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Derivatives and Corporate Risk Management: Participation and Volume Decisions in the Insurance Industry

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Abstract

In this article, the authors analyze the derivatives holdings of U.S. insurers to empirically investigate the general hypotheses developed in the financial literature to explain why widely held, value-maximizing firms engage in risk management. The authors also develop a new hypothesis suggesting that although measures of risk and illiquidity will be positively associated with an insurer's decision to engage in risk management, these same measures of risk will be negatively related to the volume of hedging for the set of firms who choose to hedge using derivatives. The authors' analysis provides considerable support for general hypotheses about hedging by value-maximizing firms. The authors also find support for the hypothesis that, conditional on having risk exposures large enough to warrant participation, firms with a larger appetite for risk will engage in less hedging than firms with lower risk tolerance.

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INTRODUCTION

The use of derivatives in corporate risk management has grown rapidly in recent years, fueled in part by the success of the financial industry in creating a variety of over-the-counter and exchange-traded products. A 1998 survey of major non-financial firms revealed that at least 80 percent are using some form of financial engineering to manage interest-rate, foreign exchange, or commodity price risk (Bodnar, Hayt, and Marston, 1998). Financial firms, including banks (see, for example, Gunther and Siems, 1995; and Shanker, 1996), savings and loans (Brewer et al., 1996), and insurers (Colquitt and Hoyt, 1997; Cummins, Phillips, and Smith, 1997) also are active in derivatives markets. Although the types of risks confronting managers vary across industries, there is substantial commonality in the underlying rationale for the use of derivatives and the financial engineering techniques that are employed.

At first glance, the widespread use of derivatives seems inconsistent with modern finance theory, which provides little motivation for hedging by widely held corporations. According to theory, shares of such corporations are held by diversified investors who operate in frictionless and complete markets and thus can eliminate non-systematic risk through their portfolio choices. In this context, risk management at the firm level is a dead-weight cost that destroys shareholder value. Although valuable as a starting point, this frictionless theory has given way in recent years to a richer set of hypotheses whereby various market imperfections create motivations for value-maximizing corporate managers to alter the risk/return profile of the firm.[1] Among the market imperfections that have been identified are corporate income taxation, costs of financial distress, various types of agency costs, and information asymmetries between managers and investors. Financial firms such as insurers and banks also are motivated to hedge by product market considerations because their customers are particularly sensitive to insolvency risk (Merton and Perold, 1993). Non-value-maximizing motives resulting from uncontrolled agency problems and managerial risk aversion also may play a role in motivating risk management (MacMinn and Han, 1990).

This article provides new evidence on the use of derivatives for corporate risk management by examining factors that influence the use of financial derivatives in the U.S. insurance industry. The authors investigate rationales that might explain both the decision to use derivatives as well as the volume of these transactions. The principal objective is to empirically investigate the general motivations for corporate risk management as well as several more specific hypotheses relating to the insurance industry. The insurance industry provides a particularly revealing setting in which to analyze risk management because insurers are required to disclose considerably more information about their derivatives transactions than are firms in other industries.

Prior research suggests that the factors motivating corporations in general to manage risk are also important in the insurance industry (Santomero and Babbel, 1997; Cummins and Santomero, 1999). As financial intermediaries, life insurers are subject to significant interest-rate risk. They are also subject to liquidity risk due to their heavy investment in illiquid privately placed securities and real estate investments (including mortgages) as well as the embedded options in many insurance policies

[1] For more extensive discussions of the rationale for corporate risk management, see Smith and Stulz (1985); MacMinn (1987a); Froot, Scharfstein, and Stein (1993); Stulz (1996); and Tufano (1996).

that permit buyers to withdraw funds in response to interest-rate changes and other economic fluctuations. While property-liability insurers face some of the same risks as life insurers, they are also subject to volatile cash outflows due to liability lawsuits, property catastrophes, and other contingent events affecting claim costs. Both types of insurers face the risk of regulatory intervention, triggered by deteriorating financial condition, and exchange-rate risk due to the increasing globalization of insurance and financial markets.

As noted earlier, managerial risk aversion and incentive issues also may be important practical rationales for risk management in the insurance industry. A substantial proportion of the firms in the industry are mutual companies, the managers of which may exhibit risk aversion because of the relatively limited mechanisms available for mutual owners to control managers. It is also possible that the owners of closely held stock insurers may exhibit a degree of risk aversion to the extent that their portfolios are suboptimally diversified because of their ownership of the insurer.

In this article, the authors develop a set of hypotheses regarding corporate hedging, specify variables to represent the hypotheses, and then perform tests on a sample of life and property-liability insurers. The sample consists of all U.S. insurers reporting to the National Association of Insurance Commissioners (NAIC). The data on derivatives positions are taken from Schedule DB of the 1994 annual regulatory statements filed by insurers with state regulators. The authors' data set is unique in the literature on corporate hedging because the authors can identify virtually all derivatives transactions taking place during the year as well as open positions at year-end by type of instrument. Earlier studies either use the results of survey data (e.g., Nance, Smith, and Smithson, 1993; Dolde, 1995), investigate only a sample of firms (e.g., Graham and Rogers, 1999), or investigate firms that use derivatives designed to hedge only one risk exposure such as exchange-rate risk (e.g., Géczy, Minton, and Schrand, 1997; Allayannis and Ofek, 2001). The authors' data set allows observation of the entire portfolio of derivative securities, presumably the relevant choice variable for optimization purposes.

The authors extend the extant literature on corporate hedging behavior in three major ways. First the authors investigate both the decision to conduct derivatives transactions (the participation decision) and the volume of transactions undertaken by firms who enter derivatives markets (the volume decision). A number of studies have investigated either decision separately, but, to the authors' knowledge, no other study has formulated a specific hypothesis regarding the interrelationship between the participation and volume decisions.[2] Moreover, the authors' estimation technique, based on Cragg's (1971) extension of the Tobit methodology, permits the sign of the relationship between the explanatory variables and the decision to use derivatives to differ from that linking these variables to the volume of derivatives transactions. This is particularly important since the authors argue later that, if participation is

[2] For example, Nance, Smith, and Smithson (1993); Mian (1996); and Géczy, Minton, and Schrand (1997) investigate only the participation decision. Colquitt and Hoyt (1997), Graham and Rogers (1999), and Allayannis and Ofek (2001), among others, investigate both the participation and volume decisions. However, none of the authors discusses why they expect differences between the two decisions, and little guidance is provided for the differences they document.

driven mainly by fixed costs while, once in the market, volume decisions are mainly determined by marginal cost (in the form of risk premiums) considerations, the signs of the relationships in these two regressions may be different for some variables.

The authors' second important addition to the literature is to specify and test economic hypotheses regarding the factors driving the participation and volume decisions by insurers. There have been two prior papers on derivatives activity in the insurance industry. Cummins, Phillips, and Smith (1997) present extensive descriptive statistics on the use of derivatives by U.S. life and property-liability insurers but do not thoroughly investigate the economic rationales for their use nor develop specific economic hypotheses regarding derivatives use. Colquitt and Hoyt (1997) analyze the use of derivatives by life insurers licensed in Georgia. The authors' analysis extends their work by using data for a more recent year (their data are for 1992), including property-liability insurers as well as life insurers, investigating the universe of insurers rather than those licensed in Georgia, and testing a more extensive set of hypotheses and explanatory variables. Thus, this article should provide a more complete and deeper understanding of the rationales for insurers to engage in derivative transactions than is currently available in the literature.

The authors' third major extension is to analyze both within-year derivatives transactions as well as end-of-year positions. Previous studies investigating the extent of derivatives participation have measured this level using the end-of-period open positions as reported in either their quarterly or annual filings (e.g., Gunther and Siems, 1995b). The authors' data set provides information on transactions as they occur during the year, so the authors are able to control for some insurers who close out their positions at year-end, either for regulatory window-dressing or for other reasons, and using the year-end criterion eliminates such insurers from our sample. This may be particularly important for financial institutions like banks or insurers, which have more fluid balance sheets than do non-financial firms.

The authors' analysis provides considerable support for the hypotheses suggesting why value-maximizing firms would choose to hedge. The authors find evidence that insurers are motivated to use financial derivatives to reduce the expected costs of financial distress and to minimize the costs associated with holding additional equity capital. The authors also find evidence that insurers use derivatives to hedge asset volatility, liquidity, and exchange-rate risks. There is also some evidence that tax considerations play a role in motivating derivatives market participation—a result prior research in this area has had a difficult time identifying. Finally, the authors find support for their hypothesis that there is a per-unit risk premium associated with hedging and that, conditional on having risk exposures large enough to warrant participation, firms with higher risk tolerance will be less willing than average to pay this marginal cost.

The remainder of the paper is organized as follows: The first section formulates hypotheses and specifies variables to be used in the empirical tests. The second section describes the sample and explains the authors' estimation methodology. The results are presented in the third section, and the fourth section concludes.

HYPOTHESIS FORMULATION

This section provides the theoretical framework for the authors' empirical analysis. The authors begin by discussing their hypothesis about the relationship between the derivatives market participation and volume decisions. The authors next develop hypotheses about the value-maximizing motivations for hedging and specify variables to test these hypotheses. The maintained assumption in the value-maximization discussion is that hedging decisions are made by managers whose decisions are generally consistent with the owners' goal of maximizing firm value. The discussion then turns to the utility-maximizing motivations for hedging and the specification of variables to test this set of hypotheses. The maintained assumption in this section is that decisions are made by risk-averse managers, who pursue their own interests rather than those of the owners. Finally, the authors provide a brief discussion of the control variables.

The Participation and Volume Decisions

The authors argue below that it is likely to be value-maximizing for insurers to engage in various types of hedging activities. However, the authors assume that hedging is not costless, either in terms of fixed or variable costs. In particular, the authors recognize that, absent any fixed costs of setting up derivatives activities and obtaining expertise in their management, almost all insurers would have some non-zero positions in these additional markets for managing risk. Thus, if the participation decision is driven by these fixed costs, the authors would argue that 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.[3] 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. It follows, according to this hypothesis, that certain measures of risk may have opposite signs in the participation vs. volume regressions.[4] With this general idea in mind, the authors now

[3] Insurers are expected to have different risk tolerances due to differences in organizational form, as explained above. However, even within the stock and mutual segments of the industry, the authors observe firms with varying degrees of risk tolerance, related to operating strategies and target product markets. For example, insurers that target particularly risk-averse buyers (such as relatively risk-averse individuals) are expected to adopt low-risk strategies, whereas insurers whose clients are more risk tolerant (such as corporations) are likely to adopt higher-risk strategies in order to offer an attractive product price, contingent on maintaining a reasonable, but not necessarily the highest, financial rating.

[4] Consider the following partial equilibrium example of this hypothesis. Each firm j has an initial value of equity equal to V_{0j}. Denote the date one value of the firm as $V_{1j} = V_{0j} + \tilde{z}$, where $\tilde{z}$ is random and contained on the interval (a, b), where $a < 0$. Financial distress is introduced as a simple situation in which the firm receives 0 if $\tilde{z} < 0$. Suppose, at a fixed cost of $K > 0$, risk-neutral firms that face these costs of financial distress can participate in a forward market. For $V_{0j} < K$, there is no participation, so wealth is trivially positively related to participation in the market. Let the payoff to a short position be $f - \tilde{z}$ per contract, where f is the current forward price. Each firm can choose h_j units of these short positions, with negative values being long positions. Now the maximization problem, given participation, is given by (dropping the j subscript)

$$\max_{h} \int_{\frac{K-hf}{1-h}}^{b} [\, V_0 + \tilde{z} - K + h(f - \tilde{z})\,]\, dF(z) .$$

turn to specific rationales that have been provided for why corporations may choose to manage risk.

Value-Maximizing Motivations for Hedging

There are two primary reasons why hedging can be value-maximizing for insurers. The first reason, which applies to firms in general, is the existence of market imperfections, including the direct and indirect costs of financial distress, the underinvestment problem, and the corporate income tax. These factors are discussed in more detail below. The second reason that hedging can add value, which applies primarily to financial firms such as insurers and banks, is that the principal debt holders of financial firms are also their customers, and these customers are unusually sensitive to insolvency risk (Merton and Perold, 1993). Customers of insurers, for example, purchase insurance to protect against adverse financial contingencies and hence are more sensitive to insolvency risk than diversified bond holders who purchase corporate debt as an investment. Both theoretical and empirical evidence exists that there is a penalty for insolvency risk in the insurance market (Cummins and Danzon, 1997; Phillips, Cummins, and Allen, 1998). Thus, insurers can maximize value by maintaining low insolvency probabilities through hedging and other risk management activities. Note that this rationale for hedging does not reflect a market imperfection: the demand for safe insurance arises from rational utility maximization by individuals (e.g., Doherty and Schlesinger, 1990) and value maximization by corporate buyers (e.g., Mayers and Smith, 1982; MacMinn, 1987b).

Financial Distress. One important theory of corporate risk management is that firms engage in hedging activities to avoid the costs of financial distress. In addition to the direct costs resulting from bankruptcy, e.g., legal fees and court costs, shareholders also face costs arising before bankruptcy. For example, reputational loss may affect the firm's ability to retain relationships with key employees or suppliers. Financial distress costs also can arise if cash flows are adversely affected by contingencies that, left unhedged, may force managers to forego profitable investment projects for lack of affordable capital (e.g., Myers and Majluf, 1984; Garven and MacMinn, 1993; Froot, Scharfstein, and Stein, 1993).[5]

Assume for simplicity that z is uniformly distributed. Then the first-order condition is given by

$$\int_{\frac{K-hf}{1-h}}^{b} (f-\tilde{z})\,dF(z) - V_0 \frac{(K-f)}{(1-h)^2}\frac{1}{(b-a)}.$$

The second-order conditions for a maximum hold for $h > 0$ if $K > f$. Using the implicit function theorem, it is straightforward to verify that $dh/dV_0 < 0$, so that firms with higher initial endowments take smaller short positions. The intuition is that a higher current endowment today implies a higher expected future value should the firm remain in business, and therefore there is less need for holding short positions in the forward contract. One final note, although the authors have motivated this example by considering the case in which the firm faces financial distress costs, is that it is possible to generate similar predictions for the other frictions that motivate firms to engage in costly risk management strategies discussed in the article.

[5] See Andrade and Kaplan (1998) for one attempt to measure the costs of financial distress.

The hypothesis that firms engage in risk management to avoid nontradable costs associated with financial distress seems particularly applicable in the insurance industry. Insurers are stringently regulated and tend to incur escalating regulatory costs when they encounter financial difficulties. Insurers are also subject to risk-based capital regulations, which require regulators to take specified actions if the ratio of the insurer's actual capital to its risk-based capital falls below a sequence of thresholds, ultimately resulting in the seizure of the company.[6] Although risk-based capital constraints are not binding on most insurers, the risk-based capital rules create a *regulatory put option*, which reduces the market value of the firm even when the option is out-of-the-money.

To elucidate the role of the regulatory put option, the authors consider the option model of the firm, which expresses the value of equity as a call option on the firm's assets with striking price equal to the value of liabilities. The put-call parity relationship states the value of the call can be written equivalently as $C(A,L,\tau,\sigma,r) = A - Le^{-r\tau} + P(A,L,\tau,\sigma,r)$, where A = assets, L = liabilities, σ = the firm's risk parameter, τ = time until the next audit date, r = the risk-free rate of interest, $C(A,L,\tau,\sigma,r)$ = the value of the firm expressed as a call option, and $P(A,L,\tau,\sigma,r)$ = the value of a put option on the firm's assets with striking price equal to its liabilities [see Cummins and Danzon (1997) for more details]. The introduction of risk-based capital changes the value of the firm by subtracting the regulatory put option $P^R(A,L^R,\tau,\sigma,r)$ from the firm's value of equity, where $L^R = L + R$ and R = risk-based capital. Because $L^R > L$ and $\partial^2 P(A,L,\tau,\sigma,r)/\partial L \partial\sigma > 0$, the rate of change of the regulatory put option with respect to risk is larger than the rate of change in the put option $P(A,L,\tau,\sigma,r)$, and consequently the introduction of risk-based capital gives the value-maximizing firm an incentive to reduce risk.

Of course, this model assumes that the risk-based capital formula accurately measures $P^R(A,L,\tau,\sigma,r)$, both initially and on an ongoing basis as the firm's risk characteristics change.[7] If $\partial^2 P^R/\partial L \partial\sigma < \partial^2 P/\partial L \partial\sigma$ because of errors in the formula or other factors, the firm retains an incentive to take additional risk, although the incentive is lower in the presence of risk-based capital as long as $\partial P^R/\partial\sigma > 0$.[8]

The authors specify several variables to capture the effects of potential distress costs on the participation and volume decisions of insurers. The first set of variables pertains directly to the risk-based capital (RBC) system. The first RBC variable is a dummy variable equal to one if the highest risk-based capital regulatory action threshold is binding, i.e., if a firm's capital is less than 200 percent of its risk-based capital, and

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[6] Risk-based capital charges are calculated by applying percentage factors to balance sheet and income statement variables reflecting the principal investment and underwriting risks faced by insurers. An insurer's risk-based capital is calculated using a formula that is a function of the charges. For a more detailed description, see Cummins, Harrington, and Niehaus (1994).

[7] Cummins, Grace, and Phillips (1999) provide empirical evidence that the property-liability risk-based capital formula is not very accurate in predicting insurer insolvencies.

[8] The option model is also a perfect markets financial model in that it does not incorporate most of the bankruptcy costs that motivate firms to hedge. Nevertheless, it is useful in elucidating the potential effect of risk-based capital.

equal to zero otherwise. A continuous version of this variable equal to the insurer's actual risk-based capital ratio (the ratio of actual equity capital to risk-based capital) is also tested. The expected signs of the risk-based capital variables are ambiguous and depend, among other things, on the accuracy and responsiveness of the risk-based capital formula in measuring insurer risk. As shown above, if the risk-based capital formula perfectly measures the firm's risk, risk-based capital provides an incentive for insurers to reduce risk, predicting a positive sign on the risk-based capital dummy variable and a negative sign on the risk-based capital ratio. However, if the formula is not very accurate in capturing firm risk, then the firm may retain an incentive for risk-taking behavior, and the signs on these variables could be insignificant or opposite to the sign predictions of the option model. Opposite signs are also possible if weak firms refrain from hedging because of the fear that regulatory skepticism about the use of derivatives might generate additional regulatory costs.

Another important financial distress-cost variable is the firm's equity capital-to-asset ratio. The rationale is that firms with high capital-to-asset ratios are less likely to experience financial distress because they hold adequate capital to cushion the firm against adverse loss or investment shocks. In this sense, equity capital serves as a substitute for hedging as a way to avoid financial distress costs. The authors expect an inverse relationship between the capital-to-asset ratio and the decision to engage in derivatives transactions (MacMinn 1987a).[9] However, as noted earlier, conditional on having a risk exposure high enough to make derivatives activities worthwhile, firms with a bigger appetite for leverage may find it less appealing to pay the marginal cost of hedging additional units, resulting in a lower-than-average level of derivatives activity for these firms. This rationale predicts a direct relationship between the capital-to-asset ratio and the volume of derivatives transactions, whereas an inverse relationship would be consistent with insurers viewing capital and derivatives as substitutes with regard to volume as well as participation.

A third type of financial distress variable that the authors consider are the ratios of the insurer's preferred capital stock and surplus notes to total assets. Both preferred stock and surplus notes are subordinated to the insurer's insurance debt and its conventional debt.[10] The rationale for testing preferred stock and surplus notes is that the use of such subordinated claims is a substitute for hedging (Carter and Sinkey, 1998;

[9] In the option model of the firm, there is an inverse relationship between the capital-to-asset ratio and the firm's equity value. The argument the authors are making here reflects the implicit assumption that financial distress costs not incorporated in the pure option model motivate firms to hedge.

[10] Surplus notes are contingent debt instruments issued by insurers that, as mentioned, are subordinated to policyholder liabilities and to the firm's conventional debt. The principal contingency feature in surplus note contracts specifies that interest and/or principal payments are not required unless the insurer's equity capital exceeds a specified threshold. Surplus notes are used as a source of financing for insurers and to satisfy regulatory risk-based capital requirements (Dumm and Hoyt, 1999). While surplus notes are treated as debt securities for income tax purposes and typically pay a fixed rate of interest, they also display equity-like characteristics because of the contingent triggering feature. Surplus notes are treated as nonadmitted liabilities under statutory accounting principles. As such, the statutory surplus of the issuing insurer is increased by the dollar volume of the surplus note issued. For further discussion, see Dumm and Hoyt (1999).

Dolde, 1995). The predicted signs on these variables are negative based on economic logic similar to that used in the discussion of the capital/asset ratio.

The final financial distress variable is designed to test for a relationship between hedging and insurance distribution systems. The authors specify a dummy variable equal to one if the insurer distributes its products through insurance brokers or independent agents and equal to zero if it uses an exclusive agency or a direct distribution network. Brokers perform a monitoring function for insurance buyers, screening insurers on the basis of financial strength, prices, and claim settlement practices. Insurers that distribute through brokers thus are likely to engage in more active risk management to signal their financial strength to the brokers and avoid the loss of key brokerage and customer relationships.[11] Thus, the authors expect the brokerage dummy variable to be positively related to the use of derivatives.

Interest-Rate Risk and Investment Portfolio Structure. Like other financial intermediaries, insurers issue a variety of debt claims and invest the proceeds in financial assets. Both life and property-liability insurers invest heavily in intermediate and long-term bonds and tend to have positive equity duration gaps, with the duration of assets exceeding the duration of liabilities (Staking and Babbel, 1995). There is also evidence that insurers seek to hedge the resulting duration and convexity risk (Santomero and Babbel, 1997; Cummins and Santomero, 1999). To capture the effects of interest-rate risk management, the authors specify a proxy variable for duration gap equal to the difference between the weighted average maturity of insurer assets and liabilities.[12] The authors expect a positive relationship between their proxy for the duration gap and the decision to use derivatives.

Recognizing that the authors' proxy for duration is necessarily imperfect, the authors also include several variables in the regressions to capture additional aspects of the interest-rate sensitivity of insurer equity. Primarily, these variables relate to various categories of insurer liabilities that are interest-rate sensitive either because of their maturity characteristics or because they contain embedded options and other features that may be triggered by changes in interest rates. For life insurers, interest-rate sensitive liabilities include group annuities and individual life insurance and annuities. Group annuities are held by sophisticated institutional investors such as corpo-

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[11] Similarly, Breedon and Viswanathan (1996) and DeMarzo and Duffie (1995) argue that derivatives usage can provide a signal to investors of managerial skill levels when there are significant informational asymmetries between managers and investors. Such signals are likely to be more important for insurers distributing their products through brokers or independent agents because tied agents can be expected to have more direct information on the companies they represent.

[12] Maturity is used here as a proxy for duration because the regulatory statements do not provide enough information to calculate duration. Asset maturity is calculated on the basis of information taken from Schedule D of the annual regulatory statement. Liability maturity for property-liability insurers is calculated based on information in Schedule P of the statement. For life/health insurers, the authors used average liability maturity measures suggested to them through informal discussions with experts in the field, because detailed information on the cash-flow patterns of major life insurance liability classes are not available in the regulatory statements. Additional details on the maturity calculations are available from the authors.

rate pension plans, which are generally highly sensitive to both yields and insurer financial ratings. Individual life insurance and annuities are relatively long maturity contracts that contain numerous embedded options. Property-liability insurers also issue relatively long-maturity liabilities in the commercial casualty lines.

To capture the effects of liability-related interest-rate risk on the use of derivatives, the authors separately include the proportions of total reserves represented by individual life insurance and annuities and by group annuities in the life insurer analysis. These variables are expected to be positively related to the decision to use derivatives.

For property-liability insurers, the long-tail commercial lines of business (commercial liability and workers compensation) have longer maturities than other lines of property-liability insurance and are also generally regarded as having higher underwriting risk than most other coverages. To measure the effects of exposure to commercial long-tail risk, the authors include the proportion of reserves in commercial liability (except products liability) and workers compensation insurance and separately include the proportion of reserves in products liability insurance. Products liability insurance is included separately to account for any differences in the risk characteristics of this line versus other commercial long-tail coverages.[13] The commercial liability/workers compensation variable and the products liability variable are expected to be positively related to the use of derivatives if the risk of these lines of business motivates insurers to hedge. However, because these lines have relatively long payout-tails, they provide a natural hedge against the duration risk of long-term assets held by insurers and thus may reduce somewhat the need to manage interest-rate risk through derivatives transactions.[14]

Life insurers issue another type of debt instrument, 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 (Miltersen and Persson, 1999). Accordingly, the authors expect an insurer's GIC exposure to be positively related to the use of derivatives, and the authors test this hypothesis using the ratio of GIC reserves to total reserves.

Although both life and property-liability insurers invest the majority of their funds in high-grade, publicly traded bonds, they also invest in assets with higher default risk, higher return volatilities, and/or lower liquidity. For example, investments in real estate may expose insurers to more price and liquidity risk than they would like to retain. Some life insurers also invest heavily in privately placed bonds, which are

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[13] Products liability has historically (e.g., during the mid-1980s) been a source of abnormal underwriting losses for property-liability insurers. To test the relative riskiness of products liability and other long-tail lines, the authors obtained quarterly data on commercial lines loss ratios on a confidential basis from two top-ten commercial lines insurers for the period of 1987 through 1996. Calculating the volatility of these time series reveals that products liability is *much* more volatile than the other long-tail commercial lines.

[14] Interest-rate risk is created when the durations of assets and liabilities are mismatched. As mentioned, insurers tend to have high asset durations that exceed their liability durations. Insurers with high proportions of long-tail insurance contracts in their liability structure tend to have relatively high liability durations and hence face less interest-rate risk, *ceteris paribus*, than do insurers writing short-tail lines.

subject to liquidity risk and often contain embedded options. Both life and property-liability insurers invest in collateralized mortgage obligations (CMOs), which carry similar risks.

The authors argue that it is value maximizing for insurers to manage the default, liquidity, and volatility risk arising from investments in these types of risky assets. Such risks can cause shocks to capital that might cause insurers to forego positive net present value projects to the extent that raising external capital following a capital shock is prohibitively expensive (Froot, Scharfstein, and Stein, 1993; Garven and MacMinn, 1993). To test for this effect, the authors include in their analysis the proportion of insurer assets invested in relatively risky (in terms of default, price, and/or liquidity) classes of assets. Specifically, the authors include separate variables that measure the proportion of assets invested in stocks, real estate, privately placed bonds, and both private and publicly traded CMOs.[15] The authors expect these variables to be positively related to the use of derivatives.

With the increasing globalization of financial markets, insurers are selling more insurance products in foreign markets and investing in foreign securities, either to hedge the risk of foreign liabilities or simply to enhance portfolio diversification and take advantage of attractive yields. Foreign operations expose insurers to exchange-rate risk as well as the underwriting and investment risks familiar from their domestic operations. Financial theory suggests that the optimal approach to risk management is to hedge risks where the firm does not have a comparative advantage, i.e., risks for which it will not be compensated, and to retain more of the types of risk in which the firm has a comparative advantage, and thus can earn economic rents (Stulz 1996; Schrand and Unal, 1998). Insurers are sophisticated underwriters and portfolio managers but traditionally have not had a comparative advantage in managing exchange-rate risk. Hence, value-maximization would call for most insurers to focus their risk retentions in underwriting and investments and to hedge most of their foreign exchange-rate risk.

The authors specify several variables to test the hypothesis that insurers use derivatives to manage exchange-rate risk. The variables tested to measure the level of exposure are the proportions of assets in non-U.S. and non-Canadian stocks and bonds.[16] Other proxies for foreign risk exposure include a dummy variable, set equal to one if the insurer has foreign liabilities and equal to zero otherwise, and an interaction variable equal to the product of the foreign liabilities dummy variable and the ratio of foreign bonds and stocks to total assets. A dummy variable set equal to one if the insurer has any foreign assets and zero otherwise is also tested along with the interaction between this dummy variable and the dummy variable for exposure to foreign liabilities. The authors expect a positive relationship between the foreign exposure variables and the decision to use derivatives. This expectation is again based on the rationale that it is value-maximizing to avoid shocks to capital as well as the argument that firms should hedge risks in which they have little comparative advantage. An inverse relationship is expected between both asset/liability interaction vari-

[15] For property-liability insurers, the authors include only one CMO variable, the proportion of assets in total CMOs, because these insurers have almost no privately placed CMOs.

[16] The authors also tested the proportions of assets in Canadian stocks and bonds, but these variables were not statistically significant.

ables and the use of derivatives because holding both foreign assets and foreign liabilities creates a natural hedge against exchange-rate risk that may substitute for hedging through foreign exchange derivatives.

The Underinvestment Problem. The classic underinvestment problem was first identified by Myers (1977). The basic argument is that the presence of debt in the firm's capital structure can lead it to forego positive net present value projects if the gains primarily accrue to the firm's bond holders. The underinvestment problem is more likely to occur in firms that are relatively highly leveraged, providing a motivation for firms to hedge to avoid shocks to equity that result in high leverage ratios. Mayers and Smith (1987) and Garven and MacMinn (1993) show that hedging can be used to at least partially resolve the underinvestment problem, enabling firms to capture the value that would otherwise be lost because of underinvestment. 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 insiders and outsiders. Firms may hedge to reduce the variability of their income stream and thus help to ensure that adequate internal funds are available to take advantage of attractive projects.

Researchers often use growth rates to proxy for the presence of investment opportunities that might motivate a firm to hedge. However, the growth rate variables the authors tested (growth in premiums and assets) were not statistically significant. For life insurers, the authors can specify a unique variable to serve as a proxy for growth opportunities (or, rather, the lack thereof)—the proportion of new premium volume that arises from the reinvestment of policyholder dividends and coupons from existing policies. The argument is that firms that have a relatively high proportion of revenues from existing policies rather than new policy sales are lacking in growth opportunities. The authors expect this variable to be inversely related to the use of derivatives. No comparable variable is available for property-liability insurers.

Taxes. The corporate income tax provides two primary motivations for firms to manage risk. First, firms may hedge to protect income tax credits and tax loss carryforwards, which may be lost or deferred if the firm's income falls below the amount of the tax shelter (MacMinn 1987a).[17] This tax-induced explanation for hedging has less to do with income volatility than with having enough taxable income to take advantage of existing tax shelters. Second, because of the convexity of the schedule of corporate income tax rates, firms can reduce the expected value of their income tax payments by engaging in hedging that reduces income volatility (Smith and Stulz, 1985). The tax schedules affecting both life and property-liability insurers have convex segments,[18] and property-liability insurers, in particular, engage in especially active tax management (Cummins and Grace, 1994).

Because the amount of information insurers disclose to regulators on federal income taxation is very limited, the authors are not able to test variables commonly used in

[17] Garven and Louberge (1996) reinforce this rationale for hedging by showing that reinsurance enables insurers to reallocate tax shields to those insurers that have the greatest capacity for using them.

[18] It is also noteworthy that a flat income-tax schedule combined with limited liability would also create tax convexity that would motivate firms to hedge.

the existing literature such as the amount of unused tax loss carry-forwards (e.g., Nance, Smith, and Smithson, 1993). However, the authors can specify dummy variables to proxy for insurers' tax positions. The authors specify a dummy variable equal to one if the insurer paid no federal income tax in 1994 and zero otherwise; and similar variables are specified for 1992 and 1993. The expected signs of these variables are ambiguous. On the one hand, not paying taxes may indicate the presence of tax loss carry-forwards that the insurer risks losing if it does not generate positive taxable income. This rationale would predict positive signs for the "no tax" dummy variables. On the other hand, if the insurer has been paying little or no taxes, it may indicate that it does not expect to pay taxes in the future and hence does not have a tax motivation for hedging.

A second variable designed to capture the effects of tax-induced hedging is a dummy variable equal to one if the following two conditions are met, and equal to zero otherwise: (1) federal taxes incurred is positive while taxable net income is non-positive and (2) the ratio of federal income taxes incurred to pre-tax income is less than 25 percent. This variable is an indicator for insurers that are in the alternative minimum tax (AMT) range of the tax schedule, i.e., between the AMT tax rate (20 percent) and the regular corporate tax rate (35 percent).[19] This is the range of the tax schedule deemed to reflect maximum convexity, and insurers in this range should be most likely to utilize derivatives to reduce income volatility. This "AMT" dummy variable is thus expected to have a positive relationship with the use of derivatives.

Utility-Maximizing Motivations for Hedging

Managers of insurers are assumed to be risk-averse utility maximizers. To the extent that their interests are aligned with those of owners, because of incentive compensation schemes and other disciplinary mechanisms, the authors expect the managers to pursue the owners' goal of maximizing firm value. However, in circumstances in which owners have relatively weak ability to control managers, managers may pursue an objective of maximizing their own expected utility even though doing so may be a deadweight cost to firm value. This may be especially likely for insurers that are organized as mutuals, because the mutual ownership form provides relatively limited mechanisms for owners to control managers. Thus, mutual managers may tend to place a high priority on avoiding or hedging risks that threaten their job security and fail to invest in some positive net present value projects that would increase firm value but are relatively risky.[20] This argument also predicts that because mutual man-

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[19] The 25 percent threshold was chosen somewhat arbitrarily because the authors do not know which insurers are paying the AMT and which are paying taxes at the regular rate. Because insurers do not provide information on tax loss carry-forwards, insurers paying the regular tax rate could have ratios of incurred taxes to income that are less than 35 percent. Experimentation with a few other reasonable thresholds, such as 20 percent and 15 percent, indicates that the results are not sensitive to the choice of a threshold in the 15 to 25 percent range.

[20] A more traditional argument is that the owner-policyholders of mutuals prefer the objective of value-maximization but cannot fully align the behavior of managers with this objective because of the unavailability of stock options and other market-based incentive compensation plans in the mutual ownership form. This argument also implies that mutuals would engage in more hedging activities than stock insurers would.

agers are more concerned about hedging risk, they will be more likely to use derivatives than managers of comparable stock insurers.

The managerial discretion hypothesis, however, carries the opposite prediction, i.e., that managers of mutuals will be *less* likely than managers of stock insurers to engage in derivatives transactions. Recall that this hypothesis predicts that managers of stock corporations will engage in more complex activities because the mechanisms available to the owners of stock insurers for controlling managers are more effective than those available to mutuals (Mayers and Smith, 1988).[21] This argument implies that mutuals will be constrained to less complex methods for managing the firm's risk exposure and thus will be less likely to utilize financial derivatives to the extent that derivatives trading is viewed as a complex activity.[22] The net effect of the managerial risk aversion and managerial discretion hypotheses on the tendency of mutuals to use derivatives is therefore ambiguous. To test for the potential effect of the mutual ownership form on hedging behavior, the authors specify a dummy variable equal to one for mutual insurers and equal to zero otherwise. As discussed, the expected sign of this variable is ambiguous.

The authors also consider the possibility that publicly traded and privately held stock companies may behave differently with regard to risk management. The owners of closely held firms are likely to have a high degree of control over managerial behavior and, hence, should be able to align the managers' interests with their own. Generally, the authors expect the owners of such firms to prefer value-maximization. However, it is also possible that they may exhibit a degree of risk aversion, to the extent that the wealth of the shareholders is suboptimally diversified because of their holdings in the insurer. To test for differences between publicly traded and closely held stock firms, the authors specify a dummy variable equal to one if the firm is a publicly traded stock insurer and zero otherwise. If closely held firms tend to be risk averse, the coefficient of the publicly held insurer dummy variable is predicted to be positive. However, if closely held stocks primarily pursue value-maximization, this variable will be statistically insignificant.

The ratio of surplus notes to total assets may also provide a proxy for managerial risk aversion. The presence of surplus notes in an insurer's capital structure may indicate that its managers are relatively more risk averse than the managers of firms that have not taken advantage of this source of financing. This reasoning predicts a positive relationship between surplus notes and the use of derivatives. However, if surplus notes and derivatives are substitute hedging devices, a negative coefficient is predicted.

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21 Empirical evidence supporting the managerial discretion hypothesis is presented in numerous articles, for example, Mayers and Smith (1988); Lamm-Tennant and Starks (1993); and Cummins, Weiss, and Zi (1999).

22 The rationale is that the costs associated with structuring, monitoring, and bonding a set of contracts that align the incentives of managers and owners is higher for complex activities conducted in a mutual organization than in a stock corporation. Thus, the risk management techniques employed by stock versus mutual insurers should differ to the extent the use of financial derivatives is more complex than other more traditional methods available for firms to manage financial risk.

Other Variables

The authors expect firm size to be positively correlated with derivatives activity if there are significant fixed costs in setting up a derivatives operation (e.g., in terms of personnel and computer investments) that give rise to economies of scale in derivatives trading (Booth, Smith, and Stolz, 1984; Hoyt, 1989; Stulz, 1996). However, these scale economies, if they exist, may be offset by the fact that larger insurers may be more diversified and therefore in less need of derivatives contracts as additional risk management tools. Based on the previous literature on corporate hedging by both insurers (Hoyt, 1989; Colquitt and Hoyt, 1997; Cummins, Phillips, and Smith, 1997) and other types of firms (Mian, 1996) the authors' overall expectation is that information and transactions cost economies of scale will dominate any built-in diversification benefits, resulting in greater usage of derivatives by larger insurers. The variable used to test for the size effect is the natural logarithm of total assets.

Another scale-related variable included in the authors' analysis is a dummy variable set equal to one if the insurer is a member of a group of insurers where at least one other member of the group is active in derivatives trading and to zero otherwise. If one member of the group is involved in derivatives trading, then the cost of other group members taking advantage of these risk/return opportunities is declining to the extent that each member of the group rationally does not duplicate these fixed costs. The authors expect this dummy variable to be positively related to the decision to use derivatives. However, controlling for other factors, this variable is expected to be inversely related to the volume of derivatives transactions, because having affiliated insurers trading derivatives reduces the volume needs for other members of the group.

A dummy variable is also included for unaffiliated single companies.[23] Unaffiliated insurers may be more likely to engage in risk management through derivatives trading than insurers that are members of groups because unaffiliated companies cannot insulate their overall equity capital from specific risks by placing these risks in subsidiaries. In an insurance group, the creditors of an insolvent subsidiary cannot reach the assets of other members of the group unless they are successful in "piercing the corporate veil," which usually requires a finding of fraud or similar wrongdoing. Unaffiliated companies cannot protect their overall capital in this way and hence may have more of a motivation to use derivatives than do members of groups. However, the ability of groups to isolate specific risks in subsidiaries also implies that insurance buyers are exposed to more insolvency risk when buying from an insurance group than when buying from an unaffiliated company, other things being equal. Thus, unaffiliated insurers also might be expected to exhibit higher risk tolerance under the authors' marginal cost hypothesis because they have lower insolvency risk and hence are less exposed to financial distress costs.

Although derivatives are a relatively recent risk management tool for most insurers, insurers have for a long time used reinsurance to hedge underwriting risk. More recently, insurers have used financial reinsurance to hedge their exposure to, for ex-

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[23] Thus, the excluded category not represented by the group affiliate dummy and unaffiliated single company dummy variable consists of members of groups where *at most* one group member is active in derivatives.

ample, interest-rate and market risk (Tiller and Tiller, 1995). To the extent that underwriting risk and financial risk are correlated, reinsurance designed to reduce underwriting risk could serve as a substitute for derivatives trading. However, reinsurance and financial derivatives might be complements if insurers that hedge underwriting risk are also more likely to hedge financial risk. The authors account for the use of reinsurance by including in their regressions the ratio of ceded reinsurance premiums written to direct premiums written plus reinsurance assumed.

Hedging Versus Speculation

Although the authors' hypotheses deal almost exclusively with motivations for hedging, it is difficult to completely rule out the possibility that some insurers are using derivatives purely for speculative purposes because of rogue traders or to a deliberate corporate policy to take more risk. The authors do not consider the possible existence of speculation to be a serious problem, for several reasons: First, survey research provides considerable evidence that many insurers report they are focusing on the use of derivatives as a risk-management tool (Hoyt, 1989; Lehman Brothers, 1994; Santomero and Babbel, 1997).

Second, as discussed above, financial theory suggests that the optimal approach to risk management is to hedge risks in which the firm does not have a comparative advantage and to concentrate on types of risks in which the firm does have a comparative advantage. Thus, to the extent that the majority of insurers do not have a comparative advantage in predicting returns on stocks, foreign exchange, or other assets, it would not be optimal for such firms to speculate in these markets using derivatives. Thus, the authors find it unlikely that speculative behavior is driving their results, even if a few insurers are actively speculating.

Third, with pure speculation, some of the sign patterns that the authors observe between the participation and volume regressions (see below) would not be anticipated. For example, for life insurers the privately placed bond variable has a positive coefficient in the participation (probit) equation and a negative coefficient in the volume of transactions equation. The authors argue that having more private placements motivates insurers to enter the derivatives market for hedging purposes, but, conditional on entering the market, firms with more tolerance for risk are likely to hedge less, explaining the negative sign in the volume regression. This sign would be difficult to explain under the hypothesis that insurers are using derivatives for pure speculation.[24] Likewise, tax hedging is difficult to explain under a speculation hypothesis. Finally, the authors would not expect to observe consistency of their regression results with a *wide range* of hedging-related hypotheses and variables if insurer derivatives activity were driven mainly by speculation. Insurers could speculate on stocks or foreign exchange through derivatives without holding any stocks or foreign assets. Thus, the authors believe that the weight of evidence presented is consistent

[24] Another possible explanation for the negative coefficient on the private placements variable is that having more private placements implies more diversification and hence less need to hedge. However, it is liquidity risk that differentiates private placements from other corporate bonds, and this type of liquidity risk does not decline significantly if the number of bonds is increased. Thus, the authors believe that their marginal costs interpretation provides a better explanation for this inverse relationship.

with insurers primarily using derivatives for hedging purposes. This does not mean that no speculative activity exists, only that the preponderance of derivatives transactions appear to involve hedging rather than speculation.[25]

DATA AND METHODOLOGY

The next stage of the analysis is to test the authors' hypotheses by estimating regression equations to explain the decision by insurers to participate in derivatives markets as well as the volume of derivatives transactions, conditional on the decision to participate. In this section, the authors first describe their database and then explain the regression methodology.

The Data

The authors' data come from Schedule DB of the 1994 regulatory annual statements filed by insurers with the National Association of Insurance Commissioners (NAIC). Parts A through D of Schedule DB list individual transactions across four categories of derivatives: (A) options, caps, and floors owned; (B) options, caps, and floors written; (C) collars, swaps, and forwards; and (D) futures. In Part E of schedule DB, insurers report their year-end counter-party exposure for all the contracts contained in Sections A through D. The explanatory variables used in the authors' analysis also are taken from the 1994 NAIC regulatory statements.

The authors' sample initially consisted of all life and property-liability companies that filed regulatory annual statements with the NAIC for calendar year 1994, a total of 1,760 life insurers and 2,707 property-liability insurers. Initial screening resulted in the elimination of firms with zero or negative assets, premiums, or surplus and firms that lack adequate group affiliation identifiers. The screening criteria resulted in the elimination of a large number of very small firms (accounting for only 2.2 percent of industry assets). The final sample consists of 1,216 life insurers and 1,668 property-liability insurers.

Many insurers are members of groups that operate under common ownership. Because members of groups are likely to share common financial strategies and, in many cases, common investment departments, the authors considered analyzing firms at the group level as well as the individual company level. However, Cummins, Phillips, and Smith (1997) found that the group level analysis provided virtually no information concerning the participation decision not provided by the company level analysis. In fact, some interesting information (for example, the effect of having an affiliated insurer active in derivatives markets) would be lost as a result of aggregating individual companies into groups. Consequently, the authors report only the company-level analysis in this article.

Methodology

In this article, the authors analyze the factors affecting the decision by insurers to enter the market for derivatives (the participation decision) as well as the factors

[25] The authors also observe that insurers can legitimately be using derivatives for purposes of income enhancement without taking additional risk. For example, covered call strategies are no more risky than investing in traditional assets such as stocks and bonds.

affecting the volume of transactions undertaken (the volume decision). The authors use two criteria to determine whether an insurer is active in derivatives markets and to measure the volume of derivatives transactions—derivatives transactions during the year and derivatives positions at year-end. Using the within-year criterion has the advantage of enabling the authors to analyze *all* insurers that are active in derivatives markets rather than only those that report year-end positions. Some insurers close out their positions at year-end, either for regulatory window-dressing or for other reasons, and using the year-end criterion eliminates such insurers from this sample.[26] The disadvantage of using the within-year definition of activity is that insurers that adopt short-term rollover strategies, as opposed to hedging with long-term contracts, will appear to be more aggressively managing their exposures when, in reality, the economic benefits of the two strategies are arguably very similar. Conducting the analysis under both criteria thus provides an important check on the robustness of the results.

The authors use probit analysis to study the participation decision. The dependent variable is set equal to one if an insurer had derivatives transactions during 1994 (the within-year definition) or, alternatively, if it reported derivatives holdings at year-end 1994 (the end-of-year definition) and equal to zero otherwise. The explanatory variables are those formulated above to test the authors' hypotheses. A positive sign on an explanatory variable in the probit analysis implies that the variable is associated with a higher-than-average propensity for insurers to use derivatives and vice versa if the variable carries a negative sign.

To analyze the volume of derivatives transactions, the authors adopt two approaches. The first is a Tobit analysis. In Tobit analysis, the dependent variable is equal to zero if an insurer does not use derivatives and equal to the volume of derivatives transactions divided by the total assets of the insurer if the firm uses derivatives. The authors use notional amounts to measure the volume of derivative transactions.[27] Tobit analysis is a standard procedure for dealing with censored dependent variables, where the variable is continuous for some observations but equal to zero (or some other constant) for others.

A criticism of Tobit analysis is that it measures the participation decision and the volume decision simultaneously, i.e., it forces variables to have the same signs with respect to the decision to participate and the volume of transactions, given that participation takes place. To the extent that there are reasons, like those noted earlier, why some variables in the participation and volume regressions should have oppo-

[26] In the authors' sample, there are 118 life insurers that use derivatives under the within-year criterion but only 107 under the end-of-year. For property-liability insurers, 111 users are under the within-year criterion and 77 are under the end-of-year criterion.

[27] The authors are aware that notional volume is, at best, an imprecise measure of the economic value of these activities. However, to the extent the measurement error is uncorrelated with the explanatory variables, the authors' estimates will remain unbiased. Virtually all previous analyses of derivatives transactions volume in both financial and non-financial firms have also used notational amounts. To help control for measurement error due to insurer size, the authors use the ratio of an insurer's notional transactions to its assets as the dependent variable in their Tobit models and the natural log of this variable as the dependent variable in the volume analysis (see below).

site signs, the Tobit model would be mis-specified. Consequently, the authors also use a generalization of the Tobit model, due to Cragg (1971), that does allow different parameter values for the participation and volume decisions.

Cragg's framework is quite general and allows a variety of assumptions concerning the underlying probability distributions entering into the participation and volume decisions. Here the authors adopt an approach, used previously by Gunther and Siems (1995b), that assumes a normal distribution for the participation decision and a log-normal distribution for the volume decision, conditional on the fact that the firm is participating in this market. The resulting likelihood function is

$$L=\prod_{i=1}^{N}[1-\Phi(\beta' X_i)]^{(1-I_i)}[\Phi(\beta' X_i)f(y_i \mid y_i > 0)]^{I_i},$$

where $f(y_i \mid y_i > 0) = (\sigma y_i)^{-1}(2\pi)^{-\frac{1}{2}} e^{-\frac{1}{2}\frac{(\ln y_i - \gamma X_i)^2}{\sigma^2}}, \; y_i > 0,$

where $\Phi(\bullet)$ is the standard normal distribution function, I_i is an indicator variable equal to one if the insurer uses derivatives and zero otherwise, β and γ are parameter vectors, y_i is the volume of derivatives relative to the insurer's assets for insurer *i*, and X_i is a vector of independent variables for insurer *i*. The model is equivalent to estimating a probit model for the participation decision and a lognormal regression model for the volume decision. The two parts of the model (parameter vectors) can be estimated separately. The authors conduct likelihood ratio tests of the null hypothesis that the participation and volume decisions can be modeled using the same coefficients (as in Tobit) versus the alternative hypothesis that the effect of the independent variables on participation differs significantly from their effect on transactions volume. The results of these tests are reported in the next section.

ESTIMATION RESULTS

To facilitate the discussion of results, the hypotheses, variables, and expected signs are summarized in Table 1. Table 1 also summarizes the empirical findings, with greater than or less than signs indicating the signs of the variables that are statistically significant. To keep the table as concise as possible, variables are shown as being significant if they are significant in *either* the within-year or year-end regressions. Summary statistics are presented in Table 2 and coefficient magnitudes and significance levels in Tables 3 and 4.

Descriptive Statistics

Cummins, Phillips, and Smith (1997) report that 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 use derivatives.[28]

[28] As an additional robustness check, the authors also estimated their regression models using only the firms in the largest size quartile. The results are consistent with those reported for the full sample and lead to the same conclusions.

Summary statistics for the variables appearing in the authors' models are presented in Table 2. The average notional amounts of derivatives transactions during the year and positions still open at the end of the year by life insurers are $2.629 billion and $661 million, respectively. The average notional amount of transactions for property-liability insurers both during the year and open at the end of the year is much less, only about $289 million and $90 million, respectively. Clearly, life insurers are, on average, bigger players in derivatives markets than their property-liability counterparts.

Table 2 also contains data on the means of the independent variables for derivatives users and nonusers, by insurer type, as well as *t*-tests for the significance of the differences between the means of the variables for users and nonusers. Both life and property-liability insurers that use derivatives are significantly larger than their nonuser counterparts. Life insurers engaged in derivatives activities have significantly higher proportions of their assets in real estate, publicly traded and privately placed CMOs, privately placed commercial bonds, and non-U.S./non-Canadian bonds. Life insurance users also have significantly higher proportions of group annuities and GICs on their balance sheets than do nonusers, and users have larger maturity gaps than nonusers. The direction and significance of these mean differences are consistent with the authors' hypothesis that life insurers are using derivatives to hedge interest-rate risk, volatility risk, liquidity risk, and exchange-rate risk.

Life insurers that use derivatives have lower capital-to-asset ratios than nonusers but are less likely to have risk-based capital ratios less than 200 percent.[29] Life insurance users are significantly less likely than nonusers to have incurred a federal tax liability in 1993 and 1994. Finally, users are more likely to be mutuals, less likely to be unaffiliated companies, and much more likely to have another affiliated company that is active in derivatives. The finding with respect to mutuals is consistent with the hypothesis that managers of mutuals exhibit risk-averse behavior. However, because mutual life insurers on average are much larger than stock life insurers, this may reflect an uncontrolled size effect. The finding with respect to unaffiliated companies is contrary to expectations but may also represent a size effect, because unaffiliated firms are significantly smaller on average than members of groups.

Property-liability insurers that use derivatives have higher proportions of their assets in stocks, real estate, and non-U.S./non-Canadian stocks and bonds than nonusers. Although not significant, commercial long-tail lines (other than products liability) account for a lower proportion of reserves for users than for nonusers, but products liability accounts for a significantly higher proportion of reserves for users. Like life insurers, property-liability users have larger maturity gaps and lower capital-to-asset ratios than nonusers, and users are more likely than nonusers to have an affiliate active in derivatives markets. However, there is no significant difference between mutual and stock property-liability insurers in the use of derivatives. Property-liability derivatives users are more likely to be in the AMT range of the tax schedule than nonusers. Overall, the descriptive statistics provide suggestive evidence in support of many of the authors' hypotheses; in particular the hypothesis that firms with above-

[29] The capital-to-asset ratio is known to be inversely related to size (Titman and Wessels, 1998). The authors control for this correlation in their probit, Tobit, and Cragg models by including size variable.

TABLE 1
Summary of Hypothesis and Variables Used in Regressions

Hypothesis/Variable	Predicted Effect	Signs of Significant Variables: Life Insurers Probit	Life Insurers Volume	P/L Insurers Probit	P/L Insurers Volume
Economies of Scale in Trading Derivatives					
Log(Total Assets)	Positive	> 0	> 0	> 0	
Affliated Member Active in Derivatives Dummy Variable	Positive	> 0	< 0	> 0	< 0
Costs of Financial Distress					
Capital to Asset Ratio	Negative	< 0	> 0	< 0	< 0
Policyholder Surplus to Risk-Based Capital	Ambiguous	[redacted]		> 0	
RBC Ratio is Binding, i.e., Greater Than 200	Ambiguous			[redacted]	
Brokerage Distribution System Dummy Variable	Positive	> 0	< 0		> 0
Asset-Liability Management					
Maturity Gap	Positive		< 0		
Percent of Asset Portfolio in Stocks	Positive	> 0	< 0	> 0	> 0
Percent of Asset Portfolio in Real Estate	Positive		< 0	> 0	< 0
Percent of Asset Portfolio in Publicly Traded CMOs	Positive		< 0		
Percent of Asset Portfolio in Privately Placed Bonds	Positive	> 0	< 0	[redacted]	
Percent of Asset Portfolio in Privately Placed CMOs	Positive	> 0	> 0		
Percent of Asset Portfolio in Non-U.S./Non-Canadian Bonds	Positive		< 0		
Percent of Asset Portfolio in Non-U.S./Non-Canadian Stocks	Positive		> 0		
Foreign Bonds and Stocks Dummy Variable	Positive	[redacted]		> 0	< 0
Foreign Denominated Liabilities Dummy Variable	Positive	< 0		> 0	< 0
(Foreign Bonds and Stocks) × Foreign Liabilities Interaction Term	Negative			< 0	

TABLE 1
(Continued)

Hypothesis/Variable	Predicted Effect	Signs of Significant Variables: Life Insurers Probit	Life Insurers Volume	P/L Insurers Probit	P/L Insurers Volume
Asset–Liability Management					
Percent of LH Reserves in Individual Life and Annuity Reserves	Positive	> 0	> 0		
Percent of Life/Health Reserves in Group Annuities	Positive				
Percent of LH Reserves in Guaranteed Investment Contracts	Positive	> 0	> 0		
Percent of Reserves in Commercial Long-Tail Lines (except Products Liability)	Ambiguous			< 0	
Percent of Reserves in Products Liability	Ambiguous			> 0	
Tax Management					
No Federal Taxes Incurred Dummy Variable, Current Year	Ambiguous			< 0	
No Federal Taxes Incurred Dummy Variable, Previous Year	Positive				
No Federal Taxes Incurred Dummy Variable, Prior 2 Years	Positive	> 0			
Incurred Tax Rate Between AMT and Regular Tax Rate	Positive	> 0	> 0		
Underinvestment Problem					
Percent of LH Premiums Due to Dividends Reinvestment	Negative				
Substitutes/Complements for Derivatives					
Percent of Premiums Ceded to Reinsurers	Ambiguous		> 0	< 0	> 0
Single Unaffiliated Company Dummy	Positive	> 0	< 0	> 0	
Ratio of Preferred Capital Stock to Total Assets	Negative		> 0		
Managerial Risk Aversion					
Mutual Organizational Form Dummy	Positive				< 0
Ratio of Surplus Notes to Total Assets	Negative–substitute for hedging Positive–risk aversion			> 0	> 0

Note: Shading indicates variables that do not appear in the model.

TABLE 2
Summary Statistics: Derivative Users vs. Nonusers

	Life/Health Insurers					Property/Liability Insurers				
	Users		Nonusers			Users		Nonusers		
Variable	Mean	Standard Deviation	Mean	Standard Deviation	Test Statistic: $\mu_r = \mu_u$	Mean	Standard Deviation	Mean	Standard Deviation	Test Statistic: $\mu_r = \mu_u$
Total Notional Amount Transacted During the Year (000000's)	2,629.42	13,055.75				288.845	842.156			
Total Notional Amount Reported Open at End of Year (000000's)	660.95	1,567.43				89.821	212.465			
Total Notional Amount Transacted During the Year Divided by Total Assets	1.1678	5.4279				0.232	0.441			
Total Notional Amount Reported Open at End of Year Divided by Total Assets	0.1213	0.2455				0.082	0.287			
Log(Total Assets)	21.5749	1.8355	17.5811	2.3746	18.657	20.082	1.742	17.568	1.841	13.949
Percent of Asset Portfolio in Stocks	7.53%	13.19%	7.25%	15.16%	0.204	19.31%	16.03%	9.73%	14.21%	6.804
Percent of Asset Portfolio in Real Estate	9.14%	8.57%	6.06%	11.08%	3.086	2.67%	3.62%	1.42%	3.63%	3.487
Percent of Asset Portfolio in Publicly Traded CMOs	12.20%	11.07%	7.78%	13.91%	3.523					
Percent of Asset Portfolio in Privately Placed Commercial Bonds	8.42%	7.54%	1.97%	5.12%	12.879					
Percent of Asset Portfolio in Privately Placed CMOs	0.35%	0.87%	0.06%	0.34%	7.132					
Percent of Asset Portfolio in CMOs						5.16%	7.64%	3.98%	8.50%	1.427
Foreign Denominated Liabilities Dummy Variable	0.1970	0.3992	0.0314	0.1744	8.524	0.235	0.426	0.035	0.185	9.678
Percent of Asset Portfolio in Non-U.S. and Non-Canadian Bonds	2.65%	7.49%	0.53%	2.53%	6.709	1.16%	1.83%	0.34%	1.96%	4.236
Percent of Asset Portfolio in Non-U.S. and Non-Canadian Stocks	0.27%	1.46%	0.11%	1.38%	1.304	0.55%	1.55%	0.09%	0.69%	5.948
(Foreign Bonds and Stocks) × Foreign Liabilities Interaction Term	0.52%	1.27%	0.09%	1.72%	2.790	0.35%	1.13%	0.03%	0.29%	8.079
Foreign Asset Dummy Variable						0.678	0.469	0.225	0.418	10.961
Foreign Assets Dummy Variable × Foreign Liabilities Interaction Term						0.157	0.365	0.017	0.131	8.990
Percent of LH Reserves in Individual Life and Annuity Reserves	52.37%	30.92%	47.11%	38.09%	1.525					
Percent of Life/Health Reserves in Group Annuities	6.60%	11.49%	1.69%	7.73%	6.468					
Percent of LH Reserves in Guaranteed Investment Contracts	5.56%	13.22%	0.37%	3.58%	10.220					

TABLE 2
(Continued)

	Life/Health Insurers					Property/Liability Insurers				
	Users		Nonusers			Users		Nonusers		
Variable	Mean	Standard Deviation	Mean	Standard Deviation	Test Statistic: $\mu_r = \mu_u$	Mean	Standard Deviation	Mean	Standard Deviation	Test Statistic: $\mu_r = \mu_u$
Percent of LH Premiums Due to Dividends Used to Purchase Paid-Up Additions	21.54%	28.96%	18.74%	32.45%	0.947					
Ratio of Reserves for Commercial Long-Tail Lines to Total Liabilities						31.91%	26.20%	34.53%	33.15%	0.814
Ratio of Reserves for Products Liability to Total Liabilities						2.37%	7.36%	0.90%	3.18%	4.149
Percent of Premiums Ceded to Reinsurers	12.78%	15.25%	14.27%	21.39%	0.779	32.56%	24.11%	36.82%	28.33%	1.546
Maturity Gap	6.7582	3.2026	4.9297	4.4254	4.603	6.338	3.417	4.916	4.101	3.567
Ratio of Preferred Capital Stock + Surplus Notes to Total Assets	0.0130	0.0971	0.0158	0.1130	0.271	0.011	0.040	0.011	0.055	0.068
Capital to Asset Ratio	0.1154	0.1182	0.3344	0.2664	9.334	0.333	0.142	0.420	0.208	4.330
Dummy Variable = 1 if the RBC Ratio is Binding	0.0227	0.1496	0.1052	0.3069	3.042					
Policyholder Surplus to Risk-Based Capital						8.901	9.018	14.141	20.385	2.690
Federal Taxes Incurred Dummy, Current Year	0.1212	0.3276	0.2703	0.4443	3.733	0.270	0.446	0.340	0.474	1.519
No Federal Taxes Incurred Dummy, Previous Year	0.0758	0.2656	0.1891	0.3918	3.235	0.148	0.356	0.209	0.406	1.535
No Federal Taxes Incurred Dummy, Prior 2 Years	0.1894	0.3933	0.2177	0.4129	0.748	0.235	0.426	0.247	0.431	0.280
Incurred Tax Rate < Alternative Minimum Tax Rate Dummy	0.2424	0.4302	0.2758	0.4471	0.814	0.374	0.486	0.243	0.429	3.084
Mutual Organizational Form Dummy Variable	0.1439	0.3524	0.0673	0.2507	3.151	0.226	0.420	0.214	0.410	0.305
"Pure" Stock Organizational Form Dummy Variable	0.7121	0.4545	0.5996	0.4902	2.508	0.635	0.484	0.540	0.499	1.934
Single Unaffiliated Company Dummy	0.0833	0.2774	0.2555	0.4364	4.426	0.183	0.388	0.275	0.447	2.122
Direct Writer Dummy Variable	0.0530	0.2249	0.0618	0.2409	0.398	0.270	0.446	0.188	0.391	2.103
Brokerage Distribution System	0.1212	0.3276	0.0803	0.2718	1.596	0.070	0.256	0.091	0.288	0.778
Affiliated Member Active in Derivatives Dummy Variable	0.6136	0.4888	0.0775	0.2675	19.417	0.565	0.498	0.109	0.312	14.197

Note: 1,084 Life nonusers, 118 life insurers transacted during year; 107 life insurers report open interest at end of year
1,557 P&L Nonusers, 111 P&L insurers transacted during year; 77 P&L insurers reported open interest at end of year

average risk exposure will find it beneficial to pay the fixed costs of participating in the derivatives market.[30]

An analysis of life insurer derivatives transactions reveals that both within-year and year-end transactions volume tends to be concentrated in bond and interest-rate derivatives,[31] as expected if insurers are using derivatives to hedge the duration and convexity risk inherent in their balance sheets. The largest category of derivatives for life insurers is interest-rate swaps, followed by interest-rate caps and floors. Life insurers also show significant activity in foreign currency derivatives, consistent with the finding in Table 2 that life insurers using derivatives have significantly higher holdings of foreign bonds than do nonusers. However, the volume of foreign currency transactions is much less than for bond and interest-rate contracts. The leading category of derivatives for property-liability insurers in terms of year-end positions consists of foreign currency contracts, followed by bond and interest-rate derivatives. The largest volume of within-year transactions for property-liability insurers consists of writing equity calls, suggesting that these firms may be engaging in dividend capture transactions.[32] Foreign currency transactions rank second in terms of within-year trading for property-liability insurers.

Tobit Versus Cragg Analysis

The authors first examine the null hypothesis that the relationship between the independent variables and the volume decision is not statistically different from the relationships explaining the participation decision. The dependent variable in the volume regressions is the natural logarithm of the ratio of the notional value of derivatives transactions to total assets. The ratio to total assets is used to control for the size effects and possible heteroskedasticity. The authors estimate both Tobit and Cragg models for the volume decision and compute a likelihood ratio statistic to test the null hypothesis that the coefficient vectors in the two models are the same (see Greene, 1997, p. 970). The test results, available from the authors, overwhelmingly reject the null hypothesis for both types of insurers and for both the within-year and the end-of-year models. Consequently, the authors conclude that Tobit analysis is not appropriate for analyzing the volume decision and report only the Cragg lognormal regression results for the volume decision in the tables.[33]

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[30] The authors also analyzed the bivariate correlation coefficients between the variables used in the regression models as a screen for possible multicollinearity. Although a number of the bivariate correlations are statistically significant, most are quite small and only a few are around 0.5 in absolute value, e.g., the capital-to-asset ratio and the log of assets. The regression results are very stable and are robust to the elimination of correlated variables, i.e., the signs and significances of the remaining variables hold up when various variables are dropped from the regressions.

[31] For more extensive summary statistics on the types of derivatives used by insurers, see Cummins, Phillips, and Smith (1997).

[32] Dividend capture is a covered call strategy that involves the purchase of the security for the sole purpose of receiving the dividend. By simultaneously writing a call option, the insurer is protected should the ex-dividend price fall by more than the amount of the dividend.

[33] The Tobit results generally have nearly the same significant variables (with the same signs) as the probit equations shown in the tables, indicating that the Tobit estimates are primarily driven by the participation decision rather than the volume decision.

The authors also conducted tests for heteroskedasticity in both the probit and lognormal regressions. A likelihood ratio test failed to reject the hypothesis of homoskedasticity for the error term of the probit models (see Greene, 1997, pp. 889-890). Accordingly, no adjustment for heteroskedasticity is made in the probit models. However, the Breusch-Pagan test led to rejection of the hypothesis of homoskedasticity for the lognormal volume regressions. Consequently, the lognormal standard errors reported in the regression tables are based on White's heteroskedasticity consistent covariance estimator.

Multi-Variate Results: Life Insurers

Table 3 shows the probit and lognormal regression models estimated as part of the Cragg analysis. Two sets of equations are shown—based on within-year transactions and year-end positions.

The Participation Decision. Most of the significant variables in the probit models for the probability of participation in derivatives markets are the same for the within-year and end-of-year regressions. The authors discuss these variables first and then discuss differences between the within-year and year-end models.

The coefficients on the log of assets are positive and highly significant, supporting the hypothesis that derivatives activities are subject to scale economies. The positive and significant coefficients on the dummy variable for having an affiliate active in derivatives markets also support the scale economies hypothesis and provide evidence that fixed costs play a role in the decision to use derivatives.

Positive and significant coefficients are obtained on the proportions of assets in stocks, privately placed bonds, privately placed CMOs, and non-U.S./non-Canadian stocks, providing support for the hypothesis that insurers engage in derivatives transactions to manage volatility, liquidity, and exchange-rate risks arising from the asset portfolio. The coefficients on the proportions of liabilities represented by individual life and annuity contracts and GICs are also positive and significant, consistent with the argument that insurers use derivatives to manage interest-rate risk arising from the liability portfolio.[34]

[34] As a robustness check, the authors also conducted the analysis based on insurer participation in markets for specific types of derivatives instruments. The authors estimated three additional probit equations for life insurers—for bond/interest-rate derivatives, equity derivatives, and foreign exchange derivatives. The dependent variables were set equal to one if the insurer is a user of a specific type of derivatives and to zero otherwise. These instrument-specific results indicate that the overall regression results can generally be interpreted as implying that insurers use specific instruments to hedge risks related to these instruments. For example, the proportion of assets in stocks is significant in the equity probit equation but not significant in the interest-rate or foreign exchange probit models. The privately placed bond variable is significant in the interest-rate derivatives probit equation but not in the equity derivatives equation. The CMO variable is significant in the interest-rate probit model but not in the equity or foreign exchange models, and the non-U.S./non-Canadian stock variable is significant in the foreign exchange probit model but not in the equity or interest-rate models. The GIC variable is significant in the interest-rate risk probit model but not in the equity or foreign exchange models.

TABLE 3
Cragg Regression Results: Life/Health Insurers

Variable	Within-Year Transactions Probit	Within-Year Transactions Lognormal	Year-End Positions Probit	Year-End Positions Lognormal
Intercept	–8.584 ***	–3.515	13.544 ***	–8.449***
	(6.584)	(0.999)	(7.932)	(2.952)
Log(Total Assets)	0.305***	0.157	0.530***	0.266**
	(5.309)	(0.983)	(7.034)	(2.082)
Percent of Asset Portfolio in Stocks	2.549***	–1.323	2.277**	–7.037**
	(2.807)	(0.310)	(2.153)	(2.159)
Percent of Asset Portfolio in Real Estate	–0.068	–5.407	–0.269	–4.570*
	(0.074)	(1.540)	(0.243)	(1.745)
Percent of Asset Portfolio in Publicly Traded CMOs	–0.141	–8.545***	0.825	–3.703*
	(0.232)	(3.549)	(1.180)	(1.878)
Percent of Asset Portfolio in Privately Placed Commercial Bonds	2.684**	–7.599**	3.511***	–4.741*
	(2.483)	(2.205)	(2.951)	(1.672)
Percent of Asset Portfolio in Privately Placed CMOs	36.215***	29.118*	36.907***	14.073
	(3.083)	(1.811)	(2.969)	(1.086)
Foreign Denominated Liabilities Dummy Variable	0.053	–0.305	–0.560*	–0.418
	(0.194)	(0.497)	(1.820)	(0.643)
Percent of Asset Portfolio in Non-U.S. and Non-Canadian Bonds	1.819	–3.179**	–0.742	1.565
	(1.226)	(2.398)	(0.404)	(0.448)
Percent of Asset Portfolio in Non-U.S. and Non-Canadian Stocks	9.614***	–0.214	12.323***	-4.458
	(2.586)	(0.016)	(3.153)	(0.612)
(Foreign Bonds and Stocks) × Foreign Liabilities Interaction Term	–5.700	15.281	–0.284	–0.068
	(1.377)	(0.573)	(0.077)	(0.003)
Percent of LH Reserves in Individual Life and Annuity Reserves	0.600**	0.870	0.715**	1.391*
	(1.980)	(0.927)	(2.085)	(1.910)
Percent of Life/Health Reserves in Group Annuities	0.675	–1.921	0.531	-0.904
	(0.977)	(0.891)	(0.623)	(0.472)
Percent of LH Reserves in Guaranteed Investment Contracts	1.978*	6.464***	3.314**	8.016***
	(1.937)	(3.518)	(2.518)	(5.781)
Percent of LH Premiums Due to Dividends Used to Purchase Paid-Up Additions	–0.416	0.930	–0.079	0.391
	(1.506)	(1.152)	(0.266)	(0.663)

TABLE 3
(Continued)

Variable	Within-Year Transactions Probit	Within-Year Transactions Lognormal	Year-End Positions Probit	Year-End Positions Lognormal
Percent of Premiums Ceded to Reinsurers	0.321	–0.183	–0.063	3.089***
	(0.741)	(0.124)	(0.121)	(2.952)
Maturity Gap	0.030	–0.195***	0.007	–0.186***
	(1.370)	(2.821)	(0.271)	(3.363)
Ratio of Preferred Capital Stock to Total Assets	0.335	193.100***	4.559	122.370***
	(0.037)	(2.908)	(0.655)	(4.226)
Ratio of Surplus Notes to Total Assets	–1.932	1.488	–0.159	–0.090
	(1.000)	(0.131)	(0.220)	(0.116)
Capital to Asset Ratio	–2.181**	6.153	–0.969	9.689***
	(2.057)	(1.439)	(0.804)	(2.614)
Dummy Variable = 1 if the RBC Ratio is Binding	–0.823	1.216	–0.780	0.554
	(1.623)	(1.511)	(1.400)	(0.898)
No Federal Taxes Incurred Dummy, Current Year	0.122	0.486	–0.049	–0.202
	(0.475)	(0.613)	(0.153)	(0.338)
No Federal Taxes Incurred Dummy, Previous Year	–0.190	–0.391	0.002	0.631
	(0.744)	(0.339)	(0.008)	(0.732)
No Federal Taxes Incurred Dummy, Prior 2 Years	0.309	–0.410	0.528**	–0.429
	(1.481)	(0.660)	(2.173)	(0.956)
Incurred Tax Rate < Alternative Minimum Tax Rate Dummy	0.403**	0.384	0.628***	0.792*
	(2.089)	(0.698)	(2.887)	(1.840)
Mutual Organizational Form Dummy Variable	–0.036	–0.408	–0.213	–0.263
	(0.144)	(0.751)	(0.728)	(0.615)
Single Unaffiliated Company Dummy	0.398*	–1.778**	0.053	–0.794
	(1.716)	(2.311)	(0.169)	(1.299)
Brokerage Distribution System	0.597**	–0.738	0.214	–1.400**
	(2.424)	(0.872)	(0.729)	(2.384)
Affiliated Member Active in Derivatives Dummy Variable	1.373***	–0.978**	1.278***	–0.378
	(7.756)	(1.971)	(6.575)	(0.853)
Log Likelihood Function	–188.515	104.926	–150.474	158.735
Adjusted R^2	51.33%	19.85%	58.46%	21.29%

Note: Absolute values of t-statistics shown in parentheses. White heteroskedasticity consistent standard errors are used in computing t-values for the lognormal regressions. *Significant at the 10 percent level; **Significant at the 5 percent level; ***Significant at the 1 percent level. 118 insurers transacted in derivatives during the year, 107 insurers reported positive notional values at the end of the year. 1,098 insurers did not transact in derivatives during the year; 1,109 insurers reported no open positions at the end of the year. Probit R^2 statistic is a pseudo R^2 measure. See Greene (1997), p. 891, for details.

The dummy variable set equal to one if the risk-based capital ratio is binding is not statistically significant in any of the regressions. It has a positive sign in the volume regressions, consistent with expectations, but has a negative sign in the probit regressions. The risk-based capital ratio was not significant and was not included in the final version of the regressions shown in Table 3. The insignificance of the RBC variables may be because the risk-based capital system was newly adopted for life insurers in 1994. It may also reflect the inaccuracy of the risk-based capital formula in predicting insolvency or the avoidance of derivatives by financially vulnerable firms to avoid incurring regulatory costs.

The results generally support the hypothesis that hedging is motivated by the corporate income tax. The dummy variable for no federal taxes in the second year before the regression year is positive and significant in the year-end regression, providing support for the hypotheses that insurers engage in hedging to avoid losing tax loss carry-forwards. Positive and significant coefficients on the dummy variable for having an incurred tax rate in the AMT range provide support for the hypothesis that derivatives usage is motivated by convexity of the income tax schedule.

Neither of the organizational form dummy variables that the authors tested—for mutuals and publicly traded stocks—is statistically significant. Thus, the authors do not find evidence consistent with the hypothesis that mutuals, closely held stocks, or publicly traded stocks behave differently with respect to the use of derivatives. This would be consistent with operating in a competitive market where buyers are sensitive to insolvency risk, such that firms are motivated to strive for solvency risk targets in order to succeed.

A few other variables are significant in only one of the probit regression models shown in Table 3. The capital-to-asset ratio is negative and significant in the within-year regression and negative but insignificant in the end-of-year regression. The results thus provide some support for the hypothesis that well-capitalized insurers are less likely to use derivatives because their probability of incurring distress costs is relatively low and suggests that derivatives and capital may be viewed as substitutes by some insurers. The unaffiliated single firm dummy is positive and significant at the 10 percent level in the within-year regression, consistent with the hypothesis that unaffiliated firms use derivatives more than groups because they cannot protect their overall capital from specific risks by placing those risks in separate insurers. The brokerage distribution system variable is positive and significant in the within-year probit model, supporting the hypothesis that insurers distributing insurance through brokers are more sensitive to the need to manage risk than are insurers using tied distribution systems. Contrary to expectations, the foreign denominated liabilities dummy variable is negative and significant (at the 10 percent level) in the year-end regressions.

The Volume Decision. Consistent with the marginal cost hypothesis set forth earlier, the lognormal volume regressions provide evidence that, conditional on being in derivatives, firms with more tolerance for risk choose to hedge relatively less than firms with lower risk tolerance. For example, the proportion of assets in privately placed bonds is positive in the participation (probit) regressions, but this variable is negative and significant in the volume regressions. The proportion of assets in stocks follows the same pattern, except that the stock variable is not significant in the within-year volume regression. Weaker support for the hypothesis is provided by the capital-to-asset variable. This variable is negative and significant in the within-year probit regressions, positive but not significant in the within-year volume regressions, and positive and significant in the end-of-year volume regressions.

The unaffiliated company dummy variable is positive and (weakly) significant in the within-year probit equation and negative and significant in the within-year volume regression. This finding is consistent with the authors' marginal costs hypothesis if unaffiliated firms have a higher tolerance for risk than affiliates, i.e., they are more likely to participate in derivatives markets because they cannot insulate their overall capital from specific risks but have higher risk tolerance because they expose buyers to less default risk than they would encounter in buying from a comparable group.[35]

The proportion of assets in publicly traded CMOs is negative and significant in both the within-year and end-of-year volume regressions. This finding could be interpreted as providing further support for the marginal costs hypothesis, and/or it could reflect the lower liquidity risk of publicly traded relative to privately placed CMOs, an interpretation that is reinforced by the positive and significant coefficient on the privately placed CMO variable in the within-year volume regression.

It is to be emphasized that the result with privately placed CMOs, i.e., a positive coefficient in both the participation and the volume regressions, is not necessarily inconsistent with the authors' marginal costs hypothesis. The reasoning behind the hypothesis suggests that the aversion to marginal costs may be overcome if there is a particularly compelling reason to hedge the risk of specific assets or liabilities. The fact that CMOs are considered to be especially risky investments may account for the different signs on privately placed bonds and CMOs in the volume regressions.

The GIC variable also is positive and significant in both the participation and the volume regressions. The authors have two, non-mutually exclusive explanations for this result. The first is that purchasers of GICs tend to be more sophisticated investors, on average, than the purchasers of other life insurer products. Accordingly, they may engage in more active monitoring of firm risk and hedging decisions than other investors, imposing a market penalty on insurers that under-hedge their GIC exposure. The second explanation is that an insurer's liability (product) portfolio is less likely than its asset portfolio to provide an indicator of risk tolerance. A wide range of historical, managerial, and strategic considerations having little to do with risk tolerance play a role in determining the products an insurer emphasizes. Thus, while the proportion of assets in stocks or privately placed bonds may convey significant information about risk tolerance, the firm's product portfolio is likely to be determined largely by other factors. The positive and significant coefficient on the individual life and annuity reserves variable in the year-end volume regression is also consistent with this interpretation.

The maturity gap variable is negative and significant in both the within-year and end-of-year volume regressions, suggesting that insurers with larger maturity gaps

[35] The default risk argument is developed in more detail in Cummins and Sommer (1996), who also provide empirical evidence that unaffiliated firms tend to have relatively high risk tolerance.

may have more risk tolerance than insurers with smaller maturity gaps. The dummy variable for having an incurred tax rate in the AMT range is positive and significant at the 10 percent level in the year-end volume regression, providing additional evidence that being in the convex segment of the tax schedule motivates insurers to hedge.

The proportion of premiums ceded to reinsurers is positive and significant in the end-of-year volume regression, providing some evidence that insurers view reinsurance and derivatives as complements, i.e., that insurers with relatively low risk tolerance are likely to use more derivatives and more reinsurance. An alternative interpretation that cannot be ruled out on the basis of the authors' data is that insurers with better reinsurance hedges use derivatives to take more risk for speculative purposes. A variable with similar implications is the preferred-stock to assets ratio, which is positive and significant in the volume regressions.

As expected, the "active affiliate" dummy variable is negative and significant in the within-year lognormal regression, whereas it was positive and significant in the within-year probit model. Thus, conditional on size, the transactions volumes of individual affiliates are likely to be less if other group members are also active in derivatives.

Finally, the brokerage distribution system dummy variable is negative and significant in the year-end volume regressions. The authors' analysis of life insurers using brokers versus those using other distribution systems reveals that the brokerage firms take less risk, based on a large number of asset and liability risk indicators. Consequently, the lower volume of derivatives usage for these firms seems to reflect the fact that they have less need to use derivatives to hedge than firms using other distribution systems, i.e., the variable is picking up the lower risk of these firms that is not accounted for by other variables.

Overall, the results provide support for the hypotheses that insurers engage in derivative transactions to reduce the expected costs of financial distress, manage interest-rate, exchange rate, and liquidity risk, and minimize expected tax liabilities. However, the results provide no support for the hypothesis that the managers of mutual life insurers behave differently from managers of publicly traded or closely held stock insurers. This could reflect the offsetting effects of the managerial risk aversion and managerial discretion hypotheses (see above) and/or indicate that differences among firms in managerial risk tolerance have been captured by the other independent variables in the regressions.

Multi-Variate Results: Property-Liability Insurers

The probit and lognormal regression results for property-liability insurers are shown in Table 4. As above, the authors first discuss the participation decision and then turn to a discussion of the volume decision.

The Participation Decision. The discussion in this section applies to variables that are significant in both the within-year and end-of-year probit regressions unless specifically indicated.

The property-liability models provide further support for the hypothesis that there are economies of scale in running derivatives operations. The log of total assets has a highly significant positive coefficient, and the "active affiliate" dummy variable is also positive and significant.

TABLE 4
Cragg Regression Results: Property/Liability Insurers

Variable	Within-Year Transactions Probit	Within-Year Transactions Lognormal	Year-End Positions Probit	Year-End Positions Lognormal
Intercept	–7.062***	–2.119	–7.656*	–3.631
	(6.934)	(0.574)	(6.458)	(1.034)
Log(Total Assets)	0.270***	0.022	0.286***	0.108
	(5.340)	(0.115)	(4.854)	(0.564)
Percent of Asset Portfolio in Stocks	2.357***	0.981	2.276***	5.958***
	(4.728)	(0.596)	(4.002)	(3.083)
Percent of Asset Portfolio in Real Estate	5.829***	–9.126*	2.434	0.030
	(4.119)	(1.814)	(1.107)	(0.004)
Percent of Asset Portfolio in CMOs	1.018	–1.513	–0.095	–0.677
	(1.351)	(0.513)	(0.088)	(0.173)
Foreign Denominated Liabilities Dummy Variable	0.893***	–2.079	0.344	–1.838
	(2.986)	(2.017)	(0.929)	(0.967)
Foreign Asset Dummy Variable	0.538***	–0.744*	0.553***	–0.774
	(3.665)	(1.685)	(3.185)	(1.212)
Foreign Assets Dummy Variable × Foreign Liabilities Interaction Term	–0.729*	1.112	–0.107	0.426
	(1.919)	(1.033)	(0.245)	(0.233)
Ratio of Reserves for Commercial Long-Tail Lines to Total Liabilities	–0.783***	-0.499	–0.645**	–0.929
	(3.119)	(0.639)	(2.279)	(1.203)
Ratio of Reserves for Products Liability to Total Liabilities	4.034***	–2.061	1.654	–3.082
	(3.203)	(0.950)	(0.956)	(0.648)
Percent of Premiums Ceded to Reinsurers	–0.486*	0.965	–0.197	3.280***
	(1.705)	(1.093)	(0.605)	(3.605)
Maturity Gap	0.011	–0.023	–0.011	0.024
	(0.609)	(0.371)	(0.508)	(0.306)
Ratio of Surplus Notes to Total Assets	2.216*	–10.337	–7.619	27.250*
	(1.801)	(1.188)	(0.959)	(1.717)
Ratio of Preferred Stock to Total Assets	0.263	8.534	3.150	–3.578
	(0.047)	(1.595)	(0.534)	(0.558)
Capital-to-Asset Ratio	–1.425**	–1.475	–1.298*	–8.593***
	(2.374)	(0.664)	(1.875)	(2.765)
Policyholder Surplus to Risk-Based Capital	0.008*	–0.017	0.008	0.041
	(1.727)	(0.528)	(1.501)	(1.210)

TABLE 4
(Continued)

Variable	Within-Year Probit	Transactions Lognormal	Year-End Probit	Positions Lognormal
No Federal Taxes Incurred Dummy, Current Year	–0.306*	–0.270	–0.342*	–0.070
	(1.855)	(0.548)	(1.739)	(0.116)
Ratio of Preferred Capital Stock to Total Assets	–0.139	0.068	–0.007	0.137
	(0.906)	(0.147)	(0.039)	(0.265)
Mutual Organizational Form Dummy Variable	–0.050	0.542	0.130	–0.946**
	(0.307)	(1.334)	(0.700)	(1.966)
Single Unaffiliated Company Dummy	0.903***	–0.283	1.050***	–0.496
	(4.824)	(0.498)	(4.612)	(0.708)
Brokerage Distribution System	–0.324	1.799**	–0.120	0.483
	(1.364)	(2.545)	(0.460)	(0.439)
Affiliated Member Active in Derivatives Dummy Variable	1.226***	0.565	1.313***	–1.285**
	(7.518)	(1.092)	(6.865)	(2.239)
Log Likelihood Function	–241.944	105.150	–183.310	146.439
Adjusted R^2	40.70%	2.39%	41.25%	11.59%

Note: Absolute values of t-statistics shown in parentheses. White heteroskedasticity consistent standard errors are used in computing t-values for the lognormal regressions.*Significant at the 10 percent level; **Significant at the 5 percent level; ***Significant at the 1 percent level. 111 insurers transacted in derivatives during the year, 77 insurers reported positive notional values at the end of the year. 1,557 insurers did not transact in derivatives during the year; 1,591 insurers reported no open positions at the end of the year. Probit R^2 statistic is a pseudo R^2 measure.
See Greene (1997), p. 891, for details.

The hypotheses that insurers use derivatives to manage asset volatility and/or engage in dividend capture strategies are supported by the significant positive coefficients on the proportion of the asset portfolio in stocks. The hypothesis that insurers use derivatives to hedge exchange-rate risk is supported by the significant positive coefficient on the foreign-asset exposure dummy variable. Further support is provided by the positive coefficient on the foreign liabilities dummy variable in the within-year regression. The coefficient on the interaction of the foreign assets and foreign liabilities dummy variables is statistically significant (at the 10 percent level) and negative in the within-year equation, consistent with the argument that having exposure to both foreign assets and foreign liabilities creates a natural foreign currency hedge. The hypothesis that insurers use derivatives to manage liquidity risk is supported by the real estate variable in the within-year probit regression.[36]

The equity capital-to-asset ratio is statistically significant and negative in both property-liability insurer probit regressions, consistent with the hypothesis that insurers engage in derivatives transactions to reduce the expected costs of financial distress. The ratio of actual equity capital to risk-based capital (RBC) is significant at the 10 percent level in the within-year probit model with a positive coefficient, suggesting that insurers are less likely to use derivatives the closer they are to the RBC threshold, perhaps to avoid regulatory costs due to regulator skepticism about derivatives. Another explanation is that firms with relatively high RBC ratios have lower tolerance for risk and are thus more likely to hedge using derivatives.

The dummy variable, set equal to one if no taxes are incurred in the current year, is statistically significant (at the 10 percent level) with a negative coefficient. This would be consistent with the hypothesis that insurers hedge to avoid the loss of tax loss carry-forwards, if paying no current taxes suggests that unused loss carry-forwards are not large enough to motivate hedging. This variable also could be serving as an indicator variable for insurers that have been especially successful in tax management, consistent with prior research indicating that property-liability insurers have been very successful over a long period of time in hitting their taxable income targets by using the underwriting loss tax shelter and tax favored investments (Grace, 1990; Cummins and Grace, 1994). The difference between this result and the stronger results with the tax variables in the life insurer regressions probably reflects the fact that life insurers rarely incur underwriting losses, which provide an important tax shelter for property-liability insurance firms. The proportion of reserves accounted for by products liability insurance is positive and statistically significant in the within-year probit regression, whereas the proportion of reserves accounted for by other

[36] As for life insurers, the authors also conducted the analysis separately for property-liability insurer participation in the markets for interest rate/bond derivatives, equity derivatives, and foreign exchange derivatives. The results are weaker than for life insurers but are generally consistent with the argument that insurers use specific types of contracts to hedge risks reflected in those contracts. For example, the proportion of assets in stocks is significant in the equity derivatives probit model but not in the interest-rate or foreign exchange models; and the foreign asset dummy variable is significant in the foreign exchange and equity derivatives model but not in the interest-rate derivatives model. The mutual dummy variable is statistically significant and positive in the equity derivatives probit model, providing some support for the managerial risk aversion hypothesis that mutuals hedge more than stocks.

commercial long-tail lines is negative and significant in both the within-year and year-end probits. The product liability result suggests that insurers that are active writers of products liability insurance have an incentive to hedge the high volatility inherent in this coverage. Such hedges can be constructed by transacting in derivatives on the stocks of their insured policyholders.[37] The negative sign on the non-products liability commercial variable is consistent with the argument that reserves in the lower-risk long-tail lines provide a natural hedge against the duration risk of the asset portfolio.

The ceded reinsurance variable is negative and weakly significant in the property-liability insurer within-year participation regression, whereas it was insignificant in the life insurer probit models. The negative sign on this variable is consistent with the hypothesis that firms that hedge their underwriting exposure have lower overall risk levels and therefore have less need to pay the fixed costs of entering the market for financial derivatives. The result is also consistent with the finding that insurers appear to hedge products liability risk using derivatives, because reinsurance would be another way to manage the risk of products liability losses.

The unaffiliated single company dummy variable has a highly significant positive coefficient, consistent with the hypothesis that unaffiliated companies cannot protect their capital from specific risks by placing those risks in separate insurers. Because property-liability insurers experience more volatility in their losses and operating income than do life insurers, the ability to shield capital from certain types of risks through the group organizational form may be more important for property-liability insurers, leading to the strong significance of the variable here, whereas it was weakly significant in the within-year life insurer participation model.[38] The ratio of surplus notes to total assets is significant (at the 10 percent level) and positive in the within-year probit regression. This supports the hypothesis that the use of surplus notes reflects managerial risk aversion but is not consistent with the view that the use of such subordinated claims is a substitute for hedging.

The Volume Decision. The volume regressions for property-liability insurers provide some additional support for the authors' hypothesis that, conditional on being in the derivatives market, firms with higher tolerance for risk will demand lower quantities of derivatives due to the marginal costs of hedging. The foreign liabilities dummy variable is positive and significant in the within-year probit equation but negative and significant in the within-year volume regression. The real estate vari-

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[37] For example, an insurer writing a products liability policy on a drug manufacturer could hedge the risk of lawsuits by taking a derivatives position in the manufacturer's stock. This might be especially effective in hedging the risk of products liability losses that affect many of the manufacturer's customers simultaneously, such as those resulting from unforeseen side effects of a particular drug. The positive coefficient on the products liability variable also is consistent with the DeMarzo and Duffie (1995) hypothesis that managers hedge to provide a less noisy signal of managerial quality to shareholders.

[38] For example, several insurers have set up subsidiaries to write property insurance in Florida and California because of the risk of catastrophic loss due to hurricanes and earthquakes. If a major catastrophe were to wipe out the equity of a subsidiary, the parent insurer would not be required to post additional capital, unlike the case in which the parent insurer were to write the property insurance policy.

able and the foreign asset dummy variable provide additional but weaker support for the hypothesis. Thus, although further research is clearly needed into this marginal costs hypothesis, the authors' results suggest that the hypothesis may help to explain the demand for derivatives by both life and property-liability insurers. However, the proportion of assets in stocks is positive in both the participation and volume regressions and is statistically significant in the end-of-year volume regression. This would be consistent with property-liability insurers primarily writing equity derivatives for dividend capture and/or for volatility management.

As for life insurers, the proportion of premiums ceded to reinsurers is positive and highly significant in the end-of-year volume regression for property-liability insurers. This provides additional evidence that insurers tend to view reinsurance and derivatives as complements, i.e., that they use the two types of hedging devices to deal with different risks or perhaps different loss layers or ranges for the same risks.

The ratio of surplus notes to assets is positive and significant at the 10 percent level in the year-end volume regression. This is consistent with the interpretation that this variable is proxying for managerial risk aversion. The alternative interpretation—that managers take advantage of the added capitalization to speculate in derivatives—seems unlikely considering the negative sign on the capital-to-asset ratio. Thus, the authors believe that the surplus notes variable supports the managerial risk-aversion hypothesis. The fact that surplus notes are significant for property-liability but not for life insurers may again reflect the higher underwriting risk in the property-liability industry, which provides a strong motivation for risk-averse managers to raise and hold additional levels of capital.

The mutual dummy variable is negative and significant in the end-of-year lognormal regression providing some support for the hypothesis that mutual managers are less likely to engage in a large, complex derivatives book of business consistent with the managerial discretion hypothesis.

Although the broker dummy variable is insignificant in the probit models for property-liability insurers, it is significant and positive in the within-year volume regression. This provides some support for the hypothesis that insurers are motivated to hedge as a signal of financial quality to independent distributors. Unlike life insurers, property-liability insurers using brokers do not seem markedly different from insurers using other distribution systems in terms of asset and liability risk indicators. Consequently, the higher volume of derivatives transactions would be consistent with lower risk tolerances for this group of firms. The authors would not necessarily expect life and property-liability insurers using brokers to behave identically because of the inherently different risks in the two industry segments.

CONCLUSION

In this article, the authors formulate and test a number of hypotheses regarding insurer participation and volume decisions in derivatives markets. The authors base their hypotheses on the financial theories of corporate risk management that have developed over the past several years. The two primary, and non-mutually exclusive, strands of the theoretical literature hold that corporations are motivated to hedge in order to increase the welfare of shareholders and/or managers.

The authors' results provide considerable support for the hypothesis that insurers hedge to maximize value, on the basis of the signs and significance levels of a range of variables proxying for various value-maximizing motives for hedging. Several specific hypotheses are supported by the authors' analysis. The authors find evidence that insurers are motivated to participate in derivatives markets to reduce the expected costs of financial distress—the decision to use derivatives is inversely related to the capital-to-asset ratio for both life and property-liability insurers. The authors also find evidence that insurers use derivatives to hedge asset volatility, liquidity, and exchange-rate risks. 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. Finally, the authors provide support for the hypothesis that there are significant economies of scale in running derivatives operations. Thus, only large firms and/or those with higher-than-average risk exposure would find it worthwhile to pay the fixed cost of setting up a derivatives operation.

Interestingly, however, the authors find that, conditional on being a user of derivatives, the relationship between the volume of derivatives activities and these same risk measures often displays a result exactly opposite to those found in the participation regression. The authors argue that this result is broadly consistent with the hypothesis that there is also a per unit risk premium associated with hedging and that, conditional on having risk exposures large enough to warrant participation, firms with a larger appetite for risk will be less willing than average to pay this marginal cost. Such firms, therefore, have larger-than-average risk exposure (lower-than-average derivatives positions) *vis à vis* the subgroup of insurers that use derivatives, who themselves may be, on average, higher-risk firms than nonusers.

The authors' analysis provides only weak support for the utility maximization hypothesis. The only variable that carries significant implications about this hypothesis is the ratio of surplus notes to assets, which is positively but weakly related to both the participation and volume decisions for property-liability insurers. Because surplus notes are used primarily by mutuals, this finding is consistent with risk-averse mutual managers raising capital through surplus notes as well as hedging risk using derivatives. However, the authors also find that the mutual dummy variable is inversely related to derivatives volume for property-liability insurers, consistent with the managerial discretion hypothesis. More definitive tests of the utility maximization hypothesis using variables such as the composition of boards of directors, incentive compensation plans, and (for stocks) the distribution of stock ownership provide promising areas for future research.

The authors' conclusion that insurers with higher-than-average asset risk exposures use derivative securities has important implications for insurance regulation. State regulators periodically consider imposing additional regulations on the use of derivatives by insurers, and this issue is likely to receive additional federal attention in the ongoing debate over state versus federal regulation. While more work is clearly needed regarding the net effect of derivatives on the risk profile of insurers, the authors' work suggests that derivatives can be used to improve the risk-return efficiency of the insurance market. Restricting derivatives could increase risk for some insurers now participating in derivatives markets and would reduce the ability of other insurers to access this source of risk management. The findings are also relevant in terms of reporting requirements imposed by state insurance regulators, the Financial Accounting Standards Board, and the Securities and Exchange Commission. More detailed and accurate reporting is likely to be beneficial in facilitating market monitoring of insurer derivatives activities.

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