17 Financial Risk Management in the Insurance Industry

J. David Cummins
University of Pennsylvania

Richard D. Phillips
Georgia State University

Stephen D. Smith
Georgia State University and Federal Reserve Bank of Atlanta

Abstract
This chapter has two objectives. The first objective is to survey the finance literature on corporate hedging and financial risk management with an emphasis on how the general literature applies in insurance. We begin by reviewing the theoretical rationales for widely-held, risk-neutral, profit-maximizing firms to practice risk management and then go on to discuss the empirical literature on corporate hedging. The second objective is to develop a theoretical model to provide a new explanation for why widely-held insurers manage risk. Insurers are hypothesized to invest in multiple period, private assets where the payoffs are not fully realized if the assets have to be liquidated prior to their expiration. Avoiding adverse shocks to capital that would trigger a liquidation provides the motivation for risk management in our model.

Keywords: Risk management, corporate hedging, private information, financial intermediaries, insurance.
JEL Classification Numbers: D80, G22, G13, G31.

17.1 INTRODUCTION

This chapter has two objectives. The first objective is to provide a survey of the literature on corporate hedging and financial risk management with an emphasis on how the general literature applies in insurance. We begin by reviewing the theoretical rationales for risk-neutral, profit-maximizing firms to practice risk management and then go on to discuss the empirical literature on corporate hedging. The second objective is to develop a new theoretical model to explain why the managers of risk-neutral insurance companies engage in risk management.[1] Insurers are hypothesized to invest in multiple period, private assets where the payoffs are not fully realized if the assets have to be liquidated prior to their expiration. Avoiding adverse shocks to capital that would trigger a liquidation provides the motivation for risk management in our model.

This paper draws upon three strands of modern financial theory. The first strand is perfect-markets asset pricing theory as applied to widely held firms whose shares are traded in frictionless and complete markets. This theory is based on the assumption that shares are owned by diversified investors, who eliminate non-systematic risk through their portfolio choices.[2] Investors are risk averse and choose portfolios that are optimal in terms of their taste for risk. In its simplest form, the theory envisions investors as balancing risk and return by choosing portfolios that are linear combinations of a riskless asset (e.g., Treasury bills) and the market portfolio of risky assets. Because investors can achieve an optimal risk-return position by varying the weights placed on the riskless asset and the market portfolio, such investors do not want the individual corporations that constitute the market portfolio to manage non-systematic risk. Rather, investors want firms to maximize the market value of their net worth. In perfect markets financial theory, this generally implies that firms should be risk neutral, i.e., they should take advantage of any projects available to them that have positive net present values, without regard to non-systematic project risk.[3] Because corporate risk management is costly (e.g., because it requires the use of costly managerial resources, the payment of premia for options and other derivatives used to manage risk, etc.) and because investors can engage in "home-made" risk management, expenditures on risk management at the corporate level constitute a deadweight loss to investors.

The second strand of financial theory discussed in this paper attempts to explain the existence of corporate risk management. This theory was developed because it has been observed that corporations do manage risk, in spite of the strong proscription against this type of activity in perfect-markets financial theory. In fact, the existence

[1] We follow the standard practice in the insurance economics literature in referring to insurance companies as "insurers" throughout our discussion. Insurers are assumed to be owned by shareholders who hire managers to operate the firm.

[2] Financial theory divides risk into two major types—*non-systematic risk*, which can be eliminated by investing in a diversified portfolio, and *systematic risk*, which cannot be eliminated through diversification. Non-systematic risk is considered to be firm or industry specific, whereas systematic risk affects the entire market and thus cannot be diversified away.

[3] Systematic project risk is recognized through the discount factor used to calculate the net present value of the project, i.e., it is recognized in the cost of capital. See Brealey and Myers (1996) for further discussion.

of corporate risk management can be explained by reference to *imperfections* in financial markets. Financial theorists have identified two broad categories of imperfections to explain the existence of corporate risk management. One class of imperfections consists of factors that impose costs on firms that do not manage risk. Managing risk in response to these imperfections is generally value maximizing, i.e., the market value of corporate net worth will be higher if this type of risk management is carried out than if it is not. The second class of imperfections that motivate risk management are typically associated with managerial behavior, i.e., instead of maximizing the value of the firm, managers may maximize their own utility. The extent to which this behavior is consistent with value maximization is unclear. If risk management is costless then allowing managers to hedge risk at the corporate level may be value enhancing to the extent risk averse managers demand less compensation due to the decreased likelihood that adverse outcomes will threaten their job security. However, if risk management is costly, then shareholders may have to undertake certain activities, such as the development of incentive-based compensation contracts or undertake costly monitoring, to ensure the resources of the firm are devoted to the maximization of the firm's net worth and not the manager's own utility. The value maximizing and managerial risk aversion motivations for risk management are discussed in detail in section 2 of this chapter.

The third strand of financial theory explored in this paper deals with information asymmetries and private information, both of which are assumed away in perfect markets financial theory. This theory views insurers as financial intermediaries that borrow funds from policyholders by issuing insurance policies and then "intermediate" these funds into portfolios of invested assets. Private information can be present in both the underwriting and the investment operations of an insurer. Information asymmetries are generally present between the company and its policyholders as the policyholders typically know more about their risk characteristics than does the insurer. This information asymmetry can lead to the problem adverse selection and, in the extreme case, lead the market to fail as explained in the important article by Rothschild and Stiglitz (1976) as well as much subsequent research. The company-policyholder asymmetry also presents an opportunity for the insurer to develop *private information*, i.e., information on its policyholders that is known by the insurer but not by its competitors. By insuring a policyholder over a period of time, the insurer acquires information on the policyholder's risk characteristics that is not available to competing insurers. The insurer may be able to exploit this private information to earn economic rents from policyholders that have been with the company for a period of time (see D'Arcy and Doherty 1990).

Financial intermediaries also can acquire private information in their investment operations. Generally, this involves acquiring more information about a borrower or a complex security than is possessed by the market as a whole. For example, there is considerable evidence that banks acquire information about certain types of borrowers that is difficult for other investors to replicate (Diamond 1991). This information gives banks a competitive advantage over other banks and the capital markets in dealing with these borrowers; and banks can exploit this information to earn economic rents (Rajan 1992). Likewise, insurers have an informational advantage in investing in certain types of assets. E.g., life insurers are the major source of privately placed bonds in the U.S. capital market. Privately placed bonds are analogous to bank loans in terms of providing opportunities for insurers to gain an informational advantage.[4] Insurers also invest in structured securities and other complex long-dated financial assets where the expected return on the assets may be higher due to the level of private information they contain.

In this chapter, we provide a new rationale for corporate risk management based on private information. We develop a model motivated by the observation that insurers engage in contracts covering multiple time periods for which the payoffs on those contracts may not be fully realized until they expire. For example, D'Arcy and Doherty (1990) provide empirical evidence that insurers may be willing to underprice (take a loss on) newly issued policies based on rents they expect to earn from the subset of new policyholders who stay with the company for a period of years. The motivation for underpricing new policies is that insurers cannot fully discriminate between good and bad risks who are applicants for insurance. However, by observing policyholders over a period of time, they are able to identify the bad risks and either charge them higher premiums or eliminate them from the policyholder pool. Insurers earn a profit on the good risks that remain that more than offsets the losses created by having some bad risks in the pool at the outset. The good risks are hypothesized to remain with the insurer even though their premiums are higher than would be experienced in an informationally efficient, competitive market because competitors do not observe the private information that has been accumulated and hence cannot distinguish the good risks from the bad risks that have been eliminated from the pool. Thus, the good risks do not have an incentive to leave the insurer and go back into the market.[5]

[4] Such private information would not arise for widely traded, standardized securities such as Treasury bonds and corporate equities. For private information to develop, the investor must have a unique opportunity to obtain information that is not available to others. The relationship between banks and their borrowers and between insurers and the issuers of privately placed bonds may give rise to such information.

[5] Implicit in this discussion is the assumption that the price charged to new policyholders is higher than the price the good risks have to pay if they remain with the insurer, which in turn is higher than the price the good risks would pay in an informationally efficient, competitive market. Recall that the price charged to new risks is a pooled price applying to both bad risks and good risks. Consequently, insurers could lose money on the pooled price when selling to both bad and good risks and still have sufficient slack in pricing to earn positive rents when insuring only the good risks. Another issue, discussed by D'Arcy and Doherty (1990), is that the insurer's competitors could adopt the strategy of offering insurance at favorable rates to policyholders who can present a valid renewal offer from another insurer; and, in fact, at least one major company has based a marketing campaign on this approach. In effect, by making the renewal offer, the insurer has revealed some of its private information, which can potentially be captured by competitors. D'Arcy and Doherty suggest various ways that the insurer could protect its private information by "scrambling" the renewal signal.

We refer to contractual relationships in which insurers earn economic rents from private information as *private assets*—a term encompassing both insurance policy relationships as well as investments such as privately placed bonds and other opaque assets. In our model, we assume that private assets must be held for a specified period of time in order for positive rents to be realized. We make the simplifying assumption that if insurers are forced to liquidate some or all of their positions in the private assets at some intervening time period due to a shock to the capital resources of the firm, they will only collect the par value of their investment and therefore be forced to pass up the opportunity to realize the benefits of private information. In the case of insurance policies, an adverse shock to capital may lead to a ratings downgrade or regulatory intervention that causes a "flight to quality" by the insurer's profitable long-term policyholders. In the case of investments, an adverse shock may create cash flow problems that require the insurer to liquidate long-dated private investments on unfavorable terms.

Insurers can reduce the probability of having to liquidate their positions in private assets in the intervening time periods in one of two ways. First, they can reduce the level of investment they make in the private assets and hold additional levels of cash (or some other highly liquid security). The cost of adopting such a strategy is the opportunity cost of not being able to more fully participate in a private asset with a higher expected return. This is a particularly serious problem if the private asset involves the firm's core business, as in the case of an insurer issuing insurance policies. Alternatively, insurers can engage in risk management to reduce the chance that a given shock to capital will require liquidation of the private asset. To the extent that practicing risk management is less costly than holding cash, insurers will have an incentive to transfer as much of the risk of the shock away from the firm as they can.

The theories we discuss in this chapter are quite general and also provide motivations for non-insurance firms to manage risk. However, there are two principal reasons why the discussion should be of particular interest to insurance economists: (1) Because of the nature of insurance enterprise, financial firms such as insurers are more susceptible to the agency costs associated with shareholder/manager and shareholder/customer informational asymmetries than are corporations in general. For example, insurers tend to invest in liquid asset classes which can be subject to rapid change. Financial firms thus can enter, exit, expand, and contract businesses rapidly, making them difficult to monitor effectively (Merton and Perold 1993; Perold 1999). In addition, financial firms are "opaque" in the sense that some of their activities are not publicly disclosed or disclosed only with significant time lags (Ross 1989). For example, insurers do not publicly report the adequacy of loss reserves and they disclose detailed data on their asset portfolios only in their annual regulatory statements. Information asymmetries are also endemic in the relationship between insurers and their customers. It is not a coincidence that Rothschild and Stiglitz (1976) and many subsequent papers on adverse selection have used insurance markets as the primary example of adverse selection. Thus, the deadweight costs of capital due to informational asymmetries are particularly severe in this industry, which should lead to a higher demand for risk management by insurers. (2) As financial intermediaries, the suppliers of an insurer's debt capital are also its customers; and the customers of an insurer are particularly averse to insolvency risk (credit quality) and will strictly prefer to conduct business with highly rated firms (Merton and Perold 1993; Phillips, Cummins, and Allen 1998).[6]

The chapter proceeds as follows: Section 17.2 provides a brief overview of the financial rationale for corporate hedging from the prior literature. Section 17.3 provides a summary of the empirical evidence investigating the economic factors associated with risk management and the use of derivative securities. In section 17.4, we present our theoretical analysis providing a new rationale for corporate hedging. Section 17.5 concludes the chapter.

17.2 THE RATIONALE FOR CORPORATE RISK MANAGEMENT: A SURVEY OF RECENT LITERATURE

As mentioned above, a perfect-markets approach to financial theory views corporate risk management as creating deadweight costs that reduce firm value. However, because widely held corporations do engage in risk management, researchers have developed a richer set of hypotheses to explain why corporations manage risk. One set of motivations for risk management are viewed as contributing to the maximization of firm value. These factors include various market imperfections, incentive conflicts, and information asymmetries that are hypothesized to create motivations for value-maximizing corporate managers to engage in hedging activities (see, for example, Smith and Stulz 1985; Froot, Scharfstein, and Stein 1993; Stulz 1996; and Tufano 1996). However, it is also recognized that corporations may engage in risk management activities based upon objective functions other than those that are purely value-maximizing. Such activities typically arise due to managerial risk aversion and imperfectly controlled incentive conflicts between managers and owners (Smith and Stulz 1985; Stulz 1996). This section reviews the literature that explains both the value maximizing and alternative motivations for corporate hedging.

[6] Investors are willing to supply capital to firms with various levels of insolvency risk as long as they are appropriately compensated. Customers of insurers have a greater concern about credit quality because they have purchased insurance in most cases to reduce their exposure to unfavorable contingencies that threaten their financial security. A bond investor can protect against bond defaults by specific issuers by investing in a diversified portfolio. An insurance policyholder, on the other hand, cannot diversify by purchasing numerous small insurance policies from a large number of insurers. Thus, credit risk acquires greater significance to buyers of insurance than to investors in corporate debt.

Value Maximizing Motivations for Hedging

One rationale for value-maximizing firms to engage in hedging activities is the avoidance of the costs of financial distress. Financial distress costs include the direct costs of bankruptcy such as legal fees and court costs. Financial distress costs also encompass indirect costs that arise even if the insurer does not enter bankruptcy, such as reputational losses and the disruption of relationships with employees, suppliers, and customers. For example, key managers may seek employment elsewhere if the firm encounters financial difficulties, suppliers may be reluctant to grant trade credit to a financially vulnerable firm, and customers may shift their business to competing firms in a "*flight to quality*."[7]

Financial distress costs also can arise if cash flows are adversely affected by unhedged risks that force managers to forego profitable investment projects. This is the classic under-investment problem, first identified by Myers (1977).[8] The under-investment problem arises because the presence of debt in the firm's capital structure may lead the firm to forego positive net present value projects if the gains primarily accrue to bond holders rather than shareholders. The problem is more likely to occur in highly leveraged firms, providing a motivation for firms to hedge to avoid shocks to equity that result in high leverage ratios. A related problem, identified by Froot, Scharfstein, and Stein (1993) arises if external funds are more costly than internal funds, due to, say, information asymmetries between managers and shareholders. For example, managers are likely to be better informed about the expected cash flows from a potential project than are shareholders. Firms may hedge to reduce the volatility of their cash flows and thus help to ensure the availability of internal funds to take advantage of attractive projects.

The hypothesis that firms engage in risk management to avoid financial distress costs seems particularly applicable to the insurance industry. In the insurance industry, managers are likely to have more information about the adequacy of loss reserves than do the insurer's owners, leading to higher costs for external than for internal capital. In addition, insurers are subject to stringent state solvency regulation, enforced through regulatory site audits, detailed reporting requirements, and computerized audit ratio tests (see Klein 1995). Recently adopted risk-based capital standards require insurance commissioners to institute corrective action and ultimately to seize control of financially troubled insurers when their equity capital falls below certain thresholds. This regulatory "option" on the equity of the firm reduces the value of the owners' interest in the firm (Cummins, Harrington, and Niehaus 1995). Both corporate and personal lines policyholders are very sensitive to an insurer's financial ratings and are likely to take their business elsewhere if the insurer's financial condition begins to deteriorate.

[7] See Andrade and Kaplan (1998) for one attempt to measure the costs of financial distress.
[8] See also Mayers and Smith (1987).

There are a number of risks faced by insurers that may motivate them to hedge using derivatives and other risk management strategies (Santomero and Babbel 1997). Both life and property-liability insurers issue insurance contracts that create liabilities with maturities of fifteen years or more, and both types of insurers tend to invest heavily in long-term financial assets such as bonds. These long-term assets and liabilities expose insurers to interest rate risk that can adversely affect the market values of assets, liabilities, and equity. The empirical evidence suggests that both property-liability and life insurers tend to have positive equity duration gaps, with the duration of assets exceeding the duration of liabilities (Cummins and Weiss 1991; Staking and Babbel 1995), and insurers seek to hedge the resulting duration and convexity risk (Santomero and Babbel 1997).[9]

In addition to high-grade, publicly-traded bonds, insurers also invest in assets with higher default risk, higher return volatilities, and/or lower liquidity, providing a potential motivation for hedging such risks. For example, investments in real estate may expose insurers to more price and liquidity risk than they would like to retain. Many life insurers also invest heavily in privately placed bonds and mortgages, which often contain embedded options and are also subject to liquidity risk. Both life and property-liability insurers invest in collateralized mortgage obligations (CMOs), which carry similar risks. With the increasing internationalization of financial markets, insurers have begun to invest more heavily in foreign securities, either as a hedge against foreign liabilities or simply to enhance portfolio diversification and take advantage of attractive yields. Insurers thus have the motivation to reduce their exposure to foreign currencies by hedging the exchange rate risk resulting from foreign assets and liabilities. Investment in corporate equities exposes insurers to systematic risk from market fluctuations, which cannot be eliminated through diversification but can be managed through trading in derivatives such as stock options.

Various categories of liabilities also potentially expose insurers to abnormal risks. For life insurers, these include group annuities and individual life insurance and annuities. Group annuities are held by sophisticated institutional investors such as corporate pension plans, who are sensitive to both yields and insurer financial ratings. Individual life insurance and annuities are relatively long maturity contracts that contain numerous embedded options, making them particularly sensitive to interest rate and/or equity volatility risk. For example, many asset accumulation policies include minimum yield guarantees, in effect incorporating put options that are automatically exercised against the insurer when investment yields decline or, in the case

[9] Duration and convexity risk refer to the risk of changes in the market values of assets and liabilities due to changes in interest rates. The market values of assets and liabilities equal the present value of their cash flows. If interest rates increase, the present value of the cash flows decline. If assets have longer durations than liabilities, for example, an interest rate increase will reduce the market value of assets by more than it reduces the market value of liabilities, leading to a decline in the market value of equity that can create financial distress costs.

of equity-linked annuities, during periods of downturns in the stock market. Life insurers also issue guaranteed investment contracts (GICs), similar to structured notes, that are purchased primarily by institutional investors. GICs are yield-sensitive and contain embedded options that are likely to be exercised in response to changes in interest rates and other economic fluctuations.

A related motivation for risk management by insurers and other financial intermediaries has been suggested by Allen and Santomero (1998). They point out that most investors do not actively participate directly in securities markets due to participation costs. Participation costs include the costs of learning about specific securities and continuously monitoring one's investment portfolio and trading to maintain the target level of risk. Because of these costs, a significant amount of investment takes place through intermediaries. Allen and Santomero (1998) argue that an important role played by intermediaries is to create products with relatively stable distributions of returns that require less monitoring by investors than an actively traded portfolio. Maintaining stable return distributions (e.g., on products such an equity-linked annuities) provides another motivation for insurers to manage risk.

Yet another motivation to undertake corporate hedging to maximize shareholder value is provided by the convexity of the corporate income tax schedule (Smith and Stulz 1985).[10] This convexity implies that expected tax payments can be reduced by lowering the volatility of the taxable income stream through the use of derivatives or other risk management techniques. The tax schedules affecting both life and property-liability insurers have convex segments, and property-liability insurers, in particular, are known to engage in active tax management (Cummins and Grace 1994).

Managerial Risk Aversion

As suggested earlier, managerial risk aversion and incentive conflicts between managers and owners provide alternative rationales for corporate hedging. behavior, i.e., instead of maximizing the value of the firm, managers may maximize their own utility. Managers may behave in a risk averse manner, taking less risk than would be optimal for the firm's owners, because their human capital and wealth are poorly diversified. Thus, they may be more concerned about losing their jobs which can lead to reductions in firm value to the extent hedging is not costless and/or it is costly for shareholders to monitor the actions of the managers. The extent to which this behavior is consistent with value maximization is unclear. If risk management is costless, then allowing managers to hedge risk at the corporate level may be value enhancing to the

[10] The tax schedule is strictly convex if its slope is increasing in income (i.e., if it has positive first and second derivatives). For convex tax schedules, the expected value of the tax payment is increasing in the risk of the income stream.

extent risk averse managers demand less compensation due to the decreased likelihood that adverse outcomes will threaten their job security. However, if risk management is costly then shareholders may have to undertake certain activities, such as the development of incentive-based compensation contracts or undertake costly monitoring, to ensure the resources of the firm are devoted to the maximization of the firm's net worth and not the manager's own utility.[11] Stock option plans are considered to be especially effective in this regard.

Many firms in the insurance industry are especially susceptible to friction costs created by managerial risk aversion. A substantial proportion of the firms in the industry are mutuals or closely-held stocks, where managers are likely to exhibit risk aversion because of suboptimal diversification of personal wealth, organization-specific capital, and/or the absence of effective mechanisms for owners to use as disciplining and incentive devices.

The mutual ownership form lacks effective mechanisms that owners can use to control, monitor, and discipline managers, such as the alienable claims, voting rights in elections for directors, and the proxy and takeover fights available to the owners of stock companies. The opportunities to align owner and shareholder interests through management compensation systems (such as stock option plans) also are more limited in the mutual ownership form. Thus, mutual managers are likely to behave in a risk-averse manner, placing a higher priority on avoiding or hedging risks that may threaten their jobs than on maximizing firm value. This reasoning suggests the hypothesis that managers of mutuals are more likely to engage in derivatives activity than comparable stock insurers.

An alternative prediction about mutuals is provided by the managerial discretion hypothesis, which suggests that mutuals will be relatively successful in less complex and less risky activities than stocks (Mayers and Smith 1988). To the extent that less complex and less risky activities give rise to less need for hedging, the managerial discretion hypothesis would predict that mutuals may be less active in the use of derivatives and other risk management techniques than stocks. Of course, these two hypotheses are not mutually exclusive, i.e., mutuals on average may be less risky and less complex than stocks, while at the same time mutual managers exhibit greater risk aversion than managers of similar stock insurers.

Another reason why mutual managers may fail to maximize value is provided by the *expense preference* hypothesis (e.g., Mester 1989). This hypothesis holds that mutual managers are more likely to generate expenses due to excessive consumption of perquisites and other activities that are not consistent with cost minimization.

[11] Another managerial motivation for hedging involves the use of risk management to signal managerial skill in the presence of asymmetric information (Breeden and Viswanathan 1996; DeMarzo and Duffie 1995).

Again, the rationale is that the owners of mutuals have less effective mechanisms to motivate and control managers than do the owners of stock insurers.

A final argument with regard to mutuals is that their lack of access to the capital markets may lead to rational risk averse behavior. Mutuals cannot issue new equity following an adverse shock due to higher than expected loss payments or investment losses but rather must wait for retained earnings to restore lost capital. Thus, they run the risk of having to forego attractive investment opportunities following a shock to capital and/or losing customers due to downgrades of their financial ratings. Mutuals thus may be more active in risk management than stocks in order to avoid these adverse consequences.

17.3 CORPORATE RISK MANAGEMENT: EMPIRICAL EVIDENCE

Corporations can manage risk using a wide variety of tools. The choice of investment projects, diversification across product lines, choices involving operating and financial leverage, and shareholder dividend strategies all can be viewed as techniques for managing risk. However, unlike some of these traditional methods for managing risk, derivative securities exist only for purposes of risk management. Consequently, empirical analyses of firms' use of derivatives provide somewhat "cleaner" results concerning why firms may choose to engage in risk management. It is also the case that the volume of activity in derivatives contracts has grown dramatically over the past two decades. Consequently, we focus the remainder of our discussion on empirical evidence on corporate risk management through the use of derivatives.

Most of the motivations for corporate hedging are generic, although they apply in varying degrees across industries. Consequently, it is informative to consider empirical evidence on risk management by both non-insurance and insurance firms. However, because we are primarily interested in the insurance industry, our discussion of non-insurance firms focuses on particularly noteworthy studies rather than trying to present a comprehensive survey.

Risk Management by Non-Insurance Firms

A major study investigating the question of the "motive" for risk management is by Tufano (1996), who looks at managerial compensation schemes and hedge ratios in the gold mining industry to determine whether risk management is motivated by value maximization or managerial risk aversion. Tufano argues that risk-averse managers whose compensation comes in large part through acquiring shares in the firm will want to hedge their risk. Such a policy would not necessarily benefit diversified shareholders. Tufano contrasts these managers with managers who earn a relatively large portion of their compensation through stock options. In this situation managers can walk away from the options should the firm do poorly, but if the firm does well their positions will provide high payoffs. With this form of incentive compensation, even risk-averse managers would be more willing to tolerate gold price, and therefore earnings, volatility and thus would find hedging to be less advantageous.[12] Tufano's empirical evidence suggests that managers with high option holdings manage risk less than those with high stock holdings consistent with the managerial risk-aversion hypothesis of risk management. Tufano finds almost no evidence in favor of the various rationales that would make risk management a value-maximizing decision.

Contrary to Tufano's results, some authors have provided evidence that is more consistent with the value-maximization theories of risk management. Numerous authors have investigated whether firms engage in risk management in an effort to reduce the probability of incurring financial distress costs. An early study by Wall and Pringle (1989) found support for the hypothesis as they report that firms with lower credit ratings are more likely than higher-rated firms to use interest rate swaps.[13] Other authors have considered the more general question of whether the firm's capital structure is related to the likelihood that the firm will engage in risk management via derivatives contracting. The evidence presented in these studies is mixed. For example, neither Mian (1996) nor Nance, Smith, and Smithson (1993) report any evidence to suggest that derivatives trading is related to the capital structure of the firm. A more recent study by Geczy, Minton, and Schrand (1997) investigates the relationship between the capital structure of the firm and the decision to manage foreign currency exposures using derivatives. This study differs from its predecessors by recognizing the simultaneity of a firm's capital structure and risk-management decisions. Even after controlling for simultaneity, however, the authors conclude that there does not appear to be a relationship between a firm's capital structure and the decision to use derivatives.

Two exceptions to these studies of nonfinancial firms are Dolde (1996) and Graham and Rogers (1999). Dolde finds a significant relationship between risk management and the leverage of the firm after controlling for the firm's underlying exposure to various financial risks. Graham and Rogers (1999), like Geczy, et al., investigate the hedging and debt policy decisions of the firm using a simultaneous equations approach. They find that the use of derivatives is positively related to firm leverage. Thus, these authors find evidence to suggest highly levered firms appear more likely to use derivatives to avoid the expected costs of financial distress; or as Graham and Rogers argue, firms that use derivatives can maintain higher leverage ratios and maximize firm value by increasing their interest-expense tax deductions.

[12] It is well-known that the value of a stock option is increasing in the risk of the underlying stock. Intuitively, this is because the holder of the option benefits from upside fluctuations in the stock price but loses nothing beyond the option premium in the event of downside fluctuations (see Hull 1993).

[13] For a discussion of the various types of derivative securities, see Hull (1993).

The evidence from studies investigating the decision by non-insurance financial firms to use derivatives as a way to avoid financial distress costs is also mixed. Carter and Sinkey (1998) provide weak evidence that the capital structure and risk-management decisions of U.S. commercial banks are related. Gunther and Siems (1995), who also analyze U.S. banks, report no significant relationship between the decision to use derivatives and the capital structure of the bank. Focusing only on banks that are active in derivatives markets, Gunther and Siems find that banks reporting a higher volume of derivatives activity also have higher capital ratios. This result is in fact inconsistent with the financial distress hypothesis, at least as it is usually defined in the literature.

Mixed evidence has also been presented on the use of derivatives to lower the firm's expected tax burden. In their study of non-financial companies, Nance, Smith, and Smithson (1993) find that firms with higher investment tax credits are more likely to engage in derivative transactions. In an analysis of firms reported on Compustat, Graham and Smith (1999) conclude that approximately 50 percent of the firms in their sample face convex tax schedules and therefore have an incentive to reduce the volatility of their income stream. However, in a subsequent study, Graham and Rogers (1999) use a similar methodology to estimate the convexity of the tax schedule for a large sample of firms across many industries and are unable to find any relationship between derivative holdings and tax convexity.

A number of authors have found strong evidence documenting that firms use derivatives to reduce the variability of their income stream and thus help to ensure that adequate internal funds are available to take advantage of attractive investments. Gay and Nam (1999), for example, provide results consistent with the hypothesis that non-financial firms with both low levels of liquidity and high growth opportunities tend to hedge more. This finding is consistent with managers trying to mitigate the need to seek costly external funds to finance positive net present value projects. Other authors have found similar results. For example, Geczy, Minton, and Schrand (1997) and Nance, Smith, and Smithson (1993) both found that companies with less liquidity or companies that use less preferred stock, as opposed to using straight debt, are more likely to use derivatives to avoid shocks to the internal capital resources. A recent study by Ahmed, Beatty, and Takeda (1997), investigating 152 U.S. commercial banks, also finds support for the costly external finance hypothesis.

Risk Management by Insurance Firms

Cummins, Phillips, and Smith (CPS) (1997; 2000) analyze the factors that motivate both life and property-liability insurance firms to participate in derivatives markets as well as the drivers of the volume of derivatives transactions for insurers that decide to participate (see also Colquitt and Hoyt 1997). Based on 1994 data, CPS find that about 10.9 percent of life insurers and 6.9 percent of property-liability insurers use derivatives. However, usage is much more widespread in the largest size quartile, where 34.4 percent of life and 21.1 percent of property-liability insurers are active in derivatives markets. The transactions volume for life insurers far exceeds that of property-liability insurers. The transactions volume for life insurers is concentrated in bond and interest rate derivatives, as expected if insurers are using derivatives to hedge interest rate (duration and convexity) risk. Life insurers also show significant activity in foreign currency derivatives, consistent with the argument that insurers use derivatives to manage exchange rate risk. The leading categories of derivatives transactions for property-liability insurers include equity call options, foreign currency contracts, and bond and interest rate derivatives, again consistent with the management of price volatility, foreign exchange rate risk, and interest rate risk.

Following Gunther and Siems (1995), CPS (2000) conduct a multivariate probit analysis of the decision by insurers to participate in derivatives markets and a log-normal regression analysis investigating the volume of derivatives transactions by insurers. The authors investigate both decisions as they argue hedging is not costless, either in terms of fixed or variable costs. Thus, if the participation decision is driven by fixed costs, only firms with high enough levels of risk exposure, for example, due to a high tolerance for risk per unit of expected return, would find it worthwhile to enter the derivatives market. However, conditional on being active in derivatives, firms/managers with high appetites for risk will generally hedge less at the margin to the extent that each additional unit imposes marginal costs in the form of risk premiums. As evidence in support of this hypothesis, the authors report that many of the risk measures employed in the study often display exactly the opposite signs in the participation and volume regressions. This suggests that among firms having a large enough exposure to warrant participation in derivatives markets, those with the largest exposures are less willing to incur the marginal cost associated with eliminating the exposure.

The participation investigation in the CPS analysis also provides a considerable amount of support for the hypothesis that insurers hedge to maximize value. They present evidence consistent with the use of derivatives to reduce the expected costs of financial distress. For example, the decision to use derivatives is inversely related to the capital-to-asset ratio for both life and property-liability insurers. CPS also provide evidence consistent with the use of derivatives by insurers to hedge asset volatility, liquidity, and exchange rate risks. They find significant regression coefficients on several variables related to asset risk exposure such as the proportions of assets in privately placed bonds and collateralized mortgage obligations. Life insurers appear to use derivatives to manage interest rate risk and the risk from embedded options present in their individual life insurance and GIC liabilities. There is also some evidence that tax considerations play a role in motivating derivatives market participation decisions by insurers.

On the other hand, the CPS analysis provides little or no support for the hypothesis that corporate hedging in the insurance industry is motivated by managerial risk aversion. However, their data source did not contain several important variables that would have provided a more complete test of this hypothesis, including the proportion of an insurer's stock owned by managers and the incentive features in managerial compensation plans. The use of such variables to analyze the risk aversion hypothesis is a promising area for future research.

17.4 CORPORATE HEDGING, MULTIPERIOD CONTACTS, AND PRIVATE INFORMATION

In this section, we provide a new rationale for corporate hedging using a simple model that provides conditions under which value-maximizing managers of insurers will find risk management desirable. Specifically, we assume that firms such as insurers invest in multi-period, private assets that have higher returns than publicly traded assets. However, the returns are not realized unless the assets are held to their maturity date. If the assets have to be liquidated prior to maturity, the firm receives only the par value of the investment and foregoes the assets' returns. The firm thus has a motivation to hedge risk in order to avoid an adverse shock to capital that may force the insurer to liquidate some or all of its holdings of the private asset. As discussed above, the private assets may be insurance policies, privately placed bonds, or some other type of complex, opaque investment. Although the model applies generally to any firm that can invest in private assets, we believe that it is especially applicable to insurers because of the information asymmetries arising from insurance underwriting and the prominent role played by insurers in the markets for privately placed bonds and other structured securities.

To develop the theory more formally, we consider a three date model where the returns from investing in the private asset are received at date two. Assume that there are $i = 1, \ldots, N$ firms, each endowed with capital, K, and having access to two types of securities. The first security is short-term and yields a riskless yield per period, per unit of investment, of R, where $R > 0$. The other security is a long-lived private asset yielding a random gross return per unit of investment, $\tilde{\theta}_i$, at date two, $0 \leq \tilde{\theta}_i \leq \infty$. The realization of $\tilde{\theta}_i$, θ_i, is assumed to be private information with $E_0(\tilde{\theta}_i) > (1 + R)^2$, where $E_0(\cdot)$ is the expectation taken at time zero. We assume that $\tilde{\theta}_i = 0$ with positive probability, so that, absent the expenditure of costs for monitoring, firms are unable to credibly issue securities to outside claim-holders.

We will let I_i denote the level of investment in the private security at date zero, $I_i \leq K$, $\forall\ i$ and we assume the firm cannot add to the long-lived security at date one. In addition, if any portion is sold before maturity (date two), the portion sold returns its par value, or initial investment.[14] Absent any frictions in the capital markets, the

[14] In this model we assume the firm will recoup its initial investment in the private technology asset. However, the finance literature modeling distressed asset sales predicts that firms forced to liquidate some

first best solution is clearly $I_i = K$ for any-value maximizing firm i, and the present value of the firm at date 0 will equal $V_i^0 = \frac{KE(\tilde{\theta}_i)}{(1+R)^2}$.

The first friction we introduce to the model involves a shock to the firm's value at time one, $\tilde{Z}_i$, with $E_0(\tilde{Z}_i) = 0 \ \forall \ i$. The shocks are used as a summary measure for economy-wide and idiosyncratic factors that may influence the value of the firm at the intermediate date. In particular, we assume that $\tilde{Z}_i = \beta_i \ (\tilde{\rho} - 1) + \tilde{\varepsilon}_i$ where $\tilde{\rho}$ is an observable economy-wide shock with $E(\tilde{\rho}) = 1$, $\tilde{\varepsilon}_i$ is an idiosyncratic shock with $E(\tilde{\varepsilon}_i) = 0$ and β_i is a sensitivity coefficient with respect to the economy-wide shock. We consider two cases regarding the support for the distribution of $\tilde{Z}_i$. In the first case, we assume the support to be bounded on the interval $[a_i, b_i]$ with $b_i = K$. Doing so ensures the firm will always be able to meet any shock equal to the firm's initial endowment, K. In the second case, shown in the appendix to this chapter, we relax this assumption and assume the upper bound of the support of $\tilde{Z}_i$ can be larger than the firm's initial endowment, i.e., $b_i > K$.

Recall that the gross return on the private asset, $\tilde{\theta}_i$, is realized at date two. Given a joint distribution of $\tilde{\theta}_i$ and $\tilde{Z}_i$ at time zero, say $g(\theta_i, Z_i)$, it is possible to write this in the form $g(\theta_i, Z_i) = h(\theta_i|Z_i)f(Z_i)$, where $h(\theta_i|Z_i)$ is the conditional density of θ_i given a realization of $\tilde{Z}_i$, and $f(Z_i)$ is the marginal density of $\tilde{Z}_i$.

The problem facing firm i at date zero is to choose I_i to maximize the current value of its date two payoff. We use recursive programming to solve this problem. First, define ϕ_i to be the value of the firm's liquid assets at time 1. I.e., ϕ_i is

$$\phi_i = (K - I_i)(1+R). \tag{1}$$

Then, for a given choice of I_i at date zero, if $Z_i < \phi_i$ the present value of firm i at date 1 will be

$$V_i^1 = \frac{E(\tilde{\theta}_i|\tilde{Z}_i = Z_i)I_i}{(1+R)} + \frac{(\phi_i - Z_i)(1+R)}{(1+R)} \tag{2}$$

That is, the firm is able to cover its shock using only its liquid asset position. Alternatively, if the shock is greater than the liquid assets of the firm, $Z_i \geq \phi_i$, the firm will be forced to sell some or all of its investment in the private security before maturity and realizes only the par value at time 1. The present value in this case at date 1 will be

or all of their investment in private technology assets will often be forced to accept price discounts. For a theoretical discussion, see Schleifer and Vishny (1992). Pulvino (1998) provides some recent empirical support for this prediction. The benefits of risk management would be even greater for insurers if they were forced to liquidate a portion of their investment in the private technology assets at a discount.

$$V_i^1 = \frac{E(\tilde{\theta}_i|\tilde{Z}_i = Z_i)(I_i + \phi_i - Z_i)}{(1+R)} \tag{3}$$

where $E(\tilde{\theta}_i|\tilde{Z}_i = Z_i) = \int \tilde{\theta}_i h(\theta_i|Z_i) d\theta_i$.

Working backwards, taking expectations at time zero and discounting, we have that the time zero value of firm i, V_i^0, is given by

$$V_i^0 = \frac{E_0(\tilde{\theta})I_i}{(1+R)^2} + \int_{a_i}^{\phi_i} \frac{(\phi_i - Z_i)f(Z_i)}{(1+R)} dZ_i + \int_{\phi_i}^{b_i} \frac{(\phi_i - Z_i)E(\tilde{\theta}_i|\tilde{Z}_i)f(Z_i)}{(1+R)^2} dZ_i. \tag{4}$$

We now consider the firm's investment decision under two alternative assumptions regarding the joint distribution of $\tilde{\theta}_i$ and $\tilde{Z}_i$.

Case 1. Firm level endowment shocks, $\tilde{Z}_i$, at date 1 reveal no information regarding the realization of the return on the private technology asset, $\tilde{\theta}_i$, at date 2.

In Case 1, we assume that $E(\tilde{\theta}_i|\tilde{Z}_i) = E_0(\tilde{\theta}_i)\ \forall\ Z_i$. This assumption is weaker than assuming independence but stronger than the assumption that $\tilde{\theta}_i$ and $\tilde{Z}_i$ are uncorrelated. In this case the first order condition is given by

$$\frac{\partial V_i^0}{\partial I_i} = \frac{E_0(\tilde{\theta}_i)}{(1+R)^2} - \frac{E_0(\tilde{\theta}_i)}{(1+R)}[1 - F(\phi_i)] - F(\phi_i) = 0 \tag{5}$$

where $F(\phi_i) = \int_{a_i}^{\phi_i} f(Z_i)dZ_i$. Notice that in this case the second order condition for a maximum is satisfied since

$$\frac{\partial^2 V_i^0}{\partial I_i^2} = -f(\phi_i)E_0(\tilde{\theta}_i) + f(\phi_i)(1+R) < 0 \tag{6}$$

and, by assumption, $E_0(\tilde{\theta}_i) > (1 + R)^2 > (1 + R) > 0$.

Let $I_i = I_i^*$ solve equation (5). Our focus on the demand for risk management revolves around examining the difference in the value of the firm in the absence of shocks, $V_i^0(K) = KE_0(\tilde{\theta}_i)/(1 + R)^2$, and the second best value of the firm, given by (4) and evaluated at $I_i = I_i^*$. Call this $V_i^0(I_i^*)$. Define D_i to be this difference

$$D_i = V_i^0(K) - V_i^0(I_i^*). \tag{7}$$

We argue that anything making D_i larger will encourage value maximizing firms to be more likely to engage in risk management activities to the extent that these contracts can be used to reduce D_i by mitigating the influence of the shocks. To the extent that the shocks contain some macroeconomic component, traded off-balance-sheet contracts can be effective in minimizing (7).

To investigate changes in the difference function, equation (7), first note that for any factor, call it x, we know that

$$\frac{\partial D_i}{\partial x} = \frac{\partial D_i}{\partial I_i^*}\frac{\partial I_i^*}{\partial x} + \frac{\partial D_i}{\partial x}. \tag{8}$$

However, we also note that at I^*

$$\frac{\partial D_i}{\partial I_i^*} = \frac{\partial V^{i0}(K)}{\partial I_i^*} - \frac{\partial V^{i0}(I_i^*)}{\partial I_i^*} = 0. \tag{9}$$

This last result follows from the fact that $\dfrac{\partial V^{i0}(I_i^*)}{\partial I_i^*} = 0$ and $V_i^0(K)$ is not a function of I_i^*. Equations (8) and (9) demonstrate that we only need to consider the direct effect of changes in any of the underlying factors on the difference between the first best value of the firm, $V_i^0(K)$, and the second best value of the firm $V_i^0(I_i^*)$.

Given this result, consider changes in expected return on the private technology asset, $E_0(\tilde{\theta}_i)$. Using the definition of $V_i^0(K)$ and equation (4), we have

$$\frac{\partial D_i}{\partial E_0(\tilde{\theta}_i)} = \frac{K - I^*}{(1+R)^2} - \int_{\phi_i}^{b_i} \frac{(\phi_i - Z_i)f(Z_i)}{(1+R)^2} dZ_i > 0. \tag{10}$$

So, our first result is that the demand for risk management will be higher by firms with more valuable private, but illiquid securities.

Our next result concerns the demand for risk management as a function of the distribution of shocks. This can be easily analyzed by re-writing equation (4) (and recalling $E_0(\tilde{Z}_i) = 0$) as

$$V_i^0 = \frac{E_0(\tilde{\theta}_i|\tilde{Z}_i)I_i^*}{(1+R)^2} + \frac{(K - I_i^*)E_0(\tilde{\theta}_i)}{(1+R)} + \int_{a_i}^{\phi_i} \frac{F(Z_i)dZ_i}{(1+R)}\left(1 - \frac{E_0(\tilde{\theta}_i)}{(1+R)}\right) \tag{11}$$

where the last term is obtained by integrating by parts. Consider an alternative shock, call it $\tilde{Y}_i$, with distribution function G, and $E_0(\tilde{Y}_i) = 0$. If $\tilde{Y}_i$ is also confined to the closed interval $[a_i, b_i]$, then Rothschild and Stiglitz (1970) have shown that if "$\tilde{Y}_i$ has more weight in its tails than $\tilde{Z}_i$" and both have the same mean, then $\int_{a_i}^{Y_i} [G(Z_i) - F(Z_i)]dZ_i = T(Y_i) \geq 0$ and $T(a_i) = T(b_i) = 0$.

It follows immediately from the fact that $E_0(\tilde{\theta}_i) > (1 + R)$ and equation (11) that, for any value of I_i^*, equation (11) is lower if the firm faces the riskier shock $\tilde{Y}_i$ when compared to $\tilde{Z}_i$. Thus, our second result is that, ceteris paribus, firms who face a riskier distribution of shocks will have more incentive to engage in risk management. Stated differently, firm value will be higher for those firms who can reduce the riskiness of the distribution of shocks they face, all other things held equal.

To explore this result, note that since $\tilde{Z}_i = \beta_i(\tilde{\rho} - 1) + \tilde{\varepsilon}_i$, any risk management contract whose payoff is tied to $\tilde{\rho}$ can be used to reduce the weight in the tails of the distribution of $\tilde{Z}_i$. For example, consider a forward contract that pays off $\tilde{\rho}$ at date one. Define H_i to be the number of forward contracts held short at a forward price of p_f. With H_i forward contracts, the net shock the firm now faces, $\tilde{Z}_i^h$, is

$$\tilde{Z}_i^h = -H_i(\tilde{\rho} - \rho_f) + \tilde{Z}_i. \tag{12}$$

If we assume costless hedging, i.e., $\rho_f = 1$, then

$$\begin{aligned}\tilde{Z}_i^h &= (\beta_i - H_i)(\tilde{\rho} - 1) + \tilde{\varepsilon}_i \\ &= \tilde{x}_i^h + \tilde{\varepsilon}_i.\end{aligned} \tag{13}$$

Appealing to the Rothschild and Stiglitz once again, $\tilde{Z}_i^h$ is more risky than $\tilde{\varepsilon}_i$ if $\tilde{x}_i^h$ is a mean zero random variable and $E(\tilde{x}_i^h|\varepsilon_i) = 0\ \forall\ \varepsilon_i$. Thus, choosing $H_i = \beta_i$ will eliminate the firm's exposure to the economy-wide risk (i.e., $\tilde{x}_i^h = 0$) and therefore reduce the riskiness of the firm's shock to include only its idiosyncratic component. It follows, therefore, given the Rothschild and Stiglitz result, that the value of the firm is maximized by eliminating the economy-wide portion of the firm's risk exposure and reducing the riskiness of the shocks that the firm faces. Moreover, when hedging is costless, no other terms in the firm valuation equation (equation 11), are affected since $E_0(H_i(\tilde{\rho} - 1)) = H_i(E_0(\tilde{\rho}) - 1) = 0,\ \forall\ H_i$. We also note the obvious point that if the amount of idiosyncratic risk and market risk are inversely related, firms with high levels of idiosyncratic risk will tend to have smaller positions in risk management contracts (e.g., H_i will be smaller).

Case 2. Firm level endowment shocks, $\tilde{Z}_i$, at date 1 reveal new information regarding the realization of the return on the private technology asset, $\tilde{\theta}_i$, at date 2.

The second case we consider involves relaxing the assumption that $E(\tilde{\theta}_i|Z_i) = E_0(\tilde{\theta}_i)\ \forall\ Z_i$. I.e., we allow for the possibility that the size of the shock to the firm's endowment may be correlated with the return the firm can expect on its private technology asset. For example, an unexpected strengthening in the foreign currency exchange rate between the U.S. and Korea may also signal that the underlying credit worthiness of a fixed income asset issued by a Korean corporation may also have changed. In this case, the value of the firm at date 0, using equation (4) and the fact that covariance is a linear operator, we have that

$$V_i^{0'} = V_i^0 - \frac{Cov_0[(E(\tilde{\theta}_i)|Z_i), Z_i|b_i \geq Z_i \geq \phi_i]}{(1+R)^2} \tag{14}$$

where V_i^0 is the value of the firm if $E(\tilde{\theta}_i|Z_i) = E_0(\tilde{\theta}_i)\ \forall\ Z_i$ and Cov(·) is the covariance operator. Notice that, for a given level of I_i, the value of the firm will be lower if the conditional (on Z_i) time one value of the private asset is increasing in Z_i. This result contrasts with the standard portfolio theory idea that one would want to minimize the variance of terminal wealth by seeking out assets whose value would be high when other, negative, shocks to endowment are high (i.e., Z_i is large).

The intuition for our result can be seen by recognizing that, for $\phi_i \leq Z_i \leq b_i$, some of the private security must be liquidated. Consider two private assets, with the same unconditional expectation. Suppose that for the first asset $E(\tilde{\theta}_i^1|Z_i)$ is increasing in Z_i, while, for the second, $E(\tilde{\theta}_i^2|Z_i)$ is decreasing in Z_i. Then value will, ceteris paribus, increase by choosing the second asset since the opportunity cost of liquidation $[E(\tilde{\theta}_i|Z_i) - (1 + R)]$ is low when the security must be liquidated. For example, if negative endowment shocks are being caused by a poor overall economy, value would be enhanced by holding private securities whose value, conditional on the economy, is also low. That is, the opportunity cost of having to liquidate the private asset at time 1 is lower when the size of the shock and the expected return are negatively related. Re-interpreting the shocks to be interest rate related changes in liability values, it is straightforward to show that firms may increase value by acquiring assets whose values are less, rather than more, sensitive to decreases in interest rates, e.g., mortgage backed securities.

Thus, we would argue that firms for which asset values and endowment shocks are positively dependent are more likely to utilize risk management tools, while those in the opposite position will tend to have built in insurance against the realizations of these opportunity cost.

We have not yet considered the case where the shocks to capital may result in bankruptcy. While we provide a brief set-up of this problem in the Appendix to this chapter, we note that many of the results obtained here remain. However, it is no longer the case that an increase in the riskiness of cash flows will always result in a higher demand for hedging since bankruptcy provides an option to the firm which increases in value with increases in the riskiness of cash flows. Therefore, a mean preserving spread in the distribution of shocks may increase value to the extent the increases in the value of the limited liability option may partially or totally offset the additional demand for risk management that arises from the desire to avoid liquidating the valuable private asset.

To summarize, the model yields three main predictions:

a. The demand for risk management will be higher for firms with more valuable private but illiquid investments.
b. Firms that face riskier random shock distributions will have a greater demand for risk management than firms facing less risky random shocks.
c. Firms for whom private asset returns and random endowment shocks are positively correlated are more likely to engage in risk management, whereas firms in the opposite position have a natural hedge against the costs of random shocks.

To test these propositions, one would need to have data on the composition of insurer investment portfolios in order to determine the volume of private investments, the relative rates of return on these investments, and the correlation between private investment returns and random shocks. Life insurers hold substantial amounts of privately placed bonds and mortgages, which are likely to reflect private information. Both life and property-liability insurers hold structured securities and collateralized mortgage obligations, which also can be considered to have some characteristics of private assets.

Considering insurance policies as an insurer's projects or "assets," evidence presented in D'Arcy and Doherty (1990) is consistent with the argument that insurers accumulate private information by insuring drivers over a period of time and that this private information allows them to charge relatively higher prices the longer the driver has been with the company. The amount of private information on corporate insurance buyers, on the other hand, is likely to be relatively less because the commercial insurance market is more price competitive, commercial buyers are more sophisticated than personal lines policyholders, and commercial buyers tend to have statistically credible loss data that can be easily be provided to competing insurers. Thus, we might expect personal lines insurers to have more valuable private information than that possessed by commercial lines insurers. This provides some indication of the types of hypotheses shown here might be testable based on our model.

Evidence presented in Cummins, Phillips, and Smith (1997; 2000) is also consistent with the main predictions of our model. For example, the probability that both life and property-liability insurers will engage in derivatives transactions is positively related to the ratio of stocks to total assets, consistent with firms with riskier random shock distributions having a greater demand for risk management. In addition, for life insurers, participation in derivatives markets is positively related to the percentage of reserves in individual life insurance and annuity products and in GICs. Both individual life and annuities and GICs are relatively illiquid, multiple period contracts in which insurers are likely to acquire private information. Property-liability insurers with higher ratios of products liability reserves to total liabilities are more likely to participate in derivatives markets, as expected if products liability is a line with relatively high volatility. These findings are intriguing, and it is hoped that they will motivate additional research in this area.

17.5 CONCLUSION

This chapter provides a review of the rationales that are often advanced to explain why corporations manage risk. Because the pure theory of finance views expenditures on corporate hedging as dead-weight costs that destroy firm value, the financial rationales for hedging usually involve the existence of market frictions and transactions costs that can be mitigated through corporate hedging. Firms may have a motive to hedge to reduce the expected costs of financial distress, including the disruption of relationships with key employees, suppliers, and customers. Another set of reasons for corporate hedging include the avoidance of shocks to internal capital that may force the firm to forego profitable investment opportunities and the reduction of expected taxes due to the convexity of the corporate income tax schedule. An alternative, and non-mutually exclusive, hypothesis is that hedging is motivated by managerial risk aversion, i.e., by the desire of managers to maximize their own utility rather than to maximize firm value.

The chapter also reviews the empirical literature on a specific type of hedging activity undertaken by firms—the trading of financial derivatives. For non-financial firms and banks, the evidence on the use of derivatives to maximize firm value is rather mixed. One prominent paper (Tufano, 1996) finds that risk management by gold mining firms seems to be driven primarily by executive compensation plans, i.e., by managerial utility maximization. The evidence from research on the relationship between the use of derivatives and firm capital structure and, more generally, the use of derivatives to reduce financial distress costs also has been mixed. Stronger evidence has been found that firms use derivatives to lower their expected tax payments and to reduce the variability of their cash flows to help ensure adequate internal funds. Cummins, Phillips, and Smith (1997; 2000) present convincing evidence that insurers use derivatives to reduce financial distress costs and to hedge risks resulting from investment return volatility, liquidity, and exchange rate risk. They also find evidence supporting the hypothesis that insures use derivatives to hedge risks affecting the value of liabilities. We expect corporate hedging through derivatives and other devices to become increasingly important in the years to come and to provide numerous research opportunities for economists.

The chapter also provides a theoretical analysis that leads to a new rationale for corporate hedging. We postulate a firm that has the opportunity to invest in a long-lived investment project which has an especially attractive return due to private information or other factors. However, the return is realized only if the project is held until maturity. The firm is subject to random shocks that may necessitate the liquidation of part or all of the project prior to maturity. If liquidation occurs, the firm receives only the par value of the investment and must forgo the attractive return that could have been realized at maturity. The potential loss of this return motivates the firm to engage in hedging. The theory leads to the predictions that the demand for hedging will be positively related to the expected return on the long-lived investment project and also positively related to the riskiness of the random shocks faced by the firm. A counter-intuitive prediction is that the demand for hedging will be greater if the random shock and the return on the long-lived project are positively correlated. The intuition behind this result is that the firm will be more averse to liquidating the project due to a shock in states of the world where the payoff is higher. We conclude the theoretical discussion with some suggestions for testing our hypotheses.

APPENDIX A

In this appendix we consider the case where the shocks to capital may result in bankruptcy—i.e., where $b_i > K$ under the assumption that the shock $\tilde{Z}_i$ conveys no information about the realization of the return on the private asset $\tilde{\theta}_i$. In this case the insurer will be insolvent for $Z_i > I_i + (K - I_i)(1 + R) = I_i + \phi_i$. Reworking the programming problem, we have that V_i^1 is still given by either equation (1) (if $Z_i \leq \phi_i$), equation (2) (if $\phi_i < Z_i < \phi_i + I_i$) or $V_i^1 = 0$ (if $Z_i \geq \phi_i + I_i$)). In this case, assuming that $\tilde{\theta}_i$ and $\tilde{Z}_i$ are independent and dropping the "i" subscript for notational convenience, the time zero value of firm i is given by

$$V^0 = \int_a^{\phi}\left[\frac{IE_0(\tilde{\theta}) + (\phi - Z)(1+R)^2}{(1+R)^2}\right]f(Z)dZ + \int_{\phi}^{\phi+I}\left[\frac{E_0(\tilde{\theta})(I + \phi - Z)}{(1+R)^2}\right]f(Z)dZ. \qquad \text{(A.1)}$$

Equation (A.1) can also be written, after some manipulation, as

$$V^0 = \int_a^{\phi}\left[\frac{(\phi - Z)((1+R) - E_0(\tilde{\theta}))}{(1+R)^2}\right]f(Z)dZ + \frac{E_0(\tilde{\theta})(I+\phi)}{(1+R)^2} - \int_{\phi+I}^{b}\left[\frac{E_0(\tilde{\theta})(I+\phi - Z)}{(1+R)^2}\right]f(Z)dZ. \qquad \text{(A.2)}$$

In this case the first order condition can be written as

$$\frac{\partial V^0}{\partial I} = 0 = \left[\frac{E_0(\tilde{\theta}_i) - (1+R)}{(1+R)}\right]F(\phi) - \left[\frac{E_o(\tilde{\theta}_i)R}{(1+R)^2}\right]F(\phi + I). \qquad \text{(A.3)}$$

Checking the second order conditions, we have that

$$\frac{\partial^2 V_0}{\partial I^2} = -[E_0(\tilde{\theta}_i) - (1+R)]f(\phi) + \frac{R^2}{(1+R)^2} E_0(\tilde{\theta}_i) f(\phi + I). \tag{A.4}$$

Using equation (A.3), it is straightforward to show that the second-order condition will hold (i.e., equation (A.4) will be negative) if Z is drawn from a distribution that is log concave, i.e., if $\frac{\partial^2 \ln[F(Z)]}{dZ^2} \leq 0$. To see this, note that equation (A.4) will be negative if and only if

$$\frac{f(\phi)}{f(\phi+I)} > \frac{R^2 E_0(\tilde{\theta}_i)}{[E_0(\tilde{\theta}_i) - (1+R)](1+R)^2} = \frac{RF(\phi)}{(1+R)F(\phi+I)} \tag{A.5}$$

where the last equality follows from setting equation (A.3) equal to zero and solving for $E_0(\tilde{\theta}_i) - (1 + R)$. It follows that a sufficient condition for equation (A.5) to hold is that $\frac{f(\phi)}{F(\phi)} \geq \frac{f(\phi+I)}{F(\phi+I)}$ (since $R < 1 + R$). Log concavity of F guarantees that this inequality will hold.

Some of the earlier comparative statistics go through even in the case where bankruptcy is possible. The analog to equation (7) is given by

$$D = \frac{KE_0(\tilde{\theta})}{(1+R)^2} - \int_a^{\phi} \left[\frac{IE_0(\tilde{\theta}) + (\phi - Z)(1+R)^2}{(1+R)^2} \right] f(Z)dZ - \int_{\phi}^{\phi+I} \left[\frac{E_0(\tilde{\theta})(I + \phi - Z)}{(1+R)^2} \right] f(Z) \tag{A.6}$$

It is straightforward to show that, as before, $\frac{\partial D}{\partial E_0(\tilde{\theta}_i)} > 0$, so that firms with more valuable private assets will choose to engage in risk management. To see this, recall that

$$\frac{\partial D}{\partial E_0(\tilde{\theta})} = \frac{K}{(1+R)^2} - \frac{IF(\phi+I)}{(1+R)^2} - \int_{\phi}^{\phi+I} \frac{(\phi - Z)}{(1+R)^2} dF(Z). \tag{A.7}$$

It follows immediately that (A.7) *is non-negative since* $IF(\phi + I) < K$ and $Z > \phi$ over the range ϕ to $(\phi + I)$.

It is less straightforward to determine whether or not firms facing more risky distributions for their shocks will be more inclined to engage in risk management since limited liability provides shareholders with an option whose value is increasing in the volatility of the shocks. Therefore, a mean preserving spread in the distribution of shocks increases firm value and this may partially or totally offset the additional demand for risk management that arises from the desire to avoid liquidating the valuable private asset. Finally, while we omit details, the desire to hold assets whose conditional values are inversely related to shocks is still true.

17.6 REFERENCES

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