. This material is not required reading for this exam. It may, however, provide useful opportunities for continuing education in the future. The Joint Risk Management Section and its *Risk Management* newsletter provide additional opportunities for continuing education.

ERM material is studied throughout this journey to the CERA credential, and a strong effort has been made to have companion learnings through FAP, the ERM module and this exam. There is no single method of Enterprise Risk Management, and maintaining flexibility while considering a variety of outcomes is a key to success. The material covered in the syllabus provides a good representation of current best practices. The Sim Segal text, *Corporate Value of Enterprise Risk Management*, studied as part of the FAP modules, the James Lam text, *Enterprise Risk Management: From Incentives to Controls,* studied in earlier versions of FAP, and other material covered in the ERM module provide the candidate with a balanced view of risk management methods and techniques designed to address the needs of competing stakeholders.

The *Strategic Risk Management Practice* text (the required chapter is reproduced in study note ERM-107-12), written by Torben Andersen and Peter Schroder, provides an excellent introduction to the strategic side of risk management, with both upside opportunities and downside mitigation. At this point there are no errata posted.

Practice Specific Readings

Each case study extension has assigned syllabus readings that relate to that specific extension. The readings support the overall ERM exam learning objectives, while providing information on practical applications of ERM in that specialty area.

This courseware will not separately review the readings related to the six extensions nor does it provide a guide to the case study.

Examination questions for the extensions will be primarily based on the extension readings and will normally, but not always, involve application to the case study. Extension questions may also rely on material in the core readings.

How to Use This Document

Candidates use a variety of methods to prepare for an exam, and by this point in your actuarial career you likely have found a method that works for you. If you prefer to read everything from a single text or paper before moving on that's not a problem. You should note that this courseware is developed to maintain consistency with the syllabus, including its learning objectives and learning outcomes. As you proceed through the courseware document, each section will start with the learning outcomes associated with that section. This will be followed by a listing of the required resources tied to that section.

At the end of the document is a glossary with only minor changes from the original version of this courseware. The glossary contains terms from sources that are no longer required reading for the exam, but which may continue to be useful in your study. This glossary will not generally include formal, technical, definitions but rather a layman's definition designed to help you understand the concept as it is used within that section. You might also want to use formal glossaries from other textbooks or a website like www.riskglossary.com . While an effort has been made to include the significant terms covered on the syllabus, there is no guarantee that an exam question will refer only to terms defined here.

Following the resource list, the syllabus material is discussed under the Required Reading heading, providing a suggested order of reading and highlighting some of the key points. Some sections in this document under the heading Supplemental Material are designed to support learning outcomes that were not thoroughly covered in the required readings. The candidate is responsible for learning this material. When material is labeled as Background only (Sweeting Chapter 9 is the only Background reading for this exam), this means it will not be directly tested but provides material that supports other required readings.

In this study note, the terms "candidate" and "you" will often be used interchangeably to provide some variety in the wording. The goal is to make this document helpful to you, and readability is very important in that context.

If you believe that something should be added to the courseware, or changed, to aid future candidates please let the curriculum team at the SOA know by sending an email to education@soa.org. This document will be updated periodically as the syllabus material changes so it will become a living document.

Section 1: Risk Categories and Identification

Learning Objective and Outcomes

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

OUTCOMES: The candidate will be able to:

A. Explain risk concepts and be able to apply risk definitions to different entities
B. Explain risk taxonomy and its application to different frameworks
C. Identify and assess the potential impact of risks faced by an entity, including but not limited to, market risk, currency risk, credit risk, counterparty risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, legal risk, operational risk, project risk and strategic risk.

Resources

- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Chapter 7, Definitions of Risk
  - Chapter 8, Risk Identification
- *Value-at-Risk: The New Benchmark for Managing Financial Risk, Jorion, 3rd Edition*
  - Chapter 13, Liquidity Risk (also a resource for LO-3)
- ERM-107-12: *Strategic Risk Management Practice,* Andersen and Schroeder, 2010,
  - Chapter 7: Strategic Risk Analysis (also a resource for LO-4)
- ERM-117-14: American Academy of Actuaries Practice Note: Insurance Enterprise Risk Management Practices (pages 4-26, also a resource for LO-4)
- ERM-702-12: International Actuarial Association Practice Note: Enterprise Risk Management for Capital and Solvency Purposes in the Insurance Industry (pages 9-38, also a resource for LO-3 and LO-4)

Why are we studying enterprise risk management (ERM)? It is so we will make better decisions. What do we mean by that?

1. Consider both returns AND risk
2. Manage volatility of results
3. Optimize results
4. Better understand risks
5. Communicate risk practices consistently

The material covered in Section 1 contains material preliminary to what is covered later in the syllabus for the ERM exam and should be read first. While not quantitative in nature, it provides the underlying background material for completing the ERM process.

Subsection A: The candidate will first become familiar with the basics of ERM by reading Chapter 7 of Sweeting. The supplemental material breaks down Enterprise Risk Management into its components and shares the SOA's definition of ERM.

Subsection B: Learning Outcome 1B covers Chapter 8 of Sweeting, discussing ERM tools and a discussion of risk taxonomy as the risk team identifies the risks covered.

Subsection C: The final Learning Outcome covers risk identification and analysis. The topic is introduced using materials from Jorion and Andersen and Schroder. Chapters 7 and 8 of Sweeting also apply.

Learning Outcome 1A

The candidate will be able to: explain risk concepts and be able to apply risk definitions to different entities.

RESOURCES

- ERM-702-12: International Actuarial Association Practice Note: Enterprise Risk Management for Capital and Solvency Purposes in the Insurance Industry (pages 9-38, also a resource for LO-3)
- ERM-117-14: American Academy of Actuaries Practice Note: Insurance Enterprise Risk Management Practices (pages 4-26, also a resource for LO-4)
- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Chapter 7, Definitions of Risk

Each subsection will build on earlier readings, and this courseware suggests an order of reading to maintain this continuity. Let's start with the required readings and then we will circle back with some supplemental material that will pull it together in a coherent manner.

REQUIRED MATERIAL

Read ERM-702-12, International Actuarial Association Practice Note on Enterprise Risk Management for Capital and Solvency Purposes in the Insurance Industry. This reading provides a quick introduction to ERM and how to implement ERM in an insurance organization. Keep in mind as you read this material that ERM is an evolving field. While the required material covers common methods, there is not one single best practice to point to. In fact, including a variety of opinions and methodologies is one of the best ERM practices there is!

ERM 702-12 starts with risk management and corporate governance. A board's responsibilities include approving the insurer's overall risk management strategy and/or policy, ensuring that the insurer is managed by an adequately competent management team, setting risk appetite, and ensuring the effective implementation of appropriate risk

management and internal controls framework. The success of ERM is also critically dependent on the executive management's commitment. The first major challenge for a newly appointed CRO is the creation of an appropriate risk function structure or managing a fragmented set of risk structures within an insurer. The structure should align with the distribution of management accountability. CRO and CFO strategies need to be integrated so that they support the generation of adequate returns at appropriate level of capital to protect all policyholders.

A risk management culture is the combination of behaviors of staff in an insurance organization. Thus, a key consideration for the promotion of ERM is the desired behavioral incentives in relation to management of risks. There are three aspects to consider in development of appropriate risk behavior incentive programs:

1. Risk management is not about eliminating risk (which would inhibit growth/change),

2. Risk programs should provide an encouraging environment for people to confidently escalate bad news without fear of retaliation and should involve people with adequate skills, and

3. Capability and empowerment to manage risk situations are critical components.

The incentive programs should be designed to target an appropriate level of staff and encourage desired risk behaviours. The risk function should also be involved in the early planning stages of any new activities to ensure appropriate risk assessments of an insurer's strategic direction (including major projects/product changes).

A risk management policy is a board-approved policy that outlines how the insurer strategically and operationally manages each relevant and material risk category. This approach links the use of tolerance limits, supervisory and economic capital requirements, processes, and methods for monitoring risk. A risk tolerance statement is a higher-level statement that communicates the level of exposure to risks deemed acceptable to the board, which is translated into risk limits that can be used by business on daily basis.

Three key sources of feedback are the outputs from periodic risk assessments external factors and emerging risks (looking forward), and movements in key risk indicators (the present) and unexpected loss events (looking back). An effective feedback loop is based on established reporting thresholds, management escalation protocols, and risk aggregation that allows organizations to identify sources of excessive risk.

The reading ERM-702-12 is complemented by ERM-117-14, an American Academy of Actuaries Practice Note on Insurance Enterprise Risk Management Practices.

ERM-117-14, developed by the ERM Committee of the American Academy of Actuaries, presents an overview of the ERM process and the role of the actuary within the ERM

process. As part of the definition of ERM, concepts related to the practice and review of ERM including risk culture, risk organization and risk governance are addressed. The document explains and provides context around the key concepts to the ERM process.

The document makes note that effective ERM relies on two primary goals:

- Identification, evaluation and quantification of risks and their correlations and/or dependencies
- Ensuring the organization actively leverages its risk management knowledge to implement strategies to achieve appropriate risk and return trade-offs in accordance with an organization's values, goals and risk appetite.

A successful ERM process will be integrated within the company and iterative in nature to provide opportunities for continuous improvement.

Now read Sweeting Chapter 7, Definitions of Risk. It is impossible to manage a risk that has not been identified and defined, and a firm's specific risks are unique to its changing circumstances. This impacts how the risks are addressed and prioritized. This unique reaction to risk is the goal of Sweeting's Chapter 7, Definitions of risk. The glossary in this section provides a good summary of much of this chapter's information, but there are a few points worth reiterating here.

The author segments mortality and longevity risk into four categories: level, volatility, catastrophe and trend. This compares with the non-life insurance risks of underwriting, volatility, catastrophe and trend. They are similar, of course, but understanding the nuances between them will help the candidate get his hands around other risks as well. We use the terms incidence and intensity as components of underwriting risk, but mortality risk is a special case where incidence is the mortality rate and intensity is the face amount of the policy. Catastrophe risk can help us understand another difference between life and non-life risk. While mortality can spike due to specific events such as a tsunami or pandemic, non-life losses can also exhibit sudden increases due to court rulings regarding coverage. An insurer might have thought a specific event was not covered but later the courts might disagree, as happened with asbestosis.

Next we will discuss a few interesting topics covered in this chapter. As in all parts of this courseware document, this review is not comprehensive and does not replace reading the source material.

Trend Risk

Trend risk considers both the possibility that mortality rates will improve as well as the possibility that they will worsen. While a decline in smoking has been a major contributor to lower mortality, the evolving increase in overweight adults is expected to slow or reverse this

trend. The trend risk can be driven by either incidence or intensity of claims (for mortality risk obviously only incidence can vary given today's product designs). For non-life claims, various cycles are often misinterpreted as trends. The risk manager should put trends in the context of court rulings, advances in health care and underwriting cycles among other shocks to the risk platform that need interpretation.

Operational risk

Operational risk tends to overlap with risks in other major categories. The risk manager needs to consider instances where an event could be considered any of multiple operational risks or as a combination of financial and operational risks. A recent example would be the financial crisis starting in 2007. What was the driver that caused liquidity risk to balloon? Any of counterparties, credit, financial infrastructure, regulatory, crime, moral hazard, agency, bias, model and residual risks could be considered. The risk manager overseeing the process needs to manage each of these risks and understand that they interact with each other, sometimes directly and sometimes indirectly through higher order effects.

Behavioral finance

Behavioral finance is listed as a form of bias. A cleaner split might be to consider deliberate bias, including agency risk and possibly criminal acts, and subconscious bias. Unintentional biases are often caused by decisions that are not recognized as biases by the risk taker. One of the goals when behavioral finance is studied is to make risk takers aware of these biases. Overconfidence has several facets dealing with difficult tasks with low predictability. An illusion of knowledge is created when we have a lot of information and think this is the same as knowledge. The illusion of control makes us think results are improved when we are in control.

Researchers will often use an initial, unrelated, activity or question relating to a number to show the anchoring effect. For example, if an experiment involves spinning a wheel numbered from 0 to 99 that is fixed to stop on only two numbers, one high and one low, any response to a question that follows will be biased higher or lower based on the first result. We have also seen this result in emerging risk research, with recent risk events driving concerns about evolving risks.

When we assume that things with similar properties are alike this is called representativeness. An example is stereotyping someone by assuming she has characteristics that we have internally assigned to a group the person belongs to (e.g., race, social class).

Using rules-of-thumb can work for a period of time and then fail as financial conditions or products evolve. This is an example of heuristic simplification, although these simplified tools can be excellent for an initial analysis.

Effect of risk mitigation

Looking at risk exposures prior to risk mitigation and then again after risk tools have been applied is one of the hardest things for even a seasoned risk manager to understand. A model that works for years can suddenly blow up due to a residual risk that had not been considered previously. During the financial crisis many investors bought credit default swaps on mortgage backed securities not knowing who the true counterparty was. As it turned out, the AIG Financial Products Division had accepted a large amount of this exposure, but this was not transparent to the CDS buyer. Reinsurance is another example where the risk manager should be aware of both the residual (net) exposure and the gross exposure that exists if the counterparty does not fulfill its responsibilities.

SUPPLEMENTAL MATERIAL

What is Enterprise Risk Management?

Enterprise risk management covers a broad range of qualitative and quantitative techniques. The first line of defense is common sense. If something does not feel right then it probably is worth a closer look. A firm that encourages skepticism and contrarian thought rather than penalizing them has a healthy risk culture and provides the conditions to build a competitive advantage. A company that seeks out information to drive timely decision making understands the risks present on its balance sheet. An effective risk manager prepares a firm to succeed across a variety of potential scenarios. Let's break down the words enterprise, risk and management.

What is Risk?

When dealing with a variety of industries, professionals, investors and even risk managers, it becomes obvious that the first issue needing to be addressed is to define the term "risk". Many managers have a strong definition in their own mind, but that definition varies from person to person. How you and your organization define risk drives both risk appetite and risk culture. One of the main points of many management seminars is to recognize that others tend to not think like you do. This is important in risk management too. Risk can be defined in a number of different ways, and maintaining variety in your organization is very healthy. Consensus can be dangerous when managing risks.

Knightian Risk

This risk definition was put forth by Frank Knight in his 1921 book *Risk, Uncertainty and Profit*. He defines risk as uncertainty. This can be best explained by an example. If you were to launch yourself with no protection into the harsh conditions of space, you would die. Knight would say that this event has no risk. If there is no uncertainty, there is no risk. If you are guaranteed to fail, there is no risk. If you are guaranteed to win, there is no risk. Most practitioners consider this an extreme definition.

Downside Risk

When managing a business or portfolio, many managers consider risk only with respect to a negative outcome. Consider “good” and “bad” outcomes. For example, higher sales are usually thought of as a good outcome. Deeper analysis might show that these higher sales add risk levels that outstrip capital availability or reveal a poorly priced product. What is important is the marginal impact on the entity. A good overall outcome should be encouraged even if some lines of business would call it a bad outcome for their individual silo. High mortality is an example of this, with a life insurance line saying it is a negative financial outcome and a payout annuity line considering it a positive outcome. This is an example of an internal hedge, provided by two business lines with offsetting risks in their portfolio, and demonstrates the complexity involved when looking at a firm holistically.

To meet their regulatory needs, many companies focus on risks from a one sided perspective. Risk management is viewed as a fixed cost under this paradigm. This approach can be useful, and helps the company avoid bankruptcy. It also provides a base from which to leverage more advanced, value added, ERM efforts.

Volatility Risk

Traders, in general, focus on a volatility driven definition of risk. Opportunities abound if prices move, whether up or down. This can lower the probability of ruin. The downside of this approach is that many who think of volatility as risk are also susceptible to model risk.

Not everyone is capable of the two-sided risk approach. Risk culture can get in the way. A risk manager should nudge his firm in this direction, but trying to leap there all at once is not likely to work. Including people on the risk team who support differing definitions of risk can provide balance and lead to a better understanding of the risks accepted.

Risk management

For practical purposes, risk tends to be measured either by its volatility or by its downside exposure. Tools such as the Capital Asset Pricing Model (CAPM) are driven by historical volatility. An entity that sets goals and objectives faces downside risk that they are not accomplished. This includes solvency risk for an insurance company and the risk that an individual can’t retire when desired at a certain level of income. When specific risks are managed in isolation, without a holistic point of view, this is referred to as silo risk management.

Enterprise risk management

Extending beyond silo risk management to take a holistic approach and considering the consistent aggregation of all risks taken is ERM. This incorporates risk combinations and correlations among all risks. There are often benefits of diversification for entities taking a

variety of risks, which can be approximated with a correlation matrix. The risk manager should also look at risk concentrations as they can make an entity susceptible to a single stressful scenario. Many risk combinations do not have steady correlations, with less diversification in the tail of the distribution of results. We'll come back to that later when we discuss copulas and extreme value theory. When times are very good, as well as when times are very bad, many financial risks trend together in the same direction and their correlations increase. Unintended consequences result from poorly understood risks and interactions between risks.

During the FAP modules you might have studied Sim Segal's *Corporate Value of Enterprise Risk Management*. There he defined ERM as "the process by which companies identify, measure, manage, and disclose all key risks to increase value to stakeholders." Here we will use a slightly different definition.

The Society of Actuaries, in 2005, adopted this definition of enterprise risk management:

> *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.*

Each word adds to the definition, but what makes it stand out from many other risk management definitions is the word "exploit." When it is appropriate to create or add to a risk position (also called upside risk), the team or area responsible for ERM should get involved to consider the impact on existing risk positions and on the entity as a whole. The process moves beyond risk mitigation and into strategic planning.

Keep in mind that the word "exploit" does not refer to treatment of customers. When a firm has a competitive product that can result in higher sales at comparable prices, perhaps due to some type of competitive advantage like low cost or expertise, it should make more widgets or sell more insurance policies. The firm can exploit a business opportunity.

Learning Outcome 1B

The candidate will be able to: explain risk taxonomy and its application to different frameworks.

RESOURCES

- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Chapter 8, Risk identification

REQUIRED MATERIAL

One of the biggest challenges when managing risks is communication. Whether discussions occur between companies, professionals or external experts, each person comes to the project with his or her own unique experiences, knowledge and biases. Many times two people will realize after several hours of arguing that both were actually saying the same thing, just using different words. Many actuaries have had this experience in their career. This can be mildly irritating or can lead to more serious issues. For example, if a company uses words that differ from industry standards when dealing with external stakeholders, it can give the perception that the company is not aware of current ERM practices. In order to aid conversations, The Institute and Faculty of Actuaries in the UK sponsored a paper titled *A Common Risk Classification System for the Actuarial Profession*. This paper is used as background material for this exam, aiming to create a common risk terminology for actuaries to consider when discussing ERM outside their company.

Classification systems used by both regulators and companies were considered. Some challenges were found when there is crossover between operational risk and the financial consequences of that risk. There are also blurred boundaries, for example between credit/market risks and liquidity/market risks. The authors encourage use of an event-based (rather than cause-based) classification system to limit confusion about the causes of an event, and focus on the gross exposure rather than the net (residual) exposure after risk mitigation techniques have been applied. This is a useful paper for the practitioner, and risk managers should consider reading it in its entirety or at least reading the accompanying article from *The Actuary*, a UK based actuarial magazine.

Read Sweeting Chapter 8, Risk identification tools, now. Identifying the risks accepted (and those avoided) is a key component within enterprise risk management. Many risk managers have either learned or confirmed that they do not “know it all” when interacting with the risk owners. At the same time, risk owners can learn best practices from corporate risk managers who have a holistic view of the risks taken. Like much of ERM, risk identification is a process, not a project, meaning that it needs to be revisited periodically as new products are offered, new tools become available, or emerging risks appear.

Many companies employ SWOT analysis, identifying Strengths, Weaknesses, Opportunities and Threats to the organization. Strengths only matter if they can be used to take advantage of an opportunity or weakness. For example, employing the world’s greatest chess master has little value if you are making widgets. There is a natural mapping between the internal strengths and weaknesses and the external opportunities and threats.

Most risk managers will end up with some form of a detailed list of risks, considering frequency and severity for each based on specific exposure. They might start off with a high level prompt list, like the PESTELI acronym described below. At the next level of detail can be found what the author describes as the risk taxonomy. Examples include the COSO ERM

Framework, with its focus on operational risks, and the Basel Accords, which look at market risk, credit risk and operational risk from a bank perspective. Risk-Based Capital, developed by US insurance regulators, splits out asset risk (affiliates, credit, market and interest rates), underwriting risk and business risk (catchall meant to cover legal risk, operational risk and strategic risk, among others).

Political
Economic
Social
Technological
Environmental
Legal
Industry

SUPPLEMENTAL MATERIAL

Risk taxonomy is a way of organizing sources of risk that often has implications for the mathematical combination of these risks. These are sometimes called risk buckets. While various organizations like the Basel Accords, the NAIC and COSO have independently developed risk taxonomies, they often are similar. Mathematically, a goal is to identify and combine risks that are similar and driven by commonalities, and separate those risks that are independent or not fully correlated. Hedges, where risks offset, are generally held with the risk category they offset.

Learning Outcome 1C

The candidate will be able to: identify and assess the potential impact of risks faced by an entity, including but not limited to market risk, currency risk, credit risk, counterparty risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, legal risk, operational risk, project risk and strategic risk.

RESOURCES

- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Chapter 7, Definitions of Risk
  - Chapter 8, Risk Identification
- *Value-at-Risk: The New Benchmark for Managing Financial Risk, Jorion, 3rd Edition*
  - Chapter 13, Liquidity Risk (also a resource for LO-3)

- ERM-107-12: *Strategic Risk Management Practice*, Andersen and Schroder
  - Chapter 7, Strategic Risk Analysis (also a resource for LO-4)
- ERM-702-12: International Actuarial Association Practice Note: Enterprise Risk Management for Capital and Solvency Purposes in the Insurance Industry (pages 9-38, also a resource for LO-3)

When risks can be quantified using historically based data sets fit to a standard distribution, measuring the impact of risks is fairly straightforward. This is the case for many well documented situations. When we move away from events that follow known statistical distributions, like earthquakes in a known earthquake zone, approximations work pretty well but are not perfect. These distributions tend to have fatter tails than the theoretical distributions, meaning that extreme events happen more frequently than would be expected in the statistical distributions.

When it is hard to measure something in absolute terms, sometimes we use tools like fuzzy logic, where you provide a relative ranking on a High/Medium/Low or 1-10 scale. An example would be ranking of a potential pandemic or fraud. Using too many significant digits would imply false precision, but it is important to look at these risks. Other risks are generally unquantifiable, like reputation risk. We know they are important, but who can predict the public's response? When someone put cyanide in Tylenol capsules in 1982, Johnson & Johnson took a disaster scenario sure to destroy their reputation and turned it into a resounding reputational victory by communicating the problem, pulling the product, and making the public safer by adding seals to their packaging to make them "tamper proof." This was not a random event, and management actions and reactions of others can't be accurately modeled. Risk managers can use qualitative analysis and deterministic scenarios to determine a preferred exposure limit. This helps them see which scenarios matter for decision making and allows them to proactively develop a game plan. We'll come back to this topic later, but for now you should know that quantification is not absolute. The risk manager should measure the risks but will also be aware of the shortcomings and approximations made along the way.

REQUIRED MATERIAL

You were directed to Sweeting Chapters 7 and 8 earlier when we examined Learning Outcomes 1A and 1B, respectively. The material in Sweeting also supports this Learning Outcome 1C and should be kept in mind as you study this section. This learning outcome encompasses identification and analysis of an extensive list of risk types, and Sweeting provides a good overview of many of them.

We also introduce two other sources to be reviewed at this point, Andersen's Strategic Risk Analyses and a chapter from Jorion. They each give insight into identification of particular

types of risk. This material will be revisited in later sections since it goes beyond just identification and analysis.

In Andersen, Chapter 7 Strategic Risk Analyses (ERM-107-12), the authors consider methods of risk identification and analysis. Their discussion of environmental scanning covers viewing the environment (looking at information) and searching for important environmental developments (looking for information). Notably, this method looks marginally at the corporate periphery to identify events that will be material in the future. A key is to have the risk owners participate in the environmental scanning process so it is not viewed solely as a centrally located corporate activity, but rather one that is embedded in the business units. The PESTEL (political, economic, socio-economic, technological, environmental, legal) framework is revisited (Sweeting Chapter 8 included "industry" to form the acronym PESTELI). Another common model discussed is Porter's five forces model, which can be applied to any firm or industry.

A common risk vocabulary is critical to instilling a consistent risk culture. Internal communications become much clearer when all are using the same definitions. As you saw in Section 1B, there is wide dispersion between terms and it can be useful to have someone learn the common languages in place at other firms. Some will use industry definitions from COSO or ISO, and other professional organizations have developed projects to help their members interact with each other.

Once the risks have been identified a risk map can be created that shows the likelihood and severity of each. Risk managers will need to develop their own method of ranking the risks to enable prioritization and possibly risk mitigation efforts. An event with low likelihood but high severity should be included in these considerations. Creating a risk timing map and influence matrix will bring time horizon and correlations into a strategic discussion and discourage risk owners from focusing only on short-term crises.

One chapter of Jorion is also presented here. The focus in this section is on identification and analysis of risk. The portions of the chapter related to modeling, measurement, and management of risk will be further examined later.

In Jorion Chapter 13 review the first section of the chapter, which defines liquidity risk. Prior to the financial crisis, liquidity risk was usually discussed using only what Jorion calls asset liquidity risk. How hard was it to sell an asset over a short time period, and how close to full value could you receive? Now there is a greater appreciation for the concept of funding liquidity risk, where financing becomes difficult or unavailable.

The bid-ask spread drives the liquidity-adjusted VaR (LVAR) in a way that is greater for large portfolios.

LTCM (Long Term Capital Management) is a classic case study of how a good idea gains its own momentum and the risk culture at a firm overwhelms independent oversight. As John

Maynard Keynes is quoted as saying, “Markets can remain irrational a lot longer than you and I can remain solvent.” Leverage, i.e., borrowing to make larger positions, requires collateral. When those positions lose value in the market the required collateral goes up and may require selling the under-water assets to fund it. Leverage compounds returns when markets rise but incapacitates an entity when markets fall.

SUPPLEMENTAL MATERIAL

Insurance risk

The candidate should recognize that when insurance is used as a risk mitigation tool the buyer is reducing its operational risk (and increasing its counterparty risk) and the seller has increased the insurance risk on its balance sheet.

Contagion risk

The financial crisis starting in 2007 provides a good example of contagion risk. What started out as a problem in the home mortgage market evolved into a liquidity crisis impacting financial markets world wide. Initially, the impact looked like it could be isolated and contained. Due to unintended consequences, interactions and linkages between markets, and investor psychology, the financial impact quickly spread to a wide variety of previously (or at least recently) uncorrelated markets.

Another source of contagion risk occurs when many investors, often hedge funds, employ similar trading strategies. The investor strategies are not transparent to each other. When one asset class falls out of favor and margin calls are made, a second common asset class can fall as investors try to sell those positions to cover needs elsewhere.

Contagion risk can arise because correlations across scenarios are not constant over time. This can be very tricky to model and may best be accomplished through a deterministic stress scenario.

Section 2: Risk Modeling and Aggregation of Risks

Learning Objective and Outcomes

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

OUTCOMES: The candidate will be able to:

A. Demonstrate how each of the financial and non-financial risks faced by an entity can be amenable to quantitative analysis including an explanation of the advantages and disadvantages of various techniques such as Value at Risk (VaR), stochastic analysis, scenario analysis
B. Evaluate how risks are correlated, and give examples of risks that are positively correlated and risks that are negatively correlated
C. Analyze and evaluate risk aggregation techniques, including use of correlation, integrated risk distributions and copulas
D. Apply and analyze scenario and stress testing in the risk measurement process
E. Evaluate the theory and applications of extreme value theory in the measuring and modeling of risk
F. Analyze the importance of tails of distributions, tail correlations, and low frequency / high severity events
G. Analyze and evaluate model and parameter risk
H. Construct approaches to modeling various risks and evaluate how an entity makes decisions about techniques to model, measure and aggregate risks including but not limited to stochastic processes

Resources

- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Chapter 12, Extreme Value Theory
  - Chapter 14, Quantifying Particular Risks
  - Section 15.5, Unquantifiable Risks (also a resource for LO-3)
- *Value-at- Risk*, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007
  - Chapter 5, Computing VaR, Sections 5.1-5.3 (also a resource for LO-3)
  - Chapter 7, Portfolio Risk: Analytical Methods (primarily discussed with LO-3)
  - Section 9.3, Modeling Correlations (pages 232-236, also a resource for LO-3)
  - Chapter 12, Monte Carlo Methods (primarily discussed with LO-3)
- ERM-101-12: Measurement and Modeling of Dependencies in Economic Capital, Chapters 4-5

- ERM-103-12: Basel Committee - Developments in Modelling Risk Aggregation, pages 72-89
- ERM-104-12: Study Note on Parameter Risk, Venter and Sahasrabuddhe
- ERM 106-12: Economic Capital-Practical Considerations, Milliman (primarily discussed with LO-5)
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- ERM-117-14: American Academy of Actuaries Practice Note: Insurance Enterprise Risk Management Practices (pages 4-26)
- ERM-118-14: Model Validation Principles Applied to Risk and Capital Models in the Insurance Industry
- ERM-119-14: Aggregation of Risks and Allocation of Capital (Sections 4-7, primarily discussed in LO-5)
- ERM-120-14: IAA Note on Stress Testing and Scenario Analysis (page 1-6 and 14-17)
- ERM-124-15: Counterparty Credit Risk: The New Challenge for Global Financial Markets, Ch. 2, Defining Counterparty Credit Risk
- ERM-125-15: Loss Models Further Topics (Klugman, Panjer, Wilmot), Ch. 10 Copula Models
- ERM-602-12: *Investment Management for Insurers*, Babbel and Fabozzi, Chapter 11, The Four Faces of an Interest Model (also a resource for LO-3)
- Risk Appetite: Linkage with Strategic Planning Report (primarily discussed with LO-4)
- Modeling Tail Behavior with Extreme Value Theory, *Risk Management*, Sept. 2009
- SOA Monograph, A New Approach to Managing Operational Risk, Chapter 8 (primarily discussed with LO-4)
- Summary of “Variance of the “CTE Estimator”, *Risk Management*, August 2008 (primarily discussed in LO-3)

This Section introduces you to tools that help you quantify risk. Keep in mind that not everyone thinks about risk in the same way. While you might prefer numbers over graphs, or vice versa, Board members (and your boss) might find it easier to contemplate graphs over numbers. A healthy balance of formulas and graphs, quantitative and qualitative analysis, is needed.

Much of your prior work as a candidate has laid the groundwork for this material. For example, the syllabus refers to families of statistical distributions. If you haven’t studied or used them recently, you might need references available in case you want to look something up. First we will review the readings to be covered in this Learning Objective.

Subsection A: The material has been segmented by learning outcomes. While later in this section you will read about how to aggregate risks, here you look at them as silos, one at a time, and consider various building blocks to help analyze risk. A very important concept

presented in this section is using multiple metrics for analysis. While Value at Risk (VaR) is the title of one of the required texts, a key is to utilize multiple metrics and understand that none of them are perfect. Several are presented and each has both positive and negative features. Start by reviewing Jorion Sections 5.1 and 5.2 for an introduction to VaR as a risk measure. In Sweeting Chapter 14, Quantifying Particular Risks, the candidate will view quantification methods for various risk categories. Section 2.2 of the Risk Appetite: Linkage with Strategic Planning Report provides another overview of risk metrics.

Subsection B: Enterprise risk management involves holistic analysis, meaning that you aggregate all risks into a consistent process using assumed correlations. As an important topic with challenging material, you will see readings later in the section that look at the material in slightly different ways or specifically from the practitioner perspective. Chapter 4 of study note ERM-101-12, Measurement and Modeling of Dependencies in Economic Capital, discusses correlation concepts, and the Jorion text, Section 9.3, provides an introduction to modeling correlations.

Subsection C: The aggregation techniques, including copulas, can be technically demanding to understand. The Basel Committee paper (ERM-103-12) – Developments in Modeling Risk Aggregation (pages 72-79) provides an introduction to correlation and copula calculations. Other sources provide supporting material. Chapter 4 of ERM-101-12, referenced above, includes correlation quantification techniques, and Chapter 5 provides additional insight into copulas. ERM-125-15, Copula models, provides technical detail on different copula models. ERM-106-12, Economic Capital – Practical Considerations, covers aggregation considerations in Section 7.4. Chapter 7 of the Jorion text, which will be explained more fully in Section 3, references aggregation in a portfolio context.

Subsection D: Next you will learn about scenario and stress testing by reading ERM-120-14: IAA Note on Stress Testing and Scenario Analysis. A risk modeler will develop a single scenario to test the impact of a specific event or combination of assumption changes.

Subsection E: Many of the tools used to analyze results are similar no matter which part of the statistical distribution you are studying. The focus of ERM tends to be in the tails of the distribution, so tools developed with that in mind are considered. First read Jorion Section 5.4, Extreme-Value Theory and follow that up by reading Sweeting Chapter 12, Extreme Value Theory. The final resource for this subsection is “Modeling Tail Behavior with Extreme Values Theory.” These readings deal with the primary methods used to analyze “fat tails.”

Subsection F: Infrequent events with large consequences are of great interest to risk managers. Since they don’t happen very often, they are hard to model using historical data points. Study note ERM-101-12, Measurement and Modeling of Dependencies in Economic Capital (pages 21-81), provides a how-to guide when considering dependencies between variables. Practitioners will find this discussion paper very useful, as it ties together quite a few topics covering aggregation. Operational risk is an example of a risk that can exhibit

either high frequency / low severity or low frequency / high severity. Operational risk is addressed in the SOA Monograph: A New Approach to Managing Operational Risk, Chapter 8, which will be discussed primarily in Section 4.

Subsection G: The study note covering Parameter Risk (ERM-104-12) shows methods for estimating the uncertainty around parameters.

Subsection H: Many of the tools used to manage quantifiable risks were discussed in earlier subsections and will be revisited later in the syllabus. There are three new readings that are introduced in this section. The first new reading is from Sweeting Section 15.5, Unquantifiable Risks. For those risks not yet quantifiable the section shares a technique used in many companies to estimate likelihood (also called frequency or probability) and impact (also called severity) for decision making purposes using a risk map. The second is "The Four Faces of an Interest Rate Model" from *Investment Management for Insurers* (ERM 602-12). This note focuses on how to determine the appropriate type of interest rate model for a given situation. Finally, the third is Chapter 12 of Jorion, which introduces Monte Carlo methods; this chapter will be examined in more depth in Section 3.

Study note ERM-124-15 on defining counterparty credit risk, Counterparty Credit Risk is covered in more depth in Section 4.

The candidate will be introduced to various types of silo risk management techniques and then later in the syllabus be shown methods to aggregate them in a holistic fashion by evaluating the results of scenarios and correlations.

How entities respond to risks will vary based on risk culture, risk appetite, available capital, and sometimes plain old luck. When a risk has a lot of data associated with it, compiling these results into a distribution and developing the resultant mean and standard deviation seems very straightforward. But financial results are not controlled by the laws of physics as many of the distributions assume. Calculating closed form solutions, using Monte Carlo simulations to manage a range of results, or testing results against a single scenario will create information. Such modeling is mainly useful when understood in the context of what it does well and what it does not do well. For example, when managing mortality risk you seemingly have lots of data. But your goal is to manage future mortality risk, not measure past mortality. You want to identify a distribution that will approximate the future. Past trends have focused on decreasing mortality due to reduced smoking prevalence. But now there are trends looking at overweight populations and predicting that this will lead to increases in the diabetic population and higher mortality. How many years of data should be used? Should it be projected into the future? Should discontinuities like an influenza pandemic or a cure for cancer be considered? Are point estimates of mortality sufficient or should ranges be used? Are there actuarially significant splits that cannot be legally utilized (e.g., male/female data for group products in the United States)? Will elderly mortality continue to improve? Should an internal hedge be designed for a product by combining a payout

annuity with life insurance exposure? How do cohorts from different time periods impact the results? These are just a few of the questions surrounding what some feel is a stable, well modeled risk.

Many events are surprises to management. Organizations may initially try to manage risk using damage control through the media rather than addressing the problem directly. In 1986 the U.S. space shuttle Challenger exploded soon after liftoff due to seals that leaked on the launch pad as the temperature dropped. NASA, the U.S. space agency, faced political pressure to launch and overrode the concerns expressed by engineers about the early morning low temperatures at the launch site. A 2010 explosion on a British Petroleum (BP) deep-water drilling platform in the Gulf of Mexico created the largest accidental marine oil spill to that time. BP had several safety events in the years prior to 2010, but maintained a culture where profits overrode safety. These types of examples represent what are primarily culture issues. In a strong risk culture environment the boss can't say he is 100% behind risk management and then call and ask (tell) workers to grant special favors to business acquaintances. At the other extreme, a client told me a story once of a recent high school graduate who was entering the workforce with her first full-time job as a lowly clerk performing the logistics to issue a life insurance policy. Not an underwriter, not someone with decision-making ability, but someone whose job was to take a hand written application and put it in the computer system. This new hire saw about 10 applications in a row with almost identical information. She could have chosen to take the easy path and process them. But this person did not. She asked a question, and her doing so identifies the firm as one with a strong risk culture. The pattern did not pass the "smell test". It just didn't look right and the manager was called in. This new hire had caught a fraudulent act and saved her employer a lot of money.

Once risks have been identified, a conscious process should determine how to deal with them. Hopefully this discussion takes place before the risk has been added to the balance sheet, but that is not always possible. Options include:

1. Accept (retain) the risk – this decision should be made as a holistic decision, looking at the overall impact on the risk profile of the entity, as well as on a marginal basis
2. Transfer the risk – find a counterparty that will accept the risk for a premium (note that counterparty risk has been added when you do so)
3. Avoid the risk – the entity can consciously decide not to enter a line of business or can decide to exit that line
4. Reduce the risk – many operational risks can be reduced with minor effort, such as signs reminding employees of the importance of washing their hands, or through formal controls that monitor a process

Learning Outcome 2A

The candidate will be able to: demonstrate how each of the financial and non-financial risks faced by an entity can be amenable to quantitative analysis including an explanation of the advantages and disadvantages of various techniques such as Value at Risk (VaR), stochastic analysis and scenario analysis.

RESOURCES

- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Chapter 14, Quantifying Particular Risks
- *Value-at- Risk*, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007
  - Chapter 5, Computing VaR, Sections 5.1-5.3 (primarily discussed with LO-3)
- Risk Appetite: Linkage with Strategic Planning Report (primarily discussed with LO-4)

Understanding the value and shortcomings of metrics and tools will lead to information being used to add value. Problems arise when modelers create results but lose control of the process. When a single number is produced, no matter what caveats are presented, that number tends to take on a life of its own. Board members are rarely mathematicians and rely, perhaps too much, on those who are. In this section you will consider the pros and cons of the Value at Risk metric, and be introduced to other similar metrics, while also considering methods to analyze parameter risk.

REQUIRED MATERIAL

Sweeting Chapter 14 covers a wide range of topics. Included here are a few comments designed to help pull concepts together. The fact that particular topics are singled out here should not be considered reflective of their importance for the exam (this is true throughout the courseware document).

The bootstrapping technique, used to derive the spot rate curve from a yield curve, is a valuable and commonly used technique. Knowing how to go back and forth between the spot curve, forward curves and yield curves is not hard mathematically, but a greater depth of knowledge is gained when the risk manager goes beyond the math and understands the implications of a steep or inverted curve.

Liquidity risk has historically been evaluated qualitatively using a normal, liquid, market. The financial crisis in 2008 showed this to be insufficient as several risks that were normally independent acted in unison and markets lost liquidity. This resulted in stress testing being more commonly used to test liquidity risk. A trading book has short-term assets and liabilities, thus the time horizon tested is correspondingly short. For financial institutions with

a longer duration of liabilities, the time horizon should extend to a longer period while still reflecting a stressed scenario.

SUPPLEMENTAL MATERIAL

The VaR metric was originally designed to measure trading positions. Trading markets are considered to be liquid, so the appropriate time horizon is very short. In an evolving debate, as longer lived liabilities are measured there is a need for a longer time horizon. Whether the appropriate time horizon is measured in months, years, or decades is worth thinking about. No one answer is correct, but knowledge of the assumptions used in the testing is necessary to interpret the results.

Learning Outcome 2B

The candidate will be able to: evaluate how risks are correlated, and give examples of risks that are positively correlated and risks that are negatively correlated

RESOURCES

- *Value-at- Risk*, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007
  - Section 9.3, Modeling Correlations pages 232-236 (also a resource for LO-3)
- ERM-101-12: Measurement and Modeling of Dependencies in Economic Capital, Chapter 4 (also a resource for LO-5)

REQUIRED MATERIAL

When aggregating risks, correlations are what allow models to consider multiple risks without having to calculate every possible combination or perform stochastic on stochastic analysis. Negative correlations can provide a hedge, and less than perfectly positive correlations provide diversification benefits. During a financial crisis correlations tend to move higher, but this differs based on the actual event that occurs. Modeling of this phenomenon is currently evolving, increasingly so following the financial crisis of 2008. These changing correlations should be tested to see their impact on objectives. This is an important consideration when calculating economic capital, as regulators do not want to allow capital requirements that are too small for a stress scenario and internal capital managers do not want to deal with a procyclical capital requirement during a crisis.

Learning Outcome 2C

The candidate will be able to: analyze and evaluate risk aggregation techniques, including use of correlation, integrated risk distributions and copulas.

RESOURCES

- ERM-103-12: Basel Committee - Developments in Modelling Risk Aggregation, pages 76 -87
- ERM-101-12: Measurement and Modeling of Dependencies in Economic Capital, Chapters 4-5 (also a resource for LO-5)
- *Value-at- Risk*, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007
  - Chapter 7, Portfolio Risk: Analytical Methods (primarily discussed with LO-3)

One of the tools being used in models to aggregate risks is copulas. They allow correlations to vary, unlike previous static approaches like Variance-Covariance techniques. This means correlations can be different in the tail than other parts of the distribution. While the techniques are generally technical, copulas are discussed in several places in this syllabus, which will help the candidate gain expertise in this method.

REQUIRED MATERIAL

In the Basle Committee on Banking Supervision (BCBS) paper, Developments in Modelling Risk Aggregation (pages 72-89 are reproduced as ERM-103-12), methods of using copulas are shared. These methods require simulation, but provide a process for doing so effectively. A good way to think about copulas is that of a function mapping a Euclidean cube $[0,1]^n$ to the interval [0,1]. Along with other requirements, the multivariate distribution function must be non-decreasing in each component in order to define a unique copula.

Several types of copulas are commonly used, and ease of use and capabilities must be balanced between them. The Gaussian and t copulas are easier to simulate than the Archimedian family of copulas, but tail dependence and symmetry above two dimensions can only be combined using Archimedian copulas.

Another aggregation method is to combine results from common scenarios, being careful to identify the risk drivers for the unique portfolio being tested.

Candidates should understand the important distinction between dependence and concordance. Two variables can be associated with each other through concordance. They may not directly (or indirectly) influence each other, but both might be influenced by a third variable. Graphically you can see that the two variables move in similar ways. To show dependence one variable must influence the other, either directly or indirectly. Risk management techniques are often driven by results in the tail, driven by scenarios that do

not happen very often but which, when they do, are material to stated objectives. Risks tend to concentrate in the tail, so understanding how this might work proactively looking forward provides great information that can improve decision making.

Learning Outcome 2D

The candidate will be able to: apply and analyze scenario and stress testing in the risk measurement process.

RESOURCES

- ERM-120-14: IAA Note on Stress Testing and Scenario Analysis (page 1-6 and 14-17)

In Subsection 2D, the candidate is introduced to scenario and stress testing. These processes involve deterministic scenarios where you consider specific scenarios and how they impact a base set of objectives. Telling a story about how a specific risk impacts a business is much more intuitive than methods that overwhelm the reader with data.

Several analytical methods should be considered when looking at opportunities and testing risk mitigation strategies. Some are qualitative, highlighted by the popular “what keeps you up at night?” query. Others are quantitative. Generating a value to be used for regulatory economic capital is one example, as is a one year projection of a firm’s financial statements. Methods range from a full stochastic approach that generates variables like interest rates, equity and claims using statistical methods to deterministic projections designed around a single risk or opportunity. Best practices use a combination of these tools, and presentation style can be important. You will find that many senior managers prefer to see large amounts of data presented graphically, but some still prefer the numbers. You need to have both and be comfortable presenting across both styles.

REQUIRED MATERIAL

Deterministic scenarios tell a story. The goal may be to test the sensitivity of a single assumption or to recreate conditions that happened in the past. ERM practitioners need to be comfortable sharing results with board members, senior managers, or other stakeholders who do not have extensive technical training. This is where the ability to tell a clear story, supported by your modeling efforts, can make your work valuable. Relating the event to something familiar to them can be advantageous. While few still working remember the depression or have personally survived a natural disaster, developing a scenario based on a large drop in the stock market or an earthquake/flood can help the risk manager share the importance of the model results. These scenarios might even derive from a negative

outcome; the risk manager can reengineer the causes of a potential insolvency or what could cause the entity's rating to drop below an acceptable level. Stochastic analysis will not make this point as well. A single scenario can get lost in the details when hundreds, thousands, or millions of scenarios are generated.

Reading ERM-120-14, the IAA Note on Stress Testing and Scenario Analysis, builds a foundation for understanding different types of scenarios and how they can be used in economic capital modeling and stress testing analysis. The analysis can be challenging depending on the size of the company, the manner in which economic capital is determined and/or the type of stress testing scenario(s) used.

Distinctions are made between a scenario, a stress test and sensitivities, as these terms are sometimes used interchangeably. The final pages of this reading walk through different types of scenarios, the context in which they should be used and the degree of difficulty in constructing, validating and explaining results to senior management.

Learning Outcome 2E

The candidate will be able to: evaluate the theory and applications of extreme value theory in the measuring and modeling of risk.

RESOURCES

- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Chapter 12, Extreme Value Theory
- *Value-at- Risk*, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007
  - Chapter 5, Computing VaR, Sections 5.1-5.3 (also a resource for LO-3)
- Modeling Tail Behavior with Extreme Value Theory, *Risk Management*, Sept. 2009

REQUIRED MATERIAL

Section 2E introduces the candidate to extreme value theory as it is used to analyze the tails of distributions. The focus of ERM tends to be in the distribution's tails, recognizing that low frequency, high severity events can impact entity survival. The lack of historical data, and the potential for results in the tail to act differently than the rest of the distribution, makes this a very challenging exercise. Sweeting Chapter 12 is short, but the material provides an important base for other learning outcomes. The generalized extreme value (GEV) distribution focuses on the highest value for each of several tranches, and the parameters describe the general characteristics of the statistical distributions. The example shown in Figure 12.3 of Sweeting is very helpful in understanding the general concept. The generalized Pareto distribution also describes the tail of a distribution.

Now we turn to an article from *Risk Management* magazine (September 2009) titled Modeling Tail Behavior with Extreme Value Theory. This provides the statistician tools to segment the distribution and separate the tail above a threshold point from the rest of the distribution. This allows consideration of fat tails and could be used in a regime switching generator where the generator "jumps" between two distributions. At the end of the paper the author refers to EVT as a tool that works well in conjunction with the Delphi method. Delphi uses a panel of experts, and a series of questionnaires that continues until the panel's results have stabilized. The panel does not have to reach consensus, and reasoning is defended and shared anonymously by a facilitator so no one dominates the discussion through their personality or stature. The questionnaire does not change between rounds.

Learning Outcome 2F

The candidate will be able to: analyze the importance of tails of distributions, tail correlations, and low frequency / high severity events.

RESOURCES

- ERM-101-12: Measurement and Modeling of Dependencies in Economic Capital, Chapters 4-5 (also a resource for LO-5)
- SOA Monograph, A New Approach to Managing Operational Risk, Chapter 8 (primarily discussed with LO-4)
- Summary of "Variance of the "CTE Estimator", *Risk Management*, August 2008 (primarily discussed in LO-3)

When a risk manager looks at a single risk (silo), the methods tend to be targeted toward that risk. When focused on credit risk there is no assumption for human mortality, and when you quantify the risk of a Treasury bond there is no need to include an equity generator. This makes the model run faster and makes the most sense. As the risks need to be assembled and aggregated, the risk manager will need to learn how to manage the process. Balancing the need for detail against the need to meet the project deadline should be considered in advance. In this subsection the candidate will learn about some methods used when aggregating results in a realistic manner, along with some of the issues to consider.

REQUIRED MATERIAL

This subsection covers study note ERM-101-12, based on a seminar presented in the United Kingdom. Scenario generators create a particular challenge because they drive processes that are relied on by non-modelers who do not understand the competing options. First are models that proxy natural laws and are used to dynamically model risks such as pandemics and earthquakes. A second model category uses historical observations to fit a model. This is used for many financial processes, such as equity prices and interest rates.

The third category combines the first two, mixing physical with theoretical processes. When aggregating risks, global scenarios are developed to be used across all portfolios. The risk manager must consider if the scenarios are independent or if analysis of the risk interactions is required. Interpretation and communication of the results, looking at extreme scenarios in isolation as well as the entire range of results, provides information that can be used to make good decisions.

To help you understand the trade-offs between various aggregation methods, take some time to think about

- Model accuracy
- Methodology consistency
- Numerical accuracy
- Availability of data
- Intuitiveness (ease of communication)
- Flexibility
- Resources

Once you know your objectives and what you are trying to accomplish, you can choose the best tool for that purpose.

Just because a computer-based statistical package tells you there is a relationship between two variables, that is not the end of the discovery path; it is just the beginning as then you must determine if one of the variables is dependent on the other or simply a spurious relationship where there is no causal relationship. This is one of the most challenging aspects of modeling, as the risk manager must determine if there is a causal relationship or if perhaps there is a third variable driving both. Sometimes the answer is obvious, but often an indirect or complex relationship is present. The Anscombe's Quartet illustrates this concept and points out the importance of viewing data from various perspectives. Here the statistics (e.g., mean, variance, and correlation) are the same across four data sets, but when you look at graphs of the data it is clear that they do not come from the same underlying distribution.

Risk managers are asked to model potential results both during "normal" periods and when the results are in the tail. Tail dependency is reflected in normally independent risks that become dependent after an extreme event (or series of events), such as the 9/11 World Trade Center attack, occurs.

Copulas are an increasingly important tool used by practitioners to combine silo risk metrics with tail dependence to describe risk concentrations in parts of the distribution where the results are material. Be sure to note the Sweeting Section 10.4 errata as you study this material (some printings have already incorporated the errata).

When aggregation occurs across scenarios that are not fully correlated, meaning there are times when the results do not move in the same direction and at the same speed, diversification benefits are anticipated. The risk manager should consider the validity of this assumption given that during periods of stress many financial instruments move together that would not do so during normal periods. Factors used for correlation are often based on very short periods of time, so can move to a more risky status very quickly right at the time an entity may be looking for relief. As an example, if capital requirements include the benefits of diversification then the model might be pro-cyclical. One occurrence of this phenomenon was late in 2008 when financial market uncertainty expressed itself in a liquidity crisis and nearly all asset classes became more correlated. This can also occur when positive events lower perceived volatility and higher, correlated, returns are the result. Some practitioners and regulators use the simple summation method to avoid this risk, adding together the results from each silo risk. This can be a useful sensitivity test, but the risk manager should make sure that consistent scenarios were used across all risks.

Supporting material focused on operational risk is also included in this section because of the potential for low frequency / high severity events in the operational arena. Chapter 8 of the SOA Monograph on Operational Risk presents approaches that can be useful in modeling this risk, which is often considered difficult to quantify.

SUPPLEMENTAL MATERIAL

An interesting sidebar to the aggregation discussion is that, when collecting data across a broad historical period and reporting a single correlation result, the correlations will generally be larger in both tails. The correlations for the data in the middle of the distribution will generally be lower. Practitioners often increase the tail correlations where results are negative while maintaining the overall correlation elsewhere for conservatism.

Learning Outcome 2G

The candidate will be able to: analyze and evaluate model and parameter risk.

RESOURCES

- ERM-104-12: Study note on Parameter Risk, Venter and Sahasrabuddhe
- ERM-117-14: American Academy of Actuaries Practice Note: Insurance Enterprise Risk Management Practices (pages 4-26)
- ERM-118-14: Model Validation Principles Applied to Risk and Capital Models in the Insurance Industry

REQUIRED MATERIAL

When an assumption is made regarding a model parameter, the user must understand how credible that value is and what biases it might possess. Study note ERM-104-12 addresses this topic. The sources of uncertainty include samples, data, models and modeler error (where we do not recognize an important driver and fail to incorporate it in the model, or when we recognize as important an irrelevant piece of information).

The reading ERM-118-14 summarizes important model validation principles for risk and capital models.

The reading also presents a comprehensive model risk management framework to provide a broader context for the model validation process. The comprehensive model risk management framework includes (i) model development, (ii) model validation, (iii) model governance, and (iv) model use.

Learning Outcome 2H

The candidate will be able to: construct approaches to modeling various risks and evaluate how an entity makes decisions about techniques to model, measure and aggregate risks including but not limited to stochastic processes.

RESOURCES

- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Section 15.5, Unquantifiable Risk (also a resource for LO-3)
- *Value-at- Risk*, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007
  - Chapter 12, Monte Carlo Methods (primarily discussed with LO-3)
- ERM-602-12: *Investment Management for Insurers*, Babbel and Fabozzi, Chapter 11, The Four Faces of an Interest Model (also a resource for LO-3)
  -
- ERM-119-14: Aggregation of Risks and Allocation of Capital (Sections 4-7, primarily discussed in LO-5)
- Readings from the earlier subsections in Section 2 also support this learning outcome. As the final subsection in this section, this Learning Outcome has been discussed throughout the section.

In this subsection the readings look at some primary risks and how a risk manager can analyze those using qualitative techniques.

REQUIRED MATERIAL

When it is impossible to generate quantitative analysis that is credible, a framework for qualitative scenario analysis can be developed based on practical experience and best guesses. A risk map can rank a risk using likelihood/frequency and impact/severity, ranking from unlikely to very likely, and low impact to high impact. Some sources refer to this as fuzzy logic.

The learning outcome in this subsection asks candidates to draw from the previous subsections of Section 2 and the sources that have already been reviewed. Considering what you have learned about risk models and aggregation, you should now be in a position to develop appropriate approaches when faced with a specific situation, or to evaluate the choices an entity has made about modeling and measuring its risks. As discussed in Sweeting, this analysis should utilize a balance of quantitative and qualitative methods.

The other sources provide some further examples in support of the modeling of risks. ERM-602-12 looks at a particular type of risk, interest rate movements, and discusses how to choose an appropriate model based on the use to which it will be put. Chapter 12 of Jorion introduces Monte Carlo simulation techniques; those approaches will be discussed more thoroughly in the next section.

Section 3: Risk Measures

Learning Objective and Outcomes

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

OUTCOMES: The candidate will be able to:

A. Apply and construct risk metrics to quantify major types of risk exposure such as market risk, credit risk, liquidity risk, operational risk, regulatory risk, etc., and tolerances in the context of an integrated risk management process
B. Analyze and evaluate the properties of risk measures (e.g., Delta, volatility, duration, VaR, TVaR, etc.) and their limitations
C. Analyze quantitative financial market data and insurance data (including asset prices, credit spreads and defaults, interest rates, incidence, causes and losses) using modern statistical methods. Construct measures from the data and contrast the methods with respect to scope, coverage and application
D. Analyze risks that are not easily quantifiable, such as operational and liquidity risks

Resources

- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Chapter 9, Some Useful Statistics (Background only)
  - Section 15.5, Unquantifiable Risks (primarily discussed with LO-2)
- *Value-at- Risk*, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007
  - Chapter 5, Computing VaR, Sections 5.1-5.3 (also a resource for LO-2)
  - Chapter 7, Portfolio Risk: Analytical Methods (also a resource for LO-2 and LO-4)
  - Chapter 9, Forecasting and Risk Correlations (Section 9.3 is also a resource for LO-2)
  - Chapter 12, Monte Carlo Methods (also a resource for LO-2)
  - Chapter 13, Liquidity Risk (also a resource for LO-1)
  - Chapter 18, Credit Risk Management (excluding Appendices) (also a resource for LO-4)
- ERM-102-12: Value-at-Risk: Evolution, Deficiencies, and Alternatives
- ERM-105-12: Coherent Measures of Risk – An Exposition for the Lay Actuary - Glenn Meyers
- ERM-702-12: International Actuarial Association Practice Note: Enterprise Risk Management for Capital and Solvency Purposes in the Insurance Industry (pages 9-38, also a resource for LO-1)
- Summary of “Variance of the CTE Estimator,” *Risk Management*, August 2008
- ASOP 23: Data Quality, pages 1-8

This section focuses on the quantitative approaches to measuring specific types of risk, describing metrics such as Value at Risk (VaR) and TailVaR. There are many alternative methods used by practitioners to measure and manage risk, covering a range of deterministic and stochastic assumptions. Extreme events, in the tail of a distribution, are especially tricky to evaluate and this section shares tools developed to analyze those outcomes where correlations change and liquidity becomes in short supply. The actuary must also comply with any regulatory requirements and stay current with standards of practice for the profession in the location where he practices. An example is the Actuarial Standards of Practice (ASOPs) promulgated by the Actuarial Standards Board in the United States.

Subsection A: Here you will read three chapters from the Jorion text (Chapters 5, 7 and 13). Several readings throughout the syllabus cover metrics, generally with a focus on VaR (note that the Jorion text uses VAR). Each reading provides unique information about the metric and how it can be used. Here you should read the chapters in the order listed, with 5 and 7 showing how to extract information from the VaR metric and 13 covering the two forms of liquidity risk. You've already reviewed parts of chapters 5 and 7 in Section 2.

Subsection B: As noted in Section 2 it is key in risk measurement to utilize multiple metrics, while understanding the strengths and limitations of each. The primary textbook in this course focuses on VaR, but it is important to be familiar with other measures. The Value at Risk study note (ERM-102-12) introduces you to some alternative metrics that you will need to be able to use. You should also ALWAYS graph the data to look for outliers and patterns. A visual, qualitative, review of the data can help to determine the best way to quantify the risks. Additional readings are the Coherent Measures of Risk study note (ERM-105-12), which details the requirements of coherence and applies it to the VaR metric, and Summary of "Variance of the CTE Estimator," which provides a method of estimating the accuracy of a CTE calculation.

Subsection C: Sweeting Chapter 9 is mentioned here as background reading as it provides a nice review of some basic statistical definitions and distributions. Make sure you are aware of its contents for future reference. In Jorion Chapter 9 (you read section 9.3 earlier) you are introduced to methodologies used when volatility is not constant. Then, in Chapter 12, ways to implement Monte Carlo methods are shared. ASOP 23 on Data Quality is also covered here.

Subsection D: Jorion Chapter 18 covers credit risk in isolation from other risks. It could easily have been placed in Section 2 where we viewed other silo risks, but has been placed here to be consistent with the order in which the global CERA learning objectives are presented. You can skip the Appendices in Jorion Chapter 18.

Learning Outcome 3A

The candidate will be able to: apply and construct risk metrics to quantify major types of risk exposure such as market risk, credit risk, liquidity risk, regulatory risk, etc., and tolerances in the context of an integrated risk management process.

RESOURCES

- *Value-at- Risk*, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007
  - Chapter 5, Computing VaR, Sections 5.1-5.3
  - Chapter 7, Portfolio Risk: Analytical Methods (also a resource for LO-2 and LO-4)
  - Chapter 13, Liquidity Risk (also a resource for LO-1)
- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Section 15.5, Unquantifiable Risks (primarily discussed with LO-2)

REQUIRED MATERIAL

Value at Risk, described in Jorion Chapter 5, is the metric required by the international banking community. As with any useful metric, it has shortcomings. The risk manager should always utilize a variety of graphics and metrics when making decisions so the choice of tool does not drive the resulting recommendations. Since this particular metric has been "blessed" by its use in standardized capital requirements for banks by the Basel Committee on Banking Supervision (BCBS), Boards tend to give the results a high level of credibility. VaR is used for both regulatory capital calculations and internal calculations of capital needed. One challenge is common to both internal and external calculations. Many risk managers have found that reporting a draft result, reported as a single number, is very difficult to modify. The risk manager should also recognize that a result reported with many significant digits is often perceived to have more precision than can be justified. Using confidence bands around the VaR estimates can help communicate the true nature of the result.

The VaR calculation is straightforward. Determine the time horizon, generate the scenarios, calculate the results, sort the results, and determine the level that will be reported based on the appropriate degree of risk aversion. The Basel Committee imposes a 99% confidence level over a 10-business-day horizon, and then multiplies the result by a safety factor of 3. Many entities use this confidence level to target a specific credit rating. There are some obvious caveats regarding this process. The model must represent reality. That's not possible in the extreme. As George Box, a statistics professor at the University of Wisconsin said, "All models are wrong, but some are useful." You do the best you can and note the issues you are aware of. The model should be peer reviewed to get an outside opinion. Make sure you have enough data points beyond the point of interest; you need a lot more

scenarios to look at the 99.9% level than the 95% level. As the point of interest gets further into the tail, a parametric normal distribution becomes less appropriate.

An interesting variation from traditional VaR analysis, where only cumulative losses at the horizon are considered, is to calculate maxVAR, defined as the worst loss at the same confidence level but during the horizon period. VaR considers results only at the end of the time horizon. MaxVAR will always be at least as large as the VaR result.

The quote attributed to Desiderius Erasmus that leads off Jorion Chapter 7, "Trust not all your goods to one ship", has been used by many risk managers to provide a short definition of risk management. It embodies the concept of diversification and leads most who hear it to think about other risks in critical ways. Studying how a metric like VaR changes as the risk profile changes helps an entity make better decisions. What is the marginal impact of expanding a line of business or ceasing to add to a specific product line? Does it provide benefits of diversification or employ wrong-way risk as studied in Section 2? Do the changes interact as the risk manager anticipated qualitatively in advance of the model being run? Did the model act as expected? This type of analysis almost always leads to an improved model.

SUPPLEMENTAL MATERIAL

Historically the United States insurance industry has calculated capital requirements based on a covariance calculation assuming less than perfect correlation between the component risk charges. For this example, which is similar to but not the same as the actual U.S. Risk-Based Capital formula, let's assume a simplified 3 risk model. The formula recalls the Pythagorean Theorem, where the lengths of the sides of a right triangle satisfy the equation $a^2 + b^2 = c^2$ (where *c* is the length of the hypotenuse, *a* and *b* are the lengths of the other two sides). Geometrically, you can think of this example as expanding the Pythagorean Theorem to 3 dimensions.

$$Capital = \sqrt{R1^2 + R2^2 + R3^2}$$

If you assume that each risk (R1, R2 and R3) has 1,000 units of capital, then the overall capital requirement is 1,732, much lower than the 3,000 that would be held if no diversification benefits were assumed. Note that the Basel Committee would base the capital requirement at 3,000 of capital as they do not allow for diversification benefits. (It should be noted that the discussion is ongoing in this regard.) In normal times diversification is prevalent, but in stressed situations correlations tend to increase materially.

Back to our example, if 100 units of risks are added to R1, the overall capital requirement increases from 1,732 to 1,792 (an increase of 3.5% while undiversified capital increased from 3,000 to 3,100 or 3.3%). An increase of 100 units of risk within a component leads to

an overall increase of 60 units of risk due to diversification. This is the type of analysis behind marginal VaR and incremental VaR.

An important definition regarding operational risk is that expected losses are not considered part of economic capital, only unexpected losses, measured at a given confidence level. Methods of measuring operational risk continue to evolve using parametric and nonparametric methods, continuous and discrete events, and various assessment tools. This is one risk category where positive outcomes do not exist. Unless you are an insurance company writing coverage, there is no upside opportunity. Due to cost constraints an entity might choose not to mitigate an operational risk, but they do not consciously try to increase their operational risk profile. Operational risks should be managed by looking at the gross exposure, the cost of mitigation, and the resulting net exposure. Operational risks frequently combine with other risks (e.g., the lack of controls at Barings Bank allowed Nick Leeson to take financial risks) which can make it hard to quantify them in isolation.

Learning Outcome 3B

The candidate will be able to: analyze and evaluate the properties of risk measures (e.g., Delta, volatility, duration, VaR, TVaR, etc.) and their limitations.

RESOURCES

- ERM-102-12: Value-at-Risk: Evolution, Deficiencies, and Alternatives (also a resource for LO-2 and LO-5)
- ERM-105-12: Coherent Measures of Risk – An Exposition for the Lay Actuary, Glenn Meyers
- Summary of "Variance of the CTE Estimator," *Risk Management*, August 2008

REQUIRED MATERIAL

The Vozian study note on Value at Risk (ERM-102-12) is a very balanced paper. It presents VaR, with all its positive characteristics and its shortcomings. It is easy to overlook the degree to which the VaR metric has become established in the banking world. The international regulatory regime for banks relies on VaR as a useful metric for measuring capital requirements. By estimating the loss that a firm could incur with a certain probability during a certain period of time under normal market conditions, an analyst can use VaR to take that first step toward quantifying risk. Using the properties of coherence, a drawback to VaR is its lack of sub-additivity. This means you can't add together the resulting metric from multiple risks and get a useful result.

The easiest analytical tool is to graph the results. This will help you determine where to focus your analysis; acknowledging if the tails look fat, if the distribution appears to be normal, or if there are discontinuities will speed the information gathering process.

While VaR is set at a specific percentage, and results at other levels are not considered of interest, measures such as Expected shortfall (also called CTE conditional tail expectation or TailVaR) look at the results beyond a specific percentage. The CTE metric is coherent, which makes it easier to work with across multiple risks, and is often utilized by insurers. Other metrics are described in the study note.

This learning outcome has been covered in part by readings reviewed in earlier sections, but the Coherent Measures of Risk study note (ERM-105-12) does a nice job incorporating an example to help the candidate understand the nuances of coherence. It shows how Value at Risk and standard deviation fail to be coherent and then shows how TailVaR (also called Tail Conditional Expectation TCE, Expected Shortfall ES, Conditional Tail Expectation CTE) meets the requirements.

In Summary of "Variance of the CTE Estimator," published in the August 2008 *Risk Management* newsletter, the authors summarize their 2005 paper from the North American Actuarial Journal. The article suggests using variance reduction techniques and a practical process called variance verification to keep sample sizes manageable. This reflects one of the modeler's great balancing acts, additional run-time versus accuracy.

Learning Outcome 3C

Analyze quantitative financial market data and insurance data (including asset prices, credit spreads and defaults, interest rates, incidence, causes and losses) using modern statistical methods. Construct measures from the data and contrast the methods with respect to scope, coverage and application.

RESOURCES

- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Chapter 9, Some Useful Statistics (Background only)
- *Value-at- Risk*, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007
  - Chapter 9, Forecasting and Risk Correlations (section 9.3 is also a resource for LO-2)
  - Chapter 12, Monte Carlo Methods (also a resource for LO-2)
- ASOP 23: Data Quality

REQUIRED MATERIAL

With each financial crisis and catastrophic disaster, risk managers gain knowledge and improve the tools they have to work with. Advances in computing power have aided these efforts. During the financial crisis it became apparent that assuming stable volatility was insufficient when measuring risk deep in the tails of a distribution. Volatility tends to cluster. During normal times the correlations between risk variables may be modeled as

independent processes, but during a crisis lack of information can drive fear and reduce liquidity. This combination of changing volatility and changing correlations, especially when both are increasing simultaneously, can be very hard in practice to model. In Jorion Chapter 9 the candidate is presented with several tools that can be used to adjust estimated volatility in a model using historical data, from a simple moving average to GARCH (generalized autoregressive conditional heteroskedastic) and exponential models that give more weight to recent information.

One of the issues to keep in mind with models is the goal of economic capital. It is designed to provide a buffer for unexpected losses. If a model automatically adjusts for increasing volatility and increasing correlations, then the economic capital result will increase just as the crisis is hitting and the buffer is needed. This is called procyclicality. Some of the current regulatory capital requirements attempt to address this procyclicality by adding an additional buffer during stable periods so an upsurge in volatility does not immediately raise the capital requirement.

Using Monte Carlo and quasi-Monte Carlo methods to build stochastic scenarios is a key to understanding the risks inherent in many complex financial instruments. These methods depend on computer capacity and balance complete models with approximations. Various sampling techniques are described in Jorion Chapter 12. These can reduce run-time but must be understood. For example, one simulation technique results in scenario sets that are 2^n-1, so for n starting at 3 the results are 7, 15, 31, 63, etc. If you are using a metric that looks at the worst 1% of scenarios you need to have enough data points to be comfortable with the results.

Risk-neutral distributions are used for pricing derivatives, while physical, or object, distributions are used for risk measurement. Make sure you understand this distinction.

Since actuaries rely on data in order to construct their risk measures, the issue of data quality remains at the forefront. ASOP 23: Data Quality reminds candidates of the actuarial standards applicable to the selection and use of data underlying their models.

Learning Outcome 3D

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

RESOURCES

- *Value-at- Risk*, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, 2007
  - Chapter 18, Credit Risk Management (excluding Appendices) (also a resource for LO-4)

- ERM-702-12: International Actuarial Association Practice Note: Enterprise Risk Management for Capital and Solvency Purposes in the Insurance Industry (pages 9-38, also a resource for LO-1)

REQUIRED MATERIAL

Credit risk at financial institutions is often the largest exposure, so it is appropriate to focus on some of the basics here. Models can get very complex as the risk manager expands the model from deterministic to stochastic using assumptions of the probability of default (PD), exposure at default (EAD), and the loss given default (LGD). The portfolio approach to credit risk incorporates interactions between market movements and correlations across defaults. Defaults tend to cluster, with years of benign results followed by a flurry of defaults. While calculating the mean result is useful, understanding the worst case helps the risk manager address any solvency issues. Risk managers should understand the different risk exposures accepted when credit risk mitigation tools are used, as old risks are reduced but new counterparty risks created.

As is true with other components of economic capital, a buffer is set aside to cover unanticipated credit losses. This is called the equity reserve. Loan-loss reserves are developed to cover expected credit losses.

Economic capital can be a useful tool when making decisions about risk exposures. For example, using incremental risk metrics (change in VaR when the position is eliminated from the portfolio) the risk manager can identify outliers that add risk and determine if the potential returns justify that risk. By using the same metric as is used to determine economic capital you can easily see that result. This process can be layered with other risks and provides a nice tool to prioritize risk mitigation efforts.

Section 4: Risk Management Tools and Techniques

Learning Objective and Outcomes

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

OUTCOMES: The candidate will be able to:

A. Demonstrate and analyze applicability of risk optimization techniques and the impact of an Enterprise Risk Management strategy on an organization's value. Analyze the risk and return trade-offs that result from changes in the organization's risk profile.
B. Demonstrate means for transferring risk to a third party, and estimate the costs and benefits of doing so
C. Demonstrate means for reducing risk without transferring it
D. Demonstrate how derivatives, synthetic securities, and financial contracting may be used to reduce risk or to assign it to the party most able to bear it
E. Develop an appropriate choice of a risk mitigation strategy for a given situation (e.g., reinsurance, derivatives, financial contracting), which balances benefits with inherent costs, including exposure to credit risk, basis risk, moral hazard and other risks
F. Analyze the practicalities of market risk hedging, including dynamic hedging
G. Demonstrate the use of tools and techniques for analyzing and managing credit and counterparty risk
H. Analyze funding and portfolio management strategies to control equity and interest rate risk, including key rate risks. Contrast the various risk measures and be able to apply these risk measures to various entities. Explain the concepts of immunization including modern refinements and practical limitations
I. Analyze the application of Asset Liability Management and Liability Driven Investment principles to Investment Policy and Asset Allocation
J. Demonstrate risk management strategies for other key risks (for example, operational, strategic, legal, and insurance risks)
K. Apply best practices in risk measurement, modeling and management of various financial and non-financial risks faced by an entity

Resources

- *Financial Enterprise Risk Management*, Sweeting, 2011
  - Chapter 16, Responses to Risk
- *Value-at-Risk: The New Benchmark for Managing Financial Risk*, Jorion
  - Chapter 7, Portfolio Risk: Analytical Methods (primarily discussed with LO-3)
  - Chapter 18, Credit Risk Management (excluding Appendices) (primarily discussed with LO-3)

- ERM-107-12: Strategic Risk Management Practice, Andersen and Schroder, 2010
  - Chapter 7, Strategic Risk Analyses
  -
- ERM-110-12: Derivatives: Practice and Principles, Recommendations 9-24 and Section III
- ERM-111-12: Key Rate Durations: Measures of Interest Rate Risks
- ERM-112-12: Revisiting The Role of Insurance Company ALM within a Risk Management Framework (also a resource for LO-5)
- ERM-114-13: Introduction to Reinsurance, Wehrhahn (excluding all Annexes)
- ERM 115-13: Creating an Understanding of Special Purpose Vehicles, PWC
- ERM-117-14: American Academy of Actuaries Practice Note: Insurance Enterprise Risk Management Practices (pages 4-26)
- ERM-122-14: Chapter 1 of *Captives and the Management of Risk*, Kate Westover
- ERM-124-15: Counterparty Credit Risk: The New Challenge for Global Financial Markets, Ch. 2, Defining Counterparty Credit Risk
- ERM-702-12: International Actuarial Association Practice Note: Enterprise Risk Management for Capital and Solvency Purposes in the Insurance Industry (pages 9-38, also a resource for LO-1 and LO-3)
- SOA Annual Meeting – Session 53 – Assumption Setting Best Practices, Towers Watson (Steiner slides only, also a resource for LO-5)
- SOA Monograph, A New Approach to Managing Operational Risk, Chapter 8 (also a resource for LO-2 and LO-5)
- Risk Appetite: Linkage with Strategic Planning Report (also a resource for LO-2 and LO-5)

Understanding a risk has value, but is only a precursor to managing the risk. In this section the candidate will learn about tools available for risk mitigation and risk optimization. While Section 3 shared general methods to manage risks, in Section 4 specific methods utilized by practitioners are shared that relate to a variety of risks. This section also begins the transition to the strategic aspects of risk management. There are quite a few subsections in this Learning Objective. Many of the syllabus sources in this section overlap with reading in this and other sections. Keep in mind that the Learning Outcomes have been aligned with the Global CERA objectives, and that many of the readings assigned cover multiple Learning Outcomes. Let's walk through them now.

Subsection A: Asset/Liability Management, in the context of an insurance company, is a broad-based tool applicable in many circumstances. It is introduced in study note ERM-112-12 and shows how ALM can be used to mitigate risk as well as optimize returns relative to risk preferences. Real life education learned during the financial crisis that helps practitioners work with competing stakeholder goals and a challenging liquidity environment is shared in a life insurer case study. The concepts in the paper Risk Appetite: Linkage with Strategic Planning are also important considerations in risk optimization.

Subsection B: One method of transferring risk to a third party is reinsurance, and this practice is developed in Introduction to Reinsurance (ERM-114-13). Creating an Understanding of Special Purpose Vehicles (ERM-115-13) discusses an alternative method of risk transfer. These examples show the importance of understanding both the accounting requirements and the economic ramifications of the transaction, as they are not always aligned.

Subsection C: Material discussing this Learning Outcome was covered elsewhere in the syllabus. Internally based risk reduction methods were discussed in Sections 2C and 3D, where correlations and dependencies were analyzed.

Subsection D: This is one of several learning outcomes that relate to hedging of risk using derivatives or other synthetic securities. Section III of the study note, ERM-110-12, Derivatives: Practice and Principles, pulled from the Group of Thirty report, supports this learning objective, along with the sources discussed above in Subsection B.

Subsection E: Most of the material discussing this Learning Outcome has been covered elsewhere in the syllabus. Hedging is discussed in several other places in this section of the syllabus. These include Sweeting Chapter 16 Responses to Risk, and the Derivatives Practice note (ERM-110-12). The new reading for this Learning Outcome is Chapter 1 of *Captives and the Management of Risk* (ERM-122-14).

Subsection F: Dynamic hedging is discussed in Sweeting Chapter 16 and in Section III of ERM-110-12.

Subsection G: Sections 9-24 of ERM-110-12, Derivatives: Practice and Principles, discuss derivative credit risk (counterparty risk). You previously studied Jorion Chapter 18 on Credit Risk Management which covers parts of this learning outcome..

Subsection H: In addition to Sweeting Chapter 16, which has been referenced above, study note ERM-111-12, Key Rate Durations: Measures of Interest Rate Risks, provides an in-depth look at measuring interest rate risk. You also studied, in section 3, the Value-at-Risk study note (ERM-102-12) that contrasts various risk measures and how they can be used to tease information out of data. Chapter 7 of Jorion, previously discussed in Section 3, focuses particularly on analysis of portfolio risk.

Subsection I: In Subsection A you read study note ERM-112-12, Revisiting the Role of Insurance Company ALM within a Risk Management Framework. This paper shares examples about the application of these techniques that provide alternatives for management to choose from based on a desired risk appetite.

Subsection J: Andersen Chapter 7 (ERM-107-12) contains a lot of information. To fully grasp it might require more than one pass. Techniques are described and then applied to a real world case study. Commonly used tools that prioritize the risk manager’s time and effort

are described across many risk classifications, helping develop proactive efforts to mitigate the impact of future events as well as deal with them as they unfold. While part of other learning objectives, several other sources also support this learning objective, including the SOA Monograph, A New Approach to Managing Operational Risk and Chapter 16 of Sweeting.

Subsection K: Best practices are set forth in ERM-117-14. This is the sole reference for this section. However, candidates should be aware that best practices are referenced throughout many of the sources supporting Section 4.

Chapter 16 of Sweeting applies to most all of the learning outcomes in Section 4. Therefore, it is not listed with any of them. The following is an overview of that chapter.

There are many ways to respond to risk. One is to do nothing, but that will either leave an entity with no business to manage or through inertia allow others to select which risks are accepted. You can expect this to maximize the proactive entity's opportunities, while potentially devastating operations at other firms.

It is better to be proactive. Chapter 16 of the Sweeting text focuses on four categories of risk response: reduce, remove, transfer and accept. These responses assume that the risk already resides on an entity's balance sheet. Avoiding a risk is another alternative, and actually the one most common. Analysis is performed for each type of risk response.

This reading has a short section on reinsurance that covers material also studied in Subsection C.

Diversification can reduce the risk of an enterprise if the individual risks are not perfectly correlated. Hedging is a subset of diversification tools. Uncertainty can be hedged, often with derivatives that reduce both gains and losses. Counterparty risks can be reduced by using margins and collateral. Some risks are hard to quantify, and for some risk mitigation techniques it is hard to perform cost benefit analysis. Reputation risk can be especially difficult to quantify.

Indirect exposures to interest rate risk can be managed using cash flow matching techniques, also discussed elsewhere in the syllabus. Sweeting refers to obligations like pension schemes or life insurance company liabilities as examples of indirect exposures.

Several other risks are discussed in the chapter, with introductions to credit default swaps (CDS) and collateralized debt obligations (CDOs) that were so much a part of the financial crisis. Systemic risk and how to deal with it continues to evolve, and each new crisis will likely add to the tool kit. As Mark Twain said, "History does not repeat itself, but it does rhyme." One tool added in the last generation of traders is the use of circuit breakers, designed to limit excessive volatility by setting rules to temporarily stop trading based on certain drops in a specific stock or index.

Operational risks comprise most of the risks at non-financial institutions and should not be ignored at financial firms that also have market and credit risk. People risk can be especially hard to manage, everything from hiring and retention to adverse selection at insurers. Whether it is potential hires, potential policy holders, or agents, the risk manager must constantly look for clues that someone might select against your firm. Potential hires might seek out firms with no drug testing policy if they expect to test positive, applicants for insurance might stretch the truth or outright lie, and agents might represent several companies and congregate to the product that pays them the most compensation.

Learning Outcome 4A

Demonstrate and analyze applicability of risk optimization techniques and the impact of an Enterprise Risk Management strategy on an organization's value. Analyze the risk and return trade-offs that result from changes in the organization's risk profile.

RESOURCES

- ERM-112-12: Revisiting the Role of Insurance Company ALM within a Risk Management Framework (also used as a resource in Subsection 4I)
- Risk Appetite: Linkage with Strategic Planning Report (also a resource for LO-2 and LO-5)

REQUIRED MATERIAL

In an Asset/Liability Management context that aids the candidate's understanding of optimization strategies, study note ERM-112-12 shares lessons learned and situations encountered during the 2008 financial crisis and how this has impacted the insurance industry's risk management framework. This period marked the first time insurers had experienced a combination of high unrealized losses, regulatory frameworks based on both economic valuations and historical statutory capital requirements, and rating agency downgrades. All this occurred while market liquidity tightened, reducing asset values as risk premiums increased and the market for subsidiaries dried up. Opportunities to de-risk included reducing equity and alternative asset classes when values were low, adding hedges with all-time high implied volatilities and low interest rates, and reinsurance although capacity was scarce. It was not an easy time to become liquid, and points out the need for proactive plans developed in advance.

The study note goes on to compare results using a variety of risk measures, showing the importance of understanding how a specific portfolio of assets and liabilities interact under different metrics and capital requirements.

The Risk Appetite paper provides a comprehensive overview of the role that risk appetite plays in an organization's ERM process. It starts by providing a framework for setting risk

tolerances, including both quantitative and qualitative considerations. Succeeding chapters demonstrate how risk appetite can, and should, impact many of the ongoing activities of the organization, including asset allocation, new business targets, and capital allocation.

Learning Outcome 4B

The candidate will be able to: demonstrate means for transferring risk to a third party, and estimate the costs and benefits of doing so.

RESOURCES

- ERM-114-13: Introduction to Reinsurance, Wehrhahn (excluding all Annexes)
- ERM 115-13: Creating an Understanding of Special Purpose Vehicles, PWC

REQUIRED MATERIAL

Reinsurance for an insurance company theoretically is a very simple concept of risk transfer. ERM-114-13 provides a good overview of the purposes of reinsurance, the types of reinsurance agreements, and the various forms of reinsurance. Read this study note first before moving on to the more complex material.

Reinsurance is very flexible, and there are many reasons to utilize this method of risk transfer. Assets can stay with the ceding company or can transfer with the liabilities. Reinsurance can be used as a form of risk mitigation or outsourcing, moving parts of the insurance contract obligations to where the expertise is located. Such “outsourcing” could be related to administrative, investment, product or market expertise, capital availability, or tax planning initiatives.

A constantly evolving marketplace supporting special purpose entities is described in Creating an Understanding of Special Purpose Vehicles (ERM-115-13). SPVs are a means of transferring risk to capital market investors, generally through some form of securitization. Following the 2008 financial crisis, SPVs have come under increased regulatory scrutiny. Companies intending to employ a special purpose vehicle as a risk transfer mechanism must be able to evaluate the liquidity, funding, and regulatory risks that the SPV poses.

SUPPLEMENTAL MATERIAL

Concentration risk comes in many forms. When attempting to reduce a risk it must be remembered that there is no free lunch. Transferring a risk exposure often adds counterparty risk, and reinsurance is a great example of this. When a person covered by a large life insurance policy dies, his claim is with the direct writer. If the reinsurer is insolvent at the time of death that does not reduce the beneficiary’s claim; thus, the direct writing insurer has added a counterparty risk bucket to its risk balance sheet.

A similar risk exposure occurs when buying a derivative. The ultimate counterparty may not be known to the buyer, as occurred when investment banks sold protection on mortgage backed securities to parties who did not know until fall 2008 that the ultimate exposure was concentrated with the AIG Financial Products Division. A rating reduction drove collateral increases for AIG, exacerbating the financial crisis.

Learning Outcome 4C

The candidate will be able to: demonstrate means for reducing risk without transferring it.

RESOURCES

This Learning Outcome has been covered in part by readings reviewed in earlier sections. In particular, ERM-111-12 and ERM-112-12 cover specific methodologies for risk reduction.

SUPPLEMENTAL MATERIAL

Many times it is not clear where a risk should be categorized as it combines multiple risks. For example, when Nick Leeson at Barings Bank covered up his trades with fake transactions, should that be considered an operational risk or a financial risk? Risk managers need to be aware that their peers may not consistently post these risks in the same categories as you or others do. Any mapping of the effects of a certain risk should use consistent definitions. Another inconsistency can occur when a risk manager is not sure where to place a risk. There may be a miscellaneous risk category, but often these risks end up in strategic risk as a catch-all.

There are many risks that can be managed internally by an organization. These include setting up risk mitigation processes to minimize risk from employees and other agents (e.g., background checks), information technology confidentiality breaches (e.g., setting up passwords), cash flow mismatch (e.g., modeling the portfolio and using results to adjust asset and/or liability portfolios), internal hedges of liabilities, or regulatory changes (e.g., monitoring laws and regulations as they are being developed or updated). Many of these processes are simple and inexpensive to implement; many have been in place for decades and are referred to as “common sense.” An obvious one in this category is that you don’t hire a blind man to drive a truck or someone with no medical training to perform duties usually assigned to a certified doctor.

Learning Outcome 4D

The candidate will be able to: demonstrate how derivatives, synthetic securities, and financial contracting may be used to reduce risk or to assign it to the party most able to bear it.

RESOURCES

- ERM-110-12: Derivatives: Practice and Principles, Recommendations 9-24 and Section III

REQUIRED MATERIAL

The study note on Derivatives Practices and Principles (ERM-110-12) is an excerpt of the Group of Thirty report, Derivatives: Practices and Principles. The report is discussed in more detail below under learning outcome 4G. Section III of the report focuses on assessing and managing the risks of derivatives and thus provides good support for this learning outcome 4D as well.

SUPPLEMENTAL MATERIAL

Indirect exposure is also used to describe higher order exposure levels. For example, in March 2011, a magnitude 9.0 earthquake was recorded off the coast of Japan. This was the direct risk. Secondary, and other higher order, risks included a tsunami with 40 meter waves, several major nuclear accidents at the Fukushima Daiichi Nuclear Power Plant complex, supply chain disruptions, crop failures, damage from debris traveling thousands of miles from the origin, future health risks, and so on. It is often these higher order effects that are ignored when scenario plans are developed.

Some examples might help. In the United States it is unlikely that many risk managers include a Japanese earthquake in their stress testing process, but firms that rely on computer chips manufactured in Japan were heavily impacted by the disaster. In another example, suppliers relying on transport up the Mississippi River had to quickly devise alternative routes for goods following Hurricane Katrina in 2005.

Learning Outcome 4E

The candidate will be able to: develop an appropriate choice of a risk mitigation strategy for a given situation (e.g., reinsurance, derivatives, financial contracting), which balances benefits with inherent costs, including exposure to credit risk, basis risk, moral hazard and other risks.

RESOURCES

- ERM-122-14: Chapter 1 of *Captives and the Management of Risk*, Kate Westover

REQUIRED MATERIAL

This Learning Outcome is primarily covered by readings elsewhere on the syllabus. These include Jorion Chapters 7 and 18, ERM-107-12 and ERM-110-12.

In addition to this material, the reading ERM-122-14, Chapter 1 of *Captives and the Management of Risk*, defines alternative risk transfer and describes mechanisms through which it can be facilitated. Alternative risk financing mechanisms include risk purchasing groups, self-insurance pools, and captive insurance companies.

A captive insurer is an insurance company that is wholly owned and controlled by its insureds. The primary purpose of captive insurance is to insure the risk of its owners, and the primary beneficiaries of a captive's underwriting profits are its insureds. The reading describes various types of captive insurance companies: pure captives, industrial insured group captives, risk retention groups, sponsored captives, and association captives.

Learning Outcome 4F

The candidate will be able to: analyze the practicalities of market risk hedging, including dynamic hedging.

RESOURCES

This Learning Outcome has been covered by readings elsewhere on the syllabus, including Section III of ERM-110-12.

Learning Outcome 4G

The candidate will be able to: demonstrate the use of tools and techniques for analyzing and managing credit and counterparty risk

RESOURCES

- ERM-110-12: Derivatives: Practice and Principles, Recommendations 9-24 and Section III
- ERM-124-15: Counterparty Credit Risk: The New Challenge for Global Financial Markets, Ch. 2, Defining Counterparty Credit Risk
- *Value-at-Risk: The New Benchmark for Managing Financial Risk*, Jorion
  - Chapter 18, Credit Risk Management (excluding Appendices) (primarily discussed with LO-3)

REQUIRED MATERIAL

The material covered in this section starts with an excerpt of the famous Group of Thirty report, Derivatives: Practices and Principles. The report, published in 1993, continues to be representative of good practices regarding derivative usage. Recommendations about aggregating exposures, along with assessing and managing derivative risk, are important concepts to understand. Netting the exposure makes sense, but the risk taker needs to understand the impact, if any, if the counterparty becomes unable to pay in a timely manner.

The primary variables, often termed the “Greeks,” used to manage market risk on a static or dynamic basis are also defined. Practitioners should be able to converse about these metrics with mathematicians (e.g., know which derivatives are used for each) as well as with management (e.g., how the price moves with respect to changes in various aspects of interest rates). Certain timing issues related to settlement risk are demonstrated with a currency example showing how counterparty risk needs to be managed in these types of contracts.

Chapter 18 of Jorion was covered in more detail in Subsection 3D, but also supports this learning outcome.

Learning Outcome 4H

The candidate will be able to: analyze funding and portfolio management strategies to control equity and interest rate risk, including key rate risks. Contrast the various risk measures and be able to apply these risk measures to various entities. Explain the concepts of immunization including modern refinements and practical limitations.

RESOURCES

- ERM-111-12: Key Rate Durations: Measures of Interest Rate Risks
- *Value-at-Risk: The New Benchmark for Managing Financial Risk*, Jorion
  - Ch. 7, Portfolio Risk: Analytical Methods (primarily discussed with LO-3)

REQUIRED MATERIAL

Cash flow matching of assets to obligations (liabilities) utilizes a variety of techniques. Practitioners can graphically show the two sets of cash flows under a single scenario to compare them visually. While this method is not mathematically robust it is a useful means to check calculated results. If the risk manager understands that a cash flow paid further in the future has a higher duration but less present value (and so is weighted less) this will provide a basic understanding of the concept. There are several forms of duration that can be used, depending on what is allowed to vary. Macaulay duration assumes the cash flows are fixed, while effective duration allows the amount and timing of the cash flows to vary. But as was shown with Anscombe's Quartet in ERM-101-12, portfolios with widely varying risks can have the same effective duration. The study note assigned for this subsection, ERM-111-12, Key Rate Durations: Measures of Interest Rate Risks, shows how effective duration can be broken into components (linear decomposition) using the spot rate curve to address this shortcoming. The study note uses partial derivatives to allow non-parallel shifts of the spot curve to be analyzed. One of the important characteristics of key rate durations (KRDs) is that they sum back to the duration.

This learning outcome also refers more generally to portfolio management strategies. Review Chapter 7 of Jorion, previously discussed in section 3, which focuses on analysis of risk for a portfolio of securities.

SUPPLEMENTAL MATERIAL

Working with models designed to calculate KRDs is a great way to understand the risks inherent in a portfolio of assets and liabilities. Most spot curves are modeled using a few points (often 11). The combination of a behavior driver (e.g., credited rate, asset earned rate, lapse rate) using one of those points on the spot rate curve can make the model more sensitive to that point than is true in reality. Especially when entering an environment not seen for many years (e.g., high interest rates, low interest rates, steep curve, flat curve) the

risk manager should spend extra time modeling that environment to improve risk management practices as well as make the model more reflective of reality. Be skeptical. In the low interest rate environment found in 2012, an example of surprising results may be found by looking at participating whole life insurance policies (assumed dividend interest rate) or home mortgages (prepayment rates). The key rate duration metric will help the risk manager better understand the risk offsets and risk exposures in a block of business already on the balance sheet. It will also help the risk manager create replicating portfolios, which use proxies to run models much more quickly. This approach allows for quicker analytical turnaround but must be continuously tested and challenged to make sure the underlying conditions have not changed since the replication was performed.

Learning Outcome 4I

The candidate will be able to: analyze the application of Asset Liability Management and Liability Driven Investment principles to Investment Policy and Asset Allocation.

RESOURCES

- ERM-112-12: Revisiting The Role of Insurance Company ALM within a Risk Management Framework

REQUIRED MATERIAL

This study note also supports Subsection 4A and was discussed in detail there.

Learning Outcome 4J

The candidate will be able to: demonstrate risk management strategies for other key risks (for example, operational, strategic, legal, and insurance risks)

RESOURCES

- ERM-107-12: *Strategic Risk Management Practice,* Andersen and Schroder, 2010
  - Chapter 7, Strategic Risk Analyses (also a resource for LO-1)
  -
- SOA Monograph, A New Approach to Managing Operational Risk, Chapter 8 (also a resource for LO-2 and LO-5)
- ERM-702-12: International Actuarial Association Practice Note: Enterprise Risk Management for Capital and Solvency Purposes in the Insurance Industry (pages 9-38, also a resource for LO-1 and LO-3)

REQUIRED MATERIAL

Key risk indicators (KRIs) are metrics that are considered drivers of results. Deviations from expectations can trigger management teams to take action. In the complex environment we all live in, handling the unexpected in a flexible manner is the key to success. A risk manager will not be able to predict the future but will develop scenarios that lead to undesired outcomes. This allows a firm to manage the risks based on its level of risk aversion and keeps management on their toes, constantly considering alternatives to the status quo.

W.E. Deming, the father of modern quality control, developed the four stages of Plan-Do-Check-Act (PDCA) to manage experiential learning. There are many overlaps with a strong risk culture. You can learn a great deal from a failure, whether it is internal or external, and blaming the bearer of bad news does not add value. By conducting multiple experiments, looking out over time to share new information that enables early decision making, a firm can adjust earlier than competitors.

The Strategic Risk Analyses note (ERM-107-12) was covered in Subsection 1C.

The Operational Risk monograph chapter focusing on measuring and assessing operational risk is the final reading for this section. The goal here is segmenting the aggregate loss into distributions of frequency and severity, combining them using a “calculator.” This is termed the actuarial approach. Outliers, data points in the tail of the distribution, tend to be the most interesting to the risk manager and should not be automatically discounted as anomalies.

Operational risks that cause material losses seldom occur so it is challenging to accumulate enough data points to have credible data. Combinations of internal loss data (perhaps only for the core distribution), external loss data (for the tail) and expert opinion are generally needed to develop a loss distribution. Stress testing has an important role in operational risk management.

As noted in this reading, the metrics (VaR and CTE) used to calculate economic capital utilize “normal” statistical assumptions. Thus a 99.5% metric means there is a 1 in 200 chance of insolvency under normal economic conditions. It does not mean a 1 in 200 year event. This point is key to understanding the regulatory regimes being considered today.

Learning Outcome 4K

The candidate will be able to: apply best practices in risk measurement, modeling and management of various financial and non-financial risks faced by an entity.

RESOURCES

- ERM-117-14: American Academy of Actuaries Practice Note: Insurance Enterprise Risk Management Practices (pages 4-26)
- SOA 2012 Annual Meeting – Session 53 – Assumption Setting Best Practices, Towers Watson (Steiner slides only, also a resource for LO-5)

REQUIRED MATERIAL

This learning outcome is intended to tie together what the candidate has learned from the resources throughout Sections 2, 3, and 4. The term “best practices” may not have been used explicitly in the reading materials, but they provided the background needed for you to discern what would be considered best practices. The syllabus sources have provided an array of approaches to managing various risks, along with discussion of the limitations of those approaches. Taken together, you have been given guidance so that you can choose the most appropriate methodology for whatever situation you are given.

The readings specifically assigned to this learning outcome are the American Academy of Actuaries Practice Note (ERM-117-14) and the Assumptions Setting Best Practices. Practice Notes do not in themselves tell actuaries what constitute best practices. But the Practice Note does provide a roadmap for what the actuary needs to consider as he practices in the field of Enterprise Risk Management. Assumption Setting Best Practices is taken from a presentation made at the 2012 SOA Annual Meeting. It walks through the process of selecting assumptions in detail, providing examples for specific insurance risks such as mortality and economic assumptions.

Section 5: Capital Management

Learning Objective and Outcomes

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

OUTCOMES: The candidate will be able to:

A. Describe the concepts of measures of value and capital requirements (for example, EVA, embedded value, economic capital, regulatory measures, and accounting measures) and demonstrate their uses in the risk management and corporate decision-making processes
B. Define the basic elements and explain the uses of economic capital. Explain the challenges and limits of economic capital calculations and explain how economic capital may differ from external requirements of rating agencies and regulators
C. Apply risk measures and demonstrate how to use them in capital assessment. Contrast regulatory, accounting, statutory and economic capital
D. Propose techniques for allocating / appropriating the cost of risks/capital/hedge strategy to business units in order to gauge performance (risk adjusted performance measures)
E. Demonstrate the ability to develop a capital model for a representative financial firm

Resources

- ERM-101-12: Measurement and Modelling of Dependencies in Economic Capital, Chapter 3
- ERM-106-12: Economic Capital-Practical Considerations-Milliman (also a resource for LO-2)
- ERM-112-12: Revisiting the Role of Insurance Company ALM within a Risk Management Framework (discussed with LO-4)
- ERM-119-14: Aggregation of Risks and Allocation of Capital (Sections 4-7)
- ERM-123-14: S&P Enterprise Risk Management Criteria (paragraphs 1-71, 86-88)
- ERM-501-12: Risk Based Capital-General Overview
- ERM-126-15: ORSA – An International Requirement, Sections 3.1 and 4.1
- Risk Appetite: Linkage with Strategic Planning Report (discussed with LO-4)
- SOA 2012 Annual Meeting – Session 53 – Assumption Setting Best Practices, Towers Watson (Steiner slides only, discussed with LO-4)

Section 5 is where the candidate should see the tools described in earlier sections come together in ways that allow practitioners to quantify economic risk. The readings discuss ways to use metrics in the tails of distributions, how stakeholders are using standardized

metrics to calculate required capital, and ways to quantify operational risks that are consistent with other risk metrics so they can be aggregated.

Subsection A: The candidate starts off by reviewing the article Risk Appetite: Linkage With Strategic Planning Report, which we have seen previously in Sections 3 and 4Subsection B: Study note ERM-106-12 is the primary resource for building an economic capital model. It supports all of Subsections 5B through 5E. Candidates may want to first read the entire note and then refer back to the appropriate pages as each learning outcome is studied in more detail.

This Learning Outcome is covered by reading ERM-106-12, Economic Capital-Practical Considerations.

Subsection C: This Learning Outcome has been covered by readings elsewhere on the syllabus. These include ERM-106-12, Economic Capital-Practical Considerations, referenced earlier in this LO, but with a particular emphasis on sections 5 and 6, and ERM-112-12, Revisiting the Role of Insurance Company ALM within a Risk Management Framework, covered in LO-4.

Subsection D: This section focuses on tail risk and issues the practitioner needs to think through in order to get useful results from an economic capital model. Candidates read Chapter 3 of study note ERM-101-12, Measurement and Modelling of Dependencies in Economic Capital, Section 7 of ERM-106-12, and Section 5 of the Risk Appetite paper.

Subsection E: This section is the culmination of Section 5, where candidates are asked to pull together all of the material on economic capital and demonstrate the ability to develop a capital model. In addition to referencing ERM-106-12, an article on Assumption Setting Best Practices provides direction.

Learning Outcome 5A

The candidate will be able to: describe the concepts of measures of value and capital requirements (for example, EVA, embedded value, economic capital, regulatory measures, and accounting measures) and demonstrate their uses in the risk management and corporate decision-making processes.

RESOURCES

- Risk Appetite: Linkage with Strategic Planning Report (discussed with LO-4)
- ERM-123-14: S&P Enterprise Risk Management Criteria (paragraphs 1-71, 86-88)
- ERM-126-15: ORSA – An International Requirement, Sections 3.1 and 4.1

REQUIRED READING

The Risk Appetite reading for this subsection is repeated from Learning Objectives 2 and 4 and was discussed in LO-4.

The reading ERM-123-14, S&P Enterprise Risk Management Criteria, provides a rating agency view (Standard & Poor's Ratings Services) with regard to assessing a company's ERM process. There are five areas of risk management that encompass the ERM analysis process:

- Risk management culture
- Risk controls
- Emerging risk management
- Risk models
- Strategic risk management

Each of the aforementioned areas are individually scored by Standard & Poor's (S&P) in their analysis to rate and insurer's ERM process.

The article further expands to provide more context around the scoring methodology through a series of example tables. Appendix II provides examples of risk controls related to major risk categories including credit risk, interest rate risk, market risk, insurance risk and operational risk.

The ORSA reading provides an overview of the own risk and solvency assessment (ORSA) from an international perspective. The ORSA process is an internal assessment of risks associated with an insurer's business plan and adequacy of capital resources to support the corresponding risks. This includes on-going processes to support risk identification, measurement, articulation of risk appetite/tolerance, implementation of risk limits/controls, risk mitigation strategies development, capital adequacy assessment, risk governance and reporting.

Under ORSA, insurers will need to provide a high-level summary report to regulators on an annual basis. This summary report should describe the company's ERM program, risk assessment for each material risk, and aggregation of individual risk assessment to determine financial resources needed to support current and planned business strategies.

ORSA's core purposes are to foster internal risk management, enhance management awareness of the interactions between risks, and increase understanding of the relationship between overall risk exposure and capital needed.

The intent is not for insurers to treat it as a new regulatory reporting but, to embed the ORSA process into the business planning, and to leverage much of existing ERM capabilities to develop a maximally useful process.

Learning Outcome 5B

The candidate will be able to: define the basic elements and explain the uses of economic capital. Explain the challenges and limits of economic capital calculations and explain how economic capital may differ from external requirements of rating agencies and regulators.

RESOURCES

- ERM-106-12: Economic Capital-Practical Considerations-Milliman (also a resource for LO-2)

REQUIRED READING

Economic capital is a generic term that means little without listing the parameters that define it. Regulator goals will differ from those of capital models used for internal purposes or proxies used by rating agencies. For an insurer the amount needed for expected events is covered by the reserve, and capital is an amount in addition to meet pre-defined requirements. Economic capital deals with the tail of the distribution, which is why several tools associated with extreme events and correlations that vary in the tail have been discussed. These parameters also include a specified measure of risk tolerance (e.g., Value at Risk or CTE), a probability threshold and a specified time horizon.

Economic capital calculations are not meant to cover extreme events that have not previously occurred. For example, perhaps a large asteroid will hit the earth in the future and change the environment as we know it, but that does not need to be considered here. There is often a degree of latitude around what historical data to use, but it should be predictive in nature. There will be differences of opinion about what to include, so transparency of assumptions is important.

Another application of economic capital models is for allocation of capital across business lines. The practitioner must decide whether to allocate diversification and how to do so. The candidate should understand the reasons to allocate the benefits of imperfect correlations, the methods to do so, and when a firm might not want to allocate those benefits to a business line.

Economic Capital - Practical Considerations (ERM-106-12) reading defines economic capital in two ways: Required Economic Capital is the amount of economic capital a business believes it needs, and Available Economic Capital reflects what the business actually has in excess of the liabilities. Capital refers to the discounted present value of future cash flows. Some will define cash flows as pure cash in and cash out, while others look at an accounting regime to define cash flows.

ERM-106-12 supports most of the learning objectives in Section 5. For this learning outcome, Sections 1 through 4 of the study note are the relevant portions. We will return to the remaining sections of the note with the next few learning outcomes.

Candidates will find that the examples given in study note ERM-106-12 enhance their knowledge of issues related to economic capital. The IAA paper "A Global Framework for Insurer Solvency Assessment", published in 2004 and referred to in ERM-106-12, defines five major risk types; underwriting, credit, market, operational and liquidity risk. Note that liquidity risk here is described as asset liquidity risk in other readings. The paper goes on to segment modeling components of volatility risk, uncertainty risk, and extreme events. As computers have gotten faster, some assumptions once thought of as fixed have evolved in this way. Examples include default risk, mortality risk, and premiums/revenue collected.

These model improvements do not lessen the importance of stress testing specific assumptions and events.

There is an ongoing debate about the likelihood of receiving diversification benefits in extreme scenarios. Some are skeptical and do not accept reduced economic capital results for entities holding multiple risks. They argue that tail dependencies wipe out this benefit. At the very least it would make sense to run a stress test where no diversification credit was given.

Learning Outcome 5C

The candidate will be able to: apply risk measures and demonstrate how to use them in economic capital assessment. Contrast and understand regulatory, accounting, statutory and economic capital.

RESOURCES

- ERM-101-12: Measurement and Modelling of Dependencies in Economic Capital, Chapter 3
- ERM-106-12: Economic Capital-Practical Considerations-Milliman (also a resource for LO-2)
- ERM-112-12: Revisiting the Role of Insurance Company ALM within a Risk Management Framework (discussed with LO-4)
- ERM-501-12: Risk Based Capital-General Overview

REQUIRED READING

Study note ERM-106-12, Economic Capital-Practical Considerations was, discussed earlier in this section. Sections 5 and 6 of the note are most relevant to this learning outcome. Study note ERM-112-12, Revisiting the Role of Insurance Company ALM within a Risk Management Framework was discussed with LO-4.

The reading ERM-501-12 provides a general overview of the National Association of Insurance Commissioners (NAIC) Risk Based Capital (RBC) system. RBC is risk-based capital adequacy standard that provides regulatory authority for timely action if an insurer's regulatory capital falls below certain thresholds.

There are separate RBC formulas for each major type of insurance: life, property & casualty, and health. Common risks considered in each RBC model include asset risk, credit risk, interest rate risk, market risk, insurance risk, and general business risk.

The RBC formula results in an Authorized Control Level (ACL). An insurer's total adjusted capital (TAC) is compared to the calculated ACL. The ratio TAC to ACL results in one of five regulatory actions (including no action).

Learning Outcome 5D

The candidate will be able to: propose techniques for allocating / appropriating the cost of risks/capital/hedge strategy to business units in order to gauge performance (risk adjusted performance measures).

RESOURCES

- ERM-101-12: Measurement and Modelling of Dependencies in Economic Capital, Chapter 3
- ERM-106-12: Economic Capital-Practical Considerations-Milliman (also a resource for LO-2)
- ERM-119-14: Aggregation of Risks and Allocation of Capital (Sections 4-7)
- Risk Appetite: Linkage with Strategic Planning Report (discussed with LO-4)

REQUIRED READING

In this final subsection before tying everything together, the readings discuss practical considerations of economic capital calculations as well as tail dependencies and extreme values.

Reading ERM-106-12, Economic Capital-Practical Considerations, was initially introduced in Learning Outcome 3B. It introduces the candidate to the questions that must be answered when fully implementing economic capital. Various stakeholders differ in their Economic

Capital definitions, depending on the accounting regime. For example, an economic balance sheet will differ from one based on statutory accounting principles. Deciding which risks to include, how to model them consistently with other risks, and their interactions will normally require basic statistical knowledge. The modeler will need to choose the metrics to be used and whether stochastic analysis or stress testing is appropriate. Risk-neutral and real-world scenarios both have their place in modeling, and a basic understanding of when each is appropriate is necessary. Diversification benefits could be granted in certain circumstances, but note that some are skeptical of awarding the benefits of partially correlated risks when tail scenarios are involved. Section 7 of the note is most relevant here.

The second assigned reading is from ERM-101-12, Measurement and Modeling of Dependencies in Economic Capital. This 2010 paper looks at many of the practical considerations a modeler needs to consider when calculating economic capital. In the pages assigned to this subsection, the focus is on diversification and dependency. Some regulators use a 99.5% Value at Risk metric over one year. In this context a diversification benefit is generally allowed.

Dependency is a tricky concept for a modeler, as data may show correlation between variables with no clear causation. Without evidence showing that one variable is driving results, the model should be very careful about using such a result to calculate economic capital. Even when dealing with a causation relationship, correlation can vary across the distribution and, often for financial variables, becomes much stronger in the tail. Some argue that this is a reason to ignore diversification benefits in capital calculations as the benefit goes away just when it is needed, causing a procyclical response (capital requirement increases as stresses mount). Alternatively, a factor based method often reduces the capital requirement as market values reduce so is countercyclical.

The reading ERM-119-14, Aggregation of Risks and Allocation of Capital, discusses risk assessment methodologies, aggregation techniques, and practical applications of capital allocation.

Section 4 discusses risk assessment methodologies that can be used once a specific risk has been identified. Options include immediate stresses (instantaneous change at time zero) and projection scenarios (the change happens over time). Either option can be based upon single or multiple risk factor stresses. The type of risk that is being analyzed will influence the option chosen.

The use of single risk factor analysis versus two or more risk factors highlights the interaction between risk factors. In many situations, multivariate stress testing results are not the sum of individual stress testing of single risk factor results due to the interaction between the risk classes. Model calibration is also discussed to highlight key issues to be aware of and provide potential model solutions for some of the more common risks in the industry that companies evaluate.

Section 5 explains aggregation techniques, which can be used once the risk assessment has been completed. Some examples of aggregation may include aggregating results across different product types, lines of business or geographical regions.

It is important to take into account the risk interactions in the aggregation process. Correlation is introduced to show diversification effects (as correlation goes to negative 1) and compounding effects (as correlation goes to positive 1) between risk factors. The use of copulas and multivariate methods is summarized for a general understanding of how each method can be applied.

Section 6 addresses the application of capital allocation. Company level risk and capital is allocated down to lower levels often as part of regulatory reporting. These lower levels may include business units, product lines or even specific products. As companies become more aware of risk, many are allocating capital and risk more actively to improve areas such as pricing and performance measurement.

The Risk Appetite paper has been referenced numerous times, in both Section 5 and earlier sections. Within in that paper, Section 7 is relevant to this learning outcome.

Learning Outcome 5E

The candidate will be able to: develop a capital model for a representative financial firm.

RESOURCES

- ERM-106-12: Economic Capital-Practical Considerations-Milliman (also a resource for LO-2)
- SOA Annual Meeting – Session 53 – Assumption Setting Best Practices, Towers Watson (Steiner slides only)

REQUIRED READINGS

This section is the culmination of the previous Section 5 learning outcomes. It asks you to assimilate all of the material and show that you know how to develop an economic capital model.

All of the sources discussed in the previous subsections will help with our goal of developing an economic capital model, but we direct you again specifically to ERM-106-12and Assumption Setting Best Practices. Review ERM-106-12 in its entirety and focus on how all of the individual considerations lead to the ultimate goal of creating a robust, but practical economic capital model. Assumptions Setting Best Practices walks through the process of

selecting assumption in detail, providing examples for specific insurance risks such as mortality and economic assumptions.

REMINDER

Remember to become familiar with the case study before you arrive for the exam. Good luck!

Glossary

The following is an alphabetically ordered compilation of the individual glossaries from the five sections.

Absolute VAR	dollar loss relative to zero without reference to expected value (Jorion Chp 5)
Accumulated Other Comprehensive Income (AOCI)	balance sheet item that aggregates certain gains and losses not recognized in the P&L (profit and loss) account (ERM-111-12)
Actuarial approach	process to estimate aggregate risk by decomposing an aggregate loss distribution into the integral components of frequency and severity (OpRisk)
Adverse selection	also called anti-selection or negative selection, process in which one party has more information (asymmetric) than another and takes advantage of that to generate “bad” results for the other party (Sweeting Chp 16)
American option	option that can be exercised at any time prior to expiry (Sweeting Chp 14)
Anchor category	proportionality method of scaling external data where data set with known mean is used to scale to an unknown distribution (OpRisk)
Anchoring	behavioral bias that shows reluctance to move quickly from the current view, providing an anchor (Sweeting Chp 14)
Antithetic variable technique	variance reduction technique for symmetric distribution where random samples are doubled in size by changing the sign of each one (Jorion Chp 12)
Asset liquidity risk (also called market/product liquidity risk)	forced liquidation of assets which can create unfavorable price movements (Jorion Chp 13)
Basel II	regulation being developed internationally for bank solvency regulation, successor to Basel I and eventual predecessor of Basel III (Sharara)
Basis risk	also called correlation risk, exposure to differences in the price performance of the derivatives held and their hedges, reflects a hedge that is not a perfect replacement for the exposure (ERM-110-12)
BCBS	Basel Committee on Banking Supervision (Sharara)
Benchmark	industry standard that provides a tool to compare your results (Sweeting Chp 14)
Bermudan option	option that can be exercised at certain dates (Sweeting Chp 14)
Best hedge	additional amount to invest in an asset so as to minimize the risk of the total portfolio (Jorion Chp 7)
Bias	systemic risk where decisions are made that are not in the best interests of the organization (may be deliberate or unintentional) (Sweeting Chp 7)
Bid-ask spread	$S = [P(\text{ask}) - P(\text{bid})]/P(\text{mid})$, where P(ask) is the price asked by a seller, P(bid) is the price offered by a buyer, P(mid) is the mid-price average of the bid and ask quotes used to mark the portfolio to market; drivers include order-processing costs, asymmetric-information costs, inventory carrying costs (Jorion Chp 13)
BIS	Bank for International Settlements (Sharara)
Bootstrapping	iterative process to convert a yield curve to a spot rate curve (Sweeting Chp 14)
Business continuity risk	risk that external event will affect the physical ability of a firm to carry on business at its normal place of work (Sweeting Chp 7)
Captive reinsurer	insurance company created to finance risks of the sponsor (Westover Chp 1 ERM-122-14)

Catastrophe risk	extreme form of volatility risk, significant event or combination of events resulting in high probability of loss (Sweeting Chp 7)
Causal loop diagram (CLD)	diagram showing how interrelated variables affect one another, positive/negative feedback means two variables move in same/opposite direction (ERM-101-12)
CEIOPS (The Committee of European Insurance and Occupational Pensions Supervisors)	European Union supervisory body until 2010, since replaced by the EIOPA (European Insurance and Occupational Pensions Authority) (ERM-101-12)
Central risk function (CRF)	unit headed by Chief Risk Officer (CRO) covering all things risk related (Sweeting Chp 1)
Circuit breaker	stock exchange control to limit excessive volatility for the market as a whole, restoring stability by rebalancing the number of buy and sell orders (Sweeting Chp 16)
Coinsurance	form of reinsurance where assuming reinsurer receives proportionate share of all risks and cash flows
Collateralization	transfer of assets when OTC (over the counter) derivatives are marked to market to reduce counter-party risk (Sweeting Chp 16)
Component VAR	a partition of the portfolio VAR that indicates approximately how much the portfolio VAR would change if the given component was deleted; component VARs sum to the portfolio VAR (Jorion Chp 7)
Concordance	association between variables, may influence each other or be influenced by another variable (Sweeting Chp 10)
Conditional tail dependency	independent and identical distribution (iid) for much of distribution but shows dependency in the tail (OpRisk)
Contagion risk	risk that failure in one firm/sector/market will result in further failures (Sweeting Chp 7)
Contango	when the price of a future is higher than the expected future spot price (Sweeting Chp 16
Copulas	a joint cumulative distribution function using individual cumulative distribution functions, (Loss Models Further Topics Chp 10)
Corporate governance	process of running an organization (Sweeting Chp 1)
Counterparty risk	party to an OTC derivatives contract or securities financing transaction that may fail to perform on its contractual obligations, causing losses to the other party, also defined elsewhere with respect to reinsurance and credit risk (Gregory Chp 2 ERM-124-15))
Credit default swap (CDS)	protection against default of a bond issuer, OTC instrument similar to insurance or selling a bond short, increases counter-party risk (Sweeting Chp 16)
Credit exposure risk	risk of fluctuations in the market value of the claim on the counterparty; exposure is the amount you can lose, at the time of default this is called the exposure at default (Jorion Chp 18)
Credit migration transition matrix	table showing probability of a future rating given that an entity has a certain credit rating today, often one year in the future but can be longer, often approximated as a Markov chain but independence between years does not hold (Sweeting Chp 14)
Credit reserve	amount to set aside in anticipation of expected credit losses (Jorion Chp 18)
Credit risk	risk of default of borrowers or counterparties (Sweeting Chp 7)

Crime risk	risk of dishonest behavior (Sweeting Chp 7)
Data risk	process risk where data is poor (Sweeting Chp 7)
DCAT (Canada)	dynamic capital adequacy testing, Canadian regulation where plausible adverse scenarios measure the resulting health of the insurer (Sharara)
Deep market	positions in a liquid market can be offset with very little price impact (Jorion Chp 13)
Delphi technique	multiple rounds of surveys where experts comment on risks anonymously and independently until results are stable (could result in consensus or stalemate) (Sweeting Chp 8)
Delta risk	also called absolute price or rate risk, change in value given change in the price of an underlying, the first derivative (ERM-110-12)
Dependence	when a variable is influenced, either directly or indirectly, by another (Sweeting Chp 10)
Dimensional reduction technique	reduces number of variables in large data set to manageable number (example is PCA principal component analysis) (Sweeting Chp 14)
Dirty price	price of a bond including accrued interest (Sweeting Chp 14)
Diversified VAR	portfolio VAR taking into account diversification benefits between components (Jorion Chp 7)
Documented knowledge	information obtained from external sources (also called historical information if considered facts) (Sweeting Chp 8)
Downside risk	risk is defined based on negative outcomes to the entity (courseware Section 1A)
Dynamic hedging	process of adjusting hedge positions to remain delta neutral for a specific risk (Sweeting Chp 16)
Effective duration	ratio between the proportional change in a security's value to the infinitesimal parallel shift of the spot curve, considers changes in cash flows as well as interest rates (ERM-111-12)
Enterprise risk management (ERM)	management of all risks on a holistic basis (Sweeting Chp 1)
Environmental scanning	viewing (looking at information) and searching (looking for information) for developments; study of events, trends, issues and expectations (Andersen Chp 7 ERM-107-12)
ERM framework	ERM formalized into a process (Sweeting Chp 1)
European option	option that can be exercised only at the expiration date (Sweeting Chp 14)
Event-driven scenario	scenario formulated from plausible events, telling a story (Jorion Chp 14)
Exit value	value at which insurance liabilities could be transferred, or settled, between knowledgeable willing parties in an arm's length transaction (Sharara)
Expected shortfall (ES)	expected return above a certain probability during a certain period of time, also called TailVaR or CTE (conditional tail expectation) (ERM-102-12)
Expected value of a loss	probability of loss times severity of loss (Sweeting Chp 1)
Experiential knowledge	information obtained from experience (Sweeting Chp 8)
Exposure	quantifiable maximum loss (Sweeting Chp 1)
Extreme value theory	branch of statistics dealing with the extreme deviations from the median of probability distributions (RM Sep 2009)

Feedback risk	risk that a change in price will result in further changes in the same direction (Sweeting Chp 7)
Financial reinsurance	also called finite re, reinsurance designed to meet financial objectives, often to meet capital management needs, though it is necessary to show legitimate risk transfer
Foreign exchange risk	market or economic risk when cash flow currency received differs from cash flows due (Sweeting Chp 7)
Full two-way payments	net amount is due in both directions and does not matter if one party is in default, as contrasted to limited two-way payments where one does not pay to defaulted party (ERM-110-12)
Funding liquidity risk (also called cash flow liquidity risk)	situation where financing cannot be maintained owing to creditor or investor demands (Jorion Chp 13)
Gamma risk	also called convexity risk, occurs when relationship between the price of an underlying and the value of a transaction/portfolio is not linear, the second derivative (ERM-110-12)
GARCH	generalized autoregressive conditional heteroskedastic model, used to measure a process with changing volatility (Jorion Chp 9)
Gearing (also called leveraging)	technique that multiplies gains and losses through borrowing, using derivatives, or a business buying fixed (physical) assets to increase the proportion of fixed costs relative to variable costs (Andersen Chp 1 ERM-107-12)
Generalized extreme value (GEV) distribution	parametric method to look at tails of distributions across the Gumbel, Frechet, Weibull families (Sweeting Chp 12)
Generalized Pareto distribution	J shaped curve follows power laws with pdf asymptotic to stated minimum and x-axis (Sweeting Chp 12)
Generator function	continuous, monotonically decreasing function that transforms a number between 0 and 1 to a number between 0 and infinity (Sweeting Chp 10)
GLM (generalized linear model)	used to link linear regression model to a dependent variable, used for risks like default and mortality where dependent variable has a limited number of values (Sweeting Chp 16 defined in Chp 11)
Governance	process of high-level control of an organization (Jorion Chp 19)
Hard data	empirical information that has been collected through a systematic process on a prospective basis (OpRisk)
Heteroskedasticity	stochastic process where standard deviation is not constant across all periods (Sweeting Chp 14)
Holistic	consideration of implications for the entire entity (courseware Section 1A)
IFRS	International Financial Reporting Standards, uses fair value principles for solvency regulation, intended to be international standard and being applied in Canada (Sharara)
Incidence risk	number of claims per policy during a specific time period varies over time (Sweeting Chp 7)
Incremental VAR	change in VAR owing to a new position which could be large and nonlinear (Jorion Chp 7)
Individual VAR	VAR of one component taken in isolation (Jorion Chp 7)
Influence matrix	chart showing interaction of risk factors on qualitative basis (Andersen Chp 7 Figure 7.4 ERM-107-12)
Intensity risk	severity, amount of claim per risk, varies over time (Sweeting Chp 7)

Interest rate risk	market risk arising from unanticipated changes in interest rates (Sweeting Chp 7)
Internal hedge	position held by an entity on its balance sheet that offsets (materially) an existing risk position (Courseware Section 1A)
Key rate duration	vector representing the price sensitivity of a security to each key rate change, sums to total duration, effectively partial derivatives with respect to one part of the spot curve (ERM-111-12)
Knightian risk	risk is defined as uncertainty (courseware Section 1A)
Kurtosis	describes the shape of a random variable's probability density function (pdf). A random variable from the normal distribution has kurtosis of 3, with values greater associated with fat tails (leptokurtic) and smaller values having skinnier tails (platykurtic) (Sweeting Chp 14)
LEC	loss exceedance curve, probability of losses exceeding a threshold
Legal risk	risk of poorly drafted legal documents (sometimes regulatory risk too) (Sweeting Chp 7)
Level risk	underlying (e.g., mortality) differs from expected (Sweeting Chp 7)
Liquidation period	time required to hedge or orderly liquidate a portfolio (Jorion Chp 5)
Liquidity risk	lack of market depth or market disruption (Sweeting Chp 7)
Low-discrepancy sequence	deterministic technique to provide more uniform coverage of a sample, one example is called a Sobol procedure (Jorion Chp 12)
Marginal distribution	probability distribution where other variables have been discarded (Sweeting Chp 10)
Marginal VAR	change in portfolio VAR resulting from taking an additional dollar of exposure to a given component, the partial derivative with respect to the component position (Jorion Chp 7)
Margins	deposits posted with an exchange to ensure that if a member becomes insolvent there are assets available to cover losses (Sweeting Chp 16)
Marked-to-market	fair value accounting practice that assigns a value based on current market price of the asset or liability (Sharara)
Market risk	risk inherent from exposure to capital markets (Sweeting Chp 7)
MaxVAR	worst loss at given confidence level during the horizon period (Jorion Chp 5)
Model risk	flawed models are used to make financial decisions (Sweeting Chp 7)
Modified coinsurance	similar to coinsurance but reserves remain with the ceding company, often referred to as mod-co
Moral hazard	tendency to take undue risks because the costs are not borne by the party taking the risk, for example a business with fire insurance might be less careful about storing gasoline onsite (Sweeting Chp 16)
Normal backwardation	when the price of a future is lower than the expected future spot price (Sweeting Chp 16)
Operational risk	risk of loss resulting from inadequate or failed processes, people and systems or from external events (Jorion Chp 19); risks that impact how a firm carries on business (Sweeting Chp 7)
Option	derivative providing the right to buy or sell at a certain price at or before a specified date (Sweeting Chp 14)
Outlier	data points far in the tail that are often discarded when calculating means but are key when looking at operational risk management (OpRisk)

People risk	risk of non- criminal actions related to employment, adverse selection, moral hazard, agency risk (Sweeting Chp 7)
Pillar I	from Solvency II framework, quantitative requirements for measuring capital adequacy (modeling, factors) (Sharara)
Pillar II	from Solvency II framework, supervisory review process including risk management practices (Sharara)
Pillar III	from Solvency II framework, transparency and reporting requirements (Sharara)
Portfolio-driven scenarios	scenarios developed from vulnerabilities in the current portfolio (Jorion Chp 14)
Price discovery	discovery of implied volatility driving market-clearing prices using other observable factors; essentially you solve for the standard deviation that equates the model price with the current market price (Jorion Chp 9)
Probability of outcome	quantifiable likelihood of specific outcome or range of outcomes (Sweeting Chp 1)
Process approach	step-by-step analysis of the procedures used for all activities, linked by causal networks that explain dependencies between various steps (Jorion Chp 19)
Process risk	risk that operational process will fail or be inefficient (Sweeting Chp 7)
Pro-cyclicality	feature of some regulatory requirements causing higher capital during times of stress (Sharara)
Product liquidity	liquidity risk based on product type, e.g., U.S. dollar interest rate swap (ERM-110-12)
Project risk	operational risks in the context of a particular project (Sweeting Chp 7)
QIS5	quantitative impact study (numbered starting at 1), implementation of Solvency II completed in stages with checkpoints using QIS studies (Sharara)
RBC ratio (US)	ratio of actual capital to calculated regulatory capital, certain levels trigger regulatory actions (Sharara)
Recovery risk (1 minus the loss given default)	uncertainty in the fraction of the claim recovered after default (Jorion Chp 18)
Redington's immunization	set of constraints that assure the holder of interest rate risk that small changes in rates will not affect their position negatively (ERM-111-12)
Regulatory risk	risk that organization is negatively impacted by regulatory/legislative changes or fails to comply with existing requirements (Sweeting Chp 7)
Relative VAR	dollar loss relative to the mean (Jorion Chp 5)
Reputational risk	second order risk arising from other operational risks (Sweeting Chp 7)
Reserving risk	combination of volatility, catastrophe and trend risks (Sweeting Chp 7)
Residual risks	risks remaining after risk mitigation efforts (Sweeting Chp 7)
Rho risk	also called discount rate risk, exposure to change in value due to a change in the rate used for discounting future cash flows (ERM-110-12)
Risk	multiple definitions; outcome uncertainty; probability across range of outcomes; may consider only adverse outcomes; likely severity of a loss; exposure (Sweeting Chp 1)
Risk check list	list of risks appropriate for a particular organization or project (Sweeting Chp 8)

Risk liquidity	base components of product liquidity risk; for example, a complex derivative may be illiquid while components might be liquid and allow the risk to be hedged (ERM-110-12)
Risk management	identification, assessment and prioritization of risks (also called silo risk management when risks are not aggregated) (courseware Section 1A)
Risk management cycle	continuing process repeating Risk identification, Risk analysis, Risk evaluation, and Risk responses (Andersen Chp 1 ERM-107-12)
Risk management effectiveness (RME)	standard deviation of sales divided by the standard deviation of returns over a specified time period (Andersen Chp 1 ERM-107-12))
Risk prompt list	risk categories (e.g., PESTELI political, economic, social, technological, environmental, legal, industry) (Sweeting Chp 8)
Risk taxonomy	more detailed than prompt list, less detailed than check list (Sweeting Chp 8)
Risk-focused process analysis	risk identification approach where each process has flow charts constructed and risks identified (Sweeting Chp 8)
Run on the bank	large excess of outflows over inflows for an institution (Sweeting Chp 7)
Scenario analysis	evaluating portfolio under various extreme but probable states of the world (Jorion Chp 14)
Sensitivity testing	viewing results when moving key variables by a large amount (Jorion Chp 14)
Settlement risk	risk created when date of financial transaction differs from date of settlement, reflects risks such as price movements and default risk (ERM-110-12)
Severity of loss	quantifiable loss given an adverse outcome or range of outcomes (Sweeting Chp 1)
Silo approach to risk management	risk is managed within a single unit (Sweeting Chp 1)
SMI	Solvency Modernization Initiative of the NAIC, goal is creating state-of-the-art solvency surveillance system for US based insurers (Sharara)
Soft data	information based on empirical observations, but without a robust process and/or the data may be a proxy variable (OpRisk)
Solvency II	mandatory risk framework being introduced for insurers in Europe (Sweeting Chp 1); regulatory process developed by the European Commission requiring Solvency Capital Requirement (SCR: level with 0.5% probability that assets will not be sufficient to meet liabilities during the following year) and Minimum Capital Requirement (MCR: absolute minimum level of capital, below which urgent action would be required by the regulator) (ERM-106-12); regulation being developed in Europe for insurer solvency regulation using total balance sheet economic capital approach (Sharara)
Spurious relationship	mathematical relationship with no causal connection between two events or variables, may be coincidence or lurking variable, “correlation does not imply causation” (ERM-101-12)
Strategic responsiveness	management’s ability to respond to environmental changes (Andersen Chp 1 ERM-107-12)
Strategic risk	risk that organization’s core objectives are not fully achieved (Sweeting Chp 7)
Stratified sampling technique	one of several methods to reduce the number of scenarios needed to estimate a result; a distribution is partitioned into zones and a sample taken from each zone (Jorion Chp 12)
Stress test	a scenario designed to measure the impact of adversely adjusting a few variables that drive results (Sweeting Chp 14)

SWOT analysis	strengths and weaknesses (internal), opportunities and threats (external) (Sweeting Chp 8)
Systemic risk	risk of failure of the financial system (Sweeting Chp 7)
Tail dependency	likelihood that one risk variable will take an extreme value, given that another risk variable takes an extreme value (ERM-101-12)
Technology risk	risk of technology failure (e.g., loss/disclosure of confidential information, data corruption, computer system failure, software errors) (Sweeting Chp 7)
Theta risk	also called time decay risk, exposure to a change in the value arising from the passage of time, typically associated with options (ERM-110-12)
Thin market	illiquid market where any transaction can quickly affect prices (Jorion Chp 13)
Time aggregation	scaling parameter allowing normal distribution of 1-day returns to build longer time horizon returns (Jorion Chp 14)
Time horizon	period exposed to risk, or way risk is likely to change over period (Sweeting Chp 1)
Trend risk	rates change over time at rate that differs from assumed rate (Sweeting Chp 7)
Underlying	derivative cash flows depend on the value of this asset, could be single asset/portfolio/index/derivative (ERM-110-12)
Underwriting cycle	feature of P&C insurance industry alternating between soft (low cost) and hard (high cost) market pricing (Sharara)
Underwriting risk	risk that average level of portfolio claims differs from assumed (Sweeting Chp 7)
Undiversified VAR	sum of individual VARs, or portfolio VAR with no short positions and all correlations are unity (Jorion Chp 7)
Value at risk (VAR)	worst loss over a target horizon such that there is a low, prespecified probability that the actual loss will be larger (Jorion Chp 5) - note that value at risk is referred to as VaR or VAR and the definition is slightly different in other readings, but the implementation is the same
Value-at-Risk (VaR)	potential loss with a certain probability during a certain period of time under normal market conditions (ERM-102-12)
Variance verification	process using confidence intervals of samples within a larger scenario size to justify the validity of the asymptotic variance formula for the CTE metric (RM Aug 2008)
Vega risk	also called volatility risk, exposure to a change in the value resulting from a change in the expected volatility of the price of an underlying, typically associated with options (ERM-110-12)
Volatility clustering	periods of high and low volatility (Sweeting Chp 14)
Volatility risk	experience differs from assumed due to finite population (Sweeting Chp 7), measure of dispersion around the mean
Wrong-way risk	when one risk amplifies the effect of another, opposite of diversification, total is greater than the sum of its parts (ERM-101-12)
YRT (yearly renewable term) reinsurance	form of reinsurance where risk, but not reserves, is transferred to the reinsurer for a premium that varies by age and amount of risk