The Effect of Ceded Reinsurance on Solvency of Primary Insurers

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Primary insurance companies diversify their underwriting risk and thus improve their financial stability through buying reinsurance contracts. However, excessive use of reinsurance by an insurance company may signal the presence of financial difficulties. In fact, as research shows, a less solvent insurer tends to use more reinsurance because of its inability to raise needed capital in the financial market. Thus, regulators need to pay extra attention to insurers that overly use reinsurance since such behavior could signal an insurer's disproportionately high risk and its eventual probability of insolvency. (JEL G22)

Introduction

By ceding some premiums to other insurers (called reinsurers), a primary insurer[1] tends to diversify its underwriting risk and improve its solvency. However, the primary insurer is fully responsible for claim payments to its policyholders even if its reinsurance contracts cannot be enforced. Therefore, the use of reinsurance might raise the primary insurer's risk of being insolvent when its reinsurance contracts are not recovered. The higher the default risk of the reinsurance contracts, the higher the likelihood of greater financial burdens being placed on the primary insurer. A study by the A. M. Best Company [1991a] indicates that more than 7 percent of insolvencies among property-liability insurers between 1969 and 1990 directly resulted from the failures of reinsurers.

Also, the use of reinsurance undoubtedly has an indirect or a secondary effect on the solvency of primary insurers. Without reinsurance, many primary insurers may not write or may reduce the number or size of highly risky policies, such as policies that cover earthquake damage or environmental liabilities. In other words, the availability of reinsurance encourages primary insurers to engage in highly risky business. That, in turn, will raise their insolvency risk.

Given the fact that ceded reinsurance might improve the solvency of primary insurers on one hand and increase the insolvency risk of these insurers on the other hand, two questions are raised: How does reinsurance affect the probability of solvency of primary insurers? Does the use of reinsurance raise the frequency of insolvency of these insurers?

Although several researchers, such as Harrington and Nelson [1986], Ambrose and Seward [1988], BarNiv and Hershbarger [1990], Lee and Urrutia [1993], Grace et al. [1993], Carson and Hoyt [1994], and Cummins et al. [1994], have already explored many issues of insolvency of insurance firms. The issue of whether reinsurance raises the

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insolvency risk of primary insurers, however, has not been adequately addressed nor is it well understood. This paper aims to remedy this situation.

One important implication suggested by this study is that the use of reinsurance signals the extent of risk faced by a primary insurer. The riskier the insurance policies, such as policies in long-tailed lines (workers' compensation and medical malpractice), the more premiums the primary insurer will cede. In particular, a less solvent insurer tends to use more reinsurance because of its inability to raise needed capital in financial markets. Therefore, overuse or abuse of reinsurance by some primary insurers can be considered as a signal that these insurers are in trouble. Regulators then need to pay extra attention to such insurers.

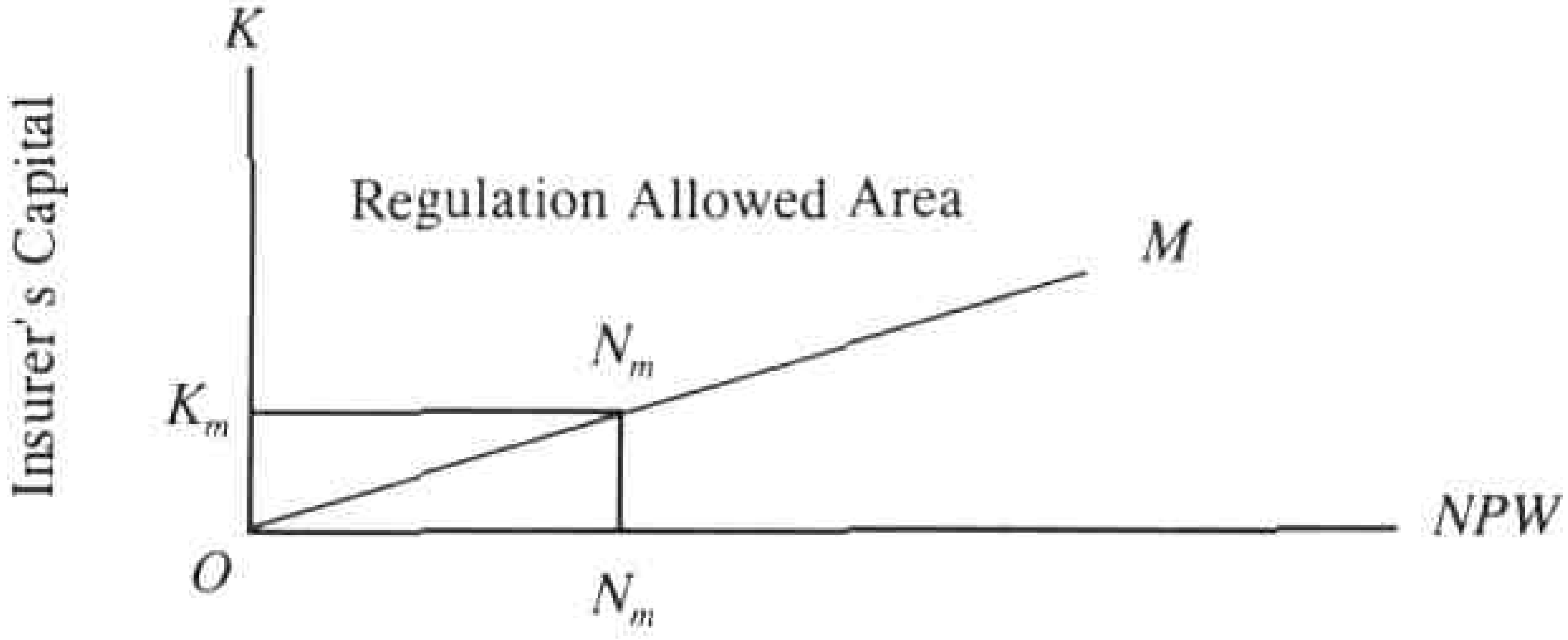
The Use of Reinsurance and Its Effects on a Primary Insurer

The motivations for a primary insurer to cede some premiums to others are complicated. An insurer reinsures because professional reinsurers have specific skills in risk management or it uses reinsurance because it has undiversified risks [Doherty and Seha, 1981, p. 950; Hoerger et al., 1990, p. 227]. An insurer also can realize some tax advantages by ceding premiums. More important, reinsurance can increase a primary insurer's surplus. This, in turn, will enable the insurer to write new policies. In particular, a less solvent insurer will tend to use more reinsurance because of the difficulty in raising needed capital.

Regulatory Constraints

The insurance industry is state regulated. To operate in a state, an insurer needs to satisfy the state's minimum capital requirement. In addition, the insurer is subject to mandated minimum reserve and surplus requirements. Figure 1 describes the regulatory constraints. The net premium written equals the total premiums written minus reinsurance ceded plus reinsurance assumed. When an insurer neither uses reinsurance and assumes no reinsurance, the net premium written is equal to the direct premiums written. K_m is the minimum capital required by regulation, and N_m is the maximum net premium allowed when the insurer has capital, K_m, so the slope of OM is the minimum policyholder surplus ratio imposed by solvency regulation, where policyholder surplus ratio is defined as the ratio of the surplus to the net premium written, and the surplus is equal to total assets minus total liability. An insurer can legally operate only in the area of KK_mN_mM. Provided an insurer is operating along line N_mM, the insurer is fully using its capacity as allowed by regulation. If an insurer is operating inside the regulation allowed area, the insurer has the extra capacity to write new policies. On the other hand, if an insurer is operating outside the allowed area, the insurer must either raise its own capital or cede premiums to other insurers. Otherwise, regulators will take measures against the insurer to implement state regulation.

FIGURE 1
Regulatory Constraints



The Value of the Firm

Let V be an insurer's total value, NPW is the net premium written, and DPW is the direct premium written. Then, the insurer's value will be a function of its capital, direct premium written, and net premium written. Thus, $V = V(K, NPW, DPW)$. The more capital or more net premium written, the higher the value of the firm. So V is an increasing function of both K and NPW. When NPW is fixed but DPW is increasing, the firm is writing more new policies but, at the same time, ceding all new premiums to other insurers. Initially, this would have the effect of increasing the value of the firm, but later on, its value tends to decrease as its direct premium written continues to increase. This happens because the firm has an optimal level of the size associated with the economy of the scale. At some point, its value will decrease when its marginal underwriting cost finally exceeds the marginal commission received from reinsurers.

Insolvency Risk of the Firm

An insurer's probability of insolvency is affected by the size of its capital, net premium written, and direct premium written. Let S be the probability of insolvency, then $S = S(K, NPW, DPW)$. Let *Rein* be the net reinsurance ceded that equals the total reinsurance ceded minus reinsurance assumed, then $Rein = DPW - NPW$. As a result, an insurer's probability of insolvency can be expressed as $S = S(K, NPW, Rein)$. The increase in capital or the decrease in the net premium written will lower the insurer's probability of insolvency. On the other hand, given that the insurer's own capital and net premium written are constant, then when an insurer uses more reinsurance, it is developing new business by ceding more premiums to others. At the beginning, using reinsurance could lower the insurer's risk of insolvency because of the effect of diversification of risks. However, when the insurer issues more and more policies without increasing its own capital, its insolvency risk will increase. This happens because the insurer has full obligation to pay its policyholders' claims no matter whether its reinsurance is recovered. In other words, when reinsurance is not fully recovered or is paid back but delayed, the primary insurer's risk of insolvency will increase.

An Insurer's Optimal Decision

An insurer wants to maximize its total value, given the regulatory constraints. In other words, the following optimal problem results:

$$\max V = V(K, NPW, DPW)$$
$$\text{subject to } K \geq K_m \text{ and } (K / NPW) \geq (K_m / N_m) \quad , \tag{1}$$

where, again, K_m is the minimum capital required and (K_m / N_m) is the minimum policyholder surplus ratio required. Given the value function described earlier, an insurer will always use its full capacity as much as possible. In other words, an insurer will always operate at the level of $K / NPW = K_m / N_m$. So, given its capital, K, the insurer will choose the net premium $NPW^* = K / (K_m / N_m)$. On the other hand, the insurer will choose its optimal direct premium written, DPW^*, so that its value reaches the maximum given capital, K, and the net premium written, NPW^*. As indicated before, such an optimal DPW^* exists. Because of the relationship between reinsurance ceded and the direct premium written, the optimal reinsurance ceded will be $Rein^* = DPW^* - NPW^*$.

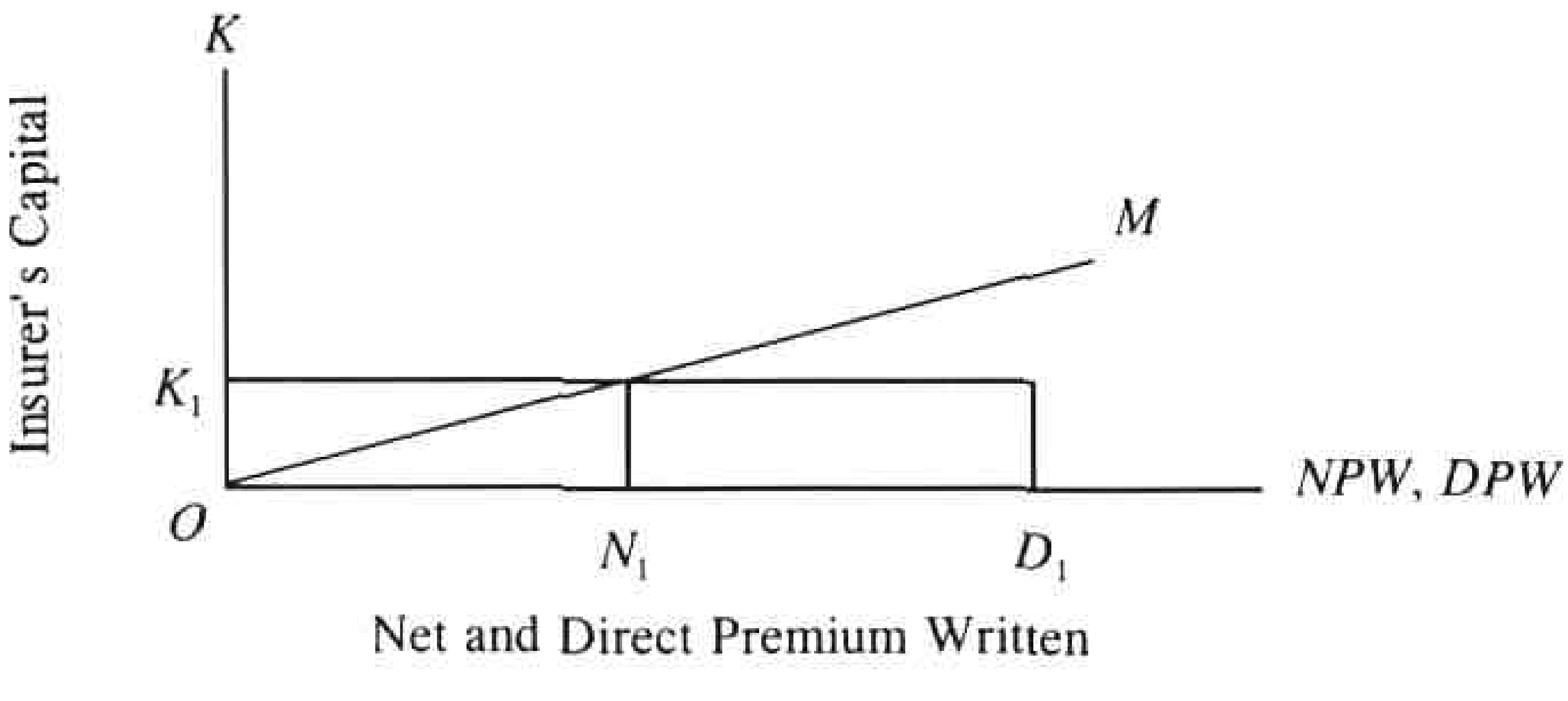
The Effects of Increasing Reinsurance on the Firm's Value and Insolvency

Case 1: Increasing reinsurance with fixed direct premium written.

It is often said that using reinsurance improves a primary insurer's solvency but reduces its value. This is true when the insurer's direct premium written is not changed. Figure 2 demonstrates the relationship between reinsurance and net premium written.

FIGURE 2

The Effect of Using Reinsurance on the Net Premium Written

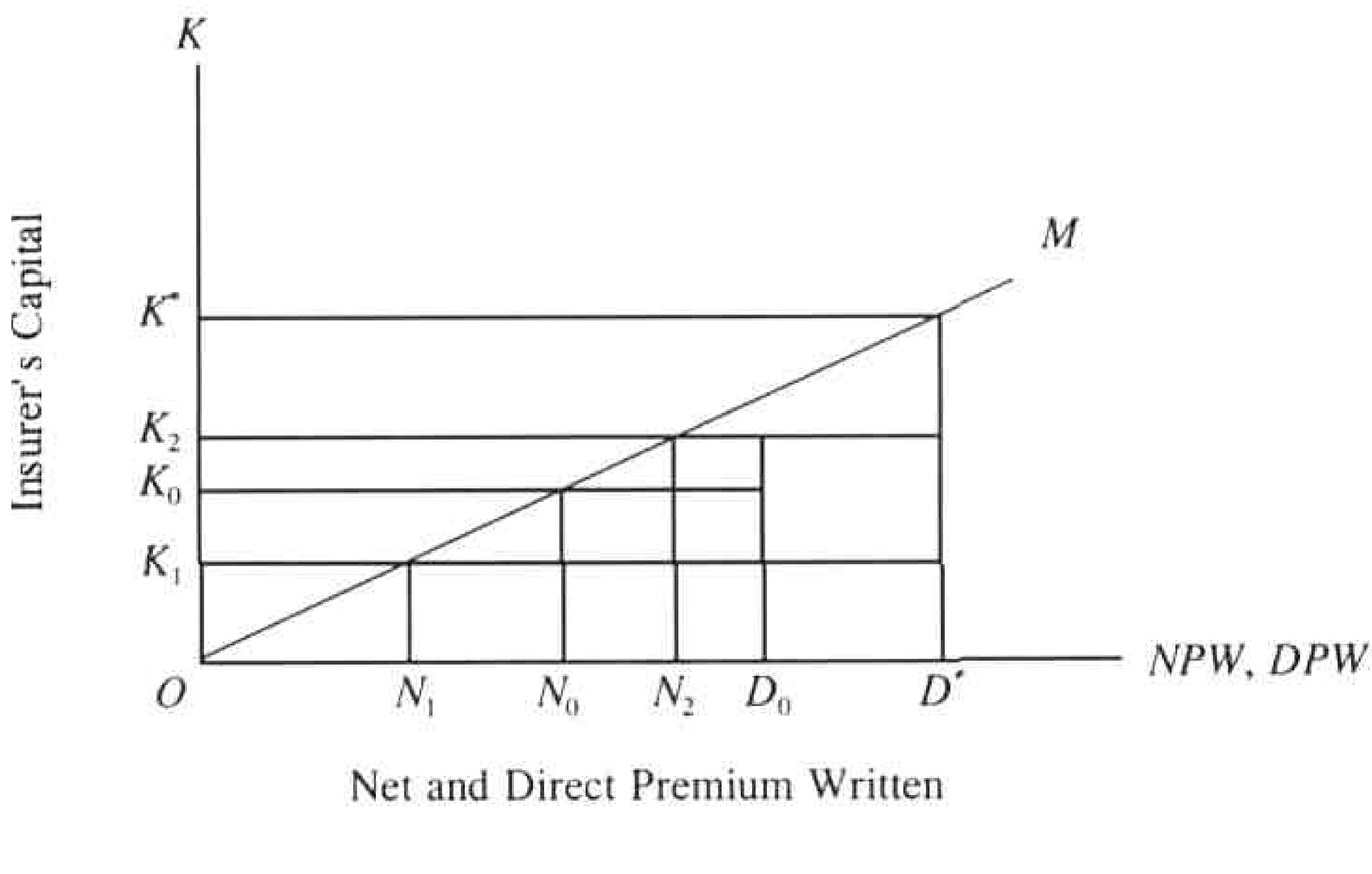


Suppose that an insurer initially has capital, K_1, with $K_1 > K_m$ and direct premium written, D_1. Initially, it uses no reinsurance. So its net premium written equals the direct premium written, that is, $NPW = DPW = D_1$. However, the insurer in this case is operating outside the regulatory allowed area because its policyholder surplus ratio is lower than that required. Assume that the insurer does not increase its capital but uses reinsurance instead. It is clear that the more reinsurance the insurer uses, the less net premium written it has. As a result, the insurer's value and the probability of insolvency will be decreasing with the increased use of reinsurance. As a value maximizer, the insurer will cede insurance associated with $(D_1 - N_1)$ of premiums, where N_1 is the net premium written.

Case 2: Effects of increasing reinsurance when direct premium written is changed.

The above case may apply to an insurer whose capacity is overused. However, it does not explain the situation where the insurer faces a new business opportunity. In addition, it cannot explain why the insurer underwrites so many policies. To meet the regulatory requirement, the insurer can simply reduce its volume of policies. Assume that two insurers A and B initially have the same capital, K_0, the same direct premium written, D_0, and the same net premium written, N_0. Therefore, both firms will cede premiums of $(D_0 - N_0)$ to reinsurers. This is shown in Figure 3. Assume further that after a while and for some reasons, insurer B's net capital is reduced to K_1, whereas insurer A's capital is increased to K_2.

FIGURE 3
Insolvency Risk of Insurers and Use of Reinsurance



First, suppose that both insurers only want to keep all of the old business they already have. In other words, they still want to have the direct premium written, D_0. To do so, insurer B must cede more premiums than before to meet the minimum surplus ratio requirement, so its total reinsurance ceded will be $D_0 - N_1$. On the other hand, if insurer

A still uses reinsurance, $D_0 - N_0$, its policyholder surplus ratio will be higher than the minimum requirement. So insurer A can either reduce its use of reinsurance or develop new business. If the insurer does not develop new business, its total reinsurance ceded will be reduced to $D_0 - N_2$. In this case, both insurers A and B have the same policyholder surplus ratio, but insurer B will be less solvent than insurer A because insurer B has less capital and relies more on reinsurance than insurer A. In other words, in this case, a less solvent insurer B tends to use more reinsurance and will have a higher insolvency risk.

Furthermore, suppose that both insurers A and B have a new business opportunity to issue new policies that would generate extra premiums of $D^* - D_0$. Due to solvency regulation, insurers A and B are not allowed to write new policies unless they can improve their surplus. To develop new business, these insurers can use one of three strategies or any combination of these three strategies: raise internal capital, raise external capital, and use reinsurance.

Raising external capital is more costly than raising internal capital. In particular, when an insurer has a high default risk, not only are outside investors reluctant to put money on it, but also existing owners of the firm do not want to supply extra capital under these circumstances. Therefore, a feasible way for insurer B to improve its surplus ratio is to cede premiums to other insurance firms. By ceding premiums, the insurer is able to reduce its net premium written and thus raise its policyholder surplus ratio. The less solvent an insurer is, the more likely it will use reinsurance to improve its surplus ratio in order to develop new business.

Why are reinsurers willing to share premiums and risks with insurer B? The reason is simple. Suppose an investor wants to take advantage of the new business opportunity available to insurer B. Should this investor put his money directly into insurer B or into insurer B through a reinsurer? If the investor puts his resources into a reinsurer that will accept insuring B's new business, he can escape the risk associated with B's old business. On the other hand, if the investor gives money to insurer B, he will be exposed not only to those risks associated with the new business but also to those brought on by the old business. Thus, as long as the new business is profitable, reinsurers are always willing to deal with insurer B regarding its new business no matter how risky insurer B's old business is.

As a result, insurer B will end up with the total direct premium written, D^*, net premium written, N_0, and reinsurance, $D^* - N_0$. On the other hand, insurer A has more feasible choices. It may be able to raise some needed capital in the financial market. The maximum capital this insurer needs to raise is $(K^* - K_1)$. Even if insurer A does not raise extra capital, it only needs to cede $(D^* - N_2)$, while its total direct premium written is the same as insurer B. In either way, the less solvent insurer (insurer B) uses more reinsurance than insurer A. Insurer B will have a higher insolvency risk than before due to the fact that its capital is not raised, but its direct premium written is increased through the use of reinsurance. Insurer B also is less solvent than insurer A because even though they both underwrite the same amount of insurance coverage, insurer B has less capital.

The conclusion from this discussion is that a less solvent insurer will use more reinsurance and that such an insurer will have a higher risk of insolvency. This is particularly true when the insurer is nearly insolvent. When an insurer is close to being insolvent, it will be in the shareholders' interest to develop new business despite its degree of riskiness. Due to solvency regulation, the insurer is not allowed to develop new business unless it improves its surplus ratio. The only way it can do that is to use reinsurance because of its inability to raise needed extra capital in the financial market. It is possible that with this tactic and a great deal of good fortune, the insurer may escape from becoming insolvent. However, in general, insurers who have a higher risk of being insolvent would eventually become insolvent despite their attempt earlier to use reinsurance in hoping to prevent the insolvency.

The Models and Sampling

The previous section predicts that a less solvent insurer will use more reinsurance and that the use of reinsurance will further raise the insurer's risk of insolvency. In this section, econometric models are developed to test whether this prediction is correct.

Econometric Models

Let g be a functional form such that $S = g(Rein, X)$, where S is the probability of insolvency, *Rein* is reinsurance ceded, and X is a vector consisting of other financial factors of the firm. Then, the partial derivative of g with respect to variable *Rein* represents the effect of ceded reinsurance on an insurer's insolvency.

To estimate such an effect, further consider whether the reinsurance ceded is endogenous. As discussed earlier, an insurer chooses its optimal direct premium written and its optimal level of reinsurance to maximize its value. Thus, reinsurance ceded is endogenous. Let h be such a functional form that $Rein = h(X')$ where X' is a vector of all factors affecting the use of reinsurance. This now results in two simultaneous equations:

$$S = g(Rein, X) \quad , \tag{2}$$

and

$$Rein = h(X') \quad . \tag{3}$$

In (3), X' may also include S, the probability of insolvency. However, in this paper, S is excluded in that equation because a firm's future probability of insolvency is used as a proxy of its probability of insolvency. Reinsurance ceded this year will affect the firm's future probability of insolvency, but it is not clear why the firm's future probability of insolvency will influence its use of reinsurance this year. To estimate (2) and (3), first specify functional forms for g and h. Function h is assumed to be linear:

$$Rein = X'\beta' + \varepsilon' \quad , \tag{4}$$

where β' are parameters to be estimated and ε' is the error term. However, assuming function g to be linear could cause serious problems: this may lead the estimated probability of insolvency to be negative or larger than 1. To avoid such an abnormal probability, a logit model is used:

$$S = \alpha Rein + X\beta + \varepsilon \quad , \tag{5}$$

where α and β are parameters to be estimated, and ε is an error term and assumed to have a logistic distribution. In addition, a new variable, y, is introduced, such that y = 1 if the insurer is insolvent and $y = 0$ otherwise. To link the relation between y and S, it is naturally assumed that $y = 1$ when $S > 0$.[2] Given these assumptions, consistent estimators can be found for parameters α and β.[3]

Sampling

Randomly selecting solvent insurers has been widely practiced in the insolvency studies of insurance. For example, Ambrose and Seward [1988] use 58 insolvent insurers and a matched-pair sample (based on organizational form and size) of 58 solvent insurers for the period 1969 through 1983 to study the relation between Best's rating and insurers' insolvency. Lee and Urrutia [1993] employ 82 insolvent insurers and the same number of solvent insurers (randomly selected based on the state of domicile and magnitude of total admitted assets) for the period 1980 through 1991 to compare the success of logit and hazard models in predicting insolvency.

To randomly select solvent insurers, first decide on a standard of selection. Such a standard can be based on the amount of total assets, that is, the state of domicile, or on the organizational form of the insurer. The choice of the standard will affect the selection of the firms and, therefore, the final results. Carson and Hoyt [1994] find that the estimated results from insolvency models are quite sensitive to the selection of sample methods. The second problem associated with randomly selecting solvent insurers is that a long time period is usually needed to guarantee that the total sample (of solvent and insolvent insurers) would be large. For instance, Ambrose and Seward [1988] use data for a time period of 14 years and Lee and Urrutia [1993] employ data for 11 years. Using a long time period may cause a serious problem because the circumstances affecting insurance may be quite different over time. For instance, insurance regulations tend to change frequently. Some of these changes directly affect premium rates and, thus, insurers' profit.

Because of the problems that result from the random selection of solvent insurers, this study includes all primary insurers with usable and complete data as reported in *Best's Key Rating Guide* [A. M. Best, 1991b] for property and liability insurance. There are 980 insurance firms included in this study. Among them, 15 were insolvent in 1991.[4]

Explanatory Variables and Summary Statistics

Based on which financial factors will most likely affect the firm's probability of insolvency and reinsurance ceded, 14 independent variables are included in the equation of insolvency, (5), and seven are included in the equation of reinsurance, (4).

Definition of Variables

Table 1 gives the definition of the 14 variables used in (5) and the expected signs of the coefficients. Most of the expected signs can be easily explained. For example, the sign of the ratio of ceded reinsurance defined by the amount of reinsurance ceded divided by the total premiums written is expected to be either positive or negative, depending on whether the use of reinsurance raises the primary insurer's risk. Since the failed insurers used more reinsurance on average in 1990 than solvent insurers, the sign is expected to be positive. The changes in premiums and in the policyholder surplus are assumed to have negative signs because high positive values of these variables mean that the insurer is financially strong. The ratio of net operating income to the premium earned has a negative sign since a high positive value of this variable would mean a large profit from investment or underwriting. Short-tailed insurance lines, such as automobile physical damage and homeowners insurance, are usually more certain in terms of expected losses than long-tailed lines, such as workers' compensation and medical malpractice. So the ratio of premiums from short-tailed lines to total premiums is expected to have a negative sign. Since insurers using the direct writers distribution system generally exhibit a larger volume of premiums, which helps diversify their risks, a dummy variable for the direct distribution system is to be negatively correlated with insolvency. In addition, an insurer grouped or affiliated with other insurers usually has some advantages of risk diversification. Mutual insurers experience fewer moral hazard problems and they are more careful in their underwriting practices. So both dummy variables, the one for affiliation and the one for ownership (mutual insurer), are assumed to have negative signs.

TABLE 1

The Definition of Explanatory Variables and Expected Signs from Regression

Variables	Definitions	Expected Sign
Rein	Ratio of reinsurance ceded to (reinsurance ceded + net premium written)	+/-
NPW/PHS	Ratio of net premium written to policyholder surplus	+
RPHS	Return to policyholder surplus	-
CNPW	Change in net premium written	-
CPHS	Change in policyholder surplus	-

TABLE 1 (CONT.)

Variables	Definitions	Expected Sign
LR/NPW	Ratio of loss reserve to net premium written	–
YIA	Yield on invested assets	–
NOI/PE	Ratio of net operating income to premium earned	–
A/PHS	Ratio of assets to policyholder surplus	–
CL	Current liquidity	–
Short-tailed	Ratio of short-tailed premium to total premium	–
Mutual	Ownership dummy (1 if mutual, 0 otherwise)	–
Group	Affiliation dummy (1 if grouped, 0 otherwise)	–
Direct	Underwriter dummy (1 if direct, 0 otherwise)	–

Notes: The expected signs are for estimates in (5).

Most of the variables for (5) have been widely examined in previous studies, except two: the ratio of ceded reinsurance and the dummy variable for affiliation. An affiliated insurer still is an independent firm, but it is owned by other insurers or grouped with other insurers. With its expected positive effect on an insurer's financial stability, it is surprising that the affiliation factor has not been included in previous studies. The next section will show that the dummy variable for the affiliation significantly affects a firm's insolvency in the single estimation (that is, (5)), but it does not have significant effects on insolvency when both (4) and (5) are simultaneously estimated.

Equation (4) includes seven variables. These are the change in net premium written in 1990, the change in policyholder surplus in 1989, the ratio of short-tailed premium to total premiums written, the size of firm, two dummy variables of mutual and grouped insurers, and a variable of rating in 1989. Since the change of policyholder surplus in 1990 will be directly affected by reinsurance ceded in 1990, the variable is not used in the model. Instead, the change of policyholder surplus in 1989 is included.

The highest rating by the A. M. Best Company, A++, was assigned a value of 12 and the lowest rating, D, was assigned a value of zero.[5] A highly rated firm may become insolvent later, but in general, a firm's rating signals the degree of the firm's financial strength. A firm's rating also affects its costs to raise needed capital in the financial market. So including a variable of rating reveals extra information about the relation between the use of reinsurance and the cost of raising needed capital.

Summary Statistics for Solvent and Insolvent Insurers

Table 2 gives summary statistics for 26 variables. Means and standard deviations are reported for both solvent and insolvent insurers. To examine whether there is any significant difference in the mean values between solvent and insolvent insurers, the t-statistic is used. The t-value is calculated under the assumption that the two populations (solvent and insolvent firms) may have different variances. In fact, most tests of equal variances show that they are significantly different.[6]

TABLE 2
Summary Statistics for Solvent and Involvent Insurers

Variables	15 Insolvent Insurers		965 Solvent Insurers		t-Value	p-Value
Rein90	0.51	(0.24)	0.32	(0.26)	4.51	.00*
Rein89	0.47	(0.23)	0.32	(0.26)	3.53	.00*
Rein88	0.50	(0.23)	0.31	(0.26)	4.34	.00*
AvRein	0.49	(0.20)	0.32	(0.24)	4.33	.00*
A/PHS	2.42	(1.31)	3.12	(1.34)	2.06	.05**
LR/NPW	1.47	(0.96)	1.28	(1.04)	0.55	.60
NPW/PHS	1.87	(1.03)	1.51	(0.91)	0.97	.36
RPHS	5.78	(5.41)	6.30	(16.30)	-0.34	.73
YIA	7.29	(1.42)	7.41	(1.71)	-0.30	.84
NOI/PE	3.40	(3.92)	15.27	(45.27)	-5.87	.00*
CL	364.83	(372.45)	174.87	(164.47)	1.97	.07
Mutual	0.13	(0.35)	0.27	(0.45)	-1.52	.14
Direct	0.27	(0.45)	0.21	(0.41)	0.43	.66
Group	0.73	(0.46)	0.76	(0.43)	-0.19	.85
Short-tailed	13.59	(20.30)	26.86	(23.11)	-2.51	.02*
CPHS90	4.52	(37.66)	8.43	(23.83)	-0.96	.34
CPHS89	5.70	(32.77)	14.34	(26.07)	-1.97	.05**
CPHS88	22.13	(49.89)	17.57	(30.43)	0.87	.38
AvCPHS	10.78	(27.10)	13.45	(16.06)	-0.97	.33
CNPW90	-4.86	(38.14)	10.80	(47.43)	-1.99	.05**
CNPW89	33.59	(98.70)	12.39	(51.15)	2.38	.02**
CNPW88	25.60	(92.36)	20.36	(72.05)	0.43	.67

TABLE 2 (CONT.)

Variables	15 Insolvent Insurers		965 Solvent Insurers		t-Value	p-Value
AvCNPW	18.11	(42.90)	14.52	(36.71)	0.58	.56
Asset90	36,886	(45,793)	188,451	(488,294)	-7.71	.00*
LogAsset	9.82	(1.31)	10.90	(1.54)	-3.18	.00*
Rating89	6.00	(2.44)	9.58	(1.64)	-5.63	.00*

Notes: * and ** denote significance at the 1 and 5 percent levels, respectively. The t-value is calculated under the assumption that the two samples have different variances. The numbers 90, 89, and 88 indicate the relevant years; *Av* denotes the three-year average from 1988 through 1990; *Asset90* denotes the total admitted assets in thousands of dollars; and *LogAsset* = *log(Asset90)*. Standard deviations are in parentheses.

The table shows that among 26 variables, 13 have significantly different mean values at the 5 percent level for solvent and insolvent insurers. In 5 of the 13 variables, insolvent insurers have larger mean values than solvent insurers. These variables are *Rein90*, *Rein89*, *Rein88*, *AvRein*, and *CNPW89*. For the other 8 variables, the insolvent insurers have lower mean values. These variables are *A/PHS*, *NOI/PE*, *CPHS90*, *CNPW90*, *short-tailed*, *Asset90*, *LogAsset*, and *Rating89*. On the other hand, for the remaining 13 variables, there is no significant difference regarding the mean values between the solvent and insolvent insurers. These variables are *LR/NPW*, *NPW/PHS*, *RPHS*, *YIA*, *CL*, *mutual*, *direct*, *group*, *CPHS90*, *CPHS88*, *AvCPHS*, *CNPW88*, and *AvCNPW*.

Table 2 clearly shows that insolvent insurers on average cede more premiums than solvent insurers. In 1990, insolvent insurers on average ceded 51 percent of their total premiums, 19 percent more than solvent insurers. From 1988 to 1990, insolvent insurers on average ceded 49 percent of their premiums per year, 17 percent more than solvent insurers.

Results

Table 3 reports estimated results for (4) using the ordinary least squares (OLS) estimation. Tables 4, 5, and 6 give estimated results for (5) using different estimations.

Factors Affecting the Use of Reinsurance

In Table 3, five variables have significant effects on using reinsurance at the 5 percent level. These variables represent the A. M. Best Company's rating that a company received in 1989 (*Rating89*), the size of the firm (*LogAsset*), the ratio of premiums in short-tailed lines to the total premiums written (*short-tailed*), and the two dummy variables (*mutual* and *group*). A firm with a higher rating is more solvent and has a lower cost to raise needed capital in the financial market, so it uses less reinsurance. The bigger the firm, the less reinsurance it uses. An insurer that is more involved in short-tailed lines has less underwriting risk, so it has less need to use reinsurance. An insurer that is grouped with others benefits from greater diversification of risks and has a better ability to raise needed capital from other affiliated insurers, so it uses less reinsurance. A mutual insurer has less ability to diversify its risk than a stock insurer, so it uses more reinsurance.

TABLE 3
Estimated Effects on Reinsurance from OLS

Variable	Parameter Estimates		t-Value	p-Value
Intercept	0.6499	(.0702)	9.256	.00*
Rating89	-0.0236	(.0048)	-4.910	.00*
CNPW90	-0.0001	(.0001)	-1.294	.20
CPHS89	0.0003	(.0002)	1.709	.09
LogAsset	-0.0110	(.0057)	-1.942	.05
Mutual	0.0604	(.0198)	3.156	.00*
Group	-0.0557	(.0198)	-2.185	.01**
Short-tailed	-0.0009	(.0004)	-2.436	.02*
Number of Observations	980			
Adjusted R^2	0.07			
F-value	11.79			.00*

Notes: * and ** denote significance at the 1 and 5 percent levels, respectively. The dependent variable is the ratio of ceded reinsurance in 1990. Standard deviations are in parentheses.

Factors Affecting Insolvency

Table 4 reports the estimated results from the OLS estimation under the assumption that reinsurance ceded is exogenous. Table 5 gives results using the OLS but under the assumption that reinsurance ceded is endogenous. Table 6 gives the estimated results from the logistic estimation under the assumption that the reinsurance ceded is endogenous. In all three cases, reinsurance ceded in 1990 has significant positive effects at the 5 percent level on the probability of insolvency. The estimated coefficient for the ratio of ceded reinsurance in 1990 (*Rein90*) from OLS in the single equation estimate is 0.0338. From OLS in the two simultaneous equations estimate, it is 0.1942. From the logistic estimation in two simultaneous estimates, it is 15.78. The ratio of assets to policyholder surplus (*A/PHS*) is the only other variable significant at 5 percent in all of the three different estimates. The net premium written to policyholder surplus (*NPW/PHS*) is significant at 5 percent in both of the OLS estimates but not significant in the logistic estimate. *Group* is significant in a single OLS estimate, *mutual* is significant in the simultaneous OLS, and *CPHS90* is significant in the logistic estimate.

TABLE 4
Estimated Effects on Insolvency from OLS (Single Equation)

Variable	Parameter Estimates		t-Value	p-Value
Intercept	0.0249	(.0233)	1.07	.29
Rein90	0.0338	(.0144)	2.35	.02**
CNPW90	0.0000	(.0001)	0.11	.91
CPHS90	-0.0000	(.0001)	-0.49	.62
LR/NPW	0.0001	(.0001)	1.06	.29
YIA	0.0028	(.0022)	1.24	.22
NOI	-0.0004	(.0001)	-0.38	.70
NPW/PHS	0.0190	(.0056)	3.38	.00*
A/PHS	-0.0170	(.0070)	-2.41	.02**
RPHS	-0.0001	(.0002)	-0.56	.58
CL90	-0.0000	(.0000)	-0.60	.55
Mutual	-0.0118	(.0086)	-1.37	.17
Group	-0.0191	(.0083)	-2.31	.02**
Direct	-0.0052	(.0083)	-0.63	.53
Short-tailed	-0.0003	(.0002)	-1.49	.14
Number of Observations	980			
Adjusted R^2	0.02			
F-value	2.13			.01*

Notes: * and ** denote significance at the 1 and 5 percent levels, respectively. The model is estimated by assuming *Rein90* is exogenous and using OLS. The dependent variable is the dummy variable of insolvency in 1991 and is defined as 1 if an insurer was insolvent in 1991, zero otherwise. Standard deviations are in parentheses.

TABLE 5
Estimated Effects on Insolvency from OLS (Simultaneous Equations)

Variable	Parameter Estimates		t-Value	p-Value
Intercept	-0.0248	(.0332)	-0.75	.46
Rein90	0.1942	(.0758)	2.56	.01*
CNPW90	-0.0001	(.0001)	0.06	.52
CPHS90	0.0000	(.0001)	0.55	.58
LR/NPW	0.0001	(.0001)	0.98	.33
YIA	0.0028	(.0022)	1.23	.22
NOI	-0.0000	(.0001)	-0.04	.97
NPW/PHS	0.0135	(.0056)	2.41	.02**
A/PHS	-0.0151	(.0070)	-2.17	.03**
RPHS	-0.0001	(.0002)	-0.61	.55
CL90	-0.0000	(.0000)	-0.93	.35
Mutual	-0.0202	(.0095)	-2.13	.03**
Group	-0.0058	(.0104)	-0.56	.57
Direct	-0.0054	(.0083)	-0.66	.51
Short-tailed	-0.0001	(.0002)	-0.38	.70
Number of Observations	980			
Adjusted R^2	0.02			
F-value	2.20			.01*

Notes: * and ** denote significance at the 1 and 5 percent levels, respectively. The model is estimated by assuming reinsurance ceded in 1990 to be endogenous and using OLS. The dependent variable is the dummy variable of insolvency in 1991 and is defined as 1 if an insurer was insolvent in 1991, zero otherwise. Standard deviations are in parentheses.

TABLE 6
Estimated Effects on Insolvency from the Logit Model
(Two Simultaneous Equations)

Variable	Parameter Estimates		Wald χ^2	p-Value
Intercept	-2.8512	(3.8430)	0.55	.46
Rein90	15.7800	(6.8548)	5.30	.02**

TABLE 6 (CONT.)

Variable	Parameter Estimates		Wald χ^2	p-Value
CNPW90	0.0051	(.0067)	5.73	.45
CPHS90	-0.0626	(.0262)	5.73	.02**
LR/NPW	0.0111	(.0084)	1.77	.18
NPW/PHS	0.7762	(.4333)	3.21	.07
YIA90	0.3137	(.1841)	2.90	.09
NOI90	-0.0402	(.0344)	1.37	.24
RPHS	0.0665	(.0394)	2.84	.09
CL	-0.0290	(.0165)	3.09	.08
A/PHS	-2.0436	(.7481)	7.46	.01*
Mutual	-1.5899	(1.1446)	1.93	.16
Group	-0.7985	(.9500)	0.71	.40
Direct	-1.5619	(1.322)	1.42	.23
Short-tailed	-0.0128	(.0197)	0.42	.52
Number of Observations	980			
-2 Log (L)	76.67			.00*

Notes: * and ** denote significance at the 1 and 5 percent levels, respectively. The model is estimated using the logistic estimation and assuming that *Rein90* is endogenous. The dependent variable is defined as 1 if an insurer was insolvent in 1991, zero otherwise. Standard deviations are in parentheses.

Estimated Effects of Changes in Using Reinsurance on Insolvency

Applying the estimated coefficients from the logit model, calculate the effects of changes in relevant explanatory variables on the probability of insolvency. Let p be the actual probability of insolvency. Then the partial derivative of p with respect to explanatory variable X_i is $p(1-p)\hat{\beta}_i$, where $\hat{\beta}_i$ is the estimate of parameter β_i. So, $\partial p / \partial X_i = p(1-p)\hat{\beta}_i$.[7] In order to calculate such a partial derivative, first estimate the actual probability of insolvency. It is natural to use the empirical frequency of insolvency as the estimate of the actual one. Of 980 firms, 15 firms were insolvent in 1991, so the frequency of insolvency was 1.531 percent.

Notice that $\partial p / \partial X_i = p(1-p)\hat{\beta}_i$ gives the effects per unit change of explanatory variable X_i. Then the total effects will be $p(1-p)\hat{\beta}_i \Delta X_i$, provided variable X_i is changed by ΔX_i. In Table 7, three scenarios of changes in using reinsurance are considered. Besides the unit increase of the ratio of ceded reinsurance, the table shows 17 percent increases in reinsurance and assumes that using reinsurance is increased by 19 percent. These two numbers are used to reflect the fact that insolvent insurers on average ceded 17 percent more insurance per year than solvent insurers from 1988 to 1990 and 19 percent more in 1990. In addition, Table 7 shows that the average frequency of insolvency in 1991 is used as p, but also that p is assumed to be 5 percent and 1 percent, respectively, to see how estimated effects are changed when the assumed actual probability of insolvency is changed. The table, for example, shows that if each insurer has an equal probability of 1.531 percent to be insolvent, then an insurer will cause that probability to increase to 6.051 percent (1.531 percent + 4.520 percent) when it uses 19 percent more reinsurance than other insurers.

TABLE 7
Estimated Effects of Changes in Using Reinsurance on Insolvency of Primary Insurers

Change of Ceded Reinsurance	Average Probability of Insolvency		
	$p = 1.531$	$p = 5$	$p = 1$
1 percent	0.238	0.750	0.156
17 percent	4.044	12.742	2.656
19 percent	4.520	14.241	2.968

Notes: All figures are in percentages. The estimated coefficient for ceded reinsurance in 1990 is 15.78 from the logistic model in Table 6.

Conclusions

A main purpose of insolvency studies of insurance is to predict what types of insurers are going to be insolvent. Many financial factors such as policyholder surplus ratio, the size, and the organizational form of an insurer have been widely examined to see how each of these factors could be used to distinguish insolvent insurers from solvent ones. Previous studies find that the ratio of premiums to surplus (the inverse of the policyholder surplus ratio) is one of the most reliable indicators of an insurer's solvency [Harrington and Nelson, 1986, p. 601]. Provided an insurer has a policyholder surplus ratio much lower than the industry's average, the firm will be in financial trouble and more likely to be insolvent. This paper examined the effects of ceded reinsurance on the insolvency of primary insurers and added further understanding of the issues of insolvency of insurers by showing that the use of reinsurance could signal an insurer's risk, thus the insurer's likelihood of insolvency. A less solvent insurer tends to use more reinsurance because of its inability to raise needed capital in the financial market. One implication from this study is that regulators need to pay extra attention to insurers that overly use reinsurance. Another implication is that including a variable of the ratio of ceded reinsurance in the insolvency model is very important because it is one of few significant variables affecting an insurer's probability of insolvency.

Footnotes

1. A primary insurer is a company that sells insurance directly to the public and sometimes buys insurance from other specialty insurance companies called reinsurers.
2. The model can be alternatively estimated by assuming $y > c$ instead of $y > 0$, where c is any constant number.
3. Using the assumptions given, probability ($y^* = 1$) = probability ($\varepsilon > -(\alpha Rein + X\beta)$) and probability ($y^* = 0$) = 1 - probability ($\varepsilon > -(\alpha Rein + X\beta)$). Then the parameters of α and β are consistently estimated by the maximum likelihood estimate.
4. An insolvent insurer is an insurer that was rated by the A. M. Best Company as E (under state supervision) or F (in liquidation) in 1991.
5. Ratings E (under state supervision) and F (insolvency) are not included because the firm that was rated E or F in 1989 does not have complete data.
6. The F-test for equal variances shows that *group, direct, mutual, short-tailed, NPW/PHS, YIA90, LR/NPW, Rein90, Rein89, Rein88,* and *AvRein* have no significant difference in variances between insolvent and solvent insurers.
7. From the assumptions of the logit model, $\ln(p/(1-p)) = X\hat{\beta}$. Then take the partial derivative with respect to X_i for the result.

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