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ENTERPRISE RISK MANAGEMENT: A VALUE CHAIN PERSPECTIVE

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1.1. INTRODUCTION

In March of 2000, lightning struck a semiconductor manufacturing facility owned by Philips Electronics (see, e.g., Latour, 2001). It caused a fire that lasted about 10 minutes and shut down the plant for only a few weeks. But the plant was the sole source of critical semiconductor devices used by Nokia and Ericsson to produce mobile phone handsets. The resulting supply disruption threatened to halt cell phone production for both firms.

At Nokia, the event received immediate executive-level attention. Nokia launched a textbook crisis management program. Within two weeks, Nokia officials were in Asia, Europe, and the United States securing alternative sources of supply. Despite the fire, Nokia experienced only minimal production disruptions.

Ericsson was far slower to react. It had no contingency plans in place to manage the disruption. Information about the event percolated slowly up to executive management. By the time the company began to mount a serious response, it was already too late. Nokia had locked in all alternative sources of supply.

The business impact on Ericsson was devastating. The firm reported over $400 million in lost revenue as a result of the supply shortages, and its stock price declined by over 14%. Nokia gained three points of market share, largely at Ericsson's expense. Some time later, Ericsson stopped manufacturing cell phone handsets and outsourced production to a contract manufacturer.

The Ericsson case is not an isolated incident. Firms face a wide variety of business risks, many related to their extended value chains. Poor demand planning and risky purchasing contracts at Cisco Systems recently precipitated $2.5 billion in inventory write-offs and led to massive layoffs (Berinato, 2001). Difficulties implementing supply chain management software at Nike led to severe inventory shortages, impacting third-quarter revenue by $100 million and shaving almost 20% off the firm's market capitalization (see, e.g., Piller, 2001; Wilson, 2001). In a case subject to widespread public scrutiny, quality problems with Ford Explorers using Firestone tires resulted in more than 100 highway fatalities and forced massive tire recalls (see, e.g., Aeppel et al., 2001; Bradsher, 2001; Kashiwagi, 2001). This not only created a potential multibillion-dollar legal exposure for the two firms, but also led to significant loss of brand valuation.

The pace of business has been accelerating, leading to increased risk. There have been dramatic shifts in the way companies interact, driven both by new technologies and new business methods. Increased use of information technology has raised productivity, while simultaneously introducing new sources of uncertainty and complexity. Value chains are leaner and far more dependent on the carefully orchestrated coordination of a complex network of supply chain partners. Product life cycles are shorter, and in many industries rapid product obsolescence is the norm. Business processes have become more automated, and without proper monitoring and management, small problems can easily escalate. Increased outsourcing has not only made firms more dependent on third parties, but also made it more difficult to detect and respond to risk events.

The consequences of failing to manage risk effectively have also increased. The interconnectedness of current value chains means that a small mistake by a single entity can have a ripple effect that impacts multiple trading partners. The equity markets are equally unforgiving. Failure to meet financial targets can result in dramatic declines in market value, even for well-managed firms. According to one study, firms reporting supply chain difficulties typically lost about 10% of their market capitalization in the two days following announcement of the event (Hendricks and Singhal, 2000).

In this chapter, risks that an enterprise faces in its business processes and ways to manage them are discussed. An overview of current practices in enterprise risk management is provided, followed by a discussion of how this integrated approach to risk management can be used to manage risks in an

enterprise's extended value chain. Finally, a general risk management framework is introduced and how it can be applied to identify, characterize, and manage value chain risks is discussed.

As the Nokia and Ericsson case demonstrates, effective risk management can provide protection against significant financial losses. However, risk management does not only add value during times of crisis. Strategic, operational, and organizational changes can help firms to not only improve their financial performance and increase customer satisfaction, but also position themselves to exploit new business opportunities as they arise.

1.2. ENTERPRISE RISK MANAGEMENT

Enterprises have traditionally failed to manage risk in an integrated fashion. Many risks are managed only at the corporate level, and attempts to effectively assess and manage risk across organizational boundaries are hindered by the absence of a consistent set of risk metrics. Interactions and potential correlations between risk factors are often ignored. This makes it difficult for firms to understand their total risk exposure, much less measure, manage, or control it.

Enterprise risk management is a technique for managing risk holistically and for closely linking risk management to the financial and business objectives of a firm. It begins by defining, at a strategic level, the firm's appetite for risk. Risk factors affecting the enterprise are addressed using a consistent methodology for measurement, management, and control. Risk is managed in an integrated fashion, across business units, business functions, and sources of risk.

Executive interest in enterprise risk management programs is growing. In a survey of more than 200 CEOs and senior executives at firms from a diverse set of industries (E.I.U., 2001), more than 40% of the respondents reported that they were managing risk on a formal enterprise risk management basis. Almost 20% more planned to do so within a year, and more than 70% planned to do so within five years. At present, only 15% of the firms managed risk on a corporate-wide basis. However, more than 40% expected to do so within three years.

Enterprises face many risks, including market risk, credit risk, operational risk, and business risk. *Market risk* is uncertainty caused by fluctuations in the market prices of financial or nonfinancial assets. For example, when a firm has operations in multiple countries, changes in foreign exchange rates can have a significant impact on both the income statement and the balance sheet. Changes in interest rates can affect a firm's interest expense, the value of its loan portfolio, and the market value of its debt. Price changes for commodities such as heating oil and electricity can have an impact on the cost of keeping factories

and office buildings running, and price changes for commodities like steel and copper can affect the cost of goods sold.

Credit risk is the risk that parties to which an enterprise has extended credit will fail to fulfill their obligations. Customer defaults, or delays in making anticipated payments, can have varying impacts on an enterprise. These range from transient effects on liquidity to ratings downgrades or even bankruptcy. It might seem that credit risk should primarily be a concern for financial services firms, but this is not the case. As recent experience in the telecommunications and computer industries has shown, a heavy credit concentration in a risky customer segment can sometimes lead to severe financial repercussions even for industrial firms.

Operational risk refers to risks caused by the way a firm operates its business. It includes risks associated with technical failures, losses caused by processing errors, and quality and cost problems caused by production errors. It also includes losses due to human error, such as fraud, mismanagement, and failure to control and monitor operations effectively.

Business risk is caused by uncertainty associated with key business drivers. Business risks tend to be more strategic than other risks and can be the most difficult to manage. Business risk factors include the overall state of the economy, fluctuations in customer demand, supply disruptions, competitive actions by rivals, technological change, legal liabilities, and regulatory changes.

There are a number of reasons why it is important to analyze and manage risk in a global, integrated fashion. Examining risk factors in isolation makes it difficult to understand interaction effects. This can increase risk management costs, since firms may unnecessarily hedge certain risks that are in reality offset by others. A fragmented approach to risk management also increases the likelihood of ignoring important risks. Even for known risks, it is important to consider the impact for the organization as a whole. Otherwise, mitigation attempts may only introduce new risks or shift the risk to less visible parts of the organization.

Failure to consider risk interactions can also cause firms to grossly underestimate their risk exposures. For example, the precipitous decline in capital investments by telecommunications firms several years ago increased risk for telecommunications equipment manufacturers along multiple dimensions. The manufacturers faced additional business risk, as uncertainty regarding demand for their products increased dramatically. They faced increased credit risk. Loans extended to high-flying customers deteriorated rapidly in credit quality as many customers neared default. They also faced increased market risk as equity values for recent strategic acquisitions declined precipitously, forcing multibillion-dollar write-downs.

1.3. VALUE CHAIN RISK MANAGEMENT

Traditionally, risk management has been the domain of the corporate treasury function, which had the primary responsibility for managing exposures to foreign exchange fluctuations, changes in interest rates, credit downgrades, and the risks of hazards such as fires, earthquakes, and liability lawsuits. Today, corporate treasurers have at their disposal an evolving but well-defined set of risk management tools and techniques (e.g., Crouhy et al., 2001).

Business risks, on the other hand, are more difficult to manage. They can be difficult to quantify, and managers often have to be satisfied with qualitative assessments of risk based on little more than intuition. Business risks can be difficult to identify, and their complex interactions with business processes make them difficult to characterize. Unlike financial risk, there are fewer well-defined risk management tools and techniques. Firms typically manage business risk in an ad hoc fashion.

Business risks can arise virtually anywhere in an enterprise's extended value chain. They affect — and are affected by — all of a firm's business processes. Successful risk management can play a critical role in improving business performance from the moment a new product is conceived until its effective end of life.

Two major trends have the potential to transform the way firms manage risk in their extended value chains. The first is increased financial innovation. In the traditional domains of insurance and financial derivatives, new products are emerging that enable firms to manage risks such as sensitivity to changes in the weather, bandwidth prices, and energy costs (Pilipovic, 1998). The financial markets have developed innovative ways to transfer and repackage risks so they can be resold to a broad set of investors. Furthermore, increased use of auctions and spot markets is increasing opportunities for supplier diversification. It is also providing greater price transparency for a wide range of products and services. This will make it easier for firms to quantify a broad set of risk factors. It will also drive the creation of new risk management products.

The second major trend is improved access to enterprise information. Widespread deployment of enterprise-level software packages to support business processes such as enterprise resource planning and supply chain management has provided firms with unprecedented access to fairly standardized information. These systems are becoming more tightly integrated, both within the enterprise and between value chain partners. Firms will soon reach the point where they have end-to-end visibility into their supply chains, from the early stages of product design to after-market support. This will enable them to detect risk events earlier and to respond more effectively.

This trend will also make it possible to more accurately analyze and characterize enterprise risks and to develop new systems and business practices to manage and mitigate risk. In particular, the integration of financial and operational systems will enable firms to use sophisticated analytics to create a tighter coupling between the high-level financial objectives of a firm and its underlying business processes.

1.4. RISK MANAGEMENT FRAMEWORK

In this section, a framework for managing enterprise risks from the perspective of an extended supply chain is introduced. As shown in Figure 1.1, the framework has three stages: risk identification, risk characterization, and risk management. Risk identification is the process of identifying the key risks that affect an organization. Once risks have been identified, they are characterized and classified. This step assesses the nature and importance of different risks and their collective impact on the organization. After risks have been identified and characterized, an effective risk management program can be established.

A risk management program is basically an action plan that specifies which risks can be addressed and how to address them. Firms have a number of "levers" they can use to manage their risk exposure. For risks that can be

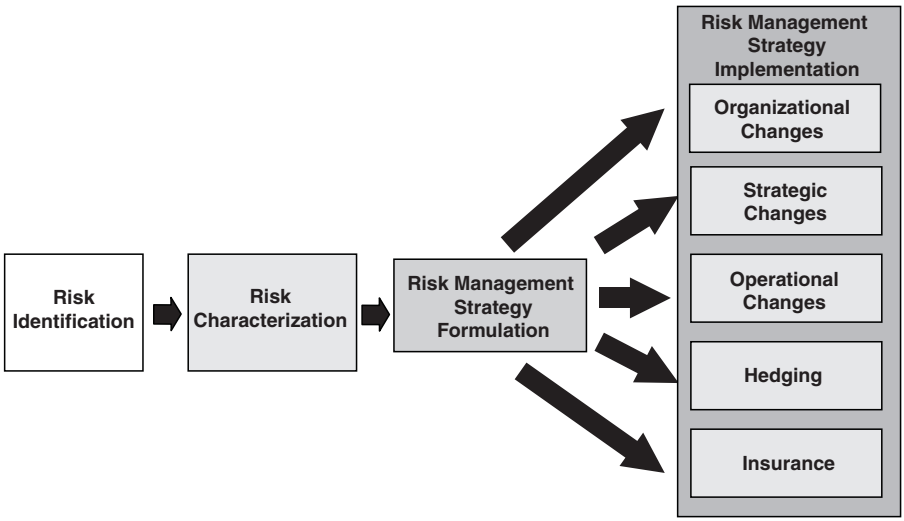

Figure 1.1. Risk management framework.

controlled, implementing changes in strategy or operations is an effective means of risk mitigation. Other categories of risk may require the introduction of new business practices and organizational controls. Certain risks cannot be controlled. For these, a firm must determine what level of risk can be tolerated and adjust its business plans or financial risk management programs accordingly. This process may entail limiting risk exposure by transferring some or all of its risk to another party, by using either financial derivatives or insurance (Doherty, 2000). In cases where derivatives and insurance are either unavailable or too costly, it could also mean foregoing certain business opportunities, exiting particular product or customer segments, or divesting certain business units.

1.5. RISK IDENTIFICATION

This section presents a number of risk identification techniques which have been broadly applied in the financial services industry (see, e.g., Crouhy et al., 2001). These approaches include scenario analysis, historical analysis, and process mapping. A risk taxonomy that is useful for categorizing value chain risks is also introduced.

1.5.1. Risk Identification Techniques

When performing a top-down strategic risk assessment, it often makes sense to start with *scenario analysis*. Scenario analysis typically begins with a series of brainstorming sessions that uncover key economic, technological, cultural, and economic trends that could affect the business performance of an enterprise. These are then used to identify potential future states of the world. Once these states of the world have been identified, each one is analyzed to understand the implications for the firm. This exercise can then be used to enumerate a broad set of existing and potential risk factors.

At a strategic level, scenario analysis is particularly effective at identifying game-changing risks that result from new technologies, changes in industry structure and dynamics, or economic shifts. Scenario analysis can also be applied at a more tactical level to explore the likely impact of existing risk factors and their interactions with risk factors looming just over the horizon.

Another way to identify potential risk factors is through *historical analysis*. This technique examines historical events to gain insight into potential future risks. In general, events with negative outcomes are identified and then categorized by determining the underlying risk factor or factors that triggered the

event. If possible, the analysis considers events that had the potential for a negative outcome, even if no actual losses were incurred. Including such events can be quite useful, since they often point to latent risks that need to be addressed. In a value chain context, events could include parts shortages, sudden shifts in customer demand, production problems, and quality difficulties.

One drawback of historical analysis is that significant risk events are often infrequent. This difficulty can be at least partially overcome by including in the analysis events affecting other companies with similar business characteristics. Another problem with historical analysis is that by definition it can only identify risk factors that have caused difficulty in the past. This leaves open the possibility that important risk factors will be overlooked, especially those related to changes in technology, business practices, or industry dynamics.

Risks can also be identified using *process mapping*. This technique begins by creating a business process map, a visual display that resembles a flowchart showing business work flows for different business functions. Process maps are comprehensive: they provide an end-to-end view of the organization or value chain processes being analyzed. Each step on the map describes an individual business process, providing details about its objective, how it is performed, who performs it, and what, if anything, can go wrong.

Once the process map is complete, it is analyzed for control gaps, potential failure points, and vulnerabilities. Special attention is paid to risks that could arise during hand-offs between (and within) departments or organizations. The analysis seeks to identify missing control procedures, such as a missing approval process, that do not show up on the process map. It also looks for steps where ill-defined tasks or duties could lead to processing errors or a breakdown in control.

Process mapping is particularly useful for identifying risks associated with poor execution. Unlike historical analysis, process mapping can identify risks with a large potential impact before an actual loss occurs. It also can help to clarify the likely impact of a potential risk exposure on the organization as a whole.

Certain risk identification methods are best suited for identifying specific classes of risk. Both process mapping and historical analysis are useful for identifying operational risks, as well as potential risks associated with value chain interactions. Market risk, on the other hand, is almost always analyzed using historical analysis. Historical analysis is also typically the technique of choice for estimating the frequency and magnitude of risk events, although it can be difficult to apply for risks to intangibles such as reputation. Historical analysis is also the best way to identify a number of value chain risks, including quality, quantity, and price risk. Finally, scenario analysis serves as a versatile tool for identifying major risks at the enterprise level.

1.5.2. Value Chain Risk Taxonomy

Successful risk management requires a consistent framework for communicating and thinking about risk. Figure 1.2 introduces a risk taxonomy that serves as the basis for a value chain perspective on enterprise risk management. As shown in the figure, enterprise risks are divided into core and noncore risks. Core risks are tightly woven into the business fabric of the firm and usually cannot be managed using financial derivatives or insurance. In contrast, noncore risks are less central to a firm's business, but can still have a significant impact.

A number of value chain risks are worth discussing in detail. Firms face risk when buying goods and services from their suppliers, developing and manufacturing new offerings, and selling goods and services to their customers. *Price risk,* for example, is the result of uncertainty about the cost of goods and services required for production and uncertainty about the prices that a firm will ultimately realize for its products in the marketplace. A related risk is *quantity risk* — the risk that the desired quantity of a good or service may not be available for purchase or sale. Sometimes quantity risk can be severe, as is the case during a supply disruption. In other cases, it is merely the result of normal supply variability. Firms also face quantity risk associated with inventories of raw materials and components, goods in the production pipeline, and inventories held to meet anticipated customer demand. Sometimes referred to as *inventory risk,* this represents the risk associated with having too much or too little inventory. Excess inventory exposes a firm to price fluctuations or product obsolescence that can impair the value of its inventory. Inventory shortages, on the other hand, can prevent a firm from meeting customer demand (Ervolina et al., 2001).

Risk factors such as quality risk and complexity risk affect a broad set of business processes. *Quality risk* is the risk associated with variability in quality, reliability, or execution. Quality risk can relate to procured goods and services, as well as to the goods and services produced or sold by a firm. It can also apply to a wide variety of value chain processes, including design, logistics, and customer support. Similarly, *complexity risk* results from product complexity, supply chain complexity, or even business process complexity.

1.6. RISK CHARACTERIZATION

Once the risk identification process is complete, the next step is to assess the nature, impact, and importance of risk factors. First the risk characterization process and a set of risk metrics are described, followed by a discussion of how risk factors interact with business processes and how they propagate through an enterprise's value chain.

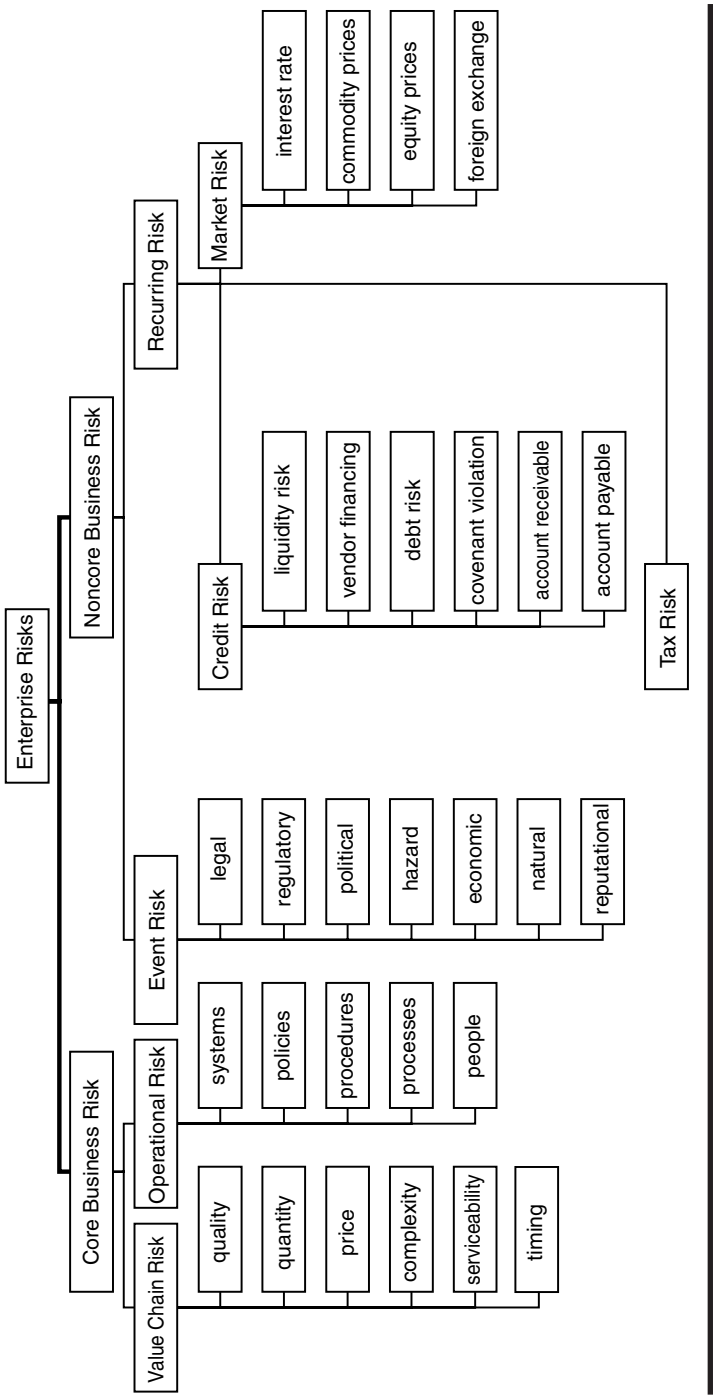

Figure 1.2. Value chain risk taxonomy.

1.6.1. Risk Characterization Process

When assessing the magnitude of a risk event, the two most important factors to consider are the probability of occurrence and the severity of the expected loss (Grimmett and Stirzaker, 1982; Lewin, 2000). If historical data are available, they are used to estimate both the size and frequency of risk events. Sometimes complete probability distributions can be constructed for each risk factor, providing a rich sense of the likelihood of an unfavorable event. When only a limited number of observations are available, specialized techniques such as extreme value analysis (Hertz, 1979) can be applied.

If quantification is impossible, either because historical data are not available or are perceived not to be suitable, a qualitative approach must be used (Bazerman, 1997). In its simplest form, qualitative analysis involves eliciting information from subject matter experts about the probability of a risk event and its likely consequences. Qualitative analysis is sometimes used in conjunction with a quantitative analysis. Typically this entails developing mathematical models similar to those described above, then using domain experts to generate model inputs based on their experience and intuition.

Even when mathematical models can be applied, risk characterization often requires considerable judgment on the part of the analyst, not only to define the model's structure and assumptions but also to assess the relevance of historical data for estimating future risks (Bazerman, 1997; Kahneman and Tversky, 1979).

The next step in the risk characterization process is to group and prioritize risks. Typically this is done by assigning risks to one of four categories based on their severity of impact and probability of occurrence (see Figure 1.3). This approach not only helps determine which risks require immediate action, but also provides insight into how individual risks can be managed. Risks in region

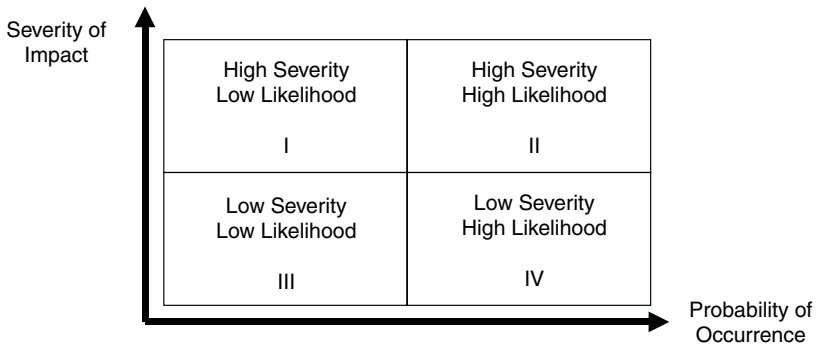

Figure 1.3. Risk characterization.

I occur infrequently but have a high impact. If possible, steps should be taken to mitigate these risks, and contingency plans should be established. As will be discussed later, insurance is frequently used for these risks.

Risks in region II are the most pressing: they have a high likelihood of occurrence and a high impact. Typically these risks are too expensive to insure, so steps should be taken to reduce either their frequency or severity. If the risks are tied to a particular product or product line, attempts should be made to verify that they are profitable enough to justify continued production.

Risks in region III have low likelihood and low severity and consequently do not require immediate attention. Nevertheless, they should be subject to periodic monitoring and review to make sure that there has been no change in their status. The high-likelihood, low-severity risks in region IV are typically managed by introducing operational changes and controls to reduce their frequency.

1.6.2. Value at Risk

Different business units typically have different risk measures, making it difficult to understand the risk exposure of a firm as a whole. A common set of risk metrics can help firms make better investments, since capital can be allocated in a fashion that accurately reflects the trade-off between risk and reward. Standardized measurements also make it possible to evaluate business lines and executives on a risk-adjusted basis. It is therefore important to establish a common framework for communicating information about risk throughout the organization.

A metric called *value at risk* is particularly useful for characterizing enterprise risks (Duffie and Pan, 1997; Jorion, 1997). Although value at risk was originally intended for assessing the risk of a portfolio of financial assets (Crouhy et al., 2001), it can also be applied to analyze multiple risks faced by a global firm. One of its key strengths is its ability to provide a common metric for comparing and managing risks across an enterprise.

Value at risk is a statistical measure of the risk associated with an investment or set of investments. It provides an estimate, usually in dollars or another unit of currency, of the most a firm can expect to lose on an investment over a specified time period at a given confidence level. For example, suppose a bank owns a highly risky portfolio of stocks. The bank analyzes the risk of the portfolio and estimates that 95% of the time it will at most lose $100 million on the portfolio in a given year. The value at risk for this risky portfolio at the 95% confidence level is then $100 million. A similar calculation on a less risky portfolio might conclude that 95% of the time, annual losses would not exceed $50 million. The value at risk for the less risky portfolio would be only $50 million.

In an enterprise setting, value at risk can be used to model the interactions of different risk factors and risk exposures. For a firm with multiple business units, the risks in different business units tend to partially offset each other in much the same way that diversification reduces the riskiness of a stock portfolio. Value at risk basically treats a firm as a portfolio of investments with different risk factors and analyzes them in the same way as a portfolio of financial assets.

One of the drawbacks of value at risk is that it can sometimes lead to a false sense of security. Although value at risk provides an estimate of how much a firm is likely to lose at a given confidence level, it does not let management know how much it could lose in the case of a very unlikely event. Although value at risk provides insight into expected losses under "normal" business conditions, it may not help much for analyzing the potential impact of truly catastrophic events.

A technique called *stress testing* can compensate for this weakness in value at risk (Committee on the Global Financial System, 2000). Stress testing develops a set of worst-case scenarios and then estimates their effect on the financial performance of a firm or a financial portfolio. When sufficient data are available, inputs to worst-case scenarios are derived using analysis of actual catastrophic events, such as earthquakes or stock market crashes. Models are then run to assess the impact of shocks similar to those during the catastrophe. Stress testing can be extremely effective as long as the model faithfully captures interactions between risk factors and considers all key risk factors.

1.6.3. Risk Interactions with Value Chain Processes

In characterizing value chain risks, it is important to understand *which* business processes they affect. Value chain risk factors often have a broad impact. For example, quantity risk affects almost the entire value chain. Parts shortfalls impact procurement, as management attention is directed toward identifying alternate sources of supply and qualifying and negotiating additional capacity with new suppliers. Parts shortages also disrupt production, causing temporary drops in utilization. They can reduce production efficiency, especially if normal operations are interrupted to expedite commitments for impacted products. Input shortages can also prevent companies from meeting customer demand, thus reducing revenue and damaging a firm's reputation. Logistics costs and complexity may increase because shipments must be expedited. Even after-market support and service can be affected because supply shortages may limit the availability of spare parts.

In characterizing risks, it is also important to understand *how* they affect different business processes. Table 1.1 shows the impact of a number of risks

Table 1.1. Risk Impact on Value Chain Processes

	Sourcing	Manufacturing	Marketing and Sales	Distribution and Logistics	Support
Quantity	■ Component shortfalls impact production, hurting sales and potentially damaging reputation for service and reliability.	■ Poor capacity planning constrains production output. ■ Poor production planning results in production constraints or excess inventory.	■ Poor demand forecasts result in either missed revenue opportunities or excess inventory throughout the supply chain.	■ Poor supply chain design and execution lead to excess inventory. ■ Poor inventory positioning prevents products from reaching customers, hurting revenue.	■ Poor warranty forecasting leads to understocking of spare parts. This causes poor customer satisfaction and loss of market share.
Price	■ Unexpected price volatility in procured components increases revenue and profit variability.	■ Excess capacity increases production costs.	■ Poor pricing decisions hurt market share, resulting in foregone profit margins or excess inventory.	■ Poor supply chain design and execution increase the need for expediting, thus increasing logistics costs.	■ Poor support network design and execution increase expediting, causing higher logistics costs.
Quality	■ Low-quality purchased parts impact manufacturing yields, hurting sales. Also affects customer satisfaction and reputation and increases warranty and support costs.	■ Low yields can constrain production output, reducing revenue. ■ Poor quality affects customer satisfaction and reputation and increases warranty and support costs. ■ Poor quality affects obsolescence and creates obstacles for marketing and sales.		■ Poor supply chain design or execution results in poor serviceability, reducing customer satisfaction and limiting ability to fulfill service models such as vendor-managed inventory and just in time.	■ Poor quality of support execution affects customer satisfaction, damaging firm's reputation.

Serviceability	■ Selecting suppliers with poor or erratic service affects production, reducing revenue and damaging reputation.	■ High production cycle time variability affects ability to deliver products to meet commitments.	■ Certain sales processes work well for certain customer segments, but are too costly to address other segments. Revenue and profit decline.	■ See entry under "Quality."	■ See entry under "Quality."
Obsolescence	■ Overordering parts characterized by rapid obsolescence results in costly inventory write-downs.	■ Obsolete production technology makes a firm uncompetitive in terms of cost structure and product portfolio.		■ Poorly positioned inventory is exposed to obsolescence, leading to inventory write-downs.	■ Obsolete products in the field can be uneconomical to support under existing maintenance agreements. ■ Inventories for obsolete spare parts result in inventory write-downs.
Complexity	■ Too many suppliers make it difficult to manage supplier relations and coordinate logistics.	■ Complex manufacturing processes increase throughput variability. This impacts quality and increases cycle time variability.	■ Complex sales processes make it difficult to do business, resulting in missed marketing opportunities and lost revenue.	■ Long logistics cycle times impact serviceability and increase inventory. This reduces customer satisfaction and increases inventory obsolescence risk.	■ Complex products make support more expensive, increasing warranty costs. ■ Complex support organizations are difficult to manage, making them unresponsive to customer needs. ■ Complex or unique processes make it difficult to hire staff and increase training requirements.

at different stages of the value chain. In general, the earlier in the chain an event occurs, the greater its impact.

1.6.4. Risk Propagation

Some risks propagate through the value chain in a comparatively well-behaved manner, making their effect on value chain partners fairly constant. Other risks are less well behaved. As they move along the value chain, their impact is amplified, sometimes with catastrophic consequences.

One comparatively well-behaved value chain risk is price risk. Assume there is a price increase of one dollar for a production input such as a computer chip. As the chip moves through the value chain, costs increase by about one dollar for anyone buying the chip either in its original state or in an intermediate product containing the chip. There may be additional cost increases to reflect profit margins, but the overall effect will be small.

Now consider how risk becomes amplified when a problem with a faulty semiconductor device is detected at different stages of the value chain. If the problem is discovered when the device is purchased, the loss will be comparatively small — approximately the cost of the device. However, if the problem is detected only after the device has been installed on a printed circuit board, the impact will be greater because the circuit board will have to be either reworked or scrapped. The impact will be greater still if the defect goes undetected and the circuit board is installed in a high-end computer. Servicing a machine in the field is costly, and field failures can cause significant financial hardship for the owner of the machine. If the defect is not an isolated incident, the costs to the computer manufacturer can increase significantly, sometimes leading to damage to its brand and reputation.

Another case where risk propagates in a nonlinear fashion is supply risk. For a product assembled from multiple components, a shortage for even a single component can halt the production of the entire product. This can lead to situations where a small, inexpensive component effectively stops production. Revenue losses associated with such shortages can be orders of magnitude larger than the cost of the constrained part.

1.7. RISK MANAGEMENT

Once a firm has characterized its risk exposure, it can begin to develop a comprehensive plan for managing, mitigating, and transferring risk. Enterprise risk can be managed in a number of ways. Changes to organizational structure

and controls can reduce execution errors and improve a firm's ability to respond to a crisis. Strategic approaches to risk management include changes to an enterprise's financial and operating leverage as well as modifications to its portfolio of customers, products, and suppliers. Operationally, a firm can manage or mitigate risk by applying risk-based analytics to a broad set of value chain processes, ranging from product design to demand planning. Financially, risk can be managed using financial derivatives such as futures, swaps, and options (Hull, 1997). Firms can also use a number of different insurance products to limit losses, particularly those associated with severe, low-frequency events.

1.7.1. Organizational Structure and Controls

One of the first steps in establishing an effective risk management program is to make sure that a firm's organizational structure is appropriate to the risks faced by the firm. This involves a number of steps, including defining the firm's risk objectives, clarifying the role of senior management, establishing effective monitoring systems, and creating a set of appropriate internal controls. Senior managers play a central role in implementing an effective risk management program. They are responsible for specifying the risks the firm is willing to bear and the firm's tolerance for risk. They are also responsible for making sure that the organization has the necessary skills and resources to support the firm's risk management strategy.

By creating an appropriate organizational structure, senior management also defines appropriate roles and responsibilities for personnel either directly or indirectly involved in risk management (Knight and Pretty, 2000). In the financial services industry, there has been a trend toward consolidation of the risk function in the office of a chief risk officer, who has the overall responsibility for developing and nurturing a firm's risk management strategy. Many nonfinancial firms are also adopting this approach.

One of the key systems that must be implemented is an integrated risk measurement and management framework. As part of this process, it is critical to establish systems for measuring and reporting different types of risk, so that a firm can effectively monitor and manage its overall risk exposure. Firms also need to establish risk assessment and audit processes coupled with a benchmarking process to provide a vehicle for keeping informed about industry best practices.

Core resources and capabilities required for effective risk management can be grouped into three broad categories: policies, methodologies, and infrastructure (see Figure 1.4). They help support a range of risk management activities, including measuring, monitoring, reporting, controlling, and mitigating risk.

Policies	Methodologies	Infrastructure
■ Risk tolerance	■ Risk profiling	■ People
■ Risk limits	■ Risk modeling	■ Data
■ Approvals processes	■ Pricing and valuation	■ Decision support systems
■ Business continuity	■ Investment analysis	■ Communications systems
■ Disclosure policies	■ Performance measurement	
■ Internal controls		

Figure 1.4. Core risk management resources and capabilities.

Risk management policies define and implement an organization's risk management strategy along multiple dimensions. At a high level, they define a firm's tolerance for risk and provide principles for evaluating the trade-off between risk and return within the context of the firm's overall business objectives. They also provide specific guidelines and procedures to disseminate a firm's risk management strategy throughout the organization.

Disclosure policies provide guidelines to help senior managers understand and report the risks inherent in their businesses. Disclosure policies clearly state the duties and responsibilities for each business unit and specify the relevant internal controls, including self-management, that must be established.

Certain policies are designed to help a firm manage unusual situations and to keep the business operating smoothly when catastrophe strikes. A continuity of business policy specifies a set of operating procedures for addressing risky events. It provides guidelines on how to respond during times of crisis and describes contingency plans, risk monitoring techniques, and procedures to recover from a business interruption.

Risk management methodologies comprise a common set of frameworks, models, tools, and analytics that support a broad range of risk management activities, including risk characterization, risk modeling, and valuation. Methodologies go beyond the mere mechanics of risk analysis; they provide guidelines and procedures for estimating different types of risk and for constructing and validating models. Valuation methodologies are used to evaluate strategic acquisitions and to perform capital budgeting. They also provide important insights when negotiating and structuring joint ventures, strategic alliances, and outsourcing deals. A comprehensive set of risk management methodologies helps a firm consistently account for risk in decision making, particularly when computing risk-adjusted returns for individual divisions and projects and when adjusting performance measurements to account for risk.

An adequate infrastructure is necessary to support risk management business processes. People are probably the most critical infrastructure component, since

they supply a broad range of capabilities to effectively detect, analyze, and mitigate risk. Risk management is data intensive and requires accurate and timely information to support effective decision making. The technological infrastructure of a firm can play a significant role in effectively processing and disseminating information about risk incidents and events.

Enterprise risk management often requires information that crosses both functional and system boundaries. In the past, this posed significant challenges for firms forced to reconcile and link data from multiple disparate legacy systems. The widespread adoption (and increased integration) of software solutions such as enterprise resource planning, supply chain management, and customer relationship management makes it easier to develop data repositories to support risk management.

Development of a cross-enterprise risk management backbone for integrating and disseminating risk management data can help companies improve their effectiveness at managing risk. This backbone would provide information to support more advanced risk management methodologies, including risk analytics and rule-based systems for detecting and responding to risk.

1.7.2. Strategic Risk Management

In this section, a number of ways to incorporate risk management into strategic decision making are discussed. First, a number of strategic approaches for altering a firm's level of risk are considered. Then several modeling and analysis techniques that support decision making under uncertainty are described.

A number of techniques have been broadly applied in the financial world to manage risk. These include leverage, diversification, and hedging. Financial forms of these techniques — as well as their strategic analogues — can be applied to modify a firm's risk profile.

Financial leverage alters risk by changing a firm's capital structure — its mix of debt and equity. Carrying more debt increases leverage — and risk. Besides issuing debt, firms can increase their financial leverage in a number of ways, including the use of capital leases and by issuing preferred stock. Firms have considerable latitude and flexibility in determining their degree of financial leverage, and techniques for determining an optimal capital structure have been widely studied and applied.

Operating leverage is determined by a firm's cost structure, rather than its capital structure. The higher a firm's fixed costs, the greater its operating leverage. One of the primary determinants of a firm's cost structure is its choice of production technology. Capital-intensive firms tend to have higher fixed costs, since they need to cover depreciation expense on their assets. This makes

their earnings more sensitive to changes in customer demand, since a larger portion of revenue must be allocated to cover fixed expenses. Capital-intensive production processes also tend to have lower unit costs. This means that at low production volumes, they are less profitable. At high production volumes, however, they have much higher profitability. Decisions about capital investments thus involve a trade-off between the risk of increasing operating leverage and the potential for higher profits.

A number of value chain decisions can have a major effect on a firm's operating leverage. Investments in highly automated production and distribution facilities increase fixed costs and hence risk. Outsourcing arrangements affect operating leverage, with the magnitude of the change determined by how the deal is structured. A long-term contract to outsource warehousing to a third-party logistics provider would have little effect on a firm's operating leverage if predetermined payments to the provider merely substitute for the fixed costs of company-owned warehouses. An agreement to outsource production to a contract manufacturer, on the other hand, could reduce operating leverage significantly, as long as contractual volume commitments are relatively low. Joint ventures and strategic alliances often entail shared investments and funding commitments and hence can affect operating leverage. The way a firm structures its supplier and customer contracts can also have a significant impact on its risk profile. Contracts with volume commitments, such as take-or-pay supply contracts,* increase operating leverage by increasing fixed charges.

An enterprise can also manage risk strategically through *diversification*. *Financial diversification* is used to reduce the risk of portfolios of financial assets. It is based on the premise that changes in the prices of securities like stocks and bonds do not move precisely in tandem, since different securities are subject to different risk factors. By constructing portfolios consisting of stocks and bonds that tend to move in different directions, price movements tend to cancel out, reducing portfolio volatility.

Operational diversification can be broadly applied to a variety of business processes at both the strategic and tactical level. Enterprises can diversify by acquiring new businesses in unrelated industries, targeting diverse market segments, broadening their product portfolios, and marketing in multiple geographic regions and to multiple customer segments.

Finance theory has developed a rich set of techniques for effectively managing portfolios of financial assets. These can be applied to strategic decision making as well. Doing so is particularly important in complex business situ-

* A take-or-pay contract obliges the customer to pay for a specified minimum number of parts or components, even if the customer actually purchases less than that minimum.

ations where it is difficult to effectively diversify using only simple analyses and intuition. Firms are now gathering and capturing more detailed information about their customers, products, and suppliers. This information can be mined to discover patterns that can be exploited to develop more efficient portfolios.

The third cornerstone of strategic risk management is *hedging*. In a process related to diversification, *financial hedging* reduces the effect of one or more risk factors on an asset such as a financial portfolio or physical commodity. A hedge is created by first identifying a security whose price movements directly track the risk factor being hedged. This security is then used to offset the impact of the risk factor. Corporations use financial hedging to reduce the uncertainty associated with a broad range of risks, including foreign exchange rates, interest rates, and commodities prices.

Operational hedging uses a similar approach, but instead of transforming risk with a financial instrument, it does so by changing a firm's strategy or operations. A simple example shows how this works. Consider a hypothetical U.S. automobile manufacturer selling cars in Japan. It has a sales and distribution network located in Japan, but no local production facilities. As a result, the company has substantial revenue denominated in yen, but most of its costs are in dollars. Its net foreign exchange exposure is the gap between the amount of yen it receives and the amount of yen it pays out. Since this gap is large, the company has considerable foreign exchange risk.

If the company establishes local production facilities in Japan, payments for running the facilities will be made in yen, as will labor costs and purchases from local suppliers. As a result of this change, a much larger percentage of the firm's costs are denominated in yen. This reduces its net yen exposure. It now has less foreign exchange risk.

A natural hedge can also be more robust than a financial hedge. Hedging revenues financially can be difficult in practice, since at the time the hedge is being executed, a firm may not know exactly how large its revenues will be. For a natural hedge, this is less of an issue, since costs tend to track revenue closely.

The decision to build a new production facility abroad clearly has many strategic implications that might outweigh the benefits of reducing foreign exchange risk. However, there are many ways to apply operational hedging that are simpler to implement and require far less investment.* For example, instead

* This is not to say that firms should ignore opportunities to establish operational hedges when making decisions about where to locate production facilities. The potential benefits of reducing foreign exchange rate risk should be carefully weighed, along with other evaluation criteria.

of moving production abroad to change its foreign exchange exposure, a firm can sometimes achieve a similar result simply by changing suppliers or by altering the terms of its supply contracts.

Other forms of operational hedges can also be constructed. The process of managing supply and demand can be improved by optimally matching supply and demand to ensure that financial performance is less sensitive to a variety of value chain risks. The approach can also be applied to contract management and to the balancing of investments in production capacity with investments in sales and marketing activity.

Another way that firms can reduce risk is through value chain restructuring. Restructuring improves the efficiency of a firm's extended value chain by removing or consolidating redundant or inefficient stages. It does so by eliminating intermediaries, simplifying business processes, or introducing new types of interactions between value chain partners. New approaches for value chain restructuring enabled by information technologies have emerged in the past few years, including middleware to support business process integration as well as the use of on-line marketplaces and collaboration networks to conduct transactions and exchange information.

Value chain restructuring can reduce risk in a number of ways. A shorter value chain means that goods spend less time being processed and thus have less exposure to risk. This is especially important for technology products and fashion goods, where every extra minute in the supply pipeline increases the risk of price declines and obsolescence. Uncertainty tends to increase over time, so the longer a product takes to reach the final customer, the greater the risk.

Value chain restructuring also decreases risk by reducing value chain complexity. This helps eliminate execution errors and reduces supply risk by making it easier to coordinate activities with suppliers. With fewer intermediaries between an enterprise and its final customers, the firm also receives more timely information about demand and supply fluctuations. Inventory and production assets can thus be utilized more efficiently.

Changing the nature of value chain interactions can also reduce risk. Often this works by altering information flows and incentives. For example, collaborative business models such as vendor-managed inventory provide suppliers with greater inventory visibility without physically shortening the value chain. Nevertheless, the supplier still receives more accurate and timely information about customer demand.

The approaches discussed here for strategically managing risk can be applied to a broad range of business processes. A number of applications of these techniques are illustrated in Table 1.2. Many of these decisions entail trade-offs, since reducing one form of risk can introduce others. For example, supplier

diversification reduces the risk of supply disruptions, but it can also increase supply chain complexity, leading to higher costs and more execution errors. Similarly, geographical diversification to reduce labor price risk may require investments in countries with high political uncertainty, increasing political, legal, and regulatory risk.

1.7.3. Operational Risk Management

Developing integrated risk management systems that link strategy, planning, and execution requires the deployment of systems, measurements, and processes for managing and mitigating operational risk. Drawing on best practices in the financial services industry, several key features of an operational risk management program will be described. Then a high-level systems architecture is presented for an integrated risk management system that integrates risk management at an operational level with an enterprise's strategy and plans.

The objective of operational risk management is to minimize business disruptions, improve the response to crises, and constrain the adverse consequence of risky events. This is accomplished by integrating several forms of risk management functionality into business operations. Many of the risk management approaches discussed here can be directly applied to reduce execution errors and improve crisis management. They can serve as a model for implementing information systems to monitor and respond to risky supply chain events. They also describe a hierarchical approach to establishing risk limits that can be applied in a production setting and provide a useful set of measurements for monitoring and tracking operational risks.

Operational risk management begins by determining how much risk a firm is willing to absorb. This is defined in terms of the amount of money the firm is willing to lose due to risky activities. Since a firm's profit potential depends on its appetite for risk, acceptable losses are determined within the context of a firm's overall financial objectives, including its profit and revenue targets.

Once acceptable risk levels have been established for the firm as a whole, risk limits are defined at the business unit level, where business managers have the ability to influence and control risk. Risk limits are often expressed in terms of value at risk, with acceptable loss levels specified for different time horizons. Establishing these limits typically involves analyzing the unit's business activities and their fit with the firm's overall tolerance for risk. Setting appropriate limits is something of a balancing act. The aim is to control the risks taken by business units without placing constraints that unnecessarily limit flexibility. If risk limits are too conservative, they can hinder the business unit's ability to meet its overall revenue and profit targets. In evaluating the performance of

Table 1.2. Approaches for Strategically Managing Risk

	Leverage	Diversification	Hedging	Restructuring
Value chain design	■ Modify using changes in production technology ■ Modify by outsourcing production	■ Geographical diversification to reduce hazard risk ■ Political unit diversification to reduce political risk and tax risk ■ Geographical diversification to reduce labor price risk	■ Natural hedging of foreign exchange risk ■ Matching inbound and outbound supply chain capacity and flexibility ■ Matching supply chain capacity to marketing capability ■ Matching supply chain flexibility to customer demand volatility	■ Value chain restructuring ■ Alternative value chain interactions ■ Supply chain redesigned to reduce cycle time and inventory ■ Value chain simplification to reduce complexity risk ■ Create growth and flexibility options
Strategic sourcing strategy	■ Increase by selecting vendors requiring capacity commitments ■ Reduce by consolidating spending to improve flexibility terms	■ Vendor diversification to reduce supply and price risk ■ Vendor diversification to reduce hazard risk	■ Hedge demand volatility with supply-demand matching ■ Natural hedging of foreign exchange risk	■ Single-source selected components to reduce complexity ■ Increase information sharing with core suppliers ■ Improve planning coordination and synchronization ■ Increase flexibility with spot market buys ■ Create growth and flexibility options
Supply and sales contract portfolio design	■ Modify by changing contract terms	■ Manage portfolio of flexibility options ■ Manage portfolio of embedded options	■ Hedge demand volatility with supply flexibility terms ■ Hedge price and foreign exchange risk with embedded options	■ Improve information sharing with contract incentives

Product portfolio design	■ Modify by making changes in portfolio composition ■ Modify by considering relationship with strategic sourcing	■ Diversify to improve portfolio risk-return trade-off	■ Hedge demand volatility with product choices ■ Parts commonality to hedge supply risk	■ Create learning, growth, and flexibility options
Strategic acquisitions	■ Modify by acquiring new production facilities ■ Modify by acquiring new production technology	■ Customer and market segment diversification to reduce demand risk ■ Geographical diversification to reduce demand risk ■ Technological diversification to reduce product risk	■ Hedge demand volatility with complementary product lines ■ Hedge supply risk with complementary suppliers	■ Create learning, growth, and flexibility options
Outsourcing, strategic partnerships, and alliances	■ Modify by investing in new joint production facilities ■ Modify by obtaining access to new production technology	■ Customer and market segment diversification to reduce demand risk ■ Geographical diversification to reduce demand risk ■ Technological diversification to reduce product risk	■ Hedge technology risk by placing multiple bets ■ Hedge demand volatility with new products ■ Hedge demand volatility by targeting new geographies and market segments	■ Create learning, growth, and flexibility options

business units and individuals, risk must be quantified and priced to verify that superior performance is not the result of taking on excessive risk. When assessing operational performance, it is thus common to use metrics such as risk-adjusted revenue or risk-adjusted profit.

Effective risk management requires extensive information. Capturing inputs directly from business operations, systems track information required to analyze risk and to support appropriate management controls. By taking a modular approach to risk management, the risk management process can be structured so risks can be managed collectively. This allows multitasking, enabling different parts of an organizations to effectively coordinate their risk management actions. Ideally, an operational risk management system should also include means for capturing and structuring organizational learning about risk.

Effective operational risk management requires continuous monitoring, not only of risks but also of the effectiveness of the program itself. Metrics for benchmarking program effectiveness include losses avoided, opportunities capitalized, the speed of new product introduction, level of management comfort, efficiency of control, and overall enterprise risk-return profile. Operational risk management programs also establish a capability for managing business contingencies. These include not only backup systems, but also procedures for handling extreme conditions. Their key aim is to establish a balance between risk control and business flexibility, while ensuring the speedy resolution of a crisis.

1.7.4. Financial Risk Management

Historically, firms have used the financial markets to manage a broad range of market risks, including foreign exchange, interest rates, equity prices, and commodity prices. As financial engineering techniques have evolved, new derivatives products have emerged to protect against a broad range of new risks (Hull, 1997). Some of these products are standardized, while others can be highly customized to meet the specific needs of a particular party.

Financial risk management is concerned primarily with risk transfer — shifting risk from one party to another. In a corporate setting, a firm typically seeks to transfer some or all of its risk to a third party, such as a bank, an insurance company, a speculator, or an investor. Risk transfers do not always reduce risk. Sometimes a firm will actually assume additional risk as part of its financial management strategy. In other cases, a firm may keep its total risk exposure constant, instead of merely transforming one form of risk into another.

In analyzing whether it makes sense to hedge a particular risk using derivatives, a firm should consider a number of factors. The first is the likely impact of the risk factor on the business. If prices for a particular risk factor are not

especially volatile, or if a firm's profitability or market value is not particularly sensitive to changes in the risk factor, then it probably does not make sense to hedge. Event though a firm's costs may be very sensitive to changes in the price of a particular part or commodity, it does not always make sense to hedge. For example, if a firm is able to pass along price increases for procured components to its customers, it may not make sense to hedge.* However, if a firm needs to hold substantial inventories of a part or commodity, this creates a risk exposure, and hedging might be appropriate.

Another factor to consider is the likelihood of being able to establish an effective hedge. Sometimes the instruments used to manage risk do not precisely offset the risk faced by a company. This could happen, for example, for an electronics firm purchasing a special type of gold for electrical interconnects. The price it pays its gold fabricator may not precisely track the price of gold traded on a commodities exchange. This introduces basis risk, the difference between price changes of the asset being hedged and price changes in the hedging instrument.

Ineffective hedges have two primary disadvantages. First, if basis risk is large, hedging not only becomes ineffective but also can actually increase risk. Furthermore, ineffective hedges may not qualify for hedge accounting treatment for financial accounting purposes. When this is the case, offsetting price changes in the hedging instrument and the asset being hedged may be reported at different times. This can have the effect of increasing the volatility in reported earnings, even though cash flows are actually less volatile in purely economic terms.

Firms also have to consider the costs associated with hedging. Transaction costs can be high, especially for options. Furthermore, it can often be difficult to completely understand all of the costs (and risks) associated with managing risk financially. This raises the possibility of incurring significant unexpected losses if certain unanticipated events transpire.

In some cases, it may be difficult to get a fair price for derivatives. This is usually not the case for exchange-traded derivatives or for widely traded over-the-counter instruments such as foreign exchange options and forward contracts. However, prices for custom derivatives products are notoriously difficult to model. This can make it difficult to determine whether an offered price is fair, especially since comparison shopping for highly custom products can be difficult. A similar problem arises for thinly traded over-the-counter derivatives in emerging markets for underlying assets such as bandwidth, electronic compo-

* In fact, when a firm can naturally offset its risk in this fashion, hedging is counterproductive. It actually increases the firm's risk, since it creates an exposure to price changes in the hedging instrument.

nents, and weather. Derivatives brokers and dealers often have significant information advantages that they can exploit with their customers, since their traders are exposed to a far broader range of marketplace transactions.

Firms also have to consider the strategic implications of their risk management activities. In low-margin industries, the cost of hedging with options may leave little room for profit. A firm locking in the prices of procured components using futures or forwards contracts may remove uncertainty about its costs, but it may increase the uncertainty of its earnings. For example, a personal computer manufacturer buying DRAM swaps to fix the price of its computer memory purchases may find its cost structure uncompetitive if DRAM prices drop dramatically. Competitors will have the advantage of buying at low market prices, while the firm has to continue paying the higher fixed price established by the swaps contract.

Supply contract terms and conditions frequently have characteristics that make them behave much like financial derivatives. Examples include price adders linked to commodities prices and pricing pegged to a particular foreign currency. Embedded derivatives effectively transfer risk between value chain partners, such as suppliers and their customers. Embedded derivatives can be exploited in several ways. Often they provide a particularly effective hedge, since the amount of risk transferred changes depending on the actual quantity of goods or services purchased through the contract. They are also sometimes mispriced. This presents an opportunity for one value chain partner to transfer away risk more cheaply than would be possible using traditional financial derivatives.

One interesting trend is the emergence of new risk management products that can be used to hedge risks closely linked to a firm's operating profits. An example is weather derivatives, financial instruments whose payoff is pegged to temperature changes at particular geographical locations. Derivatives are also emerging for electricity, telecommunications bandwidth, and electronic components such as computer memory chips. The increasing availability of such derivatives products will enable firms to manage a broader set of risks, many of which are central to their business performance.

1.7.5. Insurance

A wide variety of insurance products are available, many of which can be customized to meet particular customer needs. In addition, new products are evolving that share characteristics of both insurance and financial products. These hybrids seek to combine the efficiency of the financial markets with the specialization of insurance.

Conventional insurance focuses primarily on indemnifying a firm against losses. Insurance policies are available to protect against numerous hazards, including property damage, injuries, theft, and a variety of potential liabilities.

Insurance companies offer a grab bag of products that are loosely referred to as nontraditional insurance or alternative risk transfer (ART) products. In general, these offerings seek to address significant risks whose management requires specialized expertise not available from noninsurance firms. Examples include structured deals that offer special accounting or tax treatments, insurance against operational risk, and protection against exposures such as credit risk and the weather. These products often seek to address a firm's requirement for capital after significant business losses and are specifically designed to limit downside risk on a firm's income statement or balance sheet.

Many ART products are a special form of debt where payments are contingent on a certain event. For example, forgivable debt, such as "catastrophe bonds," is structured so that principal or interest payments are waived following a predefined event such as a natural disaster. For structured debt, principal or interest payment is linked to the market price of oil or another commodity. Other ART offerings are hybrids of debt and equity. For example, reverse convertible debt can be converted to equity at the option of the issuer to reduce its financial leverage when cash is short.

Structured deals or finite risk insurance (FRI) are products that limit the amount of risk transferred. They often also involve packaging multiple risks. FRI also usually includes a profit-sharing mechanism that allows for an ex-post adjustment in the insurance premium based on the claim experience of the purchasing firm. FRI has a longer term than conventional insurance products, with coverage typically lasting for three to five years.

It is often difficult to distinguish between insurance and financial risk management products. Furthermore, the boundary between the two is constantly shifting. Risk needs to be fairly standardized to develop liquidity in the financial markets. It also needs to be fairly easy to price, so different market participants can readily trade it. For risks that the financial markets cannot absorb, insurance can be an effective alternative. For example, weather insurance used to be the domain of insurers, but has now largely shifted to the financial markets. Since weather risk can be fairly easily standardized, and can be modeled using existing options pricing models, liquid markets for weather derivatives have quickly developed.

Firms have a number of choices regarding the types of risks to insure and how to insure them. This is illustrated in Figure 1.5, which shows appropriate risk management vehicles for risks with different frequency and severity (Dickinson, 2000; Williams et al., 1997). Insurance tends to be more expensive

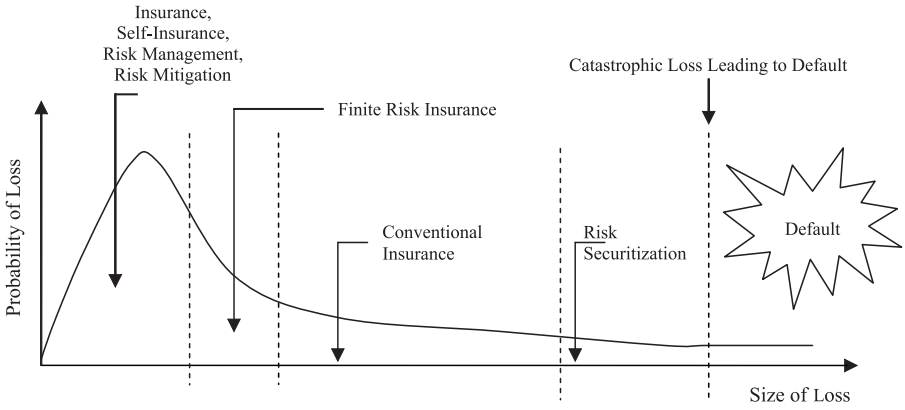

Figure 1.5. Risk coverage spectrum.

than financial forms of risk management. Insurance is therefore typically used to manage residual risk — risk that cannot effectively be addressed either operationally or through financial risk management.

For frequent, low-severity losses, firms typically use self-insurance and other risk management techniques. Since such losses are usually fairly predictable, and their consequences limited, they do not contribute significant uncertainty.

When losses are infrequent, risk tends to be harder to model. Insurance companies have developed specialized expertise that enables them to price these risks effectively. For example, estimating the expected losses associated with extremely rare events can be extraordinarily difficult and is one of the core competencies of commercial insurers and reinsurers. In particular, for rare events with extremely high potential losses, insurance may be the only option, since firms typically do not have enough capital to self-insure.

FRI and structured deals can be used as a layer between self-insurance and conventional insurance for securing postloss funding. Firms sometimes also retain some of this risk, but typically cap their potential losses through reinsurance.

Risk securitization can be used for extremely rare events that are especially severe.* Finally, there are certain business risks that cannot be insured or managed financially. These are the risks that equity holders are paid to bear. If too large a loss occurs, insurance will not be able to cover it, and the firm has no choice but bankruptcy.

Insurance innovation may some day enable insurers to offer nontraditional products targeted specifically at value chain risks, such as parts shortages or

* Risk securitization is the packaging of risk for sale in financial markets. Such products are therefore financial-insurance hybrids.

unexpected drops in customer demand.* New models will be required to estimate the potential losses from such disruptions and their frequency of occurrence. However, some of the analytics discussed earlier in the section on operational risk management could be extended to price these risks. In addition, the presence of appropriate risk-monitoring systems could be used to justify lower premiums and could provide data necessary for an insurer to assess its risk exposure prior to extending coverage.

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* Such policies would be similar to existing offerings, such as business interruption insurance and surety insurance.

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2

INTEGRATED RISK MANAGEMENT

Samir Shah

2.1. INTRODUCTION

Over the past decade, risk management has witnessed explosive growth and increased specialization. The maturity of the financial engineering discipline has fueled a frenzy in the banking sector to create ever-more exotic forms of risk packaging and risk transfer products. Banks continue to compete aggressively on the basis of their ability to transfer clients' financial risks to the capital markets. There has also been some innovation in the insurance market as insurers have developed custom products to securitize the risk of natural disasters and protect against emerging risks such as weather, cyber crime, rogue trading, and terrorism. Companies have also become more expert at self-insuring their own risks through a variety of onshore and offshore captive insurance companies. This proliferation of risk management activities occurred simultaneously with an increased specialization of risk management products and markets.

Companies at the forefront of the advances in risk management have organized their risk management function to mirror the specialization of products and markets. There are typically separate risk managers for each major category of risk (e.g., interest rate risk, foreign exchange risk, commodity price risk, credit risk, operational risk, and insurable property and casualty risks). The risk management decisions are typically not coordinated, although the overall investment in risk management activity is consolidated in the finance function. In the process, companies have lost sight of the interaction among risks. The