CHAPTER 2

Risk, Uncertainty, and Profit

As Chapter 1 suggests, two major functions of the economic system are the efficient allocation and distribution of resources to their most highly valued uses. This includes the allocation of resources across time and space and the redistribution of resources among economic agents. Derivatives provide a very efficient mechanism for the shifting of risk over time and space, to other market participants, and across different states of nature.

To appreciate this economic function of derivatives more fully and to understand more clearly how derivatives actually work, we first need to develop some basic economic concepts that underlie the vast majority of what follows in this book. In particular, we focus in this chapter on developing a complete understanding of two fundamental and distinct economic concepts that lie at the core of the theory of risk transfer in general and modern derivatives activity in particular—risk and uncertainty. Perhaps more important than our consideration of either of these terms in isolation, we also want to consider fully the relations between each of these terms to the concept of profit. Without this basic foundation, it will be nearly impossible for us to consider later questions like: When and how do traders make money? Why should firms transfer away risks to which they are exposed? How can a firm distinguish between sources of randomness that are core to the business and the profits of that business from those which are merely incidental? And the like.

Much of this chapter relies on some basic concepts from traditional neoclassical price theory. In several places, moreover, the ideas depart from the traditional neoclassical paradigm and stray into other, alternative branches of economic theory. Although not essential for this chapter, before proceeding readers may wish to review Appendix 1, in which a brief summary of the primary economic theories is considered with specific attention to differences across the theories in what is meant by the concept of equilibrium.

RISK, UNCERTAINTY, AND THE FIRM

The standard neoclassical treatment of choice under risk and uncertainty involves an axiomatic approach pioneered by von Neumann and Morgenstern (1944), Savage (1954), and others in which individuals' preferences are expressed using a mathematical functional that maps wealth or consumption over time into "units of happiness." Consumers are presumed to maximize their utility of wealth or, in the face of risk or uncertainty, to maximize the *expected value* of their utility of wealth across different random states of nature. For an introduction to this methodology, see Laffont (1989), Kreps (1990), and Gollier (2001). Machina and Rothschild (1987) provide a short but useful survey.

For the most part, however, we will not get into expected utility analysis in this book. That might seem unusual to some experienced readers—how can we ignore this huge branch of economic theory in a book about risk transfer? The simple reason is that we do not need it. Expected utility analysis may be useful for the analysis of *individual* choice under risk and uncertainty, but these methods have more limited applications when it comes to analyzing *business enterprises*. And indeed, corporations are the economic agents with which this book is primarily concerned.

The distinction between individuals and firms is often downplayed, especially for pedagogical and analytical purposes. In rigorous analysis, for example, it is tempting to simplify things by assuming that a firm's behavior can be described with the same tool used to model individual behavior—an expected utility function.[1] That allows us as modelers to make simplifying assumptions, such as the presumption that the firm is risk averse. Outside of rigorous analysis in the classroom or public dialogue, such personifications of the firm are even more tempting, even to the most seasoned theoretician or practitioner. Casual references to a firm that hedges as "risk averse," a firm that pollutes the air as "socially irresponsible," a firm that donates to the local symphony as "community involved," and the like are all useful as tools of pedagogy and discourse.

Despite its seductive appeal, the depiction of a firm as a single-acting economic agent is simply not realistic at all. Consider, for example, the seemingly clear statement that "Company Pacino prefers to take less market risk than Company DeNiro." What does it really mean to say that Company Pacino prefers one thing to another? Or that Company Pacino prefers less risk than Company DeNiro? Do we mean that the managers making the decisions at Company Pacino prefer less risk? Or that Pacino's shareholders prefer less risk? Or perhaps the creditors and customers of the firm prefer less risk? All of these questions underscore the reality that the firm is not simply an organic whole that makes its own decisions, bears its risks, and deals with those risks.[2]

In the end, a firm is just a collection of people bound together in various ways by a set of contracts. Economic theory offers several alternative explanations for when and why individuals find it sensible to form these sorts of associations by setting up corporations. Several of the dominant theories of the firm include:

- A firm is formed when the transaction costs of internal bargaining are below the transaction costs of external dealing across would-be participants in the firm (Coase, 1937).
- A firm is a risk-sharing entity designed to spread the full force of impact of the market on producers across multiple economic agents who may be able to bear such shocks collectively but might not be capable of doing so on their own (Wilson, 1969).
- A firm is an entity formed to exploit specific human capital and the benefits of "team production" (Alchian and Demsetz, 1972).
- A firm evolves to reduce the costs of disputes or bargaining among and across factors of production (Williamson, 1975).
- A firm is a nexus of contracts designed to minimize the costs arising from the separation of ownership and control (Jensen and Meckling, 1976).

No matter what role one ascribes to organizations and firms or why one believes they come into existence, the common thread across all these theories—that the firm is a collection of individuals legally bound together in some way—gives rise to certain problems. Adam Smith recognized this as early as 1776 in his treatise *An Enquiry into the Nature and Causes of the Wealth of Nations*, when he observed the potential for conflicting incentives to exist or arise across the varying numbers and types of heterogeneous individuals that comprise "the firm." Incompatible incentives not only complicate our ability to explain the actions and decisions of firms, but they also render difficult our capacity to visualize and analyze the firm as a single coherent, integrated, holistic economic agent. If a firm is a collection of individuals whose objectives and incentives are not aligned, *to whose objectives do we look* when considering "the firm"?

We could easily stop here and proceed to undertake an entire book on the subject of agency costs, the theory of the firm, and organizational decision making. But that is not our task, and, indeed, such books exist.[3] Yet, in a book about corporate risk transfer and derivatives activity, we cannot simply ignore the complex organizational conundrum underlying the organic firm whose collective decisions we seek to analyze. An immediate implication of agency costs, after all, is that it is generally impossible to ascribe to firms the same basic attitudes that individuals have toward risk; that is, the expected utility framework fails us, at least when applied directly to the firm as a single-acting economic agent.

Just consider a simple example to appreciate the practical importance of this issue. Suppose a Swiss firm has most of its costs denominated in francs and most of its revenues denominated in pounds to reflect the bulk of its sales in the United Kingdom. The firm thus has a significant amount of its business that is influenced *structurally* by exchange rate fluctuations. Now imagine that shareholders of the firm knew this when they purchased their stock, and either have preferences that are consistent with bearing franc/sterling exchange rate risk or have diversified that risk away by holding the stocks of firms whose revenues rise at the same time franc/sterling fluctuations impose losses on the Swiss firm.

Now suppose that the managers of the Swiss firm receive all of their compensation from the Swiss firm in the form of a fixed salary plus a bonus that does not exceed 20 percent of salary.[4] Suppose further that the managers are risk averse—they prefer (in an expected utility context) a fixed level of wealth to a random allocation of wealth with the same mathematical expectation as the fixed level. In the event of significant adverse exchange rate moves, the managers personally suffer—there is less from which the firm can pay the bonus, and, in the extreme, the firm goes bust and the managers lose their salaries and jobs. In the event of *favorable* exchange rate swings, the managers have a very limited upside: They can at most make a 20 percent bonus, and it is not clear that exchange rate gains will go into the bonus pool. If the managers are vested with decision-making responsibility for the firm's risk management program, their natural, rational economic tendency thus will be to hedge the company's exchange rate risk despite the inconsistency of that decision with shareholders' desires and expectations. This will make the firm as a whole appear to be averse to franc/sterling risk. Alternatively, if the shareholders are in control of the hedging decision, they will do nothing, thus making the firm appear neutral or indifferent to exchange rate risk.

When the preferences of the different parties that comprise a firm are at odds in the face of positive agency costs, there is no clear way to describe the "preferences" of "the firm." We can describe the *decisions* the firm makes—either it does or does not hedge—but we have some trouble modeling where those decisions come from without getting into a much deeper level of detail.

Culp (2001) considers the implications of agency costs like these on corporate risk management strategies in some detail. Partly for this reason but mainly because it is not central to our topic, we will simply sidestep these issues here. We cannot simply assume the firm acts like an individual—we lose too much going that route—but we *can* make an intermediate assumption that allows us to consider the firm as a collection of coordinated individuals without worrying about conflicts between different parties. Specifically and unless otherwise stated, we shall assume in this book that the decisions made by "the firm" are in fact made by the managers of the firm, and that those managers act *ex ante* (i.e., based on the information

they have at the time) to maximize the market value of the firm's assets. Known as the *market value rule*, this is equivalent to assuming that managers always pursue strategies designed *ex ante* to maximize the combined wealth of all the firm's security holders.

Assuming that corporate managers follow the market value rule is not terribly implausible. As Fama (1976) explains, the market value rule is the only criterion that maximizes the value of the firm. A company whose managers do *not* adhere to the market value rule thus cannot survive in the long run—it will be acquired by a management team that *will* pursue the market value rule. So, all we really have done in making this assumption is to gloss over the various internal contracting and incentive mechanisms that firms use to enforce the market value rule.

RISK, UNCERTAINTY, AND PROFIT

The first serious effort to explore how *firms* deal with an unknown future that did not simply presuppose a firm had an expected utility function like an individual was undertaken by Frank H. Knight. Raised as a farmer, Knight matriculated to the University of Tennessee when he was in his twenties, and graduated in 1913 with a bachelor's degree in natural sciences and a master's degree in German. From there he went to Cornell, where he worked under Alvin Johnson and Allyn Young[5] on his dissertation until its completion in 1916.

Knight's thesis was the outgrowth of a suggestion by Professor Johnson that he make an examination of "the entrepreneur" as the central figure of the economic system—in particular, of the forces that lead to the renumeration of the entrepreneur through what we call "profits." Surprising as it may seem, despite all the advances in economic theory that occurred in the "marginalist revolution" that brought classical Ricardian economics into the new era of neoclassical economics (see Appendix 1), none had concerned themselves with the firm in quite this manner. In particular, no one had undertaken any serious effort to answer questions like these: If markets are perfectly competitive as in most orthodox models so that no firms earn positive economic profits in the long run, what is the raison d'être for firms even to exist? What is the real driver of a firm's corporate profits? How does the element of randomness surrounding future events affect corporate profits? How does a firm's management decide when the randomness it faces is a problem that needs to be addressed versus when randomness is the key to the firm's competitive edge? And so on.

The fruit of Knight's exploration of these sorts of questions was a highly

acclaimed dissertation called *Cost, Value, and Profit* that won second prize in a competition by Hart, Schaffner, and Marx and that helped secure Knight a coveted faculty position in the University of Chicago's department of economics.

Knight remained at Chicago from 1917 to 1919, at which point a lack of open positions forced him to leave, whereupon he joined the faculty at the University of Iowa. During his two years at Chicago, Knight did little else but substantively revise his thesis, drawing heavily on comments and feedback from colleagues that included J. M. Clark, Jacob Viner, and Charles O. Hardy—all of whom were renowned thinkers in their own right. The final result was the publication in 1921 of his revised thesis under the title *Risk, Uncertainty, and Profit*.

Knight's *Risk, Uncertainty, and Profit* is widely considered to be one of the five most important economic texts published in the twentieth century,[6] and Knight himself went on to become one of the most influential economists of all time. He returned to Chicago in 1928 where he remained until his death in 1972.

Known as the "Grand Old Man of Chicago," Knight quickly became one of the leading intellectuals in the development of the Chicago school of economic thought—a branch of the neoclassical school of economic theory with a particular emphasis on the idea that economics is an empirical science and not a normative philosophical paradigm. (See Appendix 1.) Nobel laureate and Chicago economics professor George Stigler (1987, p. 56) called Knight "the dominant intellectual influence" at Chicago during the interwar period. In 1928, he became co-editor (with Viner) of the *Journal of Political Economy*, a journal that played a pivotal role in the evolution of the Chicago school and that is still arguably the top refereed academic journal in economics today.

Knight fostered the development of the Chicago school in part through his intellectual progeny. Among his students were three who themselves subsequently became towering figures of the Chicago school: Milton Friedman, George Stigler, and James Buchanan. All three eventually became Nobel laureates in economics. Knight himself would surely have won the economics Nobel Prize, but it was not awarded until just three years before he died. He *did* win in 1957 the Francis Walker Medal for lifetime achievement in economics, granted every five years "to the living American economist who has made the greatest contribution to economics" and generally regarded as the precursor to the economics Nobel Prize.[7]

Not content to remain limited to economic problem solving, Knight also often strayed into other social sciences to conduct research. Rather than be beaten into retreat from such incursions into related fields, as many scientists are, Knight persevered and vigorously defended his scholarly explorations. In

1942, Knight received a joint appointment from the University of Chicago as a professor of the social sciences and a joint appointment as a professor of philosophy in 1945. During these years Knight helped establish (together with economic historian John Nef and sociologist Robert Redfield) the University of Chicago's Committee on Social Thought, arguably the first formalized interdisciplinary program of its kind. The Committee would later play host to other great economists, including F. A. Hayek, another famous "economic imperialist" whose work outside of economics—specifically, in philosophy—was almost as well known as his work *in* economics, which itself secured Hayek the Nobel Prize.

Risk versus Uncertainty

Despite the voluminous modern literature on the subject, it is remarkably difficult to find a more insightful contemporary discussion of the nature of the problems faced by businesses operating in an uncertain world than the 80-year-old *Risk, Uncertainty, and Profit*. Knight's treatise about risk and how firms deal with it was theoretically path-breaking at the time, and it remains absolutely relevant today from a *practical* perspective, as well.

As the title suggests, Knight went to great lengths to distinguish between *risk* and *uncertainty*. Modern usage generally equates the two terms, at least to a first approximation. But for Knight, the two different notions of economic randomness were fundamentally distinct:

> *The practical difference between the two categories, risk and uncertainty, is that in the former the distribution of the outcome in a group of instances is known (either through calculation* a priori *or from statistics of the past experience), while in the case of uncertainty this is not true, the reason being in general that it is impossible to form a group of instances, because the situation dealt with is in a high degree unique. (Knight, 1921, p. 233)*

Risk thus represents a *quantifiable* source of randomness, whereas uncertainty is inherently *unquantifiable*.

The evaluation of an unknown future invariably involves the process of defining possible outcomes or events and associating probabilities with them. Knight (1921) and Hardy (1923) argued that there are essentially three ways of assessing probabilities once the outcomes or events to be analyzed have been defined. First, the probabilities may be purely mathematical in nature—for example, the chances of one pip showing face up when a fair die is cast. Second, the probabilities may be based on statistical inference—for example, forecasting and prediction of the weather based on a mixture of prior beliefs with actual data on comparable weather events and outcomes that have al-

ready occurred under similar circumstances. Finally come those probabilities that cannot be systematically associated with future events given the unique nature of the underlying randomness. To the extent probabilities in that circumstance can be defined and decisions about the future made, they are each based essentially on pure judgment rather than formal analysis. Hardy (1923) explains:

> *An "act of business judgment" may denote anything from an instantaneous sizing-up of and acting on a relatively simple situation, to the involved investigations and prolonged deliberation leading up to a momentous business decision or the adoptions of far-reaching business policies. Sometimes the basic data of the judgment are definite and complete; sometimes so obscure that a judgment is almost a leap in the dark, and even the shrewd executive cannot put his finger on the specific factors which determine his decision. (p. 53)*

With the explosion in the popularity of quantitative measures of risk like value at risk and earnings at risk over the past decade, many specialists increasingly argue to their commercial colleagues that *all* randomness is quantifiable. Perhaps the precision of the estimate will differ based on the methodology used, but ultimately everything can—and *should*—be thrown into a black box that will churn out an "enterprise-wide risk measure"—or so says the orthodoxy.

Contributing to this trend in thinking has been a steady move by certain regulatory and supervisory organizations to the same end. In its revision of the 1988 Basel Accord specifying minimum capital requirements for banks, for example, the Bank for International Settlements places great emphasis on the quantification of operational risks for capital adequacy purposes. When it comes to a low-severity, high-frequency risks like dollars lost from errant funds transfers, this requirement at least has some basis to it. But for low-frequency, high-severity events—for example, the disastrous events of September 11th or the Great Chicago Flood of 1991—we are getting much further away from risk and much closer to uncertainty. In fact, even those examples may still be true risks in Knight's sense, and if they are difficult to measure, then true uncertainty must be beyond the pale.

So, we are increasingly instructed by those in the risk management world that we must "think quantitatively" about virtually everything. In today's world of value at risk and Basel II and real options and everything else underlying the "enterprise-wide risk measurement" movement, Knight's distinction between risk and uncertainty is clearly heterodox, if not heretical. But to Knight, the distinction was far more than just teleology. On the contrary, Knight forcefully argued that uncertainty is a vital part of a growing economy and an emergent aspect of a well-functioning economic system.

The Causal Relation between Risk, Uncertainty, and Profit

One of the most important theoretical implications of Knight's work is that firms cannot earn positive economic profits in the long run if the only source of randomness they face is quantifiable risk. Only *true uncertainty* can be the basis of a firm's ability to earn positive economic profits sustainably and regularly:

> *That higher form of uncertainty not susceptible to measurement and hence to elimination . . . is this* true uncertainty *which by preventing the theoretically perfect outworking of the tendencies of competition gives the characteristic form of "enterprise" to economic organization as a whole and accounts for the peculiar income of the entrepreneur. (Knight, 1921, p. 232)*

The reasons that firms can sometimes earn profits in a world of uncertainty are several. One is the specialization of firms in areas where they perceive some comparative advantage in information or knowledge of a given kind. This is a sort of "division of labor" argument for the corporate sector. Less informed firms will forgo entry into industries occupied with such specialists and focus on those areas where they perceive themselves as relatively better informed, thus leaving room for both firms to earn supranormal returns in their different information specializations.

In other cases, some companies earn profits from bearing uncertainty because other firms are not willing to do so. If the production of some good is subject to such uncertainty and the good remains demanded even when sold at a price high enough to compensate the firm for bearing the commercial uncertainty associated with its production, then some firms will collect this "uncertainty premium" for undertaking to bear the uncertainty and supply the good.

Finally, as Chapter 3 will make clearer, entrepreneurial profits can sometimes be earned when firms become specialists in assuming uncertainty from those firms that are naturally vulnerable to such uncertainty but do not wish to bear it on an ongoing basis.

The Revolutionary Nature of Knight's Ideas

Knight's thinking at the time was no less than revolutionary. Until Knight, mainstream microeconomic theory did not readily admit to firms earning positive economic profits in the long run for any reason apart from imperfect competition. In classical Ricardian economics (see Appendix 1), profits simply tended toward some "natural rate" determined entirely by exogenous factors such as the aggregate endowment of land or technology in the economy.

The relative distribution of profits might vary across firms depending on their ownership of the factors of production, but not the *rate*.

In the late 1800s Walras, Jevons, Menger, Cournot, and others ushered in the "marginalist revolution" to economic theory. By Marshall (1890), the marginalist revolution had evolved into a unified theory of the price system—the neoclassical theory—that replaced the earlier classical theories. The archetypical neoclassical perspective on long-run corporate profits was articulated by Marshall, who argued that there was no natural rate of profit. Instead, each firm made its own optimal production decisions by producing more goods until the cost of the last good produced equaled the revenue from the last good produced.[8] In the short run—Marshall is perhaps most famous for introducing the concepts of a "short" and "long" run (see Appendix 1)—production optimality could yield profits to any given "inframarginal" firm. But in the long run, those profits would attract new firms into the market, and price would fall until production optimality occurred at the minimum average cost. This meant zero economic profits.

The assumption of zero economic profits in a long-run Marshallian equilibrium continues to permeate modern microeconomic analysis. As a result, positive economic profits are often regarded—even today despite Knight's insights—as attributable to some source of market power that prevents the full force of competition from attracting new firms and driving profits to zero. But all of these models presupposing that long-run profits are attributable only to market power assume all market participants are equally well informed.

Knight debunked the notion that profits could come only from market power by arguing forcefully for the importance of differential or asymmetric knowledge and information. That idea had been largely absent from prior mainstream economic theory, with the notable exception of Menger—the founder of the Austrian school of economics (see Appendix 1)—whose work first was published in German in 1871 (*Grundsätze der Volkswirthschaftslehre*) but which did not appear in English until 1950. When Menger's text was finally published in English, Knight penned the Foreword.

Risk and Uncertainty in the Real World

Imagine an economic theoretician in her white lab coat and a practicing businessman in his Brioni suit sharing a coffee at Deux Magots in Saint Germaine des Prés and discussing the role of economic modeling in the daily life of the Paris businessman. The discussion turns to Knight. Neither would really disagree with Knight's conclusions that some firms could make sustainable long-run profits when market participants do not share a common set of probabilities about the future. But the businessman might be expected to argue that despite Knight's accomplishments as a part of the history of economic thought, his accomplishments were just that and little more.

No, the economist responds. The task of economics is to make certain as-

sumptions in order to develop baseline explanations for economic phenomena. Real-world deviations from those ideals coming out of admittedly unrealistic models, she would contend, can often be explained by looking for violations in the underlying assumptions. So, not only is work like Knight's important because it advances the state of intellectual knowledge and economic theory, but it also has practical relevance.

Our Brioni-clad businessman might then reply that although true in principle, many of the major neoclassical economic models are too abstract—in either their assumptions, their object of investigation, or both—to be of any *practical* use. Knowing something about the history of economic thought himself—he must have read Appendix 1—he offers the example of Walras, who developed a system of simultaneous equations in 1874 to characterize the prices of multiple goods in a competitive general equilibrium. The work of Walras was an absolutely essential step forward in the progress of economics as a science—it was perhaps *the* founding work of "general equilibrium" theory—but it had absolutely no direct implications for the modern business. Our businessman then sips his café au lait and asks whether Knight might not be in the same category—a great thinker, perhaps, but not relevant for day-to-day corporate decision making.

Being an economic scientist and not a businesswoman, our economist may well not know how to respond to this last comment. Even if Knight demonstrated the possibility of information-driven corporate profits, what *did* he say that is relevant in the real world—that can affect the decisions the businessman has to confront later that day when he returns to his Champs d'Elysees office?

The answer lies in Knight's very distinction between risk and uncertainty—*that* is relevant in the real world. That may not yet be obvious to readers, but probably only because of differences in terminology. Corporate risk managers, after all, clearly do not show up at board meetings and present summaries of the "risk" and "uncertainty" affecting their firms.

From a practical perspective and to make things operationally easier, managers generally subclassify risks into "financial" and "nonfinancial" risks. Financial risks are those sources of randomness that can adversely affect a firm's value, cash flows, or earnings, and typically are further divided into market, credit, liquidity, and funding risks.[9] Nonfinancial risks, or those risks whose adverse outcomes are not financial per se but rather "physical," include fire, flood, personal injury or disability, contamination, and so on. "Operational" risk lies in between, and generally involves nonfinancial events that have both financial and nonfinancial repercussions. An oil company that bears the risk of losing a tanker at sea in a storm, for example, has financial and nonfinancial risks. The financial risks include the replacement cost of the ship, the loss of the oil, the consequences of defaulting on delivery promises,

and the like. But to the men and women on the ship, the nonfinancial risk of drowning is arguably more important.

Financial and nonfinancial risks in turn generally can be classified as either "core" or "noncore" (Culp, 2001, 2002a). The core risks facing a firm may be defined as those risks that the firm is in business to bear and manage so that it can earn excess economic profits. Noncore risks, by contrast, are risks to which a firm's primary business exposes it but that the firm does not necessarily need to retain in order to engage in its primary business line. The firm may well be exposed to noncore risks, but it may not wish to *remain* exposed to those risks. Core risks, by contrast, are those risks the firm is literally in business *not* to get rid of—at least not all of them.

The distinction between core and noncore risk is entirely subjective and varies firm by firm. What is a core risk for one firm may not be for another one, even when the companies are in the same sector and industry. The classification of a risk as core by any given firm, moreover, depends not just on the quality of information the firm actually has, but also on the firm's *perceived* comparative advantage in digesting that information.

As you can probably see, there is a direct correspondence between what we call core and noncore risk in current risk management lingo and what Knight called risk and uncertainty—namely, uncertainty is core risk, and risk is noncore risk.

Consider, for example, regional electricity markets. What determines the degree to which power price fluctuations represent a source of risk or uncertainty depends entirely on the degree to which the power company and the consumers and investors in the community agree on the probability distribution of power prices. If there is complete agreement about the probability distribution of power prices, it is a risk to everyone. Power price fluctuations in that case cannot be the power company's true source of comparative advantage and profitability.

Alternatively, it is quite plausible that the local power company managers have relatively better judgment about power prices than the average local investor. Knowing all its customers' basic demands *and* the capacity constraints of the local transmission system, for example, the power company managers may be able to use their experience and judgment to anticipate transmission congestion and its impact on local prices better than the rest of the market. In that case, power price fluctuations would represent a core risk and a comparative advantage to be exploited—a source of Knightian uncertainty. Of course, the moment that transmission congestion becomes amenable to formal and systematic quantification and goes beyond the good judgment of the plant managers, the possibility of changes in power prices will become a risk and a firm's opportunity to profit from its perceived superior information will vanish.

Although there is a clear relation between core risk and Knightian uncertainty and between noncore risk and Knightian risk, we *cannot*, however, draw any conclusions about whether a firm may wish to reduce its susceptibility to risk or uncertainty based on that distinction alone. To return to our previous example, the local power company may consider power price fluctuations as a source of uncertainty and, hence, profits. At the same time, huge unanticipated price swings might devastate the firm financially. Accordingly, the firm might wish to take some actions to reduce its uncertainty about price volatility *in that extreme range*. So, the firm's decision about whether to tolerate the random outcomes to which its business exposes it does not really depend on whether the randomness is risk or uncertainty.

The counterexample proves the same point. Before power markets were deregulated, power prices were not very volatile and firms were allowed to charge customers a rate based on a cost-plus tariff formula. Production costs were generally known across firms, so, together with the lack of price volatility, it is hard to believe that power companies would have viewed power price fluctuations as uncertainty. And as a matter of fact, power price fluctuations were not the source of power companies' profits in those days; profits were essentially a regulatory rent created entirely by the permissible markup in consumer tariffs above costs.

Knowing the difference between risk and uncertainty may not affect managers' and shareholders' tolerances for remaining exposed to those sources of randomness, but the distinction is of practical importance for two reasons. First, at a basic level, a firm that cannot identify the relation between randomness and corporate profits will not long survive in a competitive market. In that sense, proper identification of risk and uncertainty is an essential task of strategic management. Second, whether randomness is risk or uncertainty can affect the method a firm may choose to reduce that source of randomness *if* it wishes to do so. Explanations for when and why firms may sometimes opt to reduce their exposure to risk and uncertainty are reviewed in the last section of this chapter.

Practical Determinants of the Distinction between Risk and Uncertainty

Now that we have explored the practical importance of the distinction between risk and uncertainty, we need to determine some means by which corporate executives and risk managers can differentiate the two. Virtually by definition, this will be a hard task. That which cannot be quantitified, after all, cannot necessarily even be identified. And remember, a given source of randomness may be perceived by different firms in entirely different ways.

So, there is no single right way to differentiate between risk and uncertainty. All we can do instead is look for specific factors and telltale signs that tend to be associated with one or the other. Some of these broad determinants are discussed next.

The Role of Judgment

Fundamental to the distinction between risk and uncertainty—and the unique capacity of a firm to earn profits only from the latter—is the role of *business judgment* exercised by managers and security holders in their financial and production decisions. Business decisions, to Knight, are often based not on "true knowledge"—we will return to that slippery notion in the next subsection—but rather on managerial judgment when perfect, quantifiable knowledge is elusive. Knight explains:

> *The most important result of this survey is the emphatic contrast between knowledge as the scientist and the logician of science uses the term and the convictions or opinions upon which conduct is based outside of laboratory experiments. The opinions upon which we act in everyday affairs and those which govern the decisions of responsible business managers for the most part have little similarity with conclusions reached by exhaustive analysis and accurate measurement. (Knight, 1921, p. 230)*

In his *General Theory of Employment, Interest, and Money*, Keynes advocated an essentially similar view that business decisions rest more often on individual judgment than on quantified probabilities about the evolution of randomness. Keynes referred to this vital role of judgment in the capacity of a firm to earn a profit as "animal spirits":

> *A large proportion of our positive activities depend on spontaneous optimism rather than on a mathematical expectation, whether moral or hedonistic or economic. Most, probably, of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as a result of animal spirits—of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities. Enterprise only pretends to itself to be mainly actuated by the statements in its own prospectus, however candid and sincere. Only a little more than an expedition to the South Pole, is it based on an exact calculation of benefits to come. Thus if the animal spirits are dimmed and the spontaneous optimism falters, leaving us to depend on nothing but a mathematical expectation, enterprise will fade and die. (Keynes, 1936, pp. 161–162)*

The earlier example of the regional power company provides a useful illustration of the importance of judgment. A power plant manager with years of experience dealing with the same customers in the same grid may gradually learn literally to anticipate variables like transmission congestion. This judgment, in turn, can create an informational advantage for the firm that companies lacking comparable experience cannot exploit.

This sort of judgment in some ways is the best possible example of uncertainty as a nonquantifiable source of randomness and a potential driver of profits. Of course, market participants can assign *some* probability to congestion in an electricity grid—probabilities are just numbers, after all, and can in the worst case be picked randomly. But if uncertainty is viewed as judgment intensive, there is no way for a large number of market participants to incorporate that judgment into probability estimates. So, there will be a lack of agreement, uncertainty will persist, and, in the end, only the firm with the best judgment will be able to formulate *meaningful* probabilistic estimates of the future.

Music may provide us with an even better example. Suppose we are about to attend a performance of Beethoven's Ninth Symphony by the Chicago Symphony Orchestra (CSO) under the baton of its music director, Daniel Barenboim. We wonder how the performance will be in terms of tempo. Recognizing that there are plenty of prior performances of this piece by the CSO under Barenboim, we might look at the prior tempi and infer what the tempo will be tonight. But only if we believe the performance is itself a stable repeating event.

Adopting more of an "uncertainty" perspective in considering the tempo of the forthcoming concert, we might argue that each performance of Beethoven's Ninth is completely unique. The piece itself has no meaning as notes on a page. It becomes an organic, living thing when it is performed, but it began as silence and ended as silence and was alive only for a finite period between the two silences. In that way, every performance is a unique event—it never happened before, and it will never happen again (Barenboim and Said, 2002). True, you can assign probabilities to how the CSO will play the piece and what the tempo will be like, and those probabilities may even be guided by prior experience. But, fundamentally, the event being predicted is unique, so the inference must be based almost entirely on judgment. And as far as judgment goes, who would dare to argue that an audience member's judgment about the tempo of an upcoming performance would be superior to Maestro Barenboim's? The Maestro is clearly in a better position to analyze the uncertainty than the rest of us are.

Classification and the Knowledge Problem

Underlying Knight's distinction between risk and uncertainty is what he refers to as "the problem of knowledge," where the "problem" essentially refers to how individuals in a business setting make decisions today based on the knowledge they have today, which is by definition only partial given our inability to predict the future:

> *We live only by knowing* something *about the future; while the problems of life, or of conduct at least, arise from the fact that we know so little. . . . The essence of the situation is action according to opinion, of greater or less foundation and value, neither entire ignorance nor complete and perfect information, but partial knowledge. (Knight, 1921, p. 199)*

Knight considers knowledge to be essentially inference based on perception about a random and uncertain future: "We *perceive* the world before we react to it, and we react not to what we perceive, but always to what we *infer*" (Knight, 1921, p. 201). This in turn leads Knight to his conception of what is meant by knowledge:

> *We have, then, our dogma which is the presupposition of knowledge, in this form; that the world is made up of things, which, under the same circumstances, always behave in the same way. The practical problem of inference or prediction in any particular situation centers around the first two of these three factors: what things are we dealing with, and what are the circumstances which condition their action? From knowledge of these two sets of facts it must be possible to say what behavior is to be expected. The chief logical problem, as already noticed, lies in the conception of a "thing." For it is obvious that the "circumstances" which condition the behavior of any particular thing are composed of other things and their behavior. The assumption that under the same circumstances the same things behave in the same ways thus raises the single question of how far and in what sense the universe is really made up of such "things" which preserve an unvarying identity (mode of behavior). (Knight, 1921, pp. 204–205)*

So, Knight felt that the ability to formulate probabilistic predictions about the future was based on how well "things" could be grouped into homogeneous categories. This is also generally consistent with the notion of probability developed by Keynes (1921) in his seminal *Treatise on Probability*, published the same year as *Risk, Uncertainty, and Profit*. When people agree on how "things" can be classified, the common classification will lead to common inference, and then we have risk, not uncertainty.

A common misconception is the view that whenever the future is presumed to behave like the past, we have Knightian risk instead of uncertainty. In statistical terminology, that would imply a pure "frequentist" approach in which the true probability of a thing's occurring would be equal to the proportion of times that thing *actually has occurred* and *will continue to occur* in a long enough time series. That is at odds with the "subjectivist" approach to probability of Savage (1954) and others in which any given random event

is unique, and the probabilities associated with that event are true for that event only.

The frequentist and subjectivist perspectives represent different philosophical notions of what we mean by "probability" and what we are doing when we engage in "probabilistic inference." As a purely mechanical issue, Knight did allow for the possibility of incorporating a mixture of subjective and objective information into probabilistic estimates in a Bayesian framework. In a typical Bayesian probabilistic inference problem, prior subjective beliefs are combined with historical data or some underlying data generation process called the likelihood function into a "posterior" distribution representing both the available data and the modeler's beliefs. Knight allowed for the possibility that in such analysis, essentially *any* subjective weight could be given to the two components. A special case involves the use of a "diffuse prior" in which the modeler essentially has no opinion about the future. In this case, the posterior distribution reflects only the likelihood function based on the data itself.

Note in this connection that there is some difference between the frequentist/subjectivist debate *methodologically* and *philosophically*. From a methodology standpoint, the Bayesian approach works perfectly well to allow pure data-driven inference to be mixed with a priori opinions. But from a philosophical standpoint, there is still a question of the uniqueness of the event being predicted. Returning to Beethoven, we can combine and recombine our opinions with the available data, but that does not change the fundamental uniqueness of the event being predicted. In that sense, the event defies data-driven prediction entirely. What determines the nature of the randomness thus is not the scientific method by which the probabilities are computed, but the nature of the event itself.

What sets risk apart from uncertainty for Knight thus is not agreement or disagreement about the process by which probabilities are formed and associated with outcomes, but rather agreement or disagreement on a classification scheme to describe the outcomes themselves. In fact, Knight considered the assignment of probabilities to future events as fairly mechanical once the events were defined. *That* was the hard part.

Consider a natural disaster like a catastrophic earthquake that could impose significant property damage on a West Coast real estate developer. Prior data alone will never facilitate the prediction of "the big one" by either the developer or a prospective insurance company, but the event itself can be clearly defined. And once it is defined, probabilities can be assigned to it using some kind of nonarbitrary quantitative process. The earthquake is a *risk*.

Alternatively, Knight would probably consider directors and officers (D&O) insurance to be "uninsurable" (*sic*) and a source of uncertainty for firms, despite the existence of policies designed to manage this randomness.

(We will see in Chapter 3 that the existence of certain mechanisms like insurance can act to transform uncertainty into risk by forcing two parties to agree on a market price for a contingent claim.) D&O insurance coverage includes items like unfavorable liability outcomes in jury trials. Once a case is filed, Knight would contend that probabilities could be assigned to the outcome. And so we have a risk. But before a case is filed, people would have to be able to assign probabilities to the filing of the case itself as well as the judgment. And to go one step further back, what about the situation in which D&O insurance covers the liability for an action not yet taken? In that case, a probability would have to be defined for all the possible liability-sensitive actions of all the officers and directors, as well as the probability of detection and the outcome of adjudication. The sheer volume of quite heterogeneous possibilities essentially renders a classification scheme impossible, hence leading Knight to consider many legal risks as sources of uncertainty rather than true risk.

Time

One key component of business decisions about a random future that forces some of them into the category of decision making under uncertainty rather than risk is, quite simply, the passage of time or the dynamic nature of the decision-making process. If the world were a static place, one might imagine that almost everything could fall into the definition of risk. But as Knight emphasized, the world is not a static place. This results in a constant state of change in knowledge and in the knowledge problem. Specifically, when people's inferences and classifications of future outcomes are constantly evolving, there is no "stopping rule" that tells managers when to stop, take the knowledge they have, formulate probabilities, and act.

In any snapshot of time, knowledge may be fixed and the assessment of probabilities based on mathematical or statistical means feasible. But because business judgments typically occur over a period in which time is *not* a constant, the dynamic nature of knowledge forces the manager to exercise *some* judgment. The decision when to stop and use the knowledge available to make a probabilistic assessment (as opposed to waiting for new information to come along) is itself an exercise in judgment, which creates uncertainty for reasons discussed earlier in the judgment section. Hardy notes: "Seldom is it possible to [separate the exercise of business judgment into] temporally distinct and successive stages, so varied are the modes in which they may be subordinated, merged, reversed, and repeated" (Hardy, 1923, p. 53).

The dynamic nature of many business problems can also create uncertainty by inhibiting classification, thus creating uncertainty as in the immediately preceding section. In the D&O example, the scenarios in which directors and officers can incur liability for the firm that results in a complaint

and a trial become much more limited if we consider, say, a one-day time horizon. But over the span of a year, a lot more is possible. What is risk in extremely short frequencies or durations thus may become uncertainty as time is allowed to elapse for longer periods.

Endogeneity of the Underlying Source of Randomness

Uncertainty can also arise when either the probabilities of future events or the classification of events are *endogenous* to the problem being solved. Keynes (1936) offers a useful anecodotal example:

> *[The problem] may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole; so that each competitor has to pick, not those faces which he himself finds prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view. It is not a case of choosing those which, to the best of one's judgment, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. (p. 156)*

In this example, each contestant has an incentive to acquire as much information as possible to gain an advantage—or perhaps to stop the other contestants from gaining the advantage. But the information in question is not some exogenous fact, like the value of a car. Even if the value of a car is itself subjective—for example, a car may matter less to an eight-year-old than to her parents—enough information can eventually be acquired to formulate some systematic quantitative valuation of the car. In the Keynesian beauty contest, however, the relevant information that needs to be acquired is information about the predictions of others. O'Driscoll and Rizzo (1996) summarize: "Knowledge gained over time by [contestants] will necessarily affect the objects of each agent's prediction . . . [and] the very activity designed to cope with uncertainty (i.e., the acquisition of knowledge) is responsible for its continued existence" (p. 74).

In the Keynesian beauty contest, uncertainty is endogenous because of the essentially rivalrous nature of knowledge and the competitive nature of knowledge acquisition. But the example also reinforces the importance of the dynamic nature of the problem. In the example, the probabilities of the outcomes are unknowable because they depend on the dynamic behavior of the participants in the process. At any given point in time, the contestants might

well be able to form some kind of static prior distribution about the average contestant's guess. Endogeneity thus vanishes in a static setting. As time passes, however, the behavior of the contestants is gradually revealed, and the distributions change. And they keep changing as long as contestants keep guessing. No matter how much time passes, the probability distributions never really become stable.

Uncertainty in the Keynesian beauty contest is also easy to see because the probabilities themselves are a direct result of competitive interaction and are thus constantly changing. But we can have uncertainty that is one step removed from the probabilities, as well, simply by postulating that the model governing the behavior of a participant engaged in prediction depends on other the models used by other people engaged in prediction of the same economic phenomenon. In other words, even if the probabilities themselves are not explicitly interdependent, and interdependence in behavior is enough to create endogenous uncertainty.

An example of this type of endogeneity is the "Lucas Critique." Specifically, Nobel laureate Robert Lucas (1972) criticized the use of structural economic models for government determinations of fiscal and monetary policy. Because either the structural form or the parameters of such models depend on market participants' beliefs about what government policy would be, those same models could not in turn be used to determine that policy.

Confidence and Expectations

Knight's work inspired significant subsequent research into modeling expectations and the economics of asymmetric information (Emmett, 1999). Despite those advances and the mathematical and statistical tractability of the expectations operator (both conditional and unconditional), expectations are relatively hard to incorporate into economic modeling. Lachmann (1978) explains:

> *[Expectations] always embody . . . an experience which requires* interpretation. *It is the task of the theory of expectations to elucidate the problems our experience (and that of others insofar as it is accessible to us) sets us in judging the uncertain future, as well as to clarify the* modus interpretandi. *It is a task with which economists thus far do not seem to have come to grapple. (pp. 20–21)*

Put another way, we can model the stochastic processes from which expectations arise, but different people's opinions about why circumstances arise make it quite difficult, if not impossible, to model the *economic* processes from which expectations are formed. This, in turn, obfuscates agreement among people about expectations and thus generates uncertainty.

Stated differently, defining a nontautological learning process that meaningfully captures people's changing expectations about other people's expectations is no easy task[10] (O'Driscoll and Rizzo, 1996).

Keynes (1936) usefully summarized the problem of modeling expectations in terms of *confidence*:

> *The state of long-term expectation, upon which our decisions are based, does not solely depend, therefore, on the most probable forecast we can make. It also depends on the* confidence *with which we make this forecast—on how highly we rate the likelihood of our best forecast turning out quite wrong. If we expect large changes but are very uncertain as to what precise form these changes will take, then our confidence will be weak.* The state of confidence*, as they term it, is a matter to which practical men always pay the closest and most anxious attention. But economists have not analysed it carefully and have been content, as a rule, to discuss it in general terms. (pp. 148–149)*

In other words, firms make decisions based on their probabilistic assessments of the future. But when a firm has no confidence in the precision or stability of its expectations, its decisions will be influenced accordingly. Uncertainty thus arises when confidence is so low that any probabilistic estimates that can be assigned to the future simply cannot be taken seriously enough to put the firm's capital at risk.

Nobel laureate Sir John Hicks (1939) emphasizes that confidence—or lack thereof—can have important implications for *ex post* efficiency: "Lack of confidence in one's foresight is not necessarily a source of waste. The loss only accrues if the expectations would have been right after all. Putting insufficient faith in good judgments is a source of inefficiency; but skepticism about bad judgments may be better than trust" (pp. 134–135).

The mere existence of uncertainty is no guarantee of profits. In fact, uncertainty generated by a lack of confidence can sometimes deter entrepreneurs from taking legitimate actions that would have led to profits. As we have seen, a firm's perception of its own comparative informational advantage is the key issue, and this perception can be wrong. Hicks's quote is a useful reminder that being wrong can mean a lack of confidence in a legitimate advantage, just as it can imply the opposite. Uncertainty is a double-edged sword.

The important relation between confidence and expectations as a determinant of uncertainty became fairly pervasive in economic analysis in the twentieth century. Robinson (1951), for example, argues that "the degree of uncertainty in the market as a whole then depends on the variety of opinion within it. The same effects follow where everyone is alike, but no one feels

confident that his own best guess of what the future holds will turn out to be right" (pp. 99–100).

Putting the Pieces Together

Clearly, no simple litmus test is possible to enable any given firm to distinguish risk and uncertainty. But at least now we have some guiding principles. Uncertainty may be said to exist in the following situations: when the future cannot be described in terms of homogeneous events; when probabilities are based on the individual judgment of a business manager; when the dynamic nature of a problem requires judgment to determine when to stop and make a decision based on the available information; when the dynamic nature of a problem or some other factors endogenize the variable being predicted; or when any effort to assign probabilities results in estimates that—absent some other consideration—at least some firms are unwilling to trust for their decision-making purposes.

All of these determinants of uncertainty invariably involve some degree of abstractness. We dislike that in finance because it tends to feel very unscientific. And it well may be dissatisfying for you as a reader that we have not produced a clean way to differentiate risk from uncertainty. But as an entrepreneur, you should be thrilled. If our ability to identify uncertainty is too precise, then it isn't uncertainty anymore and the potential to profit from it goes away.

RISK AND UNCERTAINTY IN THE THEORY OF CORPORATE FINANCE

As emphasized earlier in this chapter, the motivations for a firm to reduce on occasion the randomness it faces do not depend solely on whether that randomness is risk or uncertainty. The method chosen for dealing with risk and uncertainty depends on which one the firm is facing, but not the rationale.

Why firms sometimes choose to reduce their risks and uncertainties is not a topic that Knight explored. For insight into this topic, we must turn to the theory of corporation finance.

Value Creation from the Management of Risk and Uncertainty

In the world of perfect capital markets to which many of us were introduced in business school, deliberate efforts by corporate managers to reduce risk are largely a matter of indifference to a company's stockholders. Because such investors could diversify away the risks associated with fluctuations in interest

rates or commodity prices simply by holding well-diversified portfolios, they would not pay a higher price-earnings (P/E) multiple (or, what amounts to the same thing, lower the cost of capital) for companies that choose to hedge such risk. So if hedging is unlikely to affect a firm's cost of capital and value, then why do it?

The irrelevance of risk management is an implication of the same assumptions that led to the celebrated Modigliani and Miller (1958) or "M&M" capital structure propositions—namely, that a corporation's value is independent of its capital structure, leverage, and dividend policy, and that the value of an investment project is invariant to the type of financing used to fund it.[11] The assumptions under which these irrelevance propositions hold include:

- Capital markets are perfect (in the sense of no transaction costs, taxes, costs of financial distress, restrictions on short sales, and the like).
- All firms and investors have equal access to the capital markets—that is, the terms on which a security can be issued do not depend on who or what is issuing it.
- All investors have homogeneous expectations and exhibit complete agreement about the unknown future.
- A firm's investment opportunities are not affected by its financing alternatives (apart from the impact of the latter on the relative distribution of security holder wealth).

Two decades of theoretical and empirical work on the issue of why firms hedge have produced a number of plausible explanations for how risk management can increase firm value—that is, how it can increase the firm's expected cash flows even after taking account of the costs of setting up and administering the risk management program.[12] Not surprisingly, these explanations for how risk management can add value are generally based on the violation of one or more of the M&M assumptions. Summarized briefly, such research suggests that risk management can help companies increase (or protect) their expected net cash flows mainly in the following ways:[13]

- Reducing expected tax liabilities when the firm faces tax rates that rise with different levels of taxable income.
- Reducing the expected costs of financial distress caused by a downturn in cash flow or earnings or a shortfall in the value of assets below liabilities.[14]
- Reducing potential agency conflicts between a company's creditors and stockholders, including the possibility that "debt overhang" results in the sacrifice of valuable strategic investments; overcoming the managerial risk aversion that (in the absence of explicit and formal risk management)

could lead managers to invest in excessively conservative projects to protect their annual incomes and, ultimately, their job security.

- Reducing the possibility of corporate underinvestment that arises from unexpected depletions of internal cash when the firm faces costs of external financing that are high enough to outweigh the benefits of undertaking the new investment.

As these reasons suggest, value-increasing risk management has little to do with dampening swings in reported earnings (or even, as many academics have suggested, minimizing the variance of cash flows). For most companies, the main contribution of risk management is likely to be its role in minimizing the probability of a *costly*[15] financial distress. In this sense, the optimal risk management policy may be one that provides a kind of insurance against worst-case scenarios or, to use an actual insurance term, *catastrophic* outcomes. And even when the company has relatively little debt, management may choose to purchase such catastrophic insurance to protect the company's ability to carry out the major investments that are part of its strategic plan. In the process of insuring against catastrophic outcomes and preserving a minimal level of cash flow, companies will generally discover that they can operate with less capital (or at least less equity capital) than if they left their exposures unmanaged. And to the extent that hedging proves to be a cheap substitute for capital, risk management is a value-adding proposition.

Risk versus Uncertainty Again

Knight's world itself is antithetical to the M&M world. The third assumption under which the M&M irrelevance propositions hold, after all, is complete agreement among investors. Fama (1976) describes the import of this assumption: "Any information available is costlessly available to all market agents (investors and firms), and *all agents correctly assess the implications of the information for the future prospects of firms and securities* [emphasis added]" (p. 273).

In other words, the M&M propositions hold only in a world where firms are affected *by risk*. If uncertainty affects a firm, then we cannot by definition have complete agreement and cannot be living in an M&M world. This means that deliberate actions taken by a firm to manage uncertainty *can* be a source of value added. Such actions must be traded off against any possible reduction in profits that accompanies a reduction in uncertainty, of course, but the two are not mutually exclusive. Again, as our earlier power company example shows, a firm may wish to reduce financial distress costs by managing its uncertain exposure to *large* price moves, while actively facing the uncertainties of smaller and less catastrophic price changes.

Firms also may wish to engage in the active management and control of the true risks to which they are subject. In this case, investors and firms may completely agree about the probabilities associated with a given firm encountering financial distress. That complete agreement does not mean there will be no incentive for the firm bearing those positive expected distress costs to try to reduce those costs through risk management. By engaging in a transaction like a derivatives contract, for example, the firm may reduce its own expected financial distress costs without necessarily increasing the expected costs of distress for the other firm.

NOTES

1. Culp and Miller (1995b,c) offer some examples but are highly critical of these sorts of simplifications.
2. See Jensen and Meckling (1976).
3. See, for example, Coase (1988), Jensen (2001a,b), Williamson (1998), and Williamson and Winter (1993).
4. For completeness, suppose the managers' compensation from the firm is their primary source of income.
5. Young, in particular, is not a terribly well-known economist, but his handful of contributions to economic theory are regarded by most economic historians as truly pathbreaking. See, for example, Robbins (1998).
6. See, for example, Telser (1986).
7. When the Bank of Sweden (Sveriges Riksbank) created the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel in 1968, the Walker Medal was discontinued.
8. Under perfect competition, demand and marginal revenue schedules are one and the same. With imperfect competition, production optimality occurs where marginal cost equals marginal revenue.
9. Culp (2001) provides definitions.
10. This is also another form of endogeneity.
11. The irrelevance of risk management and financing decisions are not independent. In many ways, risk management decisions are simply corporate financing decisions by another name. See Culp (2002a).
12. In principle, risk management can also reduce the firm's cost of capital. For example, managing risk can lower the capital cost for a partnership whose shareholders have most of their own wealth tied up in the firm. See especially Culp (2002a) for some other reasons.
13. Recent summaries of this extensive body of academic research can be found in Culp (2001) and Stulz (2002).
14. Although such costs include the out-of-pocket expenses associated with

any formal (or informal) reorganization, more important considerations are the diversion of management time and focus, loss of valuable investment opportunities, and potential alienation of other important corporate stakeholders (customers, suppliers, and employees) that can stem from financial trouble.

15. As the italics are meant to suggest, the possibility of financial distress is not necessarily value-reducing for all firms; in fact, for mature companies with large and stable operating cash flow and limited investment opportunities, high leverage, which, of course, raises the probability of financial distress, is likely to be a value-increasing strategy by reducing managers' natural tendency to spend (and thereby waste) excess cash flow.