

Risk Management by Akhil Kumar

Module 1 - Foundation of Risk Management

1. Risk Management

- The concept of risk management
- Difference between risk management & risk taking
- The risk management process, identify problems and challenges that can arise in the risk management process
- How to evaluate & apply tools and procedures used to measure & manage risk, including quantitative measures, qualitative assessment, and the enterprise risk management
- Distinction between expected loss and unexpected loss with examples
- The relation between risk and reward and how conflicts of interest can impact risk management
- Difference between the key classes of risks, how each type of risk can arise, and assess the potential impact of each type of risk on an organization.

2) Corporate Risk Management

After completion of this topic you will be able to

- Evaluate some advantages and disadvantages of hedging risk exposures
- Explain considerations and procedures in determining a firm's risk appetite and its business objectives
- Explain how a company can determine whether to hedge specific risk factors, including the role of the board of directors and the process of mapping risks
- Apply appropriate methods to hedge operational and financial risks, including pricing, foreign currency, and interest rate risk
- Assess the impact of risk management instruments

3) Corporate Governance and Risk Management

After completion of this topic you will be able to

- Compare and contrast best practices in corporate governance with those of risk management
- Assess the role and responsibilities of the board of directors in risk governance
- Evaluate the relationship between a firm's risk appetite and its business strategy, including the role of incentives
- Distinguish the different mechanisms for transmitting risk governance throughout an organization
- illustrate the interdependence of functional units within a firm as it relates to risk management
- Access the roles & responsibilities of a firm's audit committee

4) What is ERM?

After completion of this topic you will be able to

- Describe enterprise risk management (ERM) and compare and contrast differing definitions of ERM
- Compare the benefits and costs of ERM and describe the motivation for a firm to adopt an ERM initiative
- Describe the role and responsibilities of a chief risk officer (CRO) and assess how the CRO should interact with other senior management
- Distinguish between components of an ERM program

5) Risk Management, Governance, Culture, and Risk Taking in Banks

After completion of this topic you will be able to

- Assess methods that banks can use to determine their optimal level of risk exposure and explain how the optimal level of risk can differ across banks.
- Describe implications for a bank if it takes too little or too much risk compared to its optimal level.
- Explain ways in which risk management can add or destroy value for a bank
- Describe structural challenges and limitations to effective risk management, including the use of VaR in setting limits
- Assess the potential impact of a bank's governance, incentive structure, and risk culture on its risk profile and its performance

6) Financial Disasters

After completion of this topic you will be able to

- Analyse the key factors that led to and derive the lessons learned from the various risk management case studies

7) Deciphering the Liquidity and Credit Crunch 2007-2008

After completion of this topic you will be able to

- Describe the key factors that led to the housing bubble
- Explain the banking industry trends leading up to the liquidity squeeze and assess the triggers for the liquidity crisis
- Explain how banks created collateralized debt obligations
- Explain the purposes and uses of credit default swaps
- Describe how securitized and structured products were used by investor groups and describe the consequences of their increased use
- Describe how the financial crisis triggered a series of worldwide financial and economic consequences
- Distinguish between funding liquidity and market liquidity and explain how the evaporation of liquidity can lead to a financial crisis
- Analyse how an increase in counterparty credit risk can generate additional funding needs and possible systemic risk

8) Getting Up to Speed on the Financial Crisis: A One Weekend Reader's Guide

After completion of this topic you will be able to

- Distinguish between triggers and vulnerabilities that led to the financial crisis and their contributions to the crisis
- Describe the main vulnerabilities of short-term debt especially repo agreements and commercial paper
- Assess the consequences of the Lehman failure on the global financial markets
- Describe the historical background leading to the recent financial crisis
- Distinguish between the two main panic periods of the financial crisis and describe the state of the markets during each
- Assess the governmental policy responses to the financial crisis and review their short-term impact
- Describe the global effects of the financial crisis on firms and the real economy

9) Risk Management Failure: What Are They and When Do They Happen?

After completion of this topic you will be able to

- Explain how a large financial loss may not necessarily be evidence of a risk management failure
- Analyse and identify instances of risk management failure
- Explain how risk management failures can arise in the following areas: measurement of known risk exposures, identification of risk exposures, communication of risks and monitoring of risks
- Evaluate the role of risk metrics and analyse the shortcomings of existing risk metrics

10) The Standard Capital Asset Pricing Model

After completion of this topic you will be able to

- Understand the derivation and components of the CAPM
- Describe the assumptions underlying the CAPM
- Interpret the capital market line
- Apply the CAPM in calculating the expected return on an asset
- Interpret beta and calculate the beta of a single asset or portfolio

11) Applying the CAPM to Performance Measurement Single-Index Performance Measurement Indicators

After completion of this topic you will be able to

- Calculate, compare, and evaluate the Treynor measure, the Sharpe measure, and Jensen's alpha
- Compute and interpret tracking error, the information ratio, and the Sortino ratio

12) Arbitrage Pricing Theory and Multifactor Models of Risk and Return

After completion of this topic you will be able to

- Describe the inputs, including factor betas, to a multifactor model
- Calculate the expected return of an asset using a single-factor and a multifactor model
- Describe properties of well-diversified portfolios and explain the impact of diversification on the residual risk of a portfolio

- Explain how to construct a portfolio to hedge exposure to multiple factors
- Describe and apply the Fama-French three factor model in estimating asset returns

13) Principles for Effective Risk Data Aggregation and Risk Reporting

After completion of this topic you will be able to

- Explain the potential benefits of having effective risk data aggregation and reporting
- Describe key governance principles related to risk data aggregation and risk reporting practices
- Identify the data architecture and IT infrastructure features that can contribute to effective risk data aggregation and risk reporting practices
- Describe characteristics of a strong risk data aggregation capability and demonstrate how these characteristics interact with one another
- Describe characteristics of effective risk reporting practices

14) GARP Code of Conduct

After completion of this topic you will be able to

- Describe the responsibility of each GARP member with respect to professional integrity, ethical conduct, conflicts of interest, confidentiality of information and adherence to generally accepted practices in risk management
- Describe the potential consequences of violating the GARP Code of Conduct

Unit 2 - Capital Markets Risk Management

Uncertainty presents both risk and opportunity, eroding or enhancing value. Enterprise risk management lets financial firms deal effectively with uncertainty and associate risk with opportunity. The ability to price risk appropriately differentiates a successful player from the rest of the crowd. Firms spend a considerable amount of time and money building risk management systems to measure, monitor, mitigate and report risk. Risk management becomes more complex with financial innovation and increasing regulatory and compliance constraints. Performance measurement, attribution and maximization of risk adjusted returns also compel firms to spend more on enterprise risk applications. As financial markets become more open and deregulated, it is imperative for firms to update their enterprise risk systems in order to remain competitive. The boom in complex structured products has had an overwhelming impact on risk management departments, as proper calculations for VaR, Potential Future Exposure and Specific Risk increasingly need a wealth of security information and processing power. Additionally, compliance, surveillance, and reporting requirements have increasingly burdened risk departments with activities which require specific process workflows. Capgemini has deep domain knowledge and technical expertise in these areas. We have worked with some of the largest firms on Wall Street to provide solutions for risk data warehouses; firm-wide risk reporting across asset classes; model validations; integration with internal valuation engines and calculation grids; and data feed management including integration with security master and market data across market, credit and operational risk areas.

Solutions that Add Value to Your Business Our work has helped Capgemini clients: n Build risk dashboards n Manage risk reference data n Evaluate value at risk methodologies n Calculate maximum potential exposure n Monitor credit and trading limits n Manage regulatory capital n Ensure fast turnaround for critical reporting and regulatory needs using a global delivery model n Perform stress testing.

Capgemini has proven expertise in market, credit and operational risk and provides advisory and technology services for:

Risk analytics comprising integration with enterprise analytics and calculation engines like Summit, Algorithmics, SunGard or Commit and model validation and documentation

Risk aggregation such as risk data modelling, enterprise hierarchy and security master integration along with integration with in-house calculation engines

Risk reporting which provides custom reports using our proven global delivery model and industry standard reporting packages such as Business Objects, Cognos and Crystal Reports

Risk data management such as development or migration of data feeds, market data integration, and managed services for data maintenance

Risk technology assessment of alternative solutions including architecture reviews and recommendations

Advisory Services Capgemini's capital markets industry consultants and subject matter experts focus on high level analysis and strategy to help uncover business drivers, identify risk systems and asset classes; and define the enterprise architecture required for more effective enterprise risk management systems. Key offerings

Key offerings

Build versus buy analysis and package selection

Business analysis involving deep domain knowledge, requirements modelling and gap analysis

Model validation and implementation assessment

Credit risk systems assessment

Data management assessment

Value-At-Risk methodologies

Collateral management needs assessment

Regulatory compliance including CSE, Basel II and CAD

Quantitative and analytic services

Market and operational risk systems assessments Regulatory capital calculations

Technology Services

Capgemini brings proven development skills which span legacy to leading edge technologies. Our technology expertise has been honed on real-world projects such as: proprietary development of risk data warehouses; vendor product integration; and enhancements to existing risk frameworks. Components of an enterprise risk management system can require custom development, especially for designing computational components, web-based risk reporting and monitoring portals, and proprietary analytic engines. Our data warehouse implementation offering helps clients with the enterprise risk data centralization process. We also offer crucial production and maintenance support around the clock by taking advantage of the time difference among our global facilities.

Key offerings

Collateral management systems implementation

Enterprise risk management portal which offers the flexibility to integrate several risk frameworks into a single portal

Data management and integration development & implementation

New asset classes integration into existing risk management frameworks

Limits monitoring systems

Market and operational risk systems development

Migration of legacy applications to new proven technologies

Risk reference data and source data feed management C

Expertise Where It Counts

Proper implementation of risk management software requires thorough knowledge of how the business operates, implications of industry regulations and how to translate business requirements into a valid technical approach. Our consultants have deep domain expertise backed with a solid understanding of how to create specifications for a successful technical build out. With an average of 15 years of Wall Street experience, our Capital Markets consultants have helped many financial firms meet their goals for performing model validations; VaR methodologies; and Credit exposure calculations. Our experience across asset classes includes: n Equities and Equity Options/ Futures n Fixed Income Securities n Mortgage Backed/Asset Backed n Interest Rate Derivatives n Credit Derivatives n Structured Products n Custom Indices and Index Constituents.

Unit 3 - Credit Risk Management

Credit risk refers to the probability of loss due to a borrower's failure to make payments on any type of debt. Credit risk management is the practice of mitigating losses by understanding the adequacy of a bank's capital and loan loss reserves at any given time – a process that has long been a challenge for financial institutions.

The global financial crisis – and the credit crunch that followed – put credit risk management into the regulatory spotlight. As a result, regulators began to demand more transparency. They wanted to know that a bank has thorough knowledge of customers and their associated credit risk. And new Basel III regulations will create an even bigger regulatory burden for banks.

To comply with the more stringent regulatory requirements and absorb the higher capital costs for credit risk, many banks are overhauling their approaches to credit risk. But banks who view this as strictly a compliance exercise are being short-sighted. Better credit risk management also presents an opportunity to greatly improve overall performance and secure a competitive **advantage**.

Challenges to Successful Credit Risk Management

- **Inefficient data management.** An inability to access the right data when it's needed causes problematic delays.
- **No groupwide risk modelling framework.** Without it, banks can't generate complex, meaningful risk measures and get a big picture of groupwide risk.
- **Constant rework.** Analysts can't change model parameters easily, which results in too much duplication of effort and negatively affects a bank's efficiency ratio.
- **Insufficient risk tools.** Without a robust risk solution, banks can't identify portfolio concentrations or re-grade portfolios often enough to effectively manage risk.
- **Cumbersome reporting.** Manual, spreadsheet-based reporting processes overburden analysts and IT.

Best Practices in Credit Risk Management

The first step in effective credit risk management is to gain a complete understanding of a bank's overall credit risk by viewing risk at the individual, customer and portfolio levels.

While banks strive for an integrated understanding of their risk profiles, much information is often scattered among business units. Without a thorough risk assessment, banks have no way of knowing if capital reserves accurately reflect risks or if loan loss reserves adequately cover potential short-term credit losses. Vulnerable banks are targets for close scrutiny by regulators and investors, as well as debilitating losses.

The key to reducing loan losses – and ensuring that capital reserves appropriately reflect the risk profile – is to implement an integrated, quantitative credit risk solution. This solution should get banks up and running quickly with simple portfolio measures. It should also accommodate a path to more sophisticated credit risk management measures as needs evolve. The solution should include:

- Better model management that spans the entire modelling life cycle.
- Real-time scoring and limits monitoring.
- Robust stress-testing capabilities.
- Data visualization capabilities and business intelligence tools that get important information into the hands of those who need it, when they need it.

Unit 4 - Risk measurement

Any individual or enterprise needs to be able to quantify risk before they can decide whether or not a particular risk is critical enough to commit resources to manage. If such resources have been committed, then we need measurements to see whether the risk management process or procedure has reduced risk. And all forms of enterprises, for financial profit or for social profit, must strive to reduce risk. Without risk metrics, enterprises cannot tell whether or not they have reached risk management objectives. Enterprises including businesses hold risk management to be as important as any other objective, including profitability. Without risk metrics to measure success, failure, or incremental improvement, we cannot judge progress in the control of risk.

Risk management provides a framework for assessing opportunities for profit, as well as for gauging threats of loss. Without measuring risk, we cannot ascertain what action of the available alternatives the enterprise should take to optimize the risk-reward tradeoff. The

risk-reward tradeoff is essentially a cost-benefit analysis taking uncertainty into account. In (economic) marginal analysis terms, we want to know how many additional units of risk we need to take on in order to get an additional unit of reward or profit. A firm, for example, wants to know how much capital it needs to keep from going insolvent if a bad risk is realized. This is particularly true in firms like insurance companies and banks where the business opportunity they pursue is mainly based on taking calculated and judgment-based risks. Indeed, if they cannot measure risk, enterprises are stuck in the ancient world of being helpless to act in the face of uncertainty. Risk metrics allow us to measure risk, giving us an ability to control risk and simultaneously exploit opportunities as they arise. No one profits from establishing the existence of an uncertain state of nature. Instead, managers must measure and assess their enterprise's degree of vulnerability (risk) and sensitivity to the various potential states of nature. After reading this chapter, you should be able to define several different risk metrics and be able to discuss when each metric is appropriate for a given situation.

We will discuss several risk measures here, each of which comes about from the progression of mathematical approaches to describing and evaluating risk. We emphasize from the start, however, that measuring risk using these risk metrics is only one step as we assess any opportunity-risk issue. Risk metrics cannot stand alone. We must also evaluate how appropriate each underlying model might be for the occasion. Further, we need to evaluate each question in terms of the risk level that each entity is willing to assume for the gain each hopes to receive. Firms must understand the assumptions behind worst-case or ruin scenarios, since most firms do not want to take on risks that "bet the house." To this end, knowing the severity of losses that might be expected in the future (severity is the dollar value per claim) using forecasting models represents one aspect of quantifying risk. However, financial decision making requires that we evaluate severity levels based upon what an individual or a firm can comfortably endure (risk appetite). Further, we must evaluate the frequency with which a particular outcome will occur. As with the common English language usage of the term, frequency is the number of times the event is expected to occur in a specified period of time. The 2008 financial crisis provides an example: Poor risk management of the financial models used for creating mortgage-backed securities and credit default derivatives contributed to a worldwide crisis. The assessment of loss frequency, particularly managers'

assessment of the *severity* of losses, was grossly underestimated. We discuss risk assessment using risk metrics in the pages that follow.

As we noted risk is a concept encompassing perils, hazards, exposures, and perception (with a strong emphasis on perception). It should come as no surprise that the metrics for measuring risk are also quite varied. The aspect of risk being considered in a particular situation dictates the risk measure used. If we are interested in default risk (the risk that a contracting party will be unable to live up to the terms of some financial contract, usually due to total ruin or bankruptcy), then one risk measure might be employed. If, on the other hand, we are interested in expected fluctuations of retained earnings for paying future losses, then we would likely use another risk measure. If we wish to know how much risk is generated by a risky undertaking that cannot be diversified away in the marketplace, then we would use yet another risk measure. Each risk measure has its place and appropriate application. One part of the art of risk management is to pick the appropriate risk measure for each situation.

In this chapter, we will cover the following:

1. Links
2. Quantification of uncertain outcomes via probability models
3. Measures of risk: putting it together

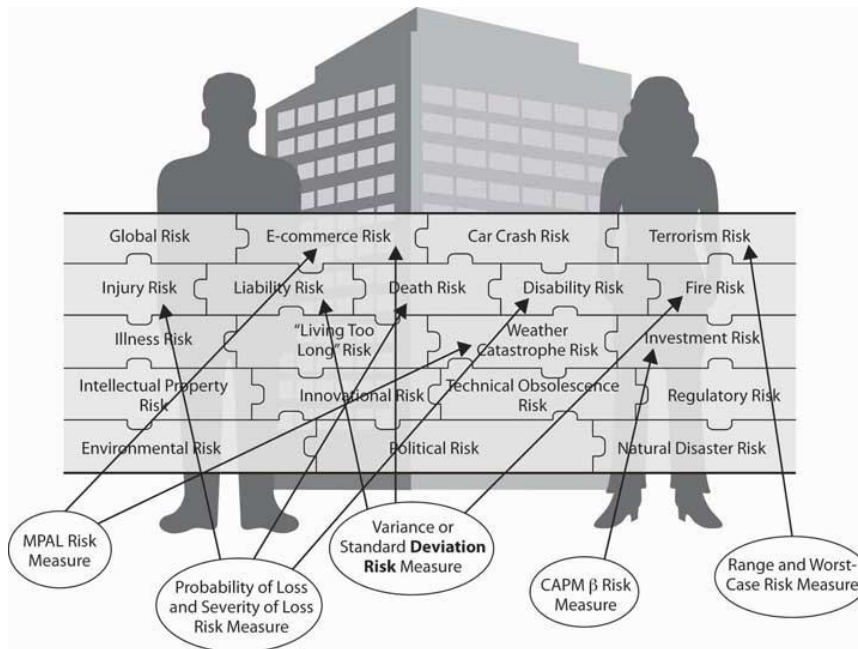
Links

The first step in developing any framework for the measuring risk quantitatively involves creating a framework for addressing and studying uncertainty itself. Such a framework lies within the realm of probability. Since risk arises from uncertainty, measures of risk must also take uncertainty into account. The process of quantifying uncertainty, also known as probability theory, actually proved to be surprisingly difficult and took millennia to develop. Progress on this front required that we develop two fundamental ideas. The first is a way to quantify uncertainty (probability) of potential states of the world. Second, we had to develop the notion that the outcomes of interest to human events, the risks, were subject to some kind of regularity that we could predict and that would remain stable over time. Developing and accepting these two notions represented path-breaking, seminal changes from previous

mindsets. Until research teams made and accepted these steps, any firm, scientific foundation for developing probability and risk was impossible.

Solving risk problems requires that we compile a puzzle of the many personal and business risks. First, we need to obtain quantitative measures of each risk. Again, as in [Chapter 1 "The Nature of Risk: Losses and Opportunities"](#), we repeat the Link puzzle in [Figure 2.1 "Links between Each Holistic Risk Puzzle Piece and Its Computational Measures"](#). The point illustrated in [Figure 2.1 "Links between Each Holistic Risk Puzzle Piece and Its Computational Measures"](#) is that we face many varied risk exposures, appropriate risk measures, and statistical techniques that we apply for different risks. However, most risks are interconnected. When taken together, they provide a holistic risk measure for the firm or a family. For some risks, measures are not sophisticated and easy to achieve, such as the risk of potential fires in a region. Sometimes trying to predict potential risks is much more complex, such as predicting one-hundred-year floods in various regions. For each type of peril and hazard, we may well have different techniques to measure the risks. Our need to realize that catastrophes can happen and our need to account for them are of paramount importance. The 2008–2009 financial crisis may well have occurred in part because the risk measures in use failed to account for the systemic collapses of the financial institutions. Mostly, institutions toppled because of a result of the mortgage-backed securities and the real estate markets. As we explore risk computations and measures throughout this chapter, you will learn terminology and understand how we use such measures. You will thus embark on a journey into the world of risk management. Some measures may seem simplistic. Other measures will show you how to use complex models that use the most sophisticated state-of-the-art mathematical and statistical technology. You'll notice also that many computations would be impossible without the advent of powerful computers and computation memory. Now, on to the journey.

Figure 2.1 Links between Each Holistic Risk Puzzle Piece and Its Computational Measures



2.1 Quantification of Uncertainty via Probability Models

LEARNING OBJECTIVES

- In this section, you will learn how to quantify the relative frequency of occurrences of uncertain events by using probability models.
- You will learn about the measures of frequency, severity, likelihood, statistical distributions, and expected values.
- You will use examples to compute these values.

As we consider uncertainty, we use rigorous quantitative studies of chance, the recognition of its empirical regularity in uncertain situations. Many of these methods are used to quantify the occurrence of uncertain events that represent intellectual milestones. As we create models based upon probability and statistics, you will likely recognize that probability and statistics touch nearly every field of study today. As we have internalized the predictive regularity of repeated chance events, our entire worldview has changed. For example, we have convinced ourselves of the odds of getting heads in a coin flip so much that it's hard to imagine otherwise. We're used to seeing statements such as "average life of 1,000 hours" on a package of light bulbs. We understand such a phrase because we can think of the length of life of a light bulb as being uncertain but statistically predictable. We routinely hear such statements as "The chance of rain tomorrow is 20 percent." It's hard for us to imagine that

only a few centuries ago people did not believe even in the existence of chance occurrences or random events or in accidents, much less explore any method of quantifying seemingly chance events. Up until very recently, people have believed that God controlled every minute detail of the universe. This belief rules out any kind of conceptualization of chance as a regular or predictable phenomenon. For example, until recently the cost of buying a life annuity that paid buyers \$100 per month for life was the same for a thirty-year-old as it was for a seventy-year-old. It didn't matter that empirically, the "life expectancy" of a thirty-year-old was four times longer than that of a seventy-year-old. The government of William III of England, for example, offered annuities of 14 percent regardless of whether the annuitant was 30 or 70 percent; (Karl Pearson, *The History of Statistics In the 17th and 18th Centuries against the Changing Background of Intellectual, Scientific and Religious Thought* (London: Charles Griffin & Co., 1978), 134. After all, people believed that a person's particular time of death was "God's will." No one believed that the length of someone's life could be judged or predicted statistically by any noticed or exhibited regularity across people. In spite of the advancements in mathematics and science since the beginning of civilization, remarkably, the development of measures of relative frequency of occurrence of uncertain events did not occur until the 1600s. This birth of the "modern" ideas of chance occurred when a problem was posed to mathematician Blaisé Pascal by a frequent gambler. As often occurs, the problem turned out to be less important in the long run than the solution developed to solve the problem.

The problem posed was: If two people are gambling and the game is interrupted and discontinued before either one of the two has won, what is a fair way to split the pot of money on the table? Clearly the person ahead at that time had a better chance of winning the game and should have gotten more. The player in the lead would receive the larger portion of the pot of money. However, the person losing could come from behind and win. It could happen and such a possibility should not be excluded. How should the pot be split fairly? Pascal formulated an approach to this problem and, in a series of letters with Pierre de Fermat, developed an approach to the problem that entailed writing down all possible outcomes that could possibly occur and then counting the number of times the first gambler won. The proportion of times that the first gambler won (calculated as the number of times the gambler won divided by the total number of possible outcomes) was taken to be the

proportion of the pot that the first gambler could fairly claim. In the process of formulating this solution, Pascal and Fermat more generally developed a framework to quantify the relative frequency of uncertain outcomes, which is now known as probability. They created the mathematical notion of expected value of an uncertain event. They were the first to model the exhibited regularity of chance or uncertain events and apply it to solve a practical problem. In fact, their solution pointed to many other potential applications to problems in law, economics, and other fields.

From Pascal and Fermat's work, it became clear that to manage future risks under uncertainty, we need to have some idea about not only the possible outcomes or states of the world but also how likely each outcome is to occur. We need a model, or in other words, a symbolic representation of the possible outcomes and their likelihoods or relative frequencies.

A Historical Prelude to the Quantification of Uncertainty Via Probabilities

Historically, the development of measures of chance (probability) only began in the mid-1600s. Why in the middle ages, and not with the Greeks? The answer, in part, is that the Greeks and their predecessors did not have the mathematical concepts. Nor, more importantly, did the Greeks have the psychological perspective to even contemplate these notions, much less develop them into a cogent theory capable of reproduction and expansion. First, the Greeks did not have the mathematical notational system necessary to contemplate a formal approach to risk. They lacked, for example, the simple and complete symbolic system including a zero and an equal sign useful for computation, a contribution that was subsequently developed by the Arabs and later adopted by the Western world. The use of Roman numerals might have been sufficient for counting, and perhaps sufficient for geometry, but certainly it was not conducive to complex calculations. The equal sign was not in common use until the late middle ages. Imagine doing calculations (even such simple computations as dividing fractions or solving an equation) in Roman numerals without an equal sign, a zero element, or a decimal point!

But mathematicians and scientists settled these impediments a thousand years before the advent of probability. Why did risk analysis not emerge with the advent of a more complete

numbering system just as sophisticated calculations in astronomy, engineering, and physics did? The answer is more psychological than mathematical and goes to the heart of why we consider risk as both a psychological and a numerical concept in this book. To the Greeks (and to the millennia of others who followed them), the heavens, divinely created, were believed to be static and perfect and governed by regularity and rules of perfection—circles, spheres, the six perfect geometric solids, and so forth. The earthly sphere, on the other hand, was the source of imperfection and chaos. The Greeks accepted that they would find no sense in studying the chaotic events of Earth. The ancient Greeks found the path to truth in contemplating the perfection of the heavens and other perfect unspoiled or uncorrupted entities. Why would a god (or gods) powerful enough to know and create everything intentionally create a world using a less than perfect model? The Greeks, and others who followed, believed pure reasoning, not empirical, observation would lead to knowledge. Studying regularity in the chaotic earthly sphere was worst than a futile waste of time; it distracted attention from important contemplations actually likely to impart true knowledge.

It took a radical change in mindset to start to contemplate regularity in events in the earthly domain. We are all creatures of our age, and we could not pose the necessary questions to develop a theory of probability and risk until we shook off these shackles of the mind. Until the age of reason, when church reforms and a growing merchant class (who pragmatically examined and counted things empirically) created a tremendous growth in trade, we remained trapped in the old ways of thinking. As long as society was static and stationary, with villages this year being essentially the same as they were last year or a decade or century before, there was little need to pose or solve these problems. M. G. Kendall captures this succinctly when he noted that “mathematics never leads thought, but only expresses it.”* The western world was simply not yet ready to try to quantify risk or event likelihood (probability) or to contemplate uncertainty. If all things are believed to be governed by an omnipotent god, then regularity is not to be trusted, perhaps it can even be considered deceptive, and variation is irrelevant and illusive, being merely reflective of God’s will. Moreover, the fact that things like dice and drawing of lots were simultaneously used by magicians, by gamblers, and by religious figures for divination did not provide any impetus toward looking for regularity in earthly endeavors.

* M. G. Kendall, "The Beginnings of a Probability Calculus," in *Studies in the History of Statistics and Probability*, vol. 1, ed. E. S. Pearson and Sir Maurice Kendall (London: Charles Griffin & Co., 1970), 30.

Measurement Techniques for Frequency, Severity, and Probability Distribution

Measures for Quantifying Uncertain Events

When we can see the pattern of the losses and/or gains experienced in the past, we hope that the same pattern will continue in the future. In some cases, we want to be able to modify the past results in a logical way like inflating them for the time value of money discussed. If the patterns of gains and losses continue, our predictions of future losses or gains will be informative. Similarly, we may develop a pattern of losses based on theoretical or physical constructs (such as hurricane forecasting models based on physics or likelihood of obtaining a head in a flip of a coin based on theoretical models of equal likelihood of a head and a tail). Likelihood is the notion of how often a certain event will occur. Inaccuracies in our abilities to create a correct distribution arise from our inability to predict futures outcomes accurately. The distribution is the display of the events on a map that tells us the likelihood that the event or events will occur. In some ways, it resembles a picture of the likelihood and regularity of events that occur. Let's now turn to creating models and measures of the outcomes and their frequency.

Measures of Frequency and Severity

Table 2.1 "Claims and Fire Losses for Group of Homes in Location A" and Table 2.2 "Claims and Fire Losses (\$) for Homes in Location B" show the compilation of the number of claims and their dollar amounts for homes that were burnt during a five-year period in two different locations labeled Location A and Location B. We have information about the total number of claims per year and the amount of the fire losses in dollars for each year. Each location has the same number of homes (1,000 homes). Each location has a total of 51 claims for the five-year period, an average (or mean) of 10.2 claims per year, which is the frequency. The average dollar amount of losses per claim for the whole period is also the same for each location, \$6,166.67, which is the definition of severity.