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Enterprise Risk Management

An Analytic Approach

A Tillinghast – Towers Perrin Monograph

Foreword

Business Risk Management…Holistic Risk Management…Strategic Risk Management… Enterprise Risk Management. Whatever you choose to call it, the management of risk is undergoing fundamental change within leading organizations. Worldwide, they are moving away from the "silo-by-silo" approach to manage risk more comprehensively and coherently.

This heightened interest in Enterprise Risk Management (ERM) has been fueled in part by external factors. In just the last few years, industry and government regulatory bodies, as well as institutional investors, have turned to scrutinizing companies' risk management policies and procedures. In more and more countries and industries, boards of directors are now required to review and report on the adequacy of the risk management processes in the organizations they govern.

And internally, company managers are touting the benefits of an enterprise-wide approach to risk management. These benefits include:

- reducing the cost of capital by managing volatility
- exploiting natural hedges and portfolio effects
- focusing management attention on risks that matter by expressing disparate risks in a common language
- identifying those risks to exploit for competitive advantage
- protecting and enhancing shareholder value.

ERM is actually a straightforward process. And, in most cases, the requisite intellectual capital and business practices needed to carry out ERM already exist within the company. But an accurate, useful ERM process is based on sound analytics. Without valid measurements, managing risk is effective and efficient only by chance.

In the following pages, we hope to add analytical rigor to the public discourse on ERM. Drawing from our client experiences, we offer a rational, scientific approach — one grounded in sound principles and practical realities.

"Risk," by definition and by nature, cannot be eliminated. Nor do leading organizations wish it gone. Rather, they want to manage the factors that influence risk so that they can pursue strategic advantage. How to identify and manage these factors is the subject of this monograph.

It is our intention to periodically update this document. We would be most interested in readers' comments and suggestions.

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I Introduction

Purpose of this monograph

Pressure to adopt ERM has increased from both internal and external forces. Although optional in most cases, a formalized risk management culture and its benefits have gained recognition and have fueled interest in the process.

With this monograph, we intend to add analytical rigor to the public discourse on ERM by presenting a scientific approach grounded in sound business principles and practical realities.

In this document, we will:

- define the ERM process
- discuss what motivates organizations to adopt ERM
- describe our conceptual ERM framework and outline the process steps
- detail a comprehensive, analytic approach to ERM
- discuss methods by which organizations implement ERM.

Definition and objective of ERM

We define ERM as follows:

ERM is a rigorous approach to assessing and addressing the risks from all sources that threaten the achievement of an organization's strategic objectives. In addition, ERM identifies those risks that represent corresponding opportunities to exploit for competitive advantage.

ERM's objective — to enhance shareholder* value — is achieved through:

- improving capital efficiency
  - providing an objective basis for allocating resources
  - reducing expenditures on immaterial risks
  - exploiting natural hedges and portfolio effects
- supporting informed decision making
  - uncovering areas of high-potential adverse impact on drivers of share value
  - identifying and exploiting areas of "risk-based advantage"
- building investor confidence
  - establishing a process to stabilize results by protecting them from disturbances
  - demonstrating proactive risk stewardship.

Motivation for considering ERM

External pressures

Some organizations adopt ERM in response to direct and indirect pressure from corporate governance bodies and institutional investors:

- In Canada, the Dey report, commissioned by the Toronto Stock Exchange and released in December 1994, requires companies to report on the adequacy of internal control. Following that, the clarifying report produced by the Canadian Institute of Chartered Accountants, "Guidance on Control" (CoCo report, November 1995), specifies that internal control should include the processes of risk assessment and risk management. While these reports have not forced Canadian-listed companies to initiate an ERM process, they do create public pressure and a strong moral obligation to do so. In actuality, many companies have responded by creating ERM processes.
- In the United Kingdom, the London Stock Exchange has adopted a set of principles — the Combined Code — that consolidates previous reports on corporate governance by the Cadbury, Greenbury and Hampel committees.

* In this monograph, the emphasis is on shareholders rather than the broader category of stakeholders (which also includes customers, suppliers, employees, lenders, communities, etc.). Though some observers prefer to define the scope of ERM to include the interests of all stakeholders, we believe this is not pragmatic at the current evolutionary state of ERM and would result in too diffuse a focus. While shareholder value is not directly relevant to some organizations (e.g., privately held and nonprofit entities), the concepts and approaches developed in this monograph clearly apply to those organizations.

This code, effective for all accounting periods ending on or after December 23, 2000 (and with a lesser requirement for accounting periods ending on or after December 23, 1999), makes directors responsible for establishing a sound system of internal control, reviewing its effectiveness and reporting their findings to shareholders. This review should cover all controls, including operational and compliance controls and risk management. The Turnbull Committee issued guidelines in September 1999 regarding the reporting requirement for nonfinancial controls.

- Australia and New Zealand have a common set of risk management standards. Their 1995 standards call for a formalized system of risk management and for reporting to the organization's management on the performance of the risk management system. While not binding, these standards create a benchmark for sound management practices that includes an ERM system.
- In Germany, a mandatory bill — the Kon TraG — became law in 1998. Aimed at giving shareholders more information and control, and increasing the accountability of the directors, it includes a requirement that the management board establish supervisory systems for risk management and internal revision. In addition, it calls for reporting on these systems to the supervisory board. Further, auditors appointed by the supervisory board must examine implementation of risk management and internal revision.
- In the Netherlands, the Peters report in 1997 made 40 recommendations on corporate governance, including a recommendation that the management board submit an annual report to the supervisory board on a corporation's objectives, strategy, related risks and control systems. At present, these recommendations are not mandatory.
- In the U.S., the SEC requires a statement on opportunities and risks for mergers, divestitures and acquisitions. It also requires that companies describe distinctive characteristics that may have a material impact on future financial performance within 10-K and 10-Q statements. Several factors broaden the requirement to report on the risks to the organization, leading to setting in place an enterprise-wide approach to risk management:
  - The report, "Internal Control — An Integrated Framework," produced by the Committee of the Sponsoring Organizations of the Treadway Commission (COSO), favors a broad approach to internal control to provide reasonable assurance of the achievement of an entity's objectives. Issued in September 1992, it was amended in May 1994. While COSO does not require corporations to report on their process of internal control, it does set out a framework for ERM within an organization.
  - In September 1994, the AICPA produced its analysis, "Improving Business Reporting — A Customer Focus" (the Jenkins report), in which it recommends that reporting on opportunities and risks be improved to include discussion of all risks/opportunities that:

    — are current

    — are of serious concern

    — have an impact on earnings or cash flow

    — are specific or unique

    — have been identified and considered by management.

    The report also recommends moving toward consistent international reporting standards, which may include disclosures on risk as is required in other countries.

Institutional investors, such as Calpers, have begun to push for stronger corporate governance and to question companies about their corporate governance procedures — including their management of risk.

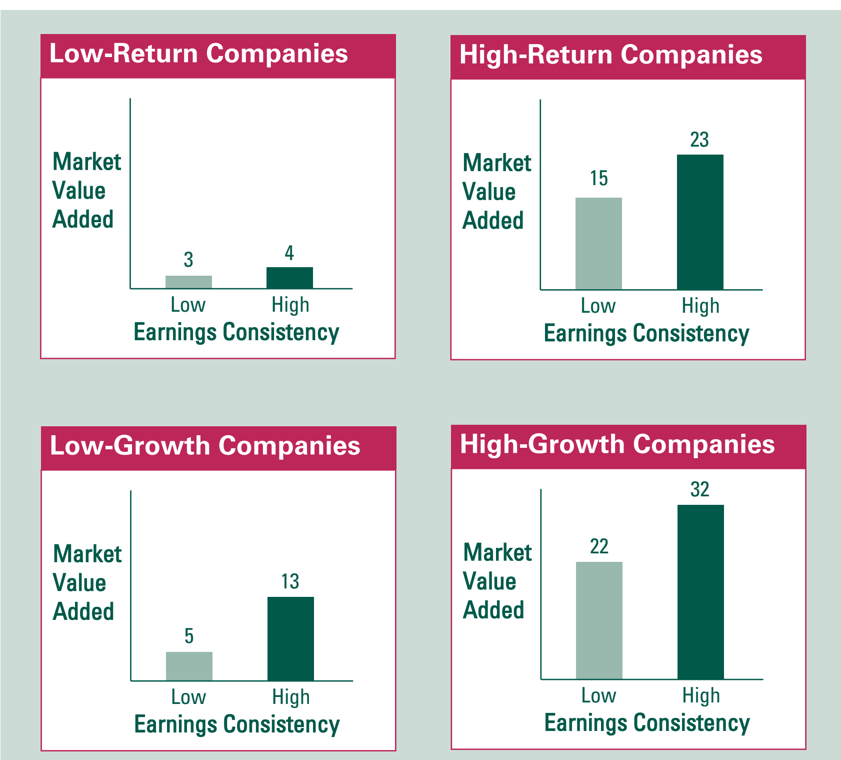
Internal reasons

Other organizations simply see ERM as good business. For example:

- The Board of Directors at a large utility mandated an integrated approach to risk management throughout the organization. They introduced the process in a business unit that was manageable in size, represented a microcosm of the risks faced by the parent and did not have entrenched risk management systems. This same unit was the focus of the parent's strategy for seeking international growth — a strategy that would take the organization into unfamiliar territory — and had no established process for managing the attendant risks in a comprehensive way.

- The CFO of a manufacturing company with an uninterrupted 40-year history of earnings growth embarked on ERM. This step followed the company's philosophy of "identifying and fixing things before they become problems." The movement was spurred by the company's rapid growth, increasing complexity, expansion into new areas and the heightened scrutiny that accompanied its recent initial public offering.
- A large retail company's new Treasurer, with the support of the CFO, wanted to "assess the feasibility of taking a broader approach to risk management in developing the organization's future strategy." As part of this effort, she hoped to "evaluate our hazard risk and financial risk programs and strategies, to identify alternative methods of organizing and managing these exposures on a collective basis."

FIGURE 1



Companies with higher earnings consistency tend to have much higher stock valuations than their similarly situated competitors. Details and definitions are presented in Appendix A.

- The Chairman of the Finance Committee of the Board at a manufacturing company complained about reports from Internal Audit that repeatedly focused on immaterial risks. His concern led to formation of a cross-functional Risk Mitigation Team to identify and report on processes to deal with risks within an ERM framework. The team now reports directly to the finance committee on a quarterly basis.

These organizations view systematic anticipation of material threats to their strategic plans as integral to executing those plans and operating their businesses. They seek to eliminate the inefficiencies built into managing risk within individual "silos." And they appreciate that their cost of capital can be reduced through managing volatility.

Some observers argue that investors do not put a premium on an organization's attempt to manage volatility. These observers maintain that investors can presumably achieve this result more efficiently by diversifying the holdings in their own portfolio. They argue further that investors do not appreciate, and do not reward, an organization that spends its resources on risk management to smooth results on investors' behalf.

Our research into the link between performance consistency and market valuation, however, indicates otherwise. We found that consistency of earnings explains a high degree of difference in share value (specifically, "market value added") among companies within an industry. This is true even after allowing for other influences such as growth and return (see *Figure 1* and Appendix A). Investors assign a higher value, all else equal, to organizations whose earnings are more consistent than those of their peers. This clearly reduces the cost of capital for these organizations.

In summary, organizations can use ERM to enhance the drivers of share value: growth, return on capital, consistency of earnings and quality of management. ERM can identify and manage serious threats to growth and return while identifying risks that represent opportunities to exploit for above-average growth and return. Achieving earnings consistency is, of course, a central goal of ERM. And institutional investors increasingly define management quality to include enterprise-wide risk stewardship.

II Framework for ERM

Company information and procedures already in place can make the ERM process efficient and effective. Our conceptual framework for ERM consists of four elements.

Assessing risk

Risk assessment focuses on risk as a threat as well as an opportunity. In the case of risk-as-threat, assessment includes identification, prioritization and classification of risk factors for subsequent "defensive" response. In the case of risk-as-opportunity, it includes profiling risk-based opportunities for subsequent "offensive" treatment.

Shaping risk

This "defensive track" includes risk quantification/modeling, mitigation and financing.

Exploiting risk

This "offensive track" includes analysis, development and execution of plans to exploit certain risks for competitive advantage.

Keeping ahead

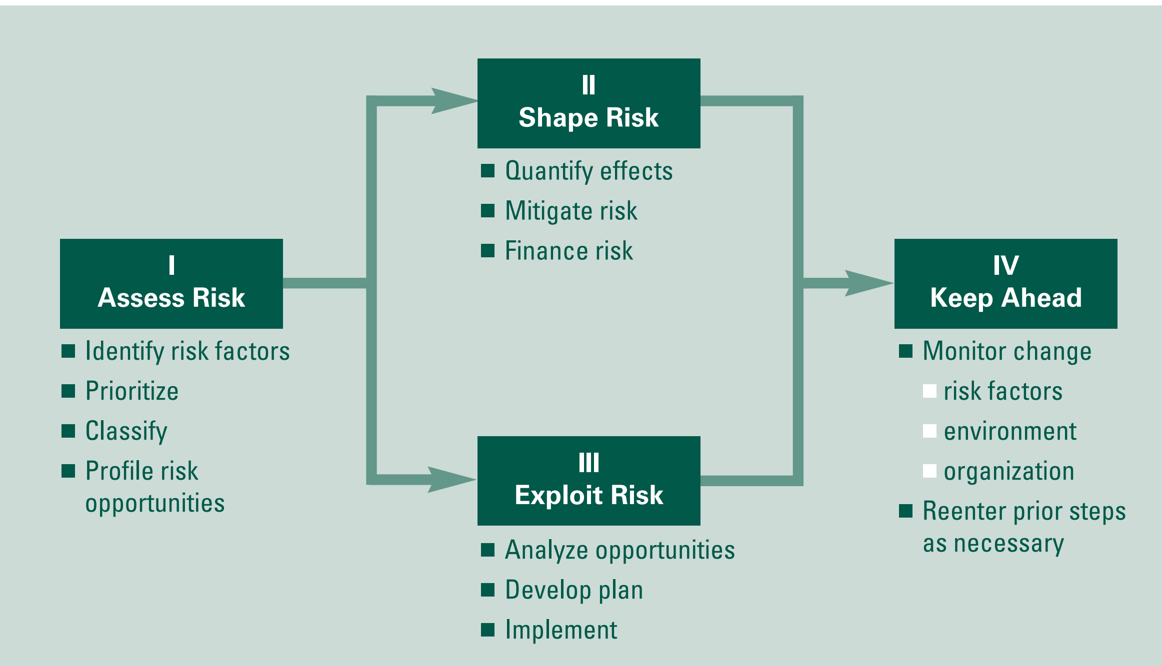
The nature of risk, the environment in which it operates, and the organization itself change with time. The situation requires continual monitoring and course corrections.

The chapters that follow provide a fuller description of the above elements (outlined in *Figure 2*).

The larger part of the discussion in this monograph is on the first two elements — risk assessment and risk shaping — as these create the foundation for the remaining elements. Accordingly, there will be more focus on the defensive track of ERM.

FIGURE 2

The Conceptual Approach to ERM



The conceptual approach to ERM is straightforward.

III A Rational Approach to Assessing Risk

Overview

We approach risk assessment believing that managing risk effectively requires measuring risk accurately — and that accurate risk measurement requires well-formulated risk modeling. Such measuring and modeling:

- allow senior management to see a compelling demonstration of the "portfolio effect," i.e., the fact that independent and/or favorably correlated risks tend to offset each other without the organization having to invest in explicit hedges
- promote the proper allocation of capital resources to risks that really matter
- permit sizing of investments in risk remediation
- provide an objective framework for systematic risk monitoring.

Do all risks that face an organization need modeling? And isn't model-building on this scale daunting?

The answer to the first question is: "No." Methods to prioritize risk factors can screen for those that require modeling. These methods are qualitative; we focus on these later in this chapter.

The answer to the second question is: "Not typically." These models often have been built and exist in some form somewhere in the organization. This will be the focus of Chapter IV.

Before we discuss the steps in risk assessment, we should distinguish risks from the risk factors underlying them. Here we focus on the negative side of risk — as a threat, not as an opportunity. In this context, risk is the possibility that something will prevent — directly or indirectly — the achievement of business objectives. Risk factors are the events or conditions that give rise to risk. Loss of market share is a risk; lack of preparedness for the entry of new competitors is a risk factor. Risk is not something that can be directly managed or controlled. Risk factors, however — the causes of risk — can be. Therefore, managing risk, and particularly assessing risk, requires focusing on its causes rather than its manifestations.

STEP 1
Identify risk factors

In this initial step, a wide net is cast to capture all risk factors that potentially affect achieving business objectives. Risk factors arise from many sources — financial, operational, political/regulatory or hazards. The key characteristic of each is that it can prevent the organization from meeting its goals. In fact, if a risk factor does not have this potential, it is not truly a risk factor under an enterprise-wide interpretation of risk. Thus, the first "screen" through which a candidate risk factor must pass is materiality.

In identifying risk factors, we favor a qualitative approach — gathering material from interviews with experts and reviewing documents. The interviews typically span the organization's:

- Senior management
- Operations management
- Corporate staff, including:
  - Finance
  - Treasury
  - Legal
  - Audit
  - Strategic Planning
  - Human Resources
  - Risk Management
  - Safety
  - Environmental.

These interviews solicit informed opinion on:

- how the business works, and the way components of the business — the interviewees' realms of responsibility — mesh
- key performance indicators used to manage the business and its components
- tolerable variation in key performance indicators over relevant time horizons
- events or conditions that cause variations beyond the risk tolerances, and the probable frequency and possible maximum effect of these.

Often we find it helpful to supplement internal interviews with interviews among the organization's external partners, their counterparties (banks, insurers, brokers), analysts, customers, and — on occasion — competitors.

We also review the organization's strategic plans, business plans, financial reports, analyst reports and risk stewardship reports.

From all these data and information, a picture emerges of the organization's:

- corporate culture
- objectives
- forms of capital (human, financial, market and infrastructure)
- business processes (which convert the capital into cash flows)
- control environment
- roles and responsibilities
- key performance measures
- risk tolerance levels
- capacity and readiness for change
- preliminary list of risk factors.

Importantly, this approach starts with the business, not a checklist of risks — far different from an audit-type approach. In other words, this approach goes from the top down and not the bottom up. Such an organic method is strongly preferable because preconceived checklists of risk factors are usually incomplete. Further, the most crucial risk factors are usually unique to each organization and its culture. This alone makes generic checklists far less relevant than a business-first approach.

STEP 2
Prioritize risk factors

The resulting list of risk factors (typically several dozen long at this stage) is not yet useful or actionable, although each factor has passed the materiality screen. It now requires prioritizing.

In Step 1 (Identify risk factors), we compiled information on each risk factor's likelihood, frequency, predictability and potential effect on the organization's key performance indicators. We also examined the quality of the process, systems and cultural controls in place to mitigate these factors. At this stage, the information is subjective, but quite sufficient. Now, the objective is to cull the list of these factors into a manageable number for senior management. The attributes of each factor can be combined in an overall score that, when combined with subjective judgment on the timing and duration of the financial impact, can be expressed as a "net present value" score. In the example in *Figure 3,* this "NPV" score is on a scale of 1 (low) to 5 (high). Once scores are assigned, we can sort the risk factors from low to high and produce a prioritized list.

A team of risk management experts typically does this evaluation and scoring. They often collaborate with representatives of management. In addition, we find a follow-up questionnaire or focus group(s) extremely helpful for cross-validation purposes. In these, the interviewees view the collective results of the identification step — the full list of risk factors, the consensus view on key performance indicators and risk tolerances, etc. Then, with this richer context and some facilitation, they can prioritize risks. We compare the results of this exercise with those from the independent prioritization conducted by the expert team, and the differences are reconciled.

The number of risk factors that will ultimately pass through the prioritization screen is often known before the process begins. Given the demands on senior management, expecting them to concentrate on a dozen or more "top priority" risk factors is unrealistic. Generally, six or less is manageable, but this depends on the organization. Also, natural breakpoints in the prioritized list and strategic links among the risk factors can influence the ultimate number. The short list should, however, contain items deserving of consideration at the highest levels of the organization — factors that should influence the strategic plan and the affected business plans, alter the day-to-day priorities of business unit managers and affect the behavior of the rank and file.

STEP 3

Classify risk factors

Still, any list of risk factors, however short and prioritized, is a sterile device. Organizing this information to clearly indicate what type of risk-shaping action is necessary comes next.

We have used several classification schemes in our work, some more detailed than others, each tailored to the client organization. One general scheme that may have nearly universal relevance is described below (see *Figure 4*). Additional refinements can be added as appropriate.

In this scheme, high-priority risk factors are of two types. One is characterized by the fact that the environment in which they arise is familiar to the organization, and the skills to remedy those risk factors are already in-house. However, for some reason, these risk factors had not been given the attention they deserve. We label these "manageable risk factors." Other risk factors arise because the organization enters unfamiliar

FIGURE 3

When Prioritizing Risk Factors...

...subjective scoring is appropriate at this stage

Risk Factors	Likelihood	Severity	Quality of Controls	Aggregate "NPV" Score (1-5)
A. Strategy				
Informal planning, process and communications allow surprises	H	H	L	4.5
Market share and earning objectives are not aligned	H	L	L	3.0
⋮				
B. Growth				
Infrastructure is increasingly strained, will be difficult to retain culture and values with the changes that growth demands	H	H	L	4.5
Increased size creates more opportunity for mistakes	M	L	M	2.0
⋮				
C. Company Reputation				
Pressure to make numbers may prompt behavior that will impair company's credibility with financial markets	M	H	H	3.5
Adverse publicity (e.g., business practices, ethics) can affect image across multiple brands	L	H	H	2.5
⋮				
D. Human Resources				
⋮				
J. Systems				
⋮				

Risk factors can be prioritized using a subjective process.

FIGURE 4

When Classifying Risk Factors...

...use a scheme that implies action

"Manageable" Risk Factors	"Strategic" Risk Factors
■ Known environment	■ Unfamiliar territory
■ Capabilities and resources on hand to address	■ Capabilities or resources may not be in place
■ Fell between the cracks?	■ Major change in market or business
Just get on with it	Requires allocation of capital or shift in strategic direction

Proper classification clearly implies the appropriate risk-shaping action.

business territory (due, perhaps, to a major acquisition, a powerful new competitor or a significant change in customer buying patterns), or the organization lacks the skills necessary to respond. These are considered "strategic risk factors" and may require significant capital outlay and/or a major change in strategic direction.

Manageable risk factors in our experience include:

- "The R&D division is not keeping pace with the demand for new products."
- "Contingency planning is weak in the critical production facilities."
- "Mid-level employees are dissatisfied with their opportunities for advancement."

Strategic risk factors we have encountered include:

- "The share value is dependent on continuing uninterrupted earnings growth; this growth must come from top-line revenue growth; and opportunities for top-line growth are limited without branching out of the organization's product line and/or niche market."
- "Needed infrastructure changes clash with the current success formula and culture."

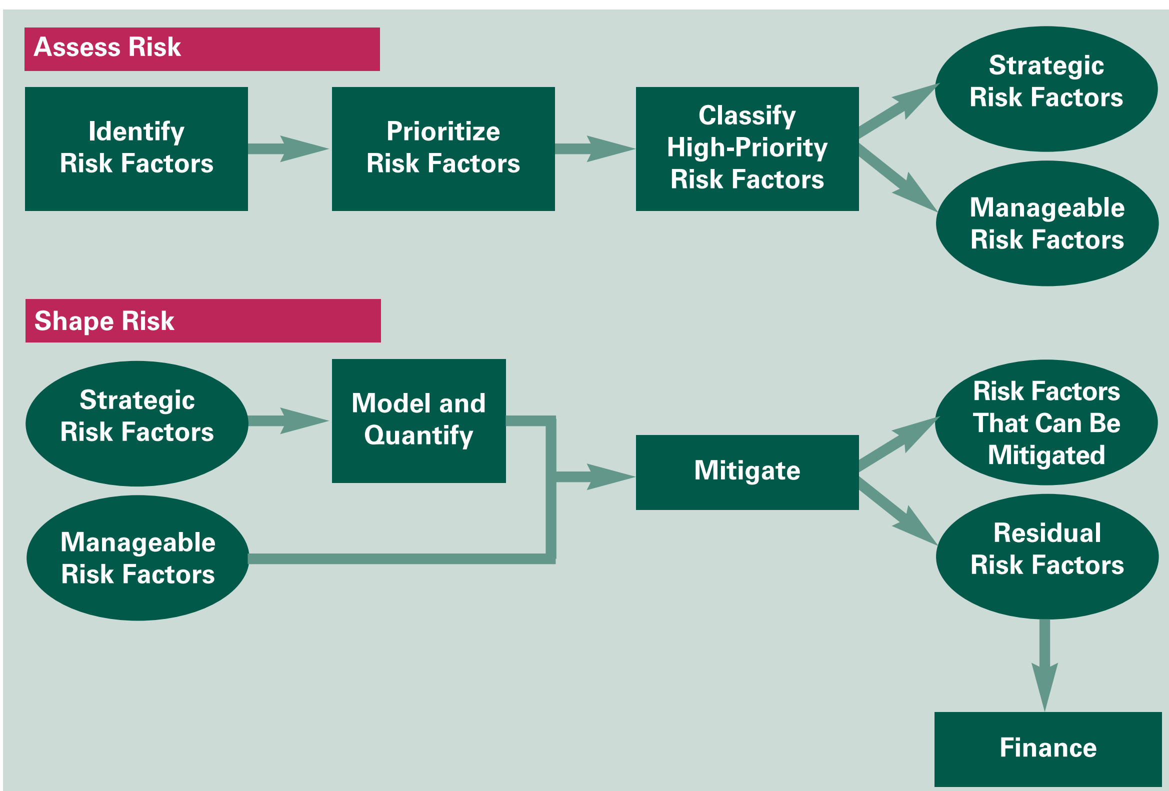
The proper response to manageable risk factors is to "just get on with it" — in other words, deal with them. The relevant skills already exist; they just need to be refocused on these high-priority items. Strategic risks, however, require greater analysis; this is covered in Chapter IV.

Recap… and segue

The steps described above are illustrated below (*Figure 5*). This graphic also illustrates the follow-on steps — the risk-shaping steps — that are the subject of the next chapter. The graphic demonstrates that not all risk factors need to be quantified and modeled, nor do all risk factors need to be financed. Risk factors needing quantification are those that pass through the "triple screen" — they are material, high-priority *and* strategic. Risk factors that need to be financed pass through the first two screens and cannot be fully mitigated through other means.

Underlying our approach to risk shaping — described in Chapter IV — is the premise that modeling, quantifying and formulating the strategy for mitigation and financing can be carried out simultaneously.

FIGURE 5



Triple screening in risk assessment creates efficiency in risk shaping.

IV A Scientific Approach to Shaping Risk

Overview

In this section, we will describe our approach to shaping risk and provide illustrations of its application. The approach to risk shaping relies heavily on Operations Research methods such as applied probability and statistics, stochastic simulation and portfolio optimization. To our knowledge, no organization has implemented this approach in its entirety as of the date of this publication, although we know of several that use portions of it in their incremental pursuit of ERM. (In Chapter VI, we describe how some of these organizations have gotten started.)

The Four Steps in Our Approach

In the first step, each source of risk is modeled as a probability distribution, and the correlation among the risk sources is determined. These probability distributions are typically expressed in terms of different operational and financial measures. The second step links these disparate distributions to a common financial measure (e.g., Free Cash Flow) through a stochastic financial model. These two steps represent the bulk of the analytical effort. At this stage, we have a holistic financial model of the business that can be used to:

- measure the volatility of the financial metric(s) under current operating conditions
- analyze the impact of risk management decisions through "what-if" scenarios.

The third step involves developing risk remediation strategies to be evaluated using the stochastic financial model. This basket of strategies represents a portfolio of risk management investment choices. In the final step, the ERM budget is allocated optimally across these strategies using portfolio optimization methods. Each step is described in greater detail below.

To illustrate this approach, we will introduce a hypothetical company (let's call it HypoCom) facing a broad array of strategic risks and show how the company would implement this approach in shaping these risks. Assume that HypoCom is a manufacturing company and has the following profile:

- Sells its product to retailers in the United States and Europe — with limited competition
- Has production plants in France, Mexico and Indonesia that deliver products to retailers through HypoCom's own distribution network
- Faces the following risks in the next fiscal year:
  - fire at a warehouse
  - volatility in the price of the raw materials used in the production process
  - possible employee union strike at the plant in France
  - possible new competitor entering the market.

While a real company, similar to HypoCom, would face many risks, we have limited their number here for the sake of simplicity. Please note, however, that the risks were selected to span those that are traditionally considered within the domain of risk management (hazard and commodity price risks) and those that are not (operational and competitor risks).

Again, to keep the example simple, we assume a one-year time horizon. At the end of this section, however, we discuss extending these steps to a more typical multi-period decision horizon.

STEP 1

Model various risk factors individually

Generate probability distributions

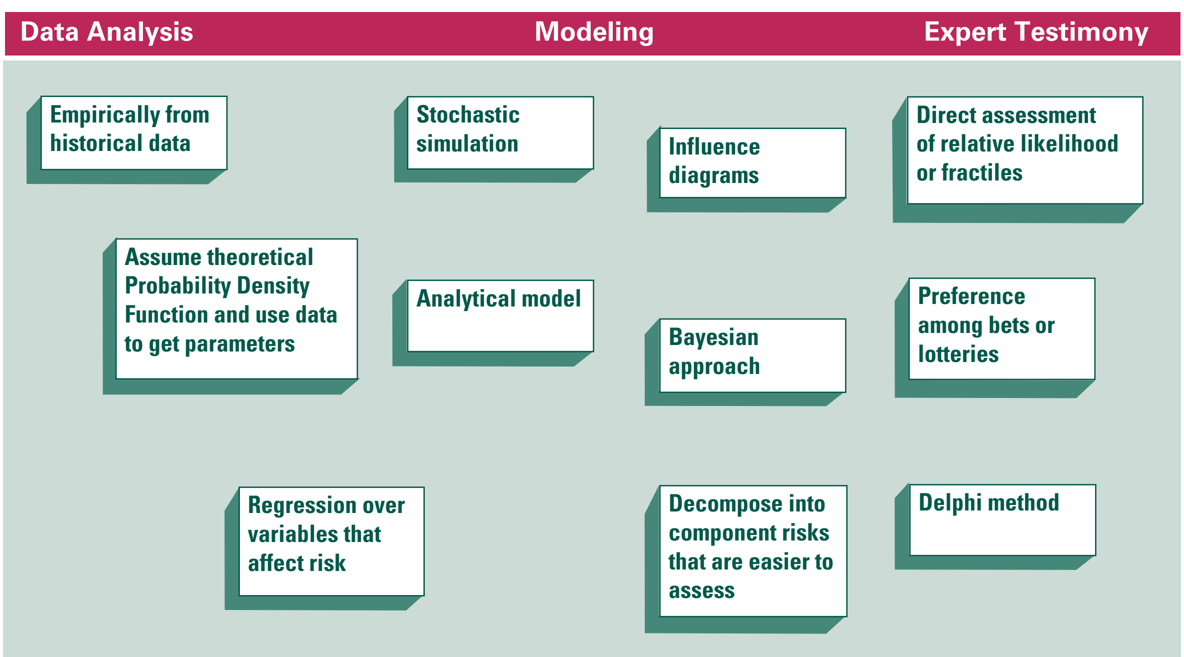
In Chapter III we outlined the approach for identifying which risk factors need to be modeled. Each risk factor contains uncertainty about how, when and to what degree it will manifest itself. This uncertainty is represented as a probability distribution. No one approach for developing probability distributions can be used for all the risks that an enterprise faces.

Risks that fall within the traditional domain of risk management — for instance, insurable risks or risks that can be hedged in the financial markets — are typically modeled using statistical methods that rely on the availability of historical data. However, when the domain is extended to enterprise-wide risks, it is unlikely that enough historical data exist to employ the same methods. Here, it is more likely that assessment of the uncertainty will be based entirely on expert testimony. Also, some risk sources will have to be modeled based on historical data combined with assumptions set by experts. Extending risk management to enterprise-wide risks suggests a continuum of methods for developing probability distributions. Such a continuum ranges from relying entirely on data to relying on expert testimony.

Figure 6 identifies methods for assessing probability distributions along this continuum. Readers of this monograph are likely to be familiar with methods based primarily on historical data (leftmost section of Figure 6). Therefore, instead of describing them, we have included references to source documents at the end of this monograph. At the opposite end of the continuum, there are formal methods developed and used by decision and risk analysts to elicit expert testimony for assessing uncertainty. We have provided brief descriptions of some of these in Appendix B. In the middle of the continuum, stochastic simulation modeling predominates for combining historical data and assumptions set through expert testimony. We will use this method to model the risk associated with an employee union strike at the HypoCom production plant in France.

(continued on page 16)

FIGURE 6



A continuum of methods for developing probability distributions ranges from those relying on data to those that rely on expert testimony. The positions of the methods identified above suggest which to use depending on the availability of data.

HypoCom – developing probability distributions for the four risks

Risk 1
Fire

A fire at a plant or warehouse can result in direct and indirect loss of sales volume. Direct losses result from destruction of inventory and work in progress. Indirect losses result from a prolonged interruption of production, through loss of short-term sales and perhaps through loss of market share. These risks have been insurable for a long time. Reliable methods exist for measuring the frequency and severity of losses based on review of historical data and business interruption worksheets. We will assume that for HypoCom, the frequency distribution is negative binomial and the severity distribution is lognormal (see references in Chapter VII for descriptions of these distributions).

Risk 2
Volatility in price of raw materials

Historical price data for commodities can be obtained from HypoCom's own purchase data or through financial markets if the commodity is traded on a futures exchange. Given the availability of data, several methods exist for developing the probability distribution. These are:

- Use empirical distribution
- Assume lognormal distribution using the sample mean and standard deviation
- Assume a stochastic process (e.g., jump diffusion) and use simulation to generate distribution of price movement.

An example of a stochastic process is the Schwartz-Smith two-factor model for the behavior of commodity prices (Schwartz & Smith 1999). The two-factor approach models both the uncertainty in the long-term trend and the short-term deviation from that trend.

For the sake of this example, we will assume that HypoCom faces a lognormally distributed price with a 2% standard deviation from the current price.

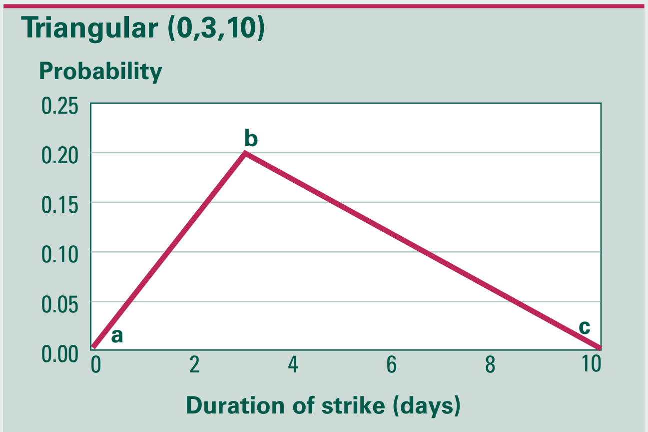
Risk 3
Employee union strike

An employee strike at the plant in France results in losses in sales volume. HypoCom services its European and U.S. markets from production at three plants (France, Mexico and Indonesia). This strike would result in a temporary shutdown of the plant in France. If the other two plants have capacity to increase production quickly enough to satisfy all demand, then there is little risk of loss in sales. But if all three plants are already running at high utilization (a more likely scenario), then the loss of one plant would result in longer lead times to market — the time from order placement to delivery. The strike would then affect HypoCom's ability to satisfy orders and lead-time commitments or expectations; this would result in a short-term loss of sales or possibly market share.

The probability distribution for the sales volume loss can be developed in three steps. First, determine the probability distribution for the length of the strike. It's quite likely that development of this distribution will have to be based almost entirely on expert testimony. As illustrated in Figure 6, there are several methods for assessing probabilities based on expert testimony: the Delphi method, eliciting preferences among bets or lotteries, and directly assessing relative likelihood or fractiles (see Appendix B for details on these methods). The labor relations manager(s) at HypoCom can be interviewed using one of these methods to determine the probability distribution for the length of the strike. For example, the result may be a triangular distribution as illustrated in *Figure 7*.

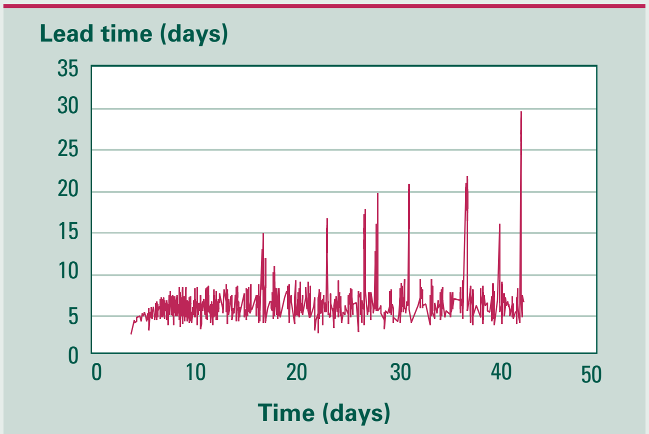
Second, develop a distribution on lead times conditioned on the length of the strike. We have developed a discrete-event stochastic simulation model of HypoCom's distribution network, using graphical, animated simulation software called ProModel®. The simulation modeled stochastic arrival of demand based on

FIGURE 7



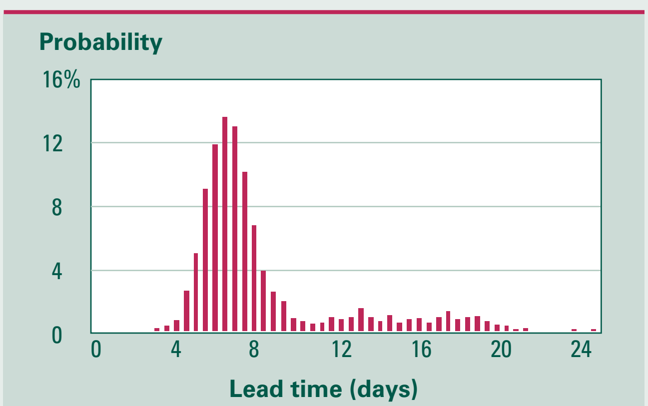
Triangular probability distribution with parameters minimum, mode and maximum (a, b and c, respectively). The expected value is (a+b+c)/3 and the standard deviation is $(a^2 + b^2 + c^2 - ab - bc - ac)/18$. This distribution is used often as a rough model when there is little historical data.

FIGURE 8



The chart shows the impact of a strike on lead times from one of the simulation runs. The strike starts on the 20th day and can last anywhere from 1 to 10 days, based on the probability distribution in Figure 7. You can see that the impact of the strike is felt long after the strike is over.

FIGURE 9



Discrete probability mass distribution generated from the lead-time data in Figure 8. The extended tail toward longer lead times is a consequence of an employee strike.

historical data, production rates at each of the plants and the logistics of distribution from the plant to regional distribution centers and then to retailers. It incorporated a distribution policy of supplying those distribution centers with the greatest backlog of orders. Inputs to this model are typically easy to get; in fact, many organizations already have a stochastic supply chain model used to optimize the logistics of their distribution network. The effect of the strike was simulated by shutting production at the plant in France and recording the increase in lead times. The chart of individual lead times in *Figure 8* is an output from a simulation run.

We usually run simulations a statistically valid number of times to attain a high level of confidence in the results. An empirical distribution of lead times based on these simulated data is shown in *Figure 9.*

Finally, determine the loss in sales conditioned on the increase in the lead times. With information in hand on the increase in the lead times, the sales and marketing managers at HypoCom would assess the effect on sales. One of the probability assessment methods for expert testimony described in Appendix B would be used here. The assessment would reflect contractual agreements with retailers as well as lead-time expectations and the competitive environment. So the final distribution on the decrease in the number of sales may be represented by a triangular distribution with parameters min. = 0, most likely = 4 million, max. = 10 million.

Risk 4
New competitor

Expert testimony provides the entire basis for the assessment of uncertainty associated with a new competitor. This process entails interviewing sales and marketing managers of HypoCom either individually or as a group. Any method described in Appendix B could be used here.

Here we develop a probability distribution on how new competition affects sales volume loss. It is helpful to dissect risk events into conditional causal events. For HypoCom, the causal events are illustrated in *Figure 10.*

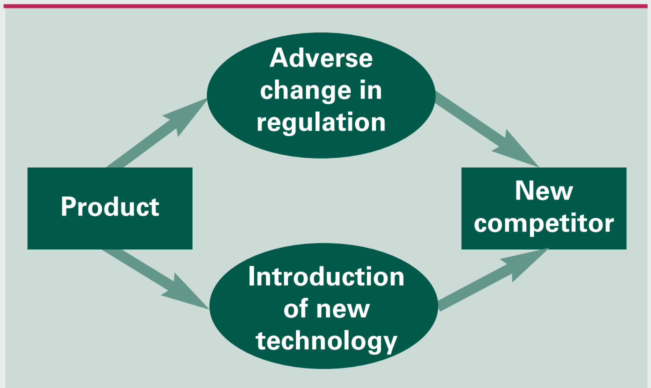
The probability of loss in sales volume due to competition, P(C), can be decomposed into:

$$P(C) = \Sigma_i P(C_i \mid R_i, T_i) P(R_i, T_i)$$

where i is the product index, $P(R_i, T_i)$ is the joint probability of an adverse change in regulation (R_i) and introduction of new technology (T_i) and $P(C_i \mid R_i, T_i)$ is the conditional probability of a loss in sales volume for product i due to new competition. If regulatory changes and introduction of new technology are not highly correlated, then $P(R_i, T_i)$ can be decomposed into the product of $P(R_i)$ and $P(T_i)$.

Instead of assessing P(C) directly, it is easier to ask different experts to assess the

FIGURE 10



Given the product, the possibility for change in regulation or introduction of new technology could influence the loss in sales due to competition.

conditional and joint probabilities. Company lobbyists are interviewed to assess the probability of adverse regulation for a specific product, $P(R_i)$, using one of two methods: preference among bets or judgment of relative likelihood (see Appendix B).

Managers of the Research and Development function are interviewed to assess the probability of introduction of new technology, $P(T_i)$. Finally, sales and marketing managers are interviewed to assess the probability of a new competitor, given the state of new regulation and technology, $P(C_i \mid R_i, T_i)$. Of course, experts may be interviewed as a group using the Delphi method (see Appendix B) instead of separately. This process is applied over all products of interest and the results summed according to the formula indicated above.

Determine correlation among risk sources

It is not enough to develop probability distributions on individual risk sources. One primary benefit of managing risks on an enterprise-wide basis is being able to take advantage of natural hedges and to explicitly reflect correlation among risks. Therefore, it is necessary to develop a matrix of correlation coefficients among pairs of risks that would be used in the next step to link the individual risk sources to a common financial measure.

It is unlikely that relevant data will exist to develop correlation among risks that span an enterprise. Thus, it is likely that this will have to be developed based on professional judgment and expert testimony. In some cases, it may be easier to develop correlations between risks implicitly by analyzing their correlation with a common linking variable. This process also ensures that a correlation matrix is internally consistent.

For HypoCom, we would expect a negative correlation between the commodity price movements and a new competitor entering the market. If the commodity price increases, it creates a greater barrier to entry into the market for a new competitor and vice versa. However, a union strike is probably positively correlated with competition. Finally, there may be some slight correlation between a union strike and the incidence of fire.

It is unlikely that correlations would be determined with a high degree of precision. Rather, it is more likely that they could be judged in fuzzy terms such as high, medium or low. These terms suggest some natural ranges for correlation coefficients such as: high correlation = .70 to .80, medium correlation = .45 to .55, low correlation = .20 to .30. Within these ranges, there should be little sensitivity on the results. The inclusion of correlations should have a significant impact on the results, but the error within these ranges should have little impact. Using these as guides, a Correlation Coefficient Matrix can be developed for HypoCom as shown in *Figure 11*.

FIGURE 11

	Fire	Commodity Price	Union Strike	New Competitor
Fire	1.0	0.0	0.2	0.0
Commodity Price	0.0	1.0	0.0	-0.5
Union Strike	0.2	0.0	1.0	0.7
New Competitor	0.0	-0.5	0.7	1.0

Correlations among risks are modeled using correlation coefficients among risk pairs. For example, the risk due to commodity price fluctuations is negatively correlated with a new competitor entering the market.

STEP 2

Link risk factors to common financial measures

Select financial metrics

The prior step provides a set of probability distributions representing enterprise-wide risks. Note that the probability distributions were expressed in terms of different units. We modeled the union strike as a probability distribution on lead time and then sales volume. Commodity price risk was modeled in terms of the price of raw materials. Other risks would be modeled in terms of the operational and financial measures that they directly affect. In this step, all these risks are combined and linked to one financial measure.

Managers of different organizations vary in their preference and propensity for the financial measures by which they manage the business. The financial measure will also vary depending on the objectives and goals of the organization. Above all, it is important that there is general agreement on the financial measure selected. For this document, we will use Free Cash Flow (FCF) to capture the impact of risk on both the income statement and balance sheet.

Develop a financial model to link risks to financial metric

Once a financial measure is selected, we can then model the aggregate impact of the sources of risk on the financial measure. We can construct a pro forma FCF model by decomposing each element in the calculation of FCF into its constituent metrics. See *Figure 12* for an illustration of this. The elements should be broken down to the level of the operational and financial measures used for modeling the individual risks in Step 1.

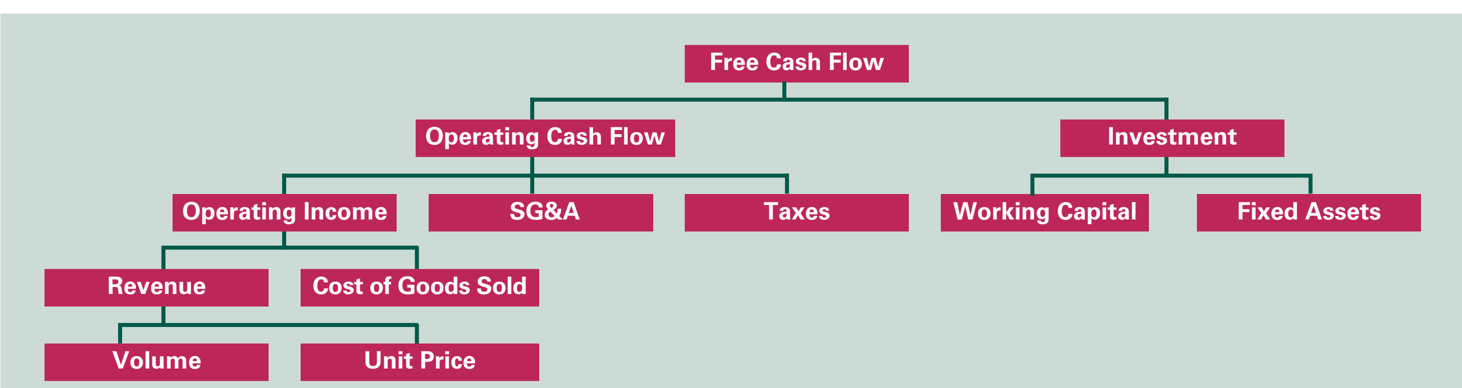
Some elements of the FCF model may be stochastic without consideration of the risks from Step 1. For example, there is some inherent uncertainty in product demand and price as well as cost of goods sold. These measures may fluctuate based on supply and demand economics. These inherent uncertainties are included in the base FCF model. The probability distributions from Step 1 are then added to the corresponding elements of the model. Finally, the Correlation Coefficient Matrix (from Step 1) is added to the model to reflect the interaction among the sources of risk. The resulting stochastic pro forma financial model links all the risks to FCF, the financial measure by which the risk remediation strategies will be evaluated in the next two steps.

Measure current level of enterprise risk before mitigation strategies

Before proceeding to risk remediation strategies, however, it is worth taking note of the value of the model thus far. At this point, we have a financial model that can be used to determine the current level of volatility in FCF. This information by itself would be extremely valuable in budgeting and financial planning. This analysis helps move managers' thinking away from the one-dimensional certainty of typical budgets and toward the range of possible outcomes and managing probable rather than definite outcomes.

(continued on page 21)

FIGURE 12



Free Cash Flow is decomposed into its elements: Operating Cash Flow and Change in Investment, which are further decomposed. Each element is broken down into its constituents until all operational and financial measures used for the distributions in Step 1 are isolated.

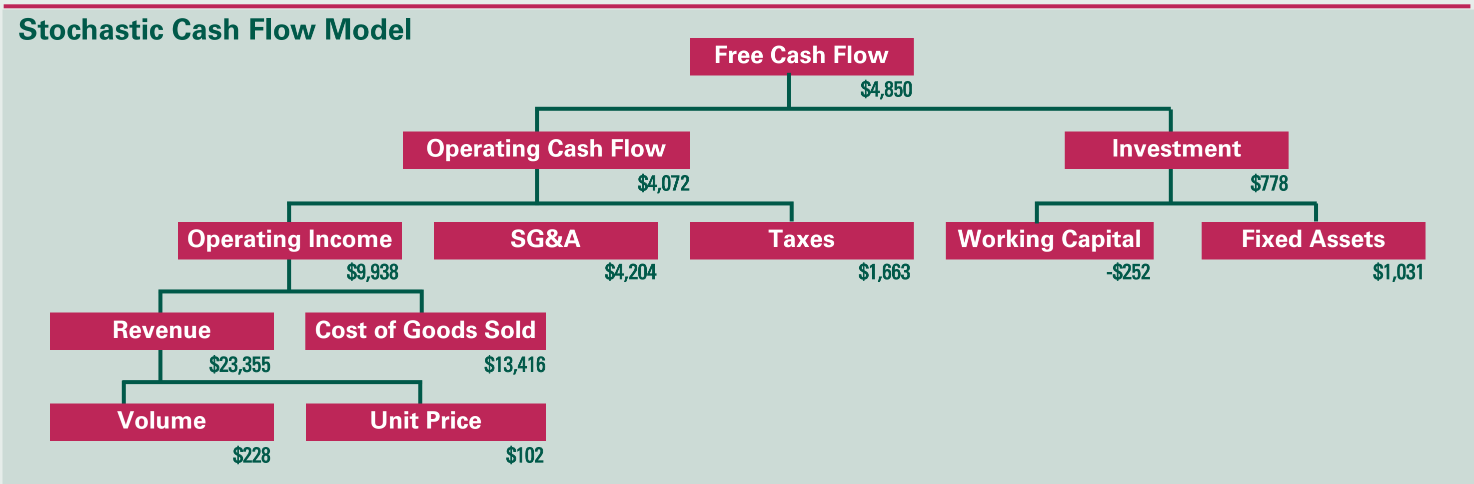
For HypoCom

We developed an FCF model (see *Figure 13*). This model includes inherent uncertainty in volume, price and cost of goods sold. It also includes a correlation of -0.7 between volume and price, and a correlation of +0.5 between price and cost of goods sold before inclusion of the four risks from Step 1.

The fire risk effect on FCF was modeled by layering on the probability of loss in Volume developed in Step 1 (see *Figure 14A*). Also, an adjustment was made to Working Capital and Fixed Assets to reflect loss of inventory and the investment in rebuilding the plant destroyed by fire. The size of this adjustment was a function of the loss in Volume (i.e., the magnitude of the loss due to fire). The other risks were incorporated similarly — as shown in *Figures 14B, 14C* and *14D.*

(continued on page 20)

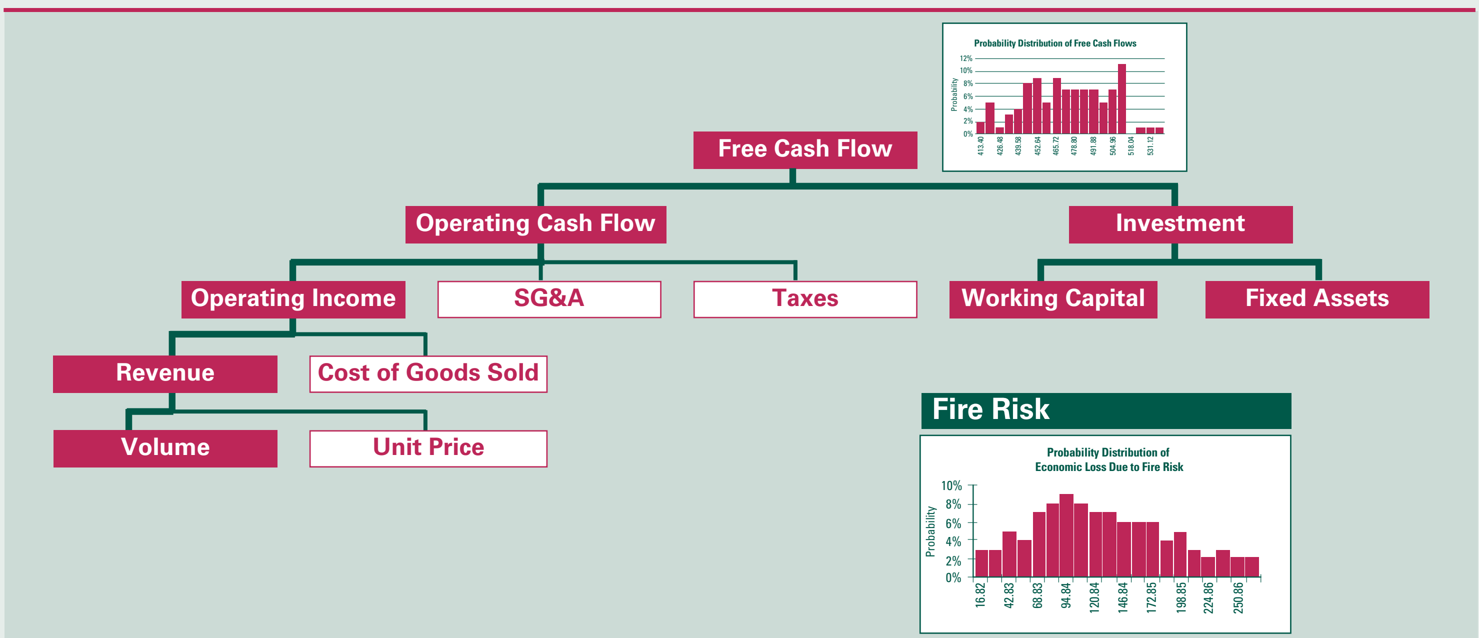
FIGURE 13



Stochastic Free Cash Flow for HypoCom. Volume, Unit Price and Cost of Goods Sold are represented as random variables with specified probability distributions and correlations.

Risk profiles are linked...

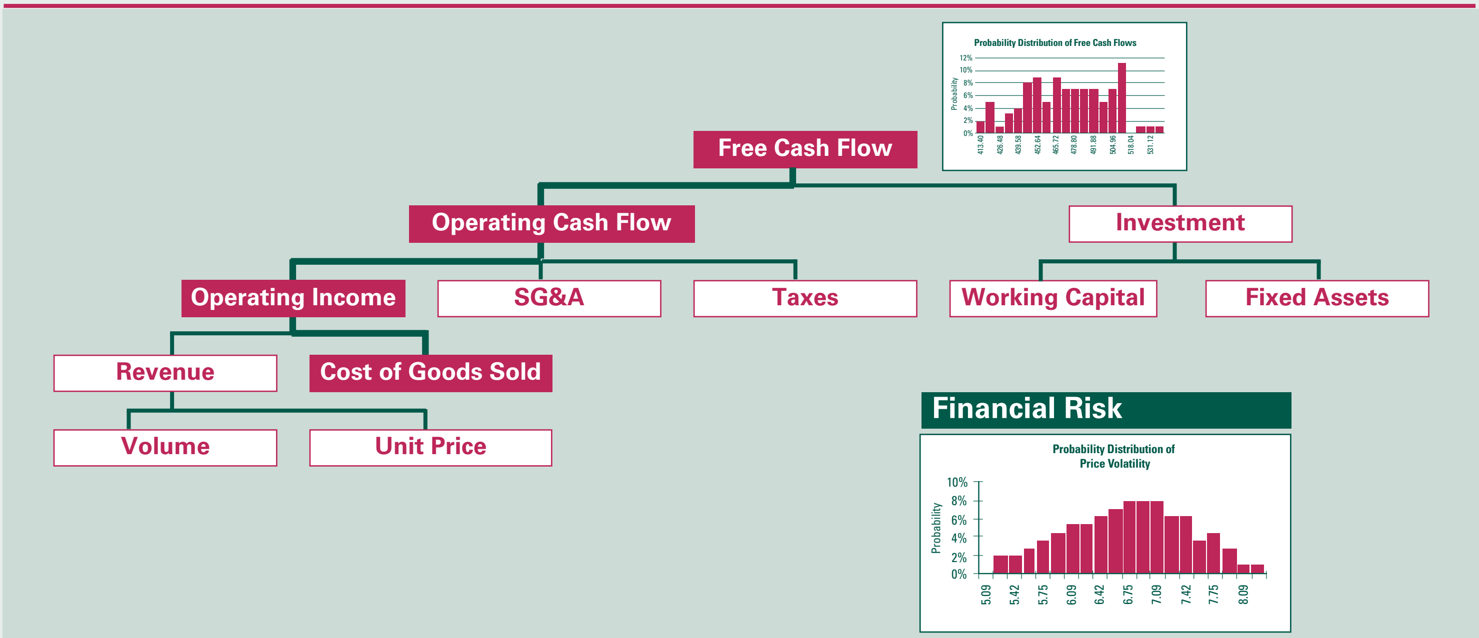
FIGURE 14A



The probability distribution for fire risk is linked to FCF through its effect on sales volume, working capital and fixed assets.

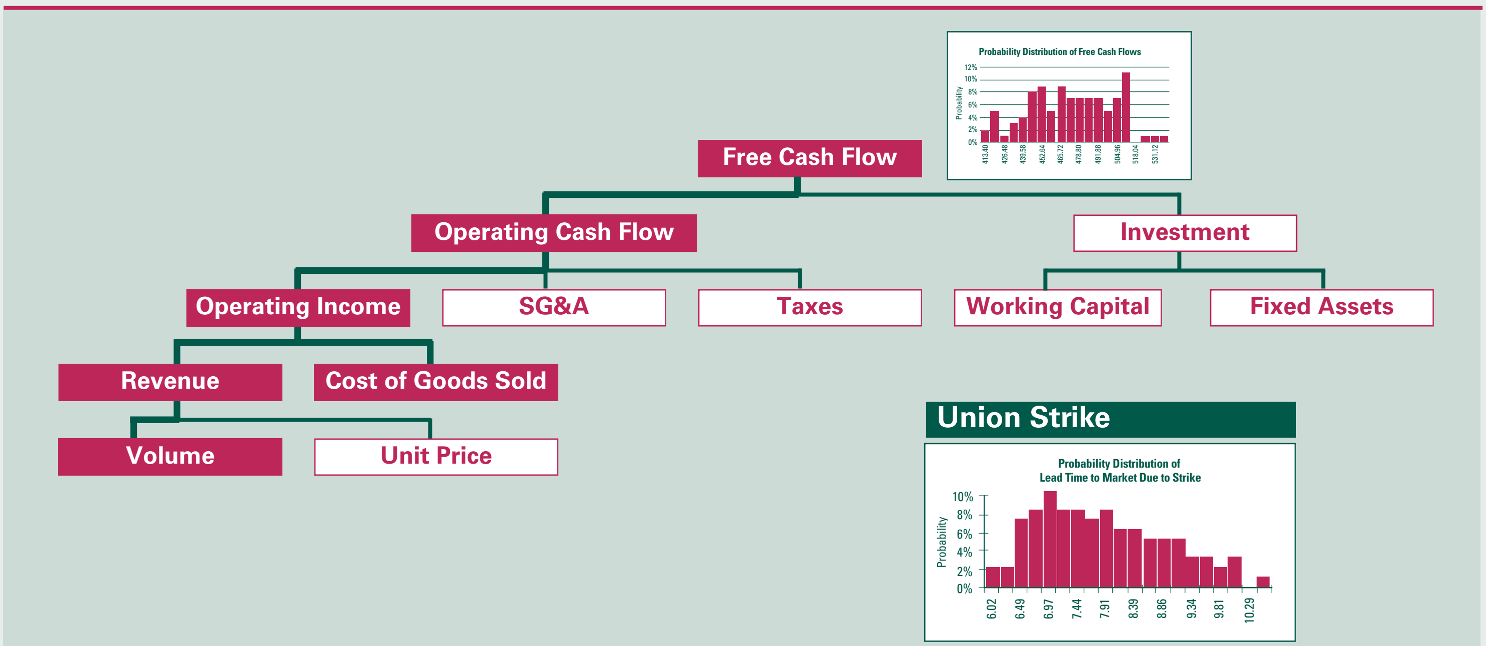
Risk profiles are linked... (cont'd)

FIGURE 14B



The probability distribution for commodity price risk is linked to FCF through its effect on cost of goods sold.

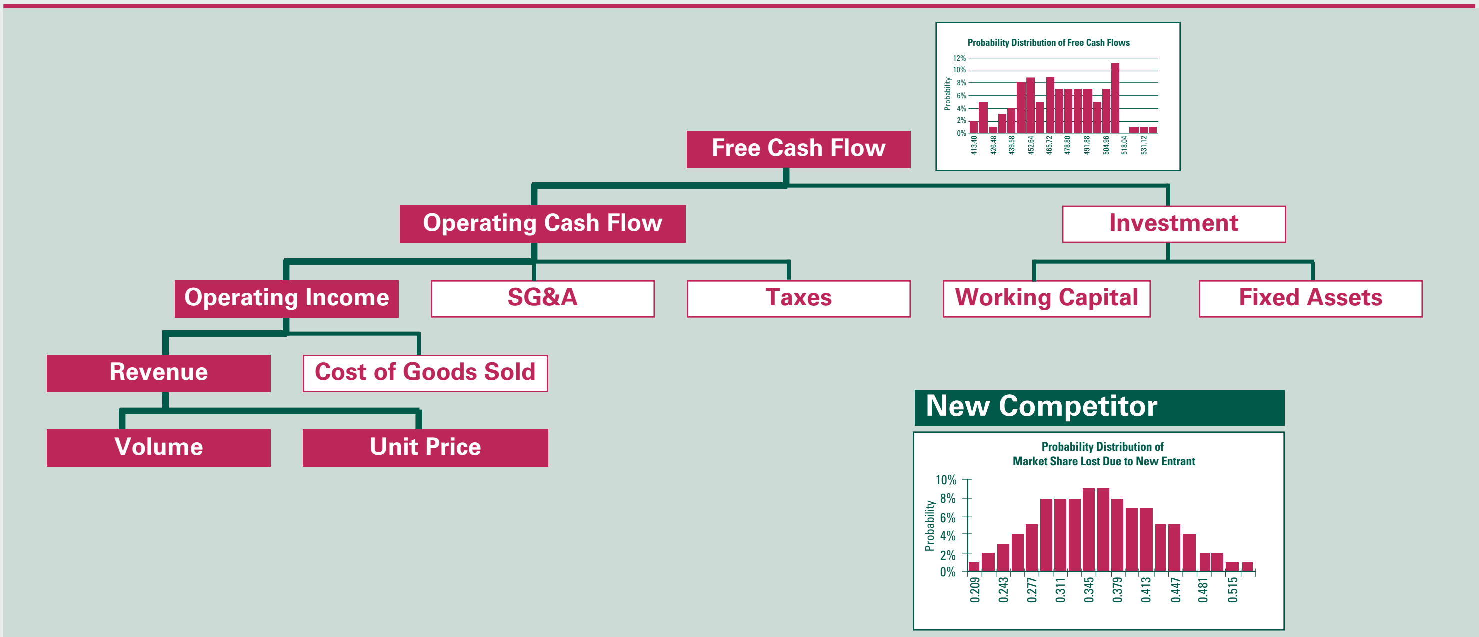
FIGURE 14C



The probability distribution for risk due to a union strike is linked to FCF through its effect on sales volume and cost of goods sold.

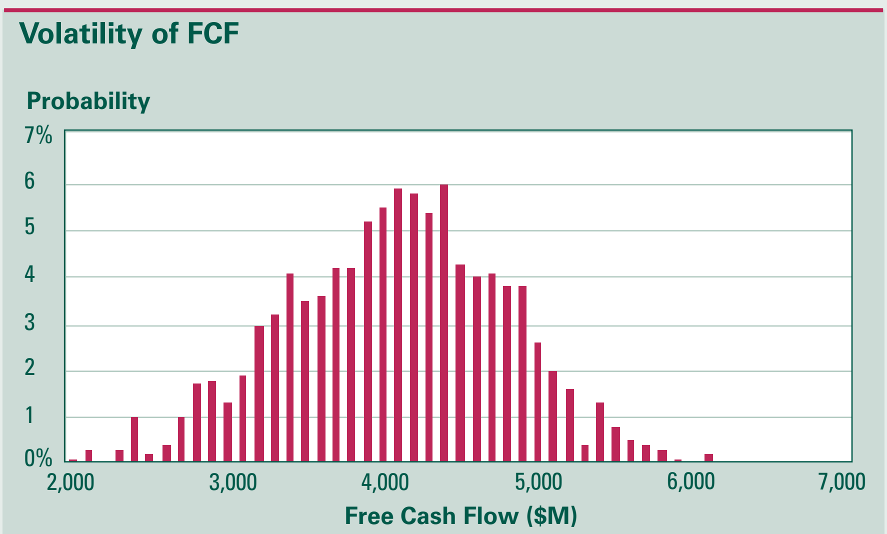
Risk profiles are linked... (cont'd)

FIGURE 14D



The probability distribution for new competitor risk is linked to FCF through its effect on sales volume and unit price.

FIGURE 15



Volatility of Free Cash Flow for HypoCom. This reflects the aggregate impact of all four risks without inclusion of any remediation strategies.

The size of the FCF model and the number of risks modeled for HypoCom were kept small to simplify describing our approach. This way, we could construct this model in MS Excel™ and run simulations using @RISK™ software. However, in practice, models are built using specialized, industrial simulation and optimization software. The aggregate impact of all four risks on FCF is shown as a probability distribution in *Figure 15.*

STEP 3

Set up a portfolio of risk remediation strategies

The steps in the analysis thus far have produced information on the current level of risk for Free Cash Flow or any other financial measure selected for this analysis. Steps 3 and 4 outline a course of action to mitigate the current level of risk based on management's risk preferences. In Step 3, a portfolio of risk remediation strategies is developed as follows.

Identify risk remediation strategies

With a measure of riskiness of the FCF established, we can now determine how to reduce this risk. We can consult domain experts on strategies for mitigating each source of risk. This is a collaborative brainstorming effort among internal and external experts on the topic. Strategies are not restricted to financial remediation through insurance or financial derivatives; in fact, for many business risks, it may be impossible to find either insurance or a hedge in the financial markets. All the risk remediation strategies together constitute a portfolio of investment choices. To determine the optimal allocation of investment, the cost and benefit of each combination of strategies must be calculated.

Model effect of each strategy on financial metric

Each strategy aims to shape the risk on FCF to suit the risk preferences of management and shareholders. Shaping the risk means altering the shape of the probability distribution for FCF. At least three meaningful ways exist to shape the probability distribution:

- Shift the first moment of the distribution, i.e., increase the expected value of FCF.
- Shift the second moment of the distribution, i.e., decrease the deviations from the expected value of FCF.
- Reduce the tail of the distribution on the down side, i.e., reduce the worst-case scenario of Cash Flow-at-Risk (CFaR). This is a Value-at-Risk (VaR) type measure that is commonly used in financial risk management. For FCF, this means increasing the 5th percentile FCF so that there is less than 5% probability of FCF falling below some threshold value.

Each risk remediation strategy will affect the probability distribution of FCF in at least one of the three ways enumerated above. Thus, the measure by which the strategies should be evaluated will be a function of these three measures — described in greater detail in Step 4.

The FCF model from Step 3 measures the effect of each combination of strategies on the distribution of FCF. Simulations are run for each possible portfolio or combination of strategies and the resulting probability distribution of FCF is recorded for use in the next step.

Keep in mind that remediation strategies focused on mitigating the effect of one risk source may create a new source(s) of risk. For example, hedging in the financial markets may create counterparty risks. These unintended sources of risks should be incorporated into the financial model if they are deemed significant.

There is typically a cost associated with implementing each strategy, which can be measured directly. The cost may vary depending on the degree to which the strategy is undertaken. For example, various levels of insurance can be purchased, each with a different premium.

For HypoCom

Strategies for mitigating each risk appear in *Figure 16.* Note that for risks falling in the traditional domain of risk management — namely, fire risk and commodity price volatility — the strategies are also conventional, i.e., insurance and financial hedging, respectively. For mitigating the risk due to a union strike, however, there are several alternatives:

- build up inventory
- contract with third parties to provide a supply of products
- satisfy some or all union demands.

Like most manufacturing companies, HypoCom's distribution centers and plants optimize their inventory and production policies to minimize cost. However, the company did this without considering the impact of a union strike. As noted above, one alternative is to build up inventory beyond optimal levels; this would certainly mitigate the strike's impact. If there is no strike, however, the buildup of inventory beyond optimal levels creates a holding cost that can be calculated directly.

Similarly, each strategy alternative listed in Figure 16 has a cost that can be measured directly. The benefit of each strategy is determined through simulations using the FCF model. There are three alternative strategies each for mitigating fire risk, commodity price risk and union strike risk. Loss of sales due to new competition has only two possible strategies in our illustration. (Note that in each case, one of the alternatives is a default "do nothing" strategy.)

Altogether, there are 54 (3 x 3 x 3 x 2) possible combinations or portfolio strategies. Each of the 54 possible portfolios was evaluated by running simulations using the FCF model and recording the resulting probability distribution on FCF. The cost/benefit information for each portfolio produced in this step will be used in the next step to determine the optimal portfolio.

FIGURE 16

	Classification of Remediation Strategies		
	Insure	**Hedge in Financial Markets**	**Mitigate Through Business Activity**
Fire	■ Full range of loss ■ Catastrophic loss		
Commodity Price Volatility		■ Upside hedge ■ Full hedge	■ Acquire supplier of commodity
Union Strike			■ Build up inventory ■ Contract with third parties for product
New Competitor			■ Reduce price

Portfolio of risk remediation strategy alternatives for HypoCom. For each risk, there is also the default strategy of "do nothing."

STEP 4

Optimize investment across remediation strategies

This step takes the results from the prior steps to determine the optimal allocation of investment to the risk management portfolio. To do this, we must formulate the decision as a portfolio optimization problem and solve it using optimization technology. The following will describe how to formulate and solve this portfolio optimization problem.

Identify optimization objective(s)

To compare portfolios of different combinations of strategies for risk remediation, first determine the criteria for the comparison. In optimization terms, this is called the objective function.

As indicated in Step 3, the risk remediation strategies alter risk in at least three meaningful ways:

- increase the expected value of FCF
- decrease the deviation from the expected value of FCF
- increase the 5th percentile of FCF distribution (CFaR) so that there is less than 5% probability of FCF falling below some threshold value.

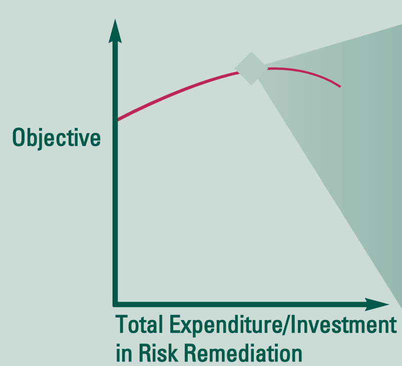
Therefore, one possibility is to use a weighted combination of these three measures as the objective function for comparing portfolios. The weightings would reflect the risk preferences of the decision-makers (who may be representing shareholder interest).

An alternative is to use expected utility of FCF as the objective function. First, a utility function must be developed that captures management's risk preferences for FCF. Development of a utility function is well documented in standard texts on decision analysis, two of which are included in the References (von Winterfeldt & Edwards 1986, Clemen 1996). The utility function is applied to the distribution of FCF to produce a distribution of utility or utiles. The expected value of this distribution is the expected utility. The relative preferences over the three measures of risk used in the prior method are captured in the shape of the utility function. One advantage of this method is that it easily extends to a multi-period objective using multi-attribute utility theory. This is explained further in a later section on multi-period risk management.

Either method can be used to develop the objective function of the portfolio optimization problem. The objective is to find the portfolio of strategies that maximizes this function.

Note that this method recognizes that management teams often differ in their risk preferences. We know that some companies are more aggressive than others in taking on strategic risks as a way of competing. Thus, the objective

FIGURE 17



	Insure	Hedge in Financial Markets	Mitigate Through Business Activity	Total
Fire	35%			35%
Increase in Commodity Price		10%		10%
Union Strike			25% Build up inventory 5% Contract with third parties	30%
New Competitor			25% Reduce price	25%
Total	35%	10%	55%	100%

The efficient frontier is a plot of all the portfolios that maximize the objective function given a fixed level of total risk remediation investment. Each point represents a unique allocation of the investment across the portfolio of strategies.

must be tailored to the unique risk preferences of the management team.

Identify constraints to optimization

Optimization may include some constraints on the optimum portfolio of strategies. A typical constraint may be a limit on the cost of implementing the portfolio of risk management strategies. There may also be constraints on the minimum/maximum level of insurance purchased, use of financial hedging, and/or the level of risk mitigated through business activity. Constraints on the downside risks to FCF may also be preferred. The constraints narrow the range of portfolios over which the objective function is maximized. Therefore, constraints have the effect of lowering the maximum value of the objective function.

Develop an efficient frontier of remediation strategies

The portfolio optimization problem as formulated above can be solved using optimization technology. Given a constraint on the size of the risk management budget, the optimization algorithms will determine the allocation of this budget to the alternative strategies that maximizes the objective function. This process can be repeated for varying levels of risk management budget. Plotting the results with the level of the risk management budget on the x-axis and the maximum value of the objective function on the y-axis produces a graph of the efficient frontier. The efficient frontier represents all the portfolios of strategies that constitute the optimal allocation of the risk management budget (see *Figure 17*).

For HypoCom

As mentioned at the end of Step 3, all 54 possible portfolios of strategies were simulated and the probability distribution of FCF was recorded. This information was then used to develop the objective function and the efficient frontier.

The objective function was based on a weighted combination of the three risk measures as follows:

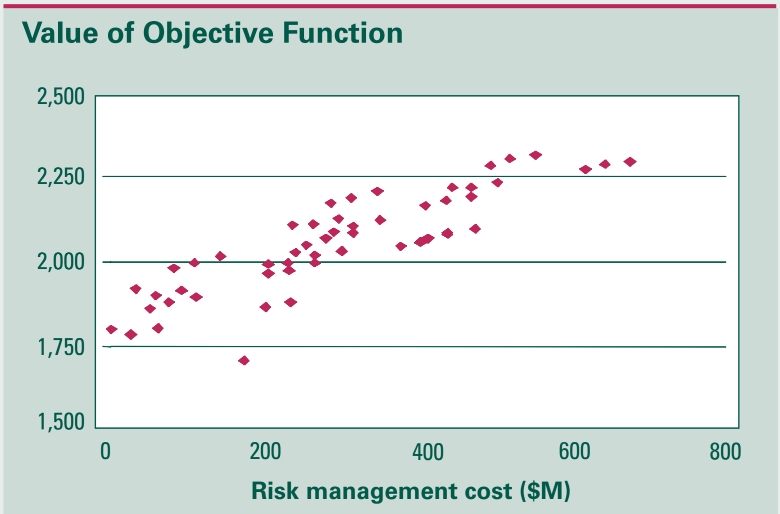
.40 * Expected FCF

\+ .30 * Length of 90% confidence range of FCF

\+ .30 * Value of FCF that has less than 5% probability of occurring.

Each of the 54 simulation runs produced a probability distribution of FCF. The objective function value was determined by applying the above formula to each of the runs. The results were plotted as an efficient frontier (see *Figure 18*).

FIGURE 18



Efficient frontier for HypoCom. Connecting all the points on top edge of the plot will produce an efficient frontier. Each point on the efficient frontier represents an optimum portfolio of strategies given the risk management cost. Portfolio points within the efficient frontier are suboptimal and should not be chosen.

Extension to multi-period risk shaping

Although the approach described above was based on a one-year decision horizon, in practice, most companies prefer a multi-year optimization analysis due to the strategic nature of this allocation. Fortunately, the method easily extends to a multi-year model.

In essence, all model variables and parameters are indexed by time (e.g., years). Thus, in Step 1, the probability distributions are developed for each time period in the investment horizon. Similarly, linking individual risks to a common financial measure involves indexing the probability distribution of FCF by year. Thus, the riskiness of FCF may vary from year to year.

The evolution of risk over time is typically modeled using a scenario generation system. A scenario generator uses stochastic differential equations (SDEs) to generate thousands of possible paths that a variable may follow over time. An SDE typically expresses a change in the value of a variable (e.g., interest rate) over a small time period as the sum of a predictable change and an unpredictable change. The predictable change is typically a deterministic function of the current value of the variable, but can also be a function of other variables with which there is correlation. The unpredictable effect is represented as a random variable with a specified probability distribution. An SDE is used iteratively to produce a scenario of how a variable can change over time. Typically, the scenario generator will model several correlated variables together to develop scenarios that are internally consistent. These scenarios are then fed into a financial model to develop stochastic forecasts of financial metrics over time. (Please refer to Section VII, "References and Recommended Reading," for papers and texts that describe scenario generation and stochastic differential equations.)

The risk remediation strategies in Step 3 may involve phased implementation of the strategy or there may be a time lag between incurring the cost for a strategy and its impact on the volatility of cash flow. In particular, the time lag may extend to more than a year.

Finally, in Step 4, the objective function based on expected utility can be extended to a weighted sum of the expected utility for each year in the time horizon. The weights applied to each year's expected utility can be determined by applying methods based on multi-attribute utility theory. Furthermore, budget constraints may vary over time.

In the multi-year time horizon, the output of the analysis is a path of risk remediation investments over the time horizon rather than separate optimum portfolios and efficient frontiers — as in the single-year case. Dynamic programming determines the optimum path of investments in risk remediation strategies.

Recap

In summary, the four-step analytical process for managing risk across an enterprise includes:

- quantifying each risk source by applying the appropriate tool and method for developing a probability distribution
- linking all the risk sources to a common financial metric
- developing a portfolio of strategies to mitigate each risk
- selecting the optimal portfolio of strategies.

The first two steps represent the bulk of the analytical effort and provide crucial information on the underlying dynamics of the enterprise. Different tools and methods (see Figure 6) for probability assessment will quantify the risk source and develop correlation among risk sources, depending on the relative availability of relevant data and domain experts. Aggregating these risks by linking them to a common financial metric provides an assessment of the overall risk to the enterprise and provides a method for determining the relative contribution of each risk source to the overall risk. Examination of the results of these two steps provides valuable insight into the business dynamics of the enterprise.

The last two steps are necessary to determine the optimal total expenditure for risk management and the most efficient allocation of that capital. Optimization also reflects constraints imposed by exogenous factors — the timing of expenditures, level of insurance, level of financial hedging and value-at-risk. In combination, the four-step analytical process lays a firm foundation for management decision making with respect to ERM.

V

A Brief Discussion of Exploiting Risk and Keeping Ahead

Risk has two faces. This monograph has focused on risk as a threat. But risk also represents an opportunity. In fact, organizations routinely pursue risk for the chance of increased reward. Companies achieve competitive advantage by correctly identifying which risks the organization can pursue better than its peers.

This advantage can arise in at least two ways (see *Figure 19*). The first relates to the nature of the risk itself. Certain risks, due to their predictability and/or effect on company financials, provide more of a risk to your competition than to your own organization. For example, currency translation risk is less of a concern to the organization whose distribution of cost of goods sold by country is similar to its distribution of revenue by country. The second way risk advantage arises relates to the organization's understanding of the risk and its capabilities to respond. For example, the oil company that, due to its hiring and training practices, has developed industry-leading capabilities in commodity risk analysis, can market these capabilities through a separate profit center.

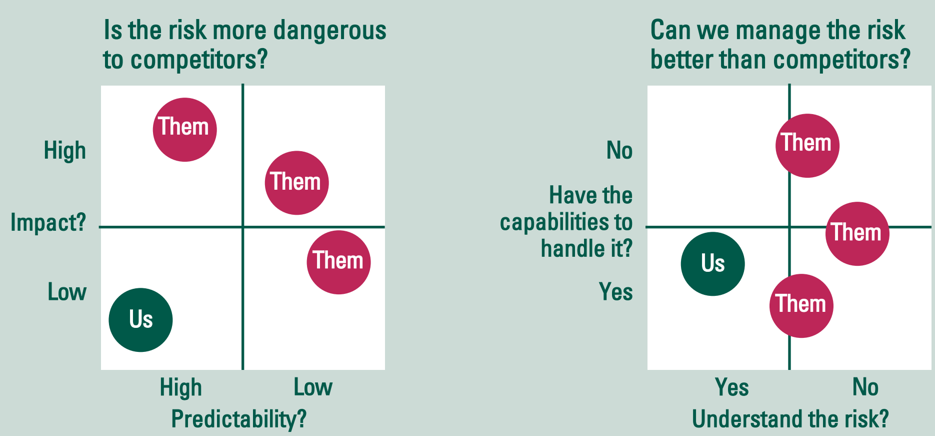
A robust ERM assessment process will be alert to both faces of risk and will form the organization's strategic response accordingly.

In the dynamic risk environment, change is constant. It occurs in the organization's underlying risk factors, in the economic, political/regulatory and competitive landscapes within which the organization operates, and in the organization itself (e.g., its business objectives, the skill sets of its managers and key employees, and even its makeup after such events as downsizing, divestitures, mergers and acquisitions). Continual monitoring of this risk environment is therefore crucial if the organization's ERM program, however successful to date, is to remain relevant. Depending on the nature and degree of these inevitable changes, farseeing management reenters the ERM process at the appropriate step(s). Not surprisingly, several organizations make ERM an integral part of their business and strategic planning processes.

FIGURE 19

If You Understand Risk, It Can Be a Competitive Advantage

Two scenarios



ERM includes identifying those risks that represent areas of competitive advantage.

VI

Implementing ERM in Phases

Implementing ERM is clearly a challenge. Most organizations have therefore "started small," undertaking the implementation in discrete, manageable phases.

We can view ERM in three dimensions (see *Figure 20*). The first represents the range of company operations. Some organizations have started small by piloting ERM in one, or a small number, of their business units or locations, for real-time fine-tuning and eventual rollout to the entire enterprise. The second dimension represents the sources of risk (hazard, financial, operational, etc.). Some organizations confine the initial scope of their ERM to a selected subset of these risk sources, for example, property catastrophe risk and currency risk. Eventually, all sources of risk would be layered in, in sequential fashion.

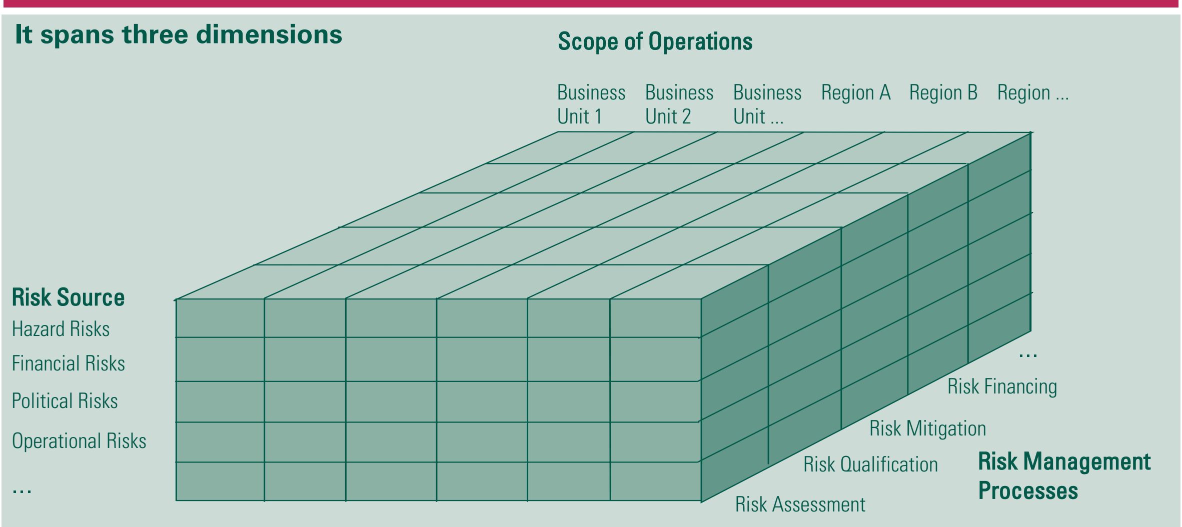
The third dimension represents the types of risk management activities or processes (risk identification, risk measurement, risk financing, etc.). Some organizations confine their initial vision to the identification and prioritization of enterprise-wide risks, with subsequent activities dependent on the results. Others begin by fashioning an integrated risk financing program around a subset of risk sources; these depend on the risk sources for which their financial service providers have integrated products. Still others begin by measuring and modeling virtually all sources of risk, regardless of their priority and the current availability of risk financing products.

While some of these approaches may appear more prudent than others, it is wise to reserve judgment. We believe no single best approach to ERM implementation exists that is appropriate for all organizations. Leading companies successfully employ a number of different phased approaches. The nature and sequence of these phases depend on the culture, strategic imperatives and management style of the organization. However, it is certain that for every organization a phased approach of some sort will be more successful than attempting to do too much, too soon.

Regardless of their starting point, many organizations include in their implementation plans the attempt to ingrain ERM into their cultures through communication, education, training and incentive programs. In some cases, these are coordinated in an extensive formal change management process to help impose the new order of things and achieve sustainable results. Clearly, to be successful, ERM needs to be more than a technique — and needs to be embraced by more than just management. These issues will be explored further in our subsequent publications.

FIGURE 20

The Universe of ERM Is Quite Large...



The scope of ERM is quite large. Organizations have variously "started small" by phasing in their implementation along one or more of ERM's three dimensions.

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Global CAP:Link, scenario generator for macroeconomic variables worldwide (such as interest rates, exchange rates and major asset classes), developed by Tillinghast – Towers Perrin, New York.

Service Model, discrete-event stochastic simulation software, developed by Promodel Corp, Orem, Utah.

VIII

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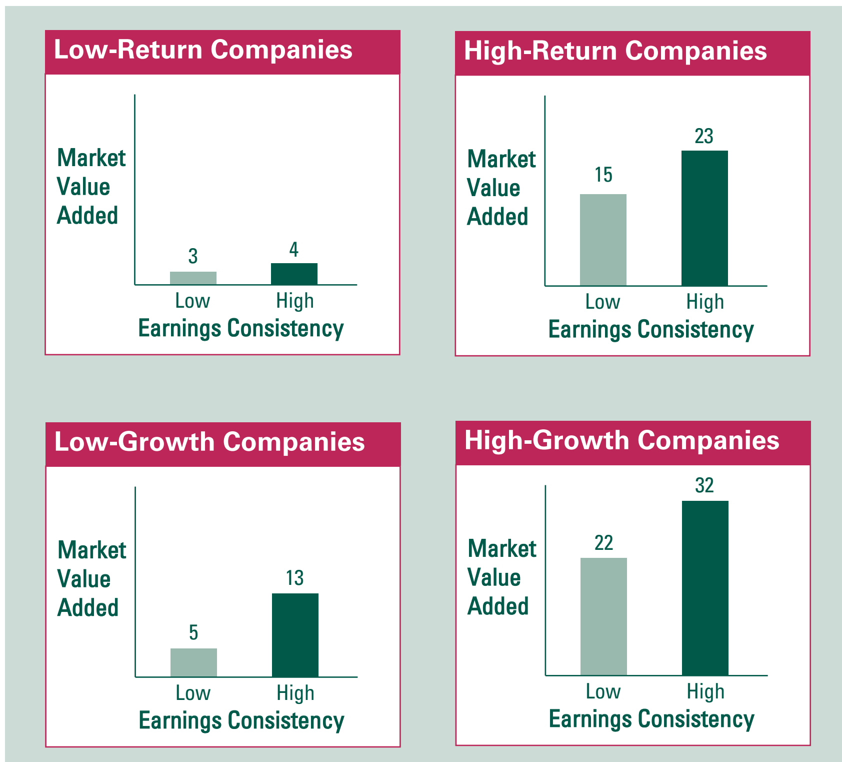
Appendix A

The Value of Consistency

- Earnings consistency typically explains 25% of annual change in share price
- Primarily affects premium over "warranted" multiple. Example (from the Integrated Petroleum Industry):



The market reacts to perceptions of how well risk is handled.

Source: Towers Perrin consistency analysis of selected industries (see following background information).

Background Information on Towers Perrin Consistency Analysis

Overview

Consistency analysis empirically estimates whether companies with more consistent earnings receive a premium market valuation relative to peers. Since many other factors — in addition to earnings consistency — shape market valuations, we use a series of basic analytic steps to attempt to control for the influence of other factors (e.g., earnings growth and return on capital) and isolate a consistency premium or discount. We use a relatively simple control process since (1) we find that more complicated methods introduce other sources of "noise" into the process and (2) consistency premiums are fairly robust across many industry groups and emerge readily with relatively simple control techniques.

A general description of the control process is provided below. For specific definitions and data sources used in the analysis, please see the Methodology section that follows.

Basic methodology

In performing consistency analysis, Towers Perrin's first step is to identify a relevant industry peer sample for a given company. Using an industry peer group helps filter out the effect of common industry factors (e.g., commodity price movements, regulatory risk) on market valuations. We typically use published industry groupings provided by Valueline or Standard & Poor's.

Next, we create a data set including a market premium measure, earnings growth rate, return on capital and earnings consistency for each peer. We employ historical growth rates and returns as surrogates for the future growth rates and returns that drive valuations. We calculate growth rates, using a least squares (regression) approach to avoid biases caused by point-to-point methodology, and average returns on capital over the measurement window (typically 10 years). To measure the market premium, we employ a standardized market value-added metric since it properly distinguishes between the capital that investors have placed in the business and the market value added to this capital.

Unlike market-to-book ratios, standardized market value added also captures the dollar growth in the value premium over time. Since the measure is standardized (indexed), it can be meaningfully compared across companies. Finally, Valueline's earnings predictability score (0%-100%) is used as the measure of earnings consistency.

We then calculate a median growth rate and return on capital for the peers and break the sample into "high growth" (growth ≥ median) and "low growth" (growth < median) and high-return (return ≥ median) and low-return (return < median) subsets.

The process is repeated one more time by calculating the median earnings predictability score for each of the four subsets and then further breaking each subset into a high earnings consistency (earnings predictability ≥ subset median) and low earnings consistency (earnings predictability < subset median). A total of eight subsets results from both steps.

Finally, an average market premium (standardized market value added) is calculated for each of the eight subsets, and the results are summarized in bar chart form.

Towers Perrin Consistency Analysis Methodology

Data Sources

- **Compustat PC Plus database**
- **Valueline Investment Survey (earnings consistency only)**

Performance Metric Definitions

"Return on Capital"

- **Definition**
  - 10-year (1989-98) average Return on Capital Employed (ROCE)
- **Formula**
  - (Income before Extraordinary Items + Special items) (Beginning Stockholders' Equity + Beginning Total Debt)
  - Perform same calculation for 10 years and take average
- **Comment**
  - Simplified return on invested capital definition (provides some adjustment for restructuring charges and other one-offs but makes simplifying assumption that special items receive no tax deduction)
  - Note: Compustat does not report after-tax special items

"Earnings Growth"

- **Definition**
  - 10-year (1989-98) least-squares EBIT growth rate
- **Formula**
  - Regress log adjusted operating income after depreciation against time to determine growth rate
- **Comment**
  - Growth rate based on regression more accurate than CAGR (which is biased by endpoints)

"Earnings Consistency"

- **Definition**
  - Valueline Earnings Predictability score as reported in Valueline Investment survey
- **Formula**
  - Valueline earnings predictability scoring based on stability of year-to-year comparisons, with recent years being weighted more heavily than earlier ones. The earnings stability is derived from the standard deviation of the percentage changes in quarterly earnings over an eight-year period. Special adjustments are made for comparisons around zero and from plus to minus.

"Market Premium"

- **Definition**
  - 1998 Standardized Market Value Added (MVA) based on 1988 ending invested capital base
- **Formula**
  - Std MVA = MVA % Capital x Indexed Capital = (M/C - 1) x Indexed Capital
  - M/C = (Stock price * Common shares outstanding + Preferred stock + Total debt)/(Shareholders' equity + Total debt)

    — All data reflect year-end 1998
  - Indexed Capital = (1998 Shareholders' equity + 1998 Total debt)/(1988 Shareholders' equity + 1988 Total debt)
- **Comment**
  - MVA captures value of growth (unlike M/B ratio) since it is measured in dollars. Standardizing MVA (by indexing every company's capital to same base year) corrects size bias of measure (so big companies with lots of capital but low M/C don't dominate smaller companies with higher M/C).

Appendix B

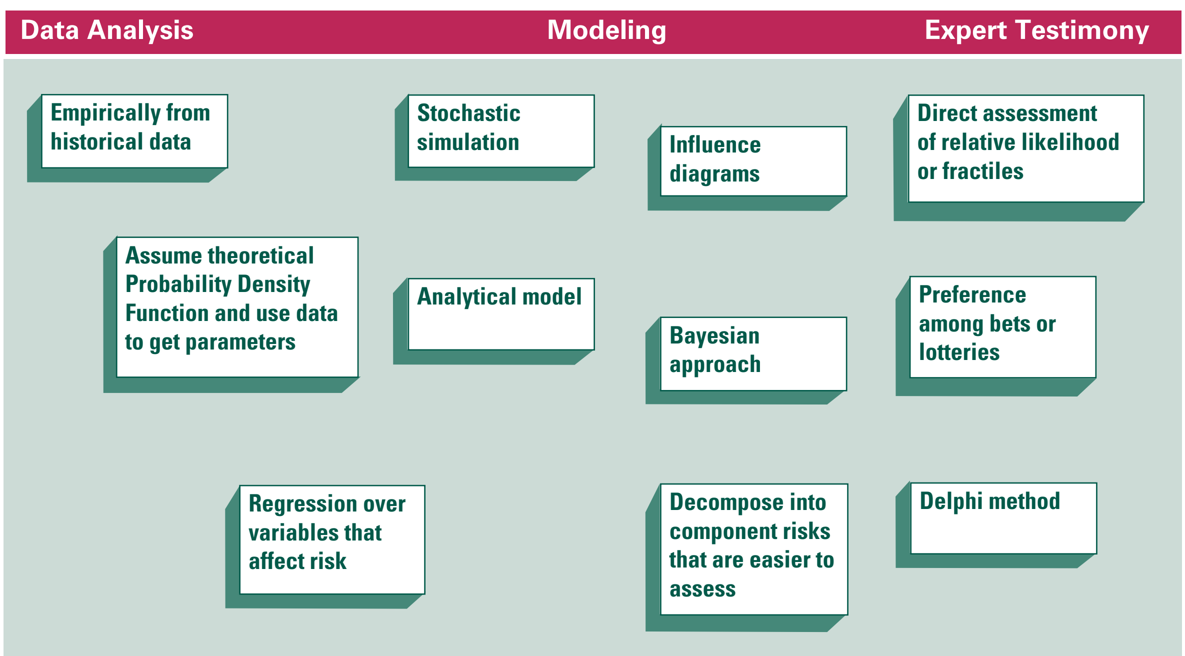
Probability Assessment Methods Based on Expert Testimony

Approaches to modeling risk

To model risk, it is necessary to understand the nature of risk itself. Risk arises from the fact that actual future results could differ from expected or projected results, often materially; one does not know with certainty what will happen in the future. In projecting into the future, one must consider a range of potential outcomes from a given event. Risk assessment aims to evaluate both the impact (financial, reputational, etc.) of each outcome and the likelihood or probability of each outcome occurring. The process develops a probability distribution that captures the impact and likelihood of given risk types or events.

There is a continuum of methods for developing probability distributions. These methods can be grouped into three principal categories: data analysis approaches, expert testimony and modeling (whose methods are often hybrids of methods from the other two categories). The choice of method depends significantly on the amount and type of historical data that are available. The methods also require varying analytical skills and experience. Each method has advantages and disadvantages over the other methods, so it is important to match the method to the facts and circumstances of the particular risk type.

Building a probability distribution of outcomes for each risk type is the first stage in developing an entire risk profile for the organization. In financial terms, each of these distributions needs to be combined with the others — taking into account correlations among risk types — and applied to the organization's financial value tree to develop a unique probability distribution of future financial results for that organization.



Estimating probabilities through expert testimony

Probability distributions for events for which there is sparse data can be estimated through expert testimony. A naive method for assessing probabilities is to ask the expert, e.g., "What is the probability that a new competitor will enter the market?" However, the expert may have difficulty answering direct questions and the answers may not be reliable.

Behavioral scientists have learned from extensive research that the naive method can produce unreliable results due to heuristics and biases. For example, individuals tend to estimate higher probabilities for events that can be easily recalled or imagined. Individuals also tend to anchor their assessments on some obvious or convenient number resulting in distributions that are too narrow. (See Clemen 1996 and von Winterfeldt & Edwards 1986 in the list of references for further examples.) Decision and risk analysts have developed several methods for accounting for these biases. Several of these methods are described below.

Preference among bets

Probabilities are determined by asking the expert to choose which side is preferred on a bet on the underlying events. To avoid issues of risk aversion, the amounts wagered should not be too large. For example, a choice is offered between the following bet and its opposite:

Bet	Opposite Side of Bet
Win $x if a competitor enters the market	Lose $x if a competitor enters the market
Lose $y if no new competition	Win $y if no new competition

The payoffs for the bet, amounts $x and $y, are adjusted until the expert is indifferent to taking a position on either side of the bet. At this point, the expected values for each side of the bet are equal in the expert's opinion. Therefore,

$$\$x\ P(C) - \$y\ (1\text{-}P(C)) = - \$x\ P(C) + \$y\ (1\text{-}P(C))$$

where P(C) is the probability of a new competitor entering the market. Solving this equality for P(C):

$$P(C) = \$y/(\$x + \$y)$$

For example, if the expert is indifferent to taking a position on either side of the following bet:

Win $900 if a competitor enters the market

Lose $100 if no new competition

then the estimated subjective probability of a new competitor entering the market is $100/($100 + $900) = 0.10.

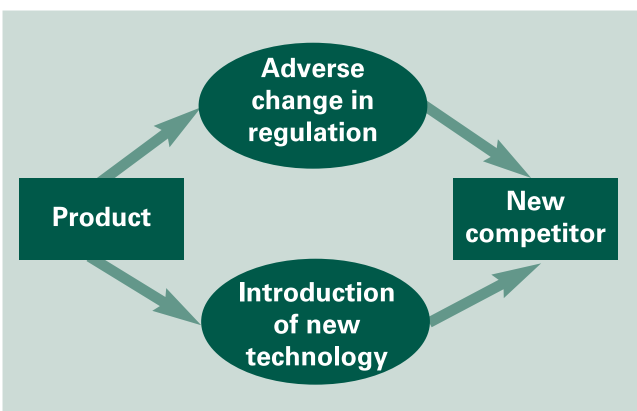
Judgments of relative likelihood

This method involves asking the expert to provide information on the likelihood of an event relative to a reference lottery. The expert is asked to indicate whether the probability of the event occurring is more likely, less likely or equally likely compared to a lottery with known probabilities. Typically, a spinning wheel (a software implementation of the betting wheels in casinos) is used on which a portion of the wheel is colored to represent the event occurring. The relative size of the colored portion is specified. The expert is asked to indicate whether the event is more, less or equally likely to occur than the pointer landing on the colored area if the wheel was spun fairly. The colored area is reduced or increased as necessary depending on the answers until the expert indicates that the two events are equally likely. This method is often used with subjects who are naive about probability assessments.

Decomposition to aid probability assessment

Often, decomposing an event into conditional causal events helps experts assess risk of complex systems. The structure of the conditional causal events can be represented by an influence diagram. Influence diagrams illustrate the interdependencies between known events (inputs), scenarios and uncertainties (intermediate variables) and an event of interest (output). An influence diagram model comprises risk nodes representing the uncertain conditions surrounding an event or outcome. Relationships among nodes are indicated by connecting arrows, referred to as arcs of influence. The graphical display of risks and their relationships to process components and outcomes facilitates visualization of the impacts of external uncertainties.

While this approach increases the number of probability assessments, it also allows input from multiple experts or specialists and helps combine empirical data with subjective data. For example, a new competitor entering the market may be decomposed using an influence diagram such as this one:



The probability of a new competitor, P(C) can be estimated, using a Bayesian approach. The approach uses Bayes' Rule, which is a formal, optimal equation for the revision of probabilities in light of new evidence contained in conditional or causal probabilities.

$$P(C) = \Sigma_i \, P(C_i \mid R_i, T_i)\, P(R_i, T_i)$$

where i is a product index, $P(R_i, T_i)$ is the joint probability of an adverse change in regulation and introduction of new technology, and $P(C_i \mid R_i, T_i)$ is the conditional probability of a new competitor entering a market for product i. This formula is useful when assessing the conditional probabilities $P(C_i \mid R_i, T_i)$ and is easier than a direct calculation of P(C).

Several different experts may be asked to assess the conditional and joint probabilities. For example, one expert (or group of experts) may assess the probability of adverse regulation for a specific product, another expert may assess probability of introduction of new technology, and yet a third may assess the probability of a new competitor given the state of new regulation and technology.

The Delphi technique

Scientists at the Rand Institute developed the "Delphi process" in the 1950s for forecasting future military scenarios. Since then it has been used as a generic strategy for developing consensus and making group decisions, and can be used to assess probabilities from a group of individuals. This process structures group communication and usually involves anonymity of responses, feedback to the group as collective views, and the opportunity for any respondent to modify an earlier judgment. The Delphi process leader poses a series of questions to a group; the answers are tabulated, and the results are used to form the basis for the next round. Through several iterations, the process synthesizes the responses, resulting in a consensus that reflects the participants' combined intuition, experience and expert knowledge.

The Delphi technique can be used to explore or expose underlying assumptions or information leading to differing judgments and to correlate informed judgments on a topic spanning a wide range of disciplines. It is useful for problems that can benefit from subjective judgments on a collective basis.

Pitfalls and biases

Estimating subjective probabilities is never as straightforward as implied in the description of the methods above. There are several pitfalls and biases to be aware of:

- None of the methods works extremely well by itself. Typically, multiple techniques must be used.
- To increase consistency, experts should be asked to assess both the probability of an event and separately the probability of the complement of the event. The two should always add up to 1.0; however, in practice they seldom do without repeated application of the assessment method.
- The events must be defined clearly to eliminate ambiguity. "What is the probability of a new competitor entering the market?" is not unambiguous. "What is the probability that a new competitor will take more than 5% market share of product A in the next two years?" more clearly defines the event.
- When assessing probabilities for rare events, it is generally better to assess odds. Odds of event E is [P(E)/P(complement of E)].

The Authors

Jerry Miccolis, a risk management consultant and consulting actuary with Tillinghast – Towers Perrin in its Parsippany, New Jersey office, has 20 years of consulting experience. He is a principal of Towers Perrin and is architect of several of Towers Perrin's multidisciplinary service offerings, including workers compensation cost management, strategic risk financing and enterprise risk management. He has served in a number of practice leadership positions, including practice leader for the worldwide risk management practice. He is a widely quoted speaker and author on risk management issues. A Fellow of the Casualty Actuarial Society (CAS) and a Member of the American Academy of Actuaries, Mr. Miccolis has served both groups on a number of professional committees, chairing several, and sitting on the Actuarial Standards Board. Mr. Miccolis also has authored and reviewed/refereed professional papers in actuarial literature and has served as an editor of CAS and Towers Perrin publications. He holds a B.S. degree in mathematics from Drexel University.

Samir Shah, a managing consultant with Towers Perrin's Strategy and Organization practice in the Washington, D.C. office, has over 15 years of consulting experience. He has provided a wide range of services to clients, including risk management, workforce planning, organizational design, process improvement and actuarial. He specializes in the application of Operations Research methods, such as computer-based simulation and optimization, to management decision making. Mr. Shah is a Fellow of the Society of Actuaries and holds an M.S. degree in Industrial Engineering and Management Sciences from Northwestern University. He is currently pursuing a Ph.D. in Operations Research with applications to Enterprise Risk Management at Northwestern. He is a member of the International Association of Financial Engineers, the Institute for Operations Research and Management Sciences, and the American Academy of Actuaries.

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If you would like to discuss specific aspects of this monograph in greater detail, or to explore the implications for your company, please contact:

Mr. Jerry Miccolis
Principal

Tillinghast – Towers Perrin
Morris Corporate Center II
Building F
One Upper Pond Road
Parsippany, NJ 07054-1050

Direct dial: 973-331-3524
Fax: 973-331-3576
E-mail: miccolj@towers.com

Mr. Samir Shah
Managing Consultant

Tillinghast – Towers Perrin
1001 19th Street North
Suite 1500
Rosslyn, VA 22209-1722

Direct dial: 703-351-4875
Fax: 703-351-4848
E-mail: shahsa@towers.com

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