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Costly Risk Bearing and the Supply of Catastrophic Insurance

Anne E. Kleffner
Neil A. Doherty

Abstract

Efficient contracts for sharing risk will allocate risk according to comparative advantage. This article considers insurance markets for earthquake risk and how comparative advantage in risk bearing can explain the amount of business individual insurers write. The respective abilities of insurers to write this risk depend on the characteristics of their entire portfolio as well as on financial features that influence the costs of risk bearing. Several recent contributions have shown why risk is costly to corporations such as insurers. The costs of risk arise from tax convexity, principal agent relationships within the firm, and the costs of financial distress. We will show how these types of features jointly determine the capacity of insurers to write earthquake insurance. We derive and estimate a cross-sectional model of earthquake insurance, and the results support the hypothesis that firms with a higher imputed cost of risk bearing assume less earthquake risk.

Introduction

Efficient contracts for sharing risk will allocate risk according to comparative advantage. For many insurance contracts, the comparative advantage is straightforward. The policyholder faces the prospect that she can lose a significant proportion of her wealth by single events such as car crashes, illnesses, and home accidents. In contrast, the insurer spreads its risk over tens of thousands of such exposures and, with such numbers, can rely on a predictable proportion of policies producing a predictable average loss. In short, the policyholder is undiversified whereas the insurer is diversified.

This comparative advantage is established only in the event that the correlation of losses between insureds is low. Earthquakes do not fit this description. The high correlations between the claims on the insurer's policies will (in the limit)

Anne E. Kleffner is Associate Professor of Insurance and Risk Management at the University of Calgary. Neil A. Doherty is Ronald A. Rosenfeld Professor in the Wharton School at the University of Pennsylvania.

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equalize the costs of risk bearing for the insurer and insured. But the insurer's comparative advantage is not necessarily entirely removed. Correlations are not perfect; while the same earthquake will affect a large proportion of policies in any seismic zone, structures will have very different levels of damage. This feature alone offers some degree of diversification. Further opportunities for diversification of this risk are present when the insurer writes policies in different locations (earthquake risk near the San Andreas system in California may have zero correlation with earthquake risk on the New Madrid fault in the midwest). Still further opportunities for diversification are available to the insurer that pools earthquake insurance with other lines of business such as fire, automobile, and liability insurance.

Insurance markets for earthquake risk can, and do, exist. The players in this market, and the amount of business they write, may still be explained by comparative advantage. However, the respective abilities of insurers to write this risk depend not simply on their ability to write large numbers of policies, but on the characteristics of their entire portfolio as well as on financial features that influence the costs of risk bearing. Several recent contributions have shown why risk is costly to corporations such as insurers. The costs of risk arise from tax convexity, principal agent relationships within the firm, and the costs of financial distress. This article addresses how these types of features jointly determine the capacity of insurers to write insurance for catastrophic losses, using earthquake as a specific example. From this we estimate a cross-sectional model of earthquake insurance which emphasizes the differing capacity of insurers to write this line of business.

THE COST OF RISK TO INSURERS

One of the major effects of writing insurance for earthquake losses is the increase in the variance of insurers' cash flows due to correlated losses and uncertainty regarding the parameters of the loss distribution. The extent to which such an increase in risk matters has been debated. According to modern financial theory—and, in particular, the capital asset pricing model (CAPM) and the arbitrage pricing theory (APT)—diversifiable risk is not priced in the capital market. Stakeholders will receive a risk premium for bearing systematic risk but not unsystematic risk, because the latter is diversifiable and therefore not priced. These theories imply that decreasing risks at the corporate level that are diversifiable at the portfolio level will not benefit stockholders because such company-specific risks can be efficiently managed by diversifying their asset holdings.

More recently, it has been argued that large, unmanaged, unsystematic risks can decrease the value of the firm by lowering the level of expected cash flows (Mayers and Smith, 1982; Smith and Stulz, 1985; Shapiro and Titman, 1985; and Cornell and Shapiro, 1987). Modigliani and Miller (1958) show that, "If there are no taxes, no transactions costs, and if the firm's real investment activities are fixed, then the firm's financial decisions will not affect firm value." However, this proposition can be restated in order to understand how management of total risk *can* affect value: If financial decisions affect value, they must do so by their impact on transaction costs, taxes, or investment decisions (Smith, 1991). Total risk lowers expectations about future cash flows by increasing the probability of suffering financial distress. This can decrease value by increasing firms' contracting costs with customers, suppliers, and employees. For example, it may diminish customer confidence, leading to reduced sales and a reduced level of operating cash flows. Also, employees will demand higher compensation in order to compensate for their ill diversified income stream (Reagan and Stulz, 1983; Shapiro and Titman, 1985; Cornell and Shapiro, 1987; Smith, Smithson, and Wilford, 1990).

An increase in risk can also give rise to management incentives that conflict with interests of other stakeholders. For example, under pressure from stockholders, managers may choose high-risk investment projects that redistribute wealth from policyholders to equityholders (Jensen and Meckling, 1976; Galai and Masulis, 1976; Myers, 1977; and Shapiro and Titman, 1985). Finally, the variance of corporate earnings can modify a firm's expected cash flows by affecting its ability to take full advantage of tax credits and writeoffs (DeAngelo and Masulis, 1980) and, given a convex tax function, the firm can decrease its expected tax liability by decreasing the variance of its income (Smith and Stulz, 1985; Smith, Smithson, and Wilford, 1990).

The literature on corporate hedging practices and the relevance of risk for the firm suggests that the cost of risk bearing to the insurer will be a function of firm characteristics that influence transaction costs, taxes, or investment decisions. The empirical evidence that tests the relevance of risk for the firm generally supports the expected relationships between risk and firm characteristics. Mayers and Smith (1990) find that firms owned by less diversified investors and smaller firms tended to reduce their risk by purchasing reinsurance. The findings of Booth, Smith, and Stolz (1984) suggest that savings and loans (S&Ls) were much more likely to use interest rate futures than were banks, and the reasons they offered had to do with size (S&Ls were larger) and the fact that S&Ls had a higher probability of facing interest rate–induced financial distress.[1] Block and Gallagher (1986) also find that larger firms were more likely to use interest rate futures and options.

Nance, Smith, and Smithson (1993) examine the use of forwards, futures, swaps, and options for different firms. They find that firms that hedged had larger investment tax credits, larger tax loss carryforwards, and more of the range of pretax income in the convex region of the tax schedule. In addition, larger firms, firms with higher debt/equity ratios, and firms with a wider range of investment projects available were more likely to hedge. Froot, Scharfstein, and Stein (1994) examine the cost associated with unfunded negative draws (foreign exchange losses, uninsured property or liability losses, etc.) which can crowd out planned investment projects. They cite evidence that such unfunded shocks usually displace new investment at a rate of 35 cents per dollar. Lamm-Tennant and Starks (1993), Smith and Stutzer (1990), and Mayers and Smith (1988) look specifically at the relationship between organizational form and risk level. All three find that stock insurers generally have higher risk levels than mutuals.

[1]The costs of financial distress are expected to be higher for smaller firms because of fixed bankruptcy costs.

This article provides further evidence of the relevance of risk for the firm. The next section presents a model that shows the effect of risk on the value of the firm. This is followed by a discussion of the firm characteristics hypothesized to affect the firm's cost of risk bearing. These characteristics are then used to empirically test whether a firm's cost of risk bearing is negatively related to the amount of undiversifiable risk it is willing to assume in its underwriting portfolio, as measured by its exposure due to a catastrophic earthquake.

Value Maximization Given Costly Risk Bearing

The literature on corporate hedging practices and the relevance of risk for the firm suggests a model of the insurer that takes into account the various costs of risk. Assume that the insurer maximizes its market value, which is described by a single-period, multifactor asset pricing model (see Doherty, 1991) as follows:

$$V = E(Y) - \delta \, COV\,(Y, M), \tag{1}$$

where Y = the terminal value of the firm,
$E(\cdot)$ = the expectations operator,
$COV\,(Y, M)$ = the vector of covariances between Y and the returns on priced factors M, and
δ = the vector of prices of these factors.

The terminal value, Y, will be allocated among claimholders, including stockholders, policyholders, and the government. Many of these claims are contingent claims, as discussed previously, which pay off in the event that Y_1 is greater than or less than some value.

Recognizing the existence of the variance-related claims described, the terminal value of the insurer may be expressed as the sum of two components. The first, PRIM, represents a set of primary cash flows that are valued according to equation (2). The second component represents a claim written on these cash flows that is related to their variance. Using value additivity and denoting the value of the variance-related claims by the function $f[\cdot]$, the value of the firm is

$$V = E\,(PRIM) - \delta \, COV\,(PRIM; M) - f\,[VAR\,(PRIM); A_f], \tag{2}$$

where A_f = the vector of other arguments of $f[\cdot]$, and the last term is the present value of the variance-related flows. Firms that have a higher cost of risk bearing, or higher variance-related costs, are therefore expected to assume less risk than firms with a lower cost of risk bearing.

Determinants of the Cost of Risk Bearing

The firm characteristics that are expected to affect an insurer's cost of risk bearing are its marketing system, organizational form, profitability, leverage, diversification, taxes, and the percent of business in personal lines of insurance. The expected relationship between the cost of risk bearing and these characteristics of the firm is described below.

We first address how the distribution system used by the insurer will affect its cost of risk. One of the principle assets of an insurer is its distribution system. Whether insurers use exclusive agents or independent agents will be important as the risk of the firm changes (see Harrington and Nelson, 1986; Datta and Garven, 1987; and Regan, 1997). Since independent agents own the renewal rights on policies they place, they have the option to transfer policies to a rival when an incumbent insurer becomes financially distressed. Such "runs" on insurers, combined with other costs of financial distress, imply that the independent agent insurer would have a higher cost of risk bearing than direct writers.[2] The distribution system used by the insurer is captured by the dummy variable IA, which takes the value one if the insurer uses the independent agent system and zero otherwise.

Ownership structure also affects insurers' cost of risk bearing because of its effect on access to capital. As the variance of insurer cash flows increases, so does the probability of suffering a shock to surplus. Insurers that have greater access to capital will be more able to finance the recovery of a catastrophic loss of surplus and, hence, will have a lower cost of risk bearing. On one hand, mutual insurers are better able to absorb deviations to surplus caused by unexpected losses since they have greater ability to pass these effects on to policyholders by varying policyholder dividends (see Marshall, 1974, and Doherty and Dionne, 1993). However, while mutuals replace a greater proportion of lost surplus from retained earnings than stocks, this advantage is more than offset by mutuals' inability to raise external capital (see Doherty, Posey, and Kleffner, 1993). Mutuals replace a lower percentage of lost capital than stock insurers, and mutuals face more severe deteriorations in leverage following a shock to surplus. This will translate into greater contraction in supply, or more acute reductions in product quality, than stock insurers following adverse draws on their total loss distribution. Accordingly, we suggest that the cost of risk bearing is lower for stock insurers than for mutuals since the former can more easily access external capital. Further, publicly-traded stock companies are expected to have better access to capital than un-

[2] For other high variance lines, such as liability, a counter argument applies. The choice of distribution system and the method of compensating agents offer opportunities for the insurer to "reinsure" risk with another risk bearer. For institutional arrangements such as sharecropping (Cheung, 1969, and Stiglitz, 1974) and franchising (Martin, 1988), the principal subcontracts a productive function to an agent and makes the agent a residual claimant on the output. Such arrangements balance the respective risk bearing abilities of the parties with the provision of appropriate incentives to the sharecropper. The provision of performance-related compensation to insurance agents provides a similar balance. We speculate that independent agent insurers are more likely to have access to such reinsurance since performance-related compensation is widespread among independent agents, but direct writers have fixed costs (salaries, severance pay, overhead employment costs, etc.) associated with their sales employees. This implies that the cost of risk bearing is higher for direct writers than for independent agent insurers. However, this argument is not expected to be as important for earthquake as it would for other high variance lines, such as liability, where the insurer expects to benefit from agents that underwrite carefully and, hence, it designs a compensation scheme to reward agents accordingly. In contrast, the problem with supplying earthquake insurance is the high correlation between losses and the catastrophic potential for loss. Therefore, performance-related compensation methods are not expected to be an efficient risk sharing arrangement for earthquake losses.

traded companies. In the empirical tests, the dummy variables STOCK and PUBLIC are used to designate insurers that are stock companies and those that are publicly traded, respectively.

Profitability is also expected to influence an insurer's cost of risk bearing by its effect on financing costs. Increasing variability of cash flows increases the likelihood of suffering a large loss of surplus. Such shocks to surplus can displace the firm from its desired leverage position, and the cost of readjusting to its desired leverage will be related to profitability (see, e.g., Cummins and Danzon, 1996). More profitable insurers have a lower expected cost of adjustment (Kleffner, 1993) and, hence, lower cost of risk bearing, since they have greater internal capital resources and it is easier for them to attract investors for a new equity issue. The profitability variable, ROE, is measured as net income after tax in period t divided by surplus in period t – 1.

The respective ability of insurers to write a risky line of insurance such as earthquake will depend on their ability to spread this risk across a portfolio of other exposures with which it has low correlation. Insurers diversify by establishing geographical spread within the earthquake line and across all lines. Such diversification lowers the probability that the insurer will suffer large fluctuations in surplus and thus lowers the probability of financial distress. Thus, the more diversified the insurer, the lower will be the cost of bearing a given earthquake insurance exposure. Diversification is measured using a Herfindahl concentration index and is labeled HERFSTAT. The index is calculated using the percentage of direct business written in each of the 50 states and the District of Columbia for each insurance company.[3]

An insurer's leverage also will influence the magnitude of its cost of risk bearing. The lower an insurer's leverage, the lower its cost of risk bearing. The rationale is that risk and leverage combine to distort incentives for project selection (see Myers, 1977). This cost can be mitigated either by reducing risk or reducing leverage. *Ceteris paribus*, the higher the leverage of the insurer, the higher will be the expected loss of value from dysfunctional project selection from any assumed level of risk. The interaction of risk and leverage is further compounded by regulatory attention. Insurers incur costs of dealing with regulation, and, for any given level of liability risk, such costs are expected to be higher for the more highly-leveraged insurer. In addition, the lower an insurer's leverage, the greater its capacity to absorb unexpected losses and the more flexibility it has in adjusting to negative surplus shocks. Thus, we postulate that the cost of risk bearing for insurers will be positively related to leverage.

Another determinant of an insurer's cost of risk is its tax position. The tax benefit from reducing risk increases as the tax schedule the insurer faces becomes more convex. The convexity of the tax function is determined by a number of factors, including the presence of tax credits and tax loss carryforwards, the likeli-

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[3] The index is calculated for each company as $H = \sum I_S^2$, where s = state = 1, ..., 51, and $I_S = PW_S/TPW$. PW_S is the dollar amount of premiums written in a particular state, and TPW is the dollar amount of total premiums written across all 50 states and the District of Columbia.

hood that such carryforwards will be used, and the discount rate. Since the convexity of a firm's tax function is likely to vary as the level of pretax income varies, convexity can only be determined for a given income level, and the income level is in turn determined by the probability distribution of different income levels. Hence, local convexities differ across firms, making it difficult to establish a unique measure of convexity. However, insurers with large, excess tax deductions will have a higher cost of risk bearing than firms without, since these may be lost in the event of bankruptcy. Short of bankruptcy, underutilized tax shields represent a cost to the firm equal to the discount taken if they are sold. The excess of a firm's tax deductions is therefore measured as the sum of the insurer's underwriting loss and its taxable investment income.

The cost of risk to an insurer also depends on whether it concentrates more in personal or commercial lines of insurance. Policyholders in personal lines have less power to negotiate the terms of the contract and are less likely to be well informed about the financial condition of the insurer. Further, they have less incentive than commercial buyers to become well informed since, if their insurer becomes insolvent, their claims would generally be met within the limits of insurance guaranty fund coverage. In contrast, the commercial demand for insurance is much more elastic and is expected to respond more to a deterioration in an insurer's financial condition, making the cost of risk greater for insurers who primarily write commercial coverages. Although the cost of risk bearing is expected to be higher for insurers concentrating in commercial lines, since insurers in California are required to offer earthquake insurance with each homeowners policy they write, we would expect a positive correlation between our measure of risk and the percentage of an insurer's business in homeowners insurance even if there was no differential in the cost of risk bearing. To control for this, the percentage of homeowners multiple peril an insurer writes is included as a control variable in the empirical tests (HOMEMP = homeowners premiums written in California/total premiums written in California).

Size is another factor that is expected to influence the cost of risk for an insurer. As the riskiness of an insurer's cash flows increases, the probability that it will encounter financial distress also increases. Financial distress may eventually lead to bankruptcy or reorganization, both resulting in considerable legal and accounting costs that tend to have a large fixed component. Therefore, the cost of risk bearing for small firms is expected to be greater than for large firms since these costs would represent a larger percentage of a small firm's assets. SIZE is measured as total assets.

Finally, all other things being equal, insurers that primarily do business in California would be expected to have a higher PML/surplus ratio than insurers that do business nationally, given the undiversified nature of their portfolio. Therefore, we control for the percentage of an insurer's business in California. The variable CALIF is measured as direct premiums written in California relative to their total direct premiums written.

DATA, METHODOLOGY, AND RESULTS

As described above, the cost of risk bearing is expected to vary with insurer characteristics. Empirical tests are performed to examine whether the magnitude of an insurer's earthquake exposure is negatively related to its cost of risk bearing. Firms' earthquake exposures are measured using probable maximum loss (PML) data from the California Department of Insurance (CDI).[4] The amount of risk an insurer assumes is measured as the fraction of an insurer's surplus at risk from a catastrophic earthquake, or PML/surplus. The PML/surplus ratio is used by the CDI as a measure of insurers' vulnerability to a catastrophic earthquake. This measure is more accurate than premiums written because a portion of the earthquake insurance coverage that is provided is not explicitly reported in insurers' annual statements, usually because it is an endorsement on another policy. The PML data are for reporting year 1987. Two sets of results are reported since each insurer reports two PML figures: one for Northern California (Zone A) and one for Southern California (Zone B). The data for the remaining variables are taken from the A. M. Best Company Property-Casualty tapes.

Table 1
Summary Statistics

Variable	Mean	Minimum	Maximum	Standard Deviation
PML/Surplus$_A$	0.0671	0	2.079	0.2542
PML/Surplus$_B$	0.0945	0	2.649	0.3591
SIZE	2.228B	13.453M	28.187B	4.158B
HOMEMP	0.0667	0	0.5981	0.1058
CALIF	0.2756	0	1.000	0.3241
LEVERAGE	0.7071	0.2089	0.9284	0.1268
HERFSTAT	0.2684	0.0326	1.000	0.3104
TAX	93.780M	−48.94M	1.498B	188.3M

Note: HOMEMP = homeowners premiums written in California / total premiums written in California. CALIF = direct premiums written in California / total direct premiums written. LEVERAGE = liabilities / assets. HERFSTAT = Herfindahl index by state = $\sum I_s^2$, where s = 1, ..., 51, and $I_s = PW_s/TPW$. STOCK = one if insurer is a stock company, zero otherwise. PUBLIC = one if insurer is publicly-traded, zero otherwise. IA = one if insurer uses the independent agency marketing system, zero otherwise. TAX = (underwriting loss + taxable investment income). ROE = net income after tax_t / surplus_{t-1}. SIZE = assets.

[4] Each year all property-liability insurers licensed to do business in California are required to report their earthquake exposures with respect to risks located in California. In this context, PML means the expected shake damage loss (after deductible) for a certain class of structure given the maximum size earthquake that is likely to occur. This definition assumes an earthquake of magnitude 8.25 on the Richter scale, which is about the size of the earthquakes that occurred in San Francisco in 1906 and in Alaska in 1964.

The sample comprises all firms that reported to the California Department of Insurance for the year 1987 and for which complete data were available from A. M. Best. This resulted in a sample of 102 firms: 76 stock companies, 5 reciprocals, and 21 mutuals. Seventy companies use the independent agency marketing system and 32 use direct writers. Summary statistics are presented in Table 1. Comparing the PML/surplus ratios for Zones A and B, we see that, for Zone B, Los Angeles, the mean ratio is very close to 0.10. The California Department of Insurance uses as a conservative rule that the potential loss on one risk should not exceed 10 percent of surplus.[5] This suggests that the ratio for some companies pushes the upper bound. We would expect those companies assuming a greater amount of risk to be those with the lowest cost of risk bearing.

The discussion in the previous section suggests that a conceptual model specifying the determinants of the amount of risk, as measured by PML, assumed by an insurer may be represented as follows:

$$\text{PML/surplus} = f(\text{SIZE, HOMEMP, CALIF, LEVERAGE, HERFSTAT, ACM, IA, TAX, PROFIT}),$$

where SIZE = insurer size,
HOMEMP = proportion of business in homeowners in California,
CALIF = proportion of business in California,
LEVERAGE = leverage,
HERFSTAT = Herfindahl index by state,
ACM = access to capital,
IA = marketing system,
TAX = excess tax deductions, and
PROFIT = profitability.

The model is estimated using the tobit estimation procedure because the dependent variable is truncated at zero. The regression equation is as follows:

$$(\text{PML/K})_j = \beta_0 + \Sigma\, \beta_i X_{ij} + \Sigma\, \tau_j Y_{ij} + \varepsilon_j, \tag{3}$$

where $(\text{PML/K})_j$ = probable maximum loss/surplus for firm j,
β_0 = intercept,
X_{ij} = control variables,
Y_{ij} = explanatory variables, and
ε_j = error term.

The variables used in estimation are defined in Table 2.[6]

The results from estimating equation (3) are presented in Table 3. Panel A presents the results using insurers' PML from Zone A (San Francisco) as the dependent variable, and Panel B corresponds to Zone B (Los Angeles).

[5]The PML exposure in a zone is considered as one risk.

[6] Tests for heteroskedasticity and multicollinearity exhibited no evidence of either.

Table 2
Variables Used for Estimation

		Expected Sign
Control Variables		
X_1 = HOMEMP	$\frac{\text{Homeowners Premiums Written in California}}{\text{Total Premiums Written in California}}$	+
X_2 = CALIF	$\frac{\text{Direct Premiums Written in California}}{\text{Total Direct Premiums Written}}$	+
Explanatory Variables		
Y1 = LEVERAGE	Liabilities/Assets	–
Y2 = HERFSTAT	Herfindahl Index by State = $\sum I_s^2$, where s = 1, ..., 51, and $I_s = PW_s/TPW$[a]	–
Y3 = STOCK	1 if insurer is a stock company, 0 otherwise	+
Y4 = PUBLIC	1 if insurer is publicly traded, 0 otherwise	+
Y5 = IA	1 if insurer uses the independent agency marketing system, 0 otherwise	–
Y6 = TAX	(Underwriting Loss + Taxable Investment Income)	+
Y7 = ROE	Net Income After $\text{Tax}_t/\text{Surplus}_{t-1}$	+
Y8 = SIZE	Assets	–

[a] PW_s is the dollar amount of premiums written in a particular state, and TPW is the dollar amount of total premiums written across all 50 states and the District of Columbia.

The signs of all variables are consistent with the testable hypotheses except for those relating to the firm's tax position, whether it is publicly traded, and the proportion of business in homeowners. However, none of these are significant. The signs for profitability and size are positive, as expected, but not significant. The following observations can also be made:

- The higher a firm's leverage, the less earthquake risk it assumes.
- The more diversified is an insurer, as measured by how concentrated it is by state, the greater the risk it assumes.
- Stock insurers assume a greater amount of risk than mutual insurers.[7]
- Insurers that use the independent agency system assume less earthquake risk than those that use the direct writer marketing system.

[7] In other regressions not reported here, access to capital was also measured as whether an insurer was held by a holding company. Insurers that are owned by a holding company are expected to have a lower cost of risk bearing than those that are not since such insurers may receive capital contributions from their parent, implying a lower cost of adjusting to surplus shocks than for insurers not held by a holding company. Those results showed that insurers that are a part of a holding company assume a greater amount of risk than those that are not.

Table 3
Tobit Estimation Results
Dependent Variable = PML/Surplus$_A$

Panel A: Zone A (San Francisco)

Variable	Coefficient	Standard Error	Z-statistic	P-value
Intercept	0.469365	0.1514	9.6	0.0019*
ASSET	3.23E−12	1.6E−11	0.04	0.8397
HOMEMP	−0.1736	0.2303	0.57	0.4510
CALIF	0.48186	0.1579	9.311	0.0023*
LEVERAGE	−0.5483	0.1958	7.84	0.0051*
HERFSTAT	−0.50173	0.1712	8.59	0.0034*
STOCK	0.09265	0.0581	2.54	0.1113
PUBLIC	−0.01876	0.0656	0.08	0.7751
IA	−0.10173	0.0570	3.18	0.0746**
TAX	−2.045E−10	3.41E−10	0.36	0.5481
ROE	0.10279	0.1008	1.04	0.3081
Panel B: Zone B (Los Angeles)				
Intercept	0.749679	0.2108	12.65	0.0004*
ASSET	1.04E−11	2.22E−11	0.22	0.6394
HOMEMP	−0.3030	0.3206	0.89	0.3446
CALIF	0.65963	0.2198	9.006	0.0027*
LEVERAGE	−0.9249	0.2726	11.51	0.0007*
HERFSTAT	−0.68166	0.2383	8.18	0.0042*
STOCK	0.13767	0.0810	2.89	0.0891**
PUBLIC	−0.01032	0.09139	0.01	0.9101
IA	−0.12680	0.0794	2.54	0.1100
TAX	−4.04E−10	4.74E−10	0.73	0.3940
ROE	0.14287	0.1404	1.04	0.3088

Note: HOMEMP = homeowners premiums written in California / total premiums written in California. CALIF = direct premiums written in California / total direct premiums written. LEVERAGE = liabilities / assets. HERFSTAT = Herfindahl index by state = $\sum I_s^2$, where s = 1, ..., 51, and $I_s = PW_s/TPW$. STOCK = one if insurer is a stock company, zero otherwise. PUBLIC = one if insurer is publicly-traded, zero otherwise. IA = one if insurer uses the independent agency marketing system, zero otherwise. TAX = (underwriting loss + taxable investment income). ROE = net income after tax_t / $surplus_{t-1}$. SIZE = assets.

* Significant at the 1 percent level. ** Significant at the 10 percent level.

That more highly leveraged firms will assume less risk is implied by the notion that such firms have a higher expected cost of dysfunctional project selection, and it is also harder for such firms to adjust to surplus shocks (Kleffner, 1993). It is more difficult for them to raise external capital, and they are more constrained regarding the adjustment in their price and quantity of insurance in response to a large loss. Furthermore, as leverage increases, so too does the expected cost of financial distress. Hence, more highly leveraged firms are predicted to have a higher cost of risk bearing and assume a lower level of risk, and the results support this prediction.[8]

The coefficient on the stock variable is positive and significant at the 10 percent level in Panel B and almost significant in Panel A. This level of significance suggests that the ability to raise external capital after a large loss is important in determining which insurers supply catastrophic insurance.[9] If an insurer must wait for the slow buildup of retained earnings after a depletion in surplus, it must also reduce the quantity of insurance provided in the short to medium term to maintain the same level of safety. This represents a loss of profit and goodwill for the insurer, and a higher cost of assuming risk.

The Herfindahl index is negative and strongly significant, implying that insurers that are more diversified by state have a lower probability of financial distress and, hence, lower expected costs of financial distress. Such insurers are able to take on a higher level of risk since the probability that they will incur a large surplus shock is lower than those that concentrate in only one or a few states.

The results also provide evidence that independent agency firms assume less earthquake risk than direct writer firms.[10] This supports the notion that agency firms have a higher cost of financial distress since agents own the policyholder list. As the risk of an insurer increases, so does the probability that an agent will cease doing business with the firm, taking policyholders with him or her. This is costly to the firm; hence, the prediction that independent agents will assume less risk.[11]

The tax variable does not provide any evidence that insurers assume less risk in order to protect unused tax deductions. Other regressions, not reported here, used the amount of income tax paid by the insurer to proxy for the presence of net operating loss (NOL) carryforwards and, hence, excess tax deductions. If the insurer reported a positive income tax amount, it was assumed that the insurer did not have an NOL carryforward and, hence, was on the flat portion of its tax schedule, making it indifferent to risk levels, all else equal. If the insurer paid zero or negative taxes, it was assumed that it had an NOL carryforward, suggesting that the firm faces a locally-convex tax schedule, making risk costly to the firm. This measure of excess tax deductions was negative but not significant. This is most likely due to the fact that income tax paid is a noisy measure of net operating loss carryforwards since insurers might be paying negative taxes but still not be in a carryforward position.

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[8] An inverse relationship between capital and risk for property-liability insurers was also found by Cummins and Sommer (1996).

[9] This is also consistent with the hypothesis that stock insurers will concentrate in lines of insurance that require greater managerial discretion due to the lower cost of controlling agency conflicts (Mayers and Smith, 1988).

[10] Since 75 percent of PML exposure is due to commercial property, it is safe to conclude that this result cannot simply be explained by direct writers being more efficient, and hence dominating, in the homeowners market, where they are required to offer earthquake insurance on each policy sold or renewed.

[11] A test for multicollinearity between the IA and STOCK variables showed that it was not just an ownership effect being detected.

The sign of the HOMEMP variable is negative, contrary to what is expected from a cost of risk bearing standpoint and institutionally, due to the requirement on insurers to offer earthquake insurance with all homeowners policies. This is most likely due to the fact that commercial exposures represent much higher dollar values than residential exposures.

CONCLUSION

This research examines the relationship between the cost of bearing risk and the amount of risk insurers assume in their underwriting portfolio. If firm-specific risk does not affect the value of the firm, then it will not affect operating decisions. However, when risk bearing is costly, firms' optimal risk level will equate the marginal cost of risk with the marginal cost of reducing that risk. The evidence presented here suggests that firms with a higher cost of bearing risk assume less risk. The existence of costly risk bearing implies that not all insurers are equally equipped to insure high-variance lines of insurance. Instead, an efficient market solution requires that those firms that have a comparative advantage in risk bearing, as determined by organizational form, leverage, diversification, and marketing structure, should assume a greater share of the risk. This is borne out by the results.

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