Effects of Integrated Risk Management on Mean and Variance of Cost Efficiency of Property/Liability Insurance Industry

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Abstract

This paper uses the property-liability insurance companies as a research sample to investigate the relation between the enhancement of cost efficiency and the usage of reinsurance and financial derivatives as risk management tools. The stochastic frontier approach is applied to consider not only the mean of cost efficiency, but also its variance. The sample includes both organizational forms of insurers, namely, stock and mutual insurers. Empirical results show that the use of financial derivatives to manage investment risks contributes to the enhancement of the mean of the cost efficiency, while the use of reinsurance to manage underwriting risks does not. That is, the more a firm uses derivatives to hedge, the higher is the cost efficiency. On the other hand, while both mechanisms of risk management do not show their influences on the volatility of cost (in)efficiency, the ratio surplus to regulatory required risk-based capital (RBC) is a factor driving the variance of cost (in)efficiency of insurance firms.

1. Introduction and Research Background

Managers undertake hedging activities to achieve firm value maximization through the reduction of expected tax (Mayers and Smith, 1992; Smith and Stulz, 1985), the reduction in the expected cost of financial distress (Smith and Stulz, 1985), the mitigation of the problem of underinvestment (Froot, Scharfstein and Stein, 1993; Froot and Stein, 1998) or increasing a firm's debt capacity (Leland, 1998). In addition, the personal utility function related to their wealth may contribute to hedging decision (Stulz, 1984; Smith and Stulz, 1985), which says risk-averse managers are motivated to hedge if their wealth is concentrated in the firm. It is noteworthy that the literature deals with risk management mainly focusing on the use of financial products of derivatives—such as options and futures contracts to manage financial risks as well as commodity risks.

This paper uses the U.S. property and liability insurance industry as a research sample to examine the research question whether insurance efficiency can be enhanced through managing underwriting risks and investment risks separately or through an integrated risk management on both underwriting and investment risks. The insurance industry differentiates itself from other industries in its firm structure that consists of not only shareholders and bondholders, but also policyholders. Policyholders pay premiums first and expect that their future policy claims will be honored swiftly and fully, and they bear higher costs of diversification, and thereby they are more risk averse than the bondholders and shareholders of an insurance company. Merton (1993, 1995a,b) argues that customers of financial firms value risk reduction more highly than do investors because their costs of diversifying are higher. In addition, price discounting for probability of insurer default is significant as shown in Phillips, Cummins and Allen (1998). As a result, risk-averse policyholders desire insurers to manage risk more aggressively to minimize the probability of default, which is consistent with the argument in Smith and Stultz (1985) that hedging can add value when firms face convex costs, such as bankruptcy costs. However, preventing itself from insolvency, insurance firms directly benefit their policyholders, but not necessarily benefit their shareholders.

On the other hand, Schrand and Unal (1998) argue that core risks create economic value while non-core risks do not, which suggests that leaving core risks exposed (unhedged) is likely to increase firm value. While underwriting risks are recognized as a core risk for insurance firms, Scordis and Barrese (2007) provide empirical evidences showing that the use of reinsurance to hedge underwriting risks creates no significant economic value to stockholders. Moreover, Mackay and Moeller (2007) empirically show that shareholders desire the firms to leave risks exposed/un-hedged to enhance firm value to the extent to which revenue function presents convexity. In addition, diversification cost to shareholders is lower than that of policyholders, and thus shareholders will desire the insurers to expose themselves more in financial risks or hedge less in the financial market to create firm value. Facing risks from financial markets and unique insurance product markets, insurers are motivated to implement an efficiently integrated risk management strategy on managing the liability risks derived from underwriting business and the asset risks from investment activities. Based on this, insurers desire to meet the expectations from shareholders and policyholders in order to create firm value on an integration basis.

This study implements a more general efficiency model to investigate whether insurers can enhance cost efficiency from managing risks in underwriting, in investment, or in both. Different from the literature related to efficiency discussions, we assess insurance efficiency not only on the *mean* of cost efficiency, but also on its *variance*. In other words, the model considers the first and the second moments of efficiency on the implementation of risk management.

The analysis of cost efficiency has been a standard tool for decades in assessing performance of financial institutions such as banks and insurance companies. The strength of cost efficiency analysis is that it is able to separate the productivity and the efficiency and thus measure the degree of efficiency of the use of resources. For instance, the purchase of derivatives will, on the one hand, increase the total costs and, on the other hand, contribute to the cost efficiency. Their distinctions can be explained by the measure of cost efficiency.

The insurance efficiency literature has a variety of discussions on market structures (market share of an insurance firm, Rai, 1996; Choi and Weiss, 2005), organizational forms (mutual vs. stocks insurers, Rubio-Misas and Zi, 2004), regulation set-up in different countries (Cummins and Rubio-Misas, 2006) and corporate activities in mergers and acquisitions (Cummins, Tennyson and Weiss, 1999), whereas it is lack of a rigorous investigation on the efficiency level that is attributed to risk management. Cummins et al. (1998) have investigated the reason that an insurance firm would participate in one risk management mechanism — the usage of derivatives, but not explore the effect on cost efficiency.

Cummins et al. (2006) and Ren (2007) examine the effects of risk management on insurance efficiency based on the respective econometric and nonparametric model, namely stochastic frontier analysis and data enveloped analysis (DEA) model, respectively. Stochastic frontier approaches are set in a parametric framework and are able to depict the causality relations between the variables in a defined function (Lin and Lin, 2006 and 2007).

Cummins et al. (2006) assume that the risk management variables are predetermined based on the assumption of the minimization of the total cost of an insurance firm. However, this predetermined risk management decision violates the practices in the insurance industry. In our study, the decision of the risk management in underwriting and financial activities results from the joint determination with capital and investment levels (Wen, Lin and Born, 2007; Froot, 2007), and thereby the degree of risk management on the derivative transactions in managing financial risks and the usage of reinsurance in managing underwriting risks becomes a jointly determined policy by financial management, capital management, risk management and the management's discretion.

Different from the approaches employed in Cummins et al. (2006) and Ren (2007), we utilize a more general efficiency model that considers the first and the second moments of cost efficiency to examine not only the respective and integrated cost efficiency improvement attributed to the risk management on underwriting activities and on investment activities, but also the improvement on the variance of cost (in)efficiency. By setting up one-step stochastic frontiers that directly and simultaneously include the input factors and firm characteristics in the analysis model, we argue that this model provides a good fit to examine the research question. That is how the management in asset risks and liability risks separately/jointly contributes to the insurance cost efficiency level. In addition, this model has theoretically proven that the estimation of efficiency level is statistically consistent and unbiased (Wang and Schmidt, 2002).

From this brand new point of view and methodology, we are able to depict the patterns of the decision-making efforts of risk management. Moreover, the suggestions based on this empirical result will contribute to the risk management of insurance firms in the future.

The empirical results show that the use of derivatives hedging reduces the mean of cost efficiency, which explains why risk management via hedging can increase firm value. And the risk management via reinsurance is not significantly associated with either mean or variance of cost efficiency. In addition, the ratio of surplus to required risk-based capital is significantly and positively related to the variance of cost efficiency. In sum, results provide evidence that hedging contributes to the cost efficiency of an insurance firm.

2. Model Specifications and Methodology

In the following, we set up the one-step stochastic frontiers model first and then proceed to the explanations of each function and variable included in the model.

Mathematically, the one-step stochastic frontiers model is set up as follows:

$$\begin{cases} \ln CR_{it} = CR\left(Q, P^A, Z, T\right) + \varepsilon_{it} + u_{it} & eq(1) \\ u_{it} = \beta^R R_{it} + \beta^F F_{it} + \eta_{it} & eq(2) \end{cases}$$

And:

$$\begin{cases} \ln CR_{it} = CR\left(Q, P^A, Z, T\right) + \varepsilon_{it} + u_{it} & eq(1) \\ \sigma_{uit}^2 = \exp(\gamma' R_{it} + \lambda F_{it}) & eq(3) \end{cases}$$

where u_{it} is defined as the one-sided cost inefficiency, and η is its residual term; ε is the normal residual term of the cost function. R_{it} is a vector of variables that are related to risk management. The cost inefficiency is represented by e^u and its numerical interpretation is with a value of 1.20 for e^u suggesting that the total cost is 20 percent above the optimal level of the cost function and thus is recognized as a measure for inefficiency level. In addition, the factors influencing the degree of u are exogenous and determined by the managerial decisions, namely, the risk management variable *R* that consists of the management on underwriting risks, investment risks or both, and financial intermediate outputs variable *F*. σ indicates the variance of cost inefficiency term u. The reasoning behind Model 2 is that the risk management can reduce the uncertainty of cash flows.

The one-step stochastic frontiers model considers not only the cost efficiency level, but also the variance of cost efficiency. Equations (1) and (2) indicate the degree of mean efficiency enhanced through the implementation of risk management, while equations (1) and (3) identify the degree of the variance of cost efficiency that is improved via risk management. The inclusion of a vector of variables that are related to risk management in equations (2) and (3) enables us to consider the separate effects from managing underwriting risks or investment risks as well as the joint effects from managing both categories of risks. The simultaneous consideration of equations (1), (2) and (3) takes the mean and variance of cost efficiency into account simultaneously, which contributes to the literature by expanding the insurance efficiency study in a deeper sense by considering the different perspectives from both shareholders (emphasizing more on efficiency enhancement) and policyholders (averse to variance).

The functions and variables included in the model are explained as follows.

The production Y is explained by Q, X^A, Z, T. Q is defined as insurance services produced using a vector of inputs X^A based on the following production function:

$$Y\left(Q; X^A, Z, T\right) = 0$$

Z is a vector of control variables—firm characteristics and T represents time.

We assume that the risk management variables *R* and financial intermediate outputs *F* are both determined by the discretion and judgment of management of an insurance company.

The cost function given the same technology level is written as:

$$CR = CR\left(Q, P^A, Z, T\right)\ e^u$$

where CR is total cost and P^A represent input prices of X^A. This cost function renders least cost given the level of insurance services Q, the input price P^A and the state of control variables Z.

For empirical applications, as indicated in insurance efficiency literature (Cummins and Weiss, 1998; Cummins et al., 2006), a translog functional form is taken as follows:

$$\begin{cases} \ln CR_{it} = \ln CR_{it} = \alpha_i + \sum_v \beta_v^Q \ln Q_{vit} + \sum_s \beta_s^A \ln P^A{}_{sit} + \beta^Z \ln Z_{it} + \mathrm{sec}ond\_order\_terms \\ \qquad + \sum_t \beta^t D_t + u_{it} + \varepsilon_{it} \qquad eq(4) \\ u_{it} = \beta^R R_{it} + \beta^F F_{it} + \eta_{it} \qquad eq(5) \end{cases}$$

And

$$\begin{cases} \ln CR_{it} = \ln CR_{it} = \alpha_i + \sum_v \beta_v^Q \ln Q_{vit} + \sum_s \beta_s^A \ln P^A{}_{sit} + \beta^Z \ln Z_{it} + \sec ond\_order\_terms \\ \quad + \sum_t \beta^t D_t + u_{it} + \varepsilon_{it} \qquad eq(4) \\ \sigma_{uit}^2 = \exp(\gamma' R_{it} + \lambda F_{it}) \qquad eq(6) \end{cases}$$

The variables are the same as defined above after equations (1), (2) and (3).

3. Statistical Hypotheses

The focal point in this study is risk management. Hence, the statistical hypotheses are proposed in this section to test the relation between risk management variables and cost efficiency. Since the risk management variables may affect either the mean or variance of cost efficiency, we illustrate two hypotheses: H1 is to test the effects of risk management on the mean of cost efficiency and H2 is for testing the effects of risk management on the variance of cost efficiency.

Therefore, the variables related to risk management activities are incorporated in the explanation of the cost inefficiency term. The variables of reinsurance premium written and the total notional amount of derivatives are to represent R1 and R2, respectively. They are assumed to contribute positively to the cost efficiency of the insurance industry.

- *H1A:* Reinsurance premium written is positively related to cost efficiency.
- *H1B:* The notional amount of derivatives is positively related to cost efficiency.

The other group of hypotheses is to test the risk management factors influencing the variance of the cost efficiency (i.e., heteroscedastic cost efficiency). They are:

- *H2A:* Reinsurance premium written is negatively associated with the variance of cost efficiency.
- *H2B*: The notional amount of derivatives is negatively associated with the variance of cost efficiency.

4. Data Sources and Variables

The major database used in this research is the insurance data reported on the regulatory annual statement filed by insurers with the National Association of Insurance Commissioners (NAIC). The sample period under this current study is year 2003. In the sample of insurers under study, there are 334 and 206 stock and mutual insurance companies, respectively, based on the availability of variables mentioned below.

This paper adopts an intermediary approach (Brockett et al., 2005)[3] in the specifications of cost function, and the variables are defined and collected. The dependent variable of the cost frontier is the total costs denoted by CR. The total costs here include the costs related to investment expenses and underwriting expenses derived from underwriting new policies, maintaining the existing policies and the reserving process.

To empirically implement the methodology of one-step stochastic frontiers, we collect the variables that are related to output prices (Q), input prices (P)[4], risk management (R) and firm characteristics Z Since investment and underwriting risks are the two major categories of risks that insurance companies intend to manage, we collect the output variables that are related to the investment and underwriting activities.

Output prices under study here are Q1 and Q2. Q1 stands for the investment-related output quantity measured by the ratio of net investment income to total assets. Q2 represents underwriting-related output quantity defined by the ratio of total loss incurred to net premium written. On the other hand, for insurance companies, the stakes of ownership can be classified by policyholders, stockholders and debt holders. Thus input prices are the variables related to each category of ownership, such as P1, P2 and P3. P1 stands for the ratio of the sum of dividend paid to the stockholders and change in Treasury stocks to the surplus; P2 is the rate of increase of surplus, that is the surplus in year 2003 divided by the surplus in year 2002; P3 denotes the ratio of interest expenses to surplus.

Moreover, with respect to the variables related to risk management, we use reinsurance premium written (*R1*) and the notional transactions amount of derivatives (*R2*) to represent the vector variable R, which plays an essential role in influencing the mean and variance of cost efficiency. Lastly, the Z factors, representing the exogenous firm characteristics variables, include the ratio of surplus to regulatory required risk-based capital (Sup_RBC) and the growth rate of net premium written (NPW_GW).

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[3] Brockett et al. (2005) indicate that the intermediary approach is more relevant than the value-added (production) approach in the insurance industry.

[4] Here we use P instead of P^A in the empirical results to make the notation concise.

5. Empirical Results

5.1 Summary of Statistics

Table 1 summarizes the descriptive statistics of the variables based on different organizational forms of insurance companies, namely stock and mutual insurers. The inputs prices are denoted by P1, P2 and P3, in which P1 is defined as the ratio of the sum of dividends paid to stockholders and the change in Treasury stocks to surplus; P2 is the change rate of surplus defined as the ratio of current year's surplus to previous year's surplus; and P3 is defined as the ratio of interest expenses to surplus, which is the relative input price. Due to data availability, for stock insurers only input prices P1 and P2 are included; whereas for mutual insurers, only P2 and P3 are included. The two-sample Z test is conducted to compare the means of these two groups of firms, and the result is demonstrated, where the means of variables for Group 1 subtracting those for Group 2 are tested.

As shown in Table 1, the mean and standard deviation of P2 for stock insurers are 1.1536 and 0.2732, respectively, which are smaller than those of mutual insurers with the mean of 1.2351 and the standard deviation of 0.3027. This fact infers that the cost of capital for stock insurers is cheaper than that for mutual insurers, though the differences are not significant.

In addition, the means of the total costs CRs for stock and mutual insurers are $216,028 (M) and $177,435 (M), respectively. The difference between the standard deviation for Group 1 and that for Group 2 is comparably small. Nevertheless, the minimum CR in Group 1 is smaller than that for Group 2.

For the output quantity variables, since we have standardized the measures, the means of Q1 and Q2 are 0.0036 and 0.0560, respectively, for stock insurers, while they are 0.0032 and 0.0538 for mutual insurers. Regarding the input prices, only P2 is the only common factor for types of insurance companies. The P2 for Group 1 is much smaller than that for Group 2 at the 1 percent significance level.

R1 and R2 are the two key risk management variables in which R1 is the amount of reinsurance written for managing underwriting risks and R2 is the notional transactions amount of derivatives for hedging investment risks. Results show that the degree of using reinsurance and financial derivatives is much larger for stock insurers than for mutual insurers at the 10 percent significance level. Specifically, the means of R1 and R2 for stock insurers are 0.3870 and 11.4687, respectively, and they are 0.0622 and 3.7731 for mutual insurers. This result suggests that stock insurers implement risk management tools more intensively than the mutual insurers do. Moreover, the standard deviations of R1 and R2 are 5.8188 and 67.6817, respectively, for the former group, while they are 0.0906 and 26.1742, respectively, for the latter group.

With respect to the exogenous variables, Zs are represented by the ratio of surplus to regulatory RBC (SUP_RBC) and the growth rate of net premium written (NPW_GW). The mean of SUP_RBC of stock insurers is smaller than that of mutual insurers, while standard deviation shows otherwise. Specifically, the means are 1.0025 and 1.0140 for the former and latter groups, respectively. Moreover, the values of mean and standard deviation of NPW_GW for stock insurers are both above those of mutual insurers. It suggests that a larger degree of growth rate of premium for stock insurers is along with a higher degree of volatility of the growth rate.

TABLE 1

Summary of Descriptive Statistics

This table reports the descriptive statistics of those variables that are employed for analysis.

	Group 1: Equity holder Owned Firms					Group 2: Mutually Owned Firms					Two-sample test
Variable	Mean	Std.Dev.	Minimum	Maximum	Firms	Mean	Std.Dev.	Minimum	Maximum	Firms	Z-Test
CR	216028	694190	0.0522	7960000	334	177435	506941	0.1316	3968190	206	0.74
Q1	0.0036	0.0040	0.0001	0.0587	334	0.0032	0.0019	0.0001	0.0194	206	1.62
Q2	0.0560	0.0383	0.0000089	0.4628	334	0.0538	0.0202	0.0007	0.2084	206	0.87
P1	0.1375	0.3067	0.0000005	2.9399	334	--	--	--	--	--	--
P2	1.1536	0.2732	0.0898	2.7395	334	1.2351	0.3027	0.3060	2.9261	206	-3.15 ***
P3	--	--	--	--	--	0.0106	0.0149	0.0000004	0.1004	206	--
R1	0.3870	5.8188	0.0000	106.3840	334	0.0622	0.0906	0.0000	0.5208	206	1.02
R2	11.4687	67.6817	0.0000	639.5658	334	3.7731	26.1742	0.0000	273.8992	206	1.86 *
SUP_RBC	1.0025	0.0185	0.9674	1.2314	334	1.0140	0.1262	0.9900	2.7500	206	-1.30
NPW_GW	2.7375	15.9319	-14.8831	190.7143	334	1.3082	1.9380	-0.2900	28.4700	206	1.62

Legend:
CR: Total Costs+Loss Reserved+Unwritten Premium in million US$.
Q1: Investment related output quantity, i.e., Net investment income/Total Assets*100
Q2: Underwriting related output quantity, i.e., Loss Incurred/Net Premium Written*100
P1: (Dividend paid+change in treasury stocks)/surplus*100
P2: Surplus in year 2003 /surplus in year 2002.
P3: Interest expenses/surplus
R1: premium written of reinsurance
R2: The notional amount of derivatives used
SUP_RBC: Surplus of the company divided by RBC
NPW_GW: the growth rate of net premium written in %.
*, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

6. Empirical Analysis

Table 2 reports the empirical results of the cost frontiers for Model 1 and Model 2 that are to depict the mean and variance of cost efficiency illustrated in the sets of equations (1) and (2), and equations (1) and (3) . In other words, the impacts of the factors of risk management (R) and firm characteristics (Z) on the mean of cost inefficiency u are represented in Model 1, and their influences on the variance of cost (in)efficiency are specified by Model 2, as indicated in Wang and Schmidt (2002). The empirical analysis is conducted by the LIMDEP 8.0 software.

Panel I and Panel II demonstrate the results of Model 1 and Model 2, respectively. Insurance companies with different organizational forms may behave differently, thus the analysis of cost efficient is separately conducted for the stock and mutual insurers. Results show that the cost frontiers for these two types of insurance firms are different. For example, as shown in Panel I, it is found that the parameters in the cost frontiers for Group 1 are all insignificant. Nevertheless, in the reduction of the mean of cost inefficiency, the risk management variable R2 (the use of financial derivatives) is significant at the 1 percent statistical level, while the use of reinsurance and surplus level relative to RBC are insignificant in explaining u. In other words, R2, the notional amount of derivatives contributes positively and significantly to the cost efficiency of insurance firms. The more derivatives used for managing investment risks, the higher efficiency level is operated. The cost frontier for Group 2 firms is statistically more significant: the coefficients of lnP3 and lnP2lnP2 are negatively significant at the 1 percent level; and lnQ2lnQ2, lnP3lnQ1, lnP2lnQ1 are significant at the 10 percent level.

Consistent with the results for stock insurers, the use of derivatives (R2) in mutual insurance companies is a significant factor in increasing the mean of cost efficiency at the 5 percent statistical level. The results suggest that regardless of the organizational form of an insurance company, adopting the risk management mechanism in managing investment risks can enhance the firm's cost efficiency. As found in Scordis and Barrese (2007), while underwriting risks are recognized as a core risk for insurance firms, the use of reinsurance to hedge underwriting risks creates no significant economic value.

After having confirmed that managing investment risks for insurance firms can enhance their cost efficiency, we intend to further investigate whether such risk management mechanism can improve the variance of cost efficiency. Results are shown in Panel II of Table 2. With respect to the cost frontiers, the input variables of lnP1 and lnP3 are significant for stock insurers and mutual insurers, respectively.

Additionally, even though the significance of the input price variable is stronger in mutual insurance firms, it does not nullify the estimation of the cost frontier for Group 1. When a cross-sectional cost function is estimated for stock insurers, it was found that the firm-specific risks can be diversified away for publicly traded stock insurers. Therefore, their estimates of cost frontiers are not so significant, while the estimates of cost frontiers are more relevant for mutual insurers. Furthermore, Panel II shows that neither of the risk management mechanisms in managing investment and underwriting risks can significantly influence the variance of cost inefficiency. Nevertheless, the variable of SUP_RBC, the amount of surplus relative to regulatory required RBC, is the significant key variable that drives up the variance of u for both stock and mutual insurers. In other words, an increase in SUP_RBC will push up the variance of cost inefficiency u. Results suggest that when insurance firms can efficiently conduct risk management mechanisms, the more holding in surplus relative to the regulatory required capital level may cause a higher degree volatility of the cost inefficiency.

TABLE 2

Cost Frontiers of Model 1 and Model 2

Panel I: Model 1 R and Z in the Mean of Cost Inefficiency u							
Group1: Stock Insurers				**Group 2: Mutual Insurers**			
Variable	**Coefficient**	**t-value**		**Variable**	**Coefficient**	**t-value**	
Constant	36.49	0.62		Constant	13.46	0.68	
lnQ1	5.92	0.34		lnQ1	0.31	0.06	
lnQ2	-1.69	-0.26		lnQ2	4.36	0.77	
lnP1	-4.81	-1.32		lnP3	-3.64	-2.76	***
lnP2	19.66	0.60		lnP2	8.85	0.54	
lnP1lnP2	1.15	1.02		lnP3lnP2	-1.03	-1.33	
lnP1lnP1	-0.12	-1.25		lnP3lnP3	0.02	0.29	
lnP2lnP2	2.69	0.57		lnP2lnP2	-6.19	-2.18	**
lnQ1lnQ2	-0.65	-0.55		lnQ1lnQ2	1.97	1.84	
lnQ1lnQ1	0.44	0.29		lnQ1lnQ1	-0.32	-0.83	
lnQ2lnQ2	0.12	0.69		lnQ2lnQ2	-1.27	-1.65	*
lnP1lnQ1	-0.24	-0.39		lnP3lnQ1	-0.34	-1.69	*
lnP1lnQ2	-0.38	-0.82		lnP3lnQ2	-0.56	-1.29	
lnP2lnQ1	-0.61	-0.11		lnP2lnQ1	3.62	1.69	*
lnP2lnQ2	3.99	0.86		lnP2lnQ2	-4.76	-0.91	
Parameters in mean of u				**Parameters in mean of u**			
SUP_RBC	-1.99	0.00		SUP_RBC	-0.04	-0.01	
NPW_GW	-0.02	0.00		NPW_GW	0.03	0.01	
R1	1.24	0.00		R1	-0.01	0.00	
R2	-0.03	-3.61	***	R2	-0.09	-2.49	**
Variance parameters				**Variance parameters**			
Λ	0.07	0.00		Λ	1.83	3.22	***
Σ	7.02	24.75	***	Σ	6.54	4.75	***

TABLE 2

Cost Frontiers of Model 1 and Model 2(Continued)

Panel II: Model 2 R and Z in the Variance of Cost Inefficiency u							
Group1: Stock Insurers				**Group 2: Mutual Insurers**			
Variable	**Coefficient**	**t-value**		**Variable**	**Coefficient**	**t-value**	
Constant	31.19	0.74		Constant	12.02	0.55	
lnQ1	5.71	0.41		lnQ1	0.67	0.12	
lnQ2	-2.02	-0.31		lnQ2	2.45	0.39	
lnP1	-5.48	-1.74	*	lnP3	-3.76	-2.75	***
lnP2	17.78	0.61		lnP2	8.90	0.56	
lnP1lnP2	0.96	0.86		lnP3lnP2	-1.28	-1.57	
lnP1lnP1	-0.11	-1.04		lnP3lnP3	0.02	0.34	
lnP2lnP2	2.64	0.57		lnP2lnP2	-5.40	-1.78	
lnQ1lnQ2	-0.66	-0.57		lnQ1lnQ2	1.85	1.61	
lnQ1lnQ1	0.46	0.38		lnQ1lnQ1	-0.26	-0.67	
lnQ2lnQ2	0.13	0.72		lnQ2lnQ2	-1.33	-1.67	
lnP1lnQ1	-0.31	-0.60		lnP3lnQ1	-0.36	-1.65	
lnP1lnQ2	-0.50	-1.17		lnP3lnQ2	-0.58	-1.37	
lnP2lnQ1	-0.65	-0.13		lnP2lnQ1	3.06	1.38	
lnP2lnQ2	3.70	0.85		lnP2lnQ2	-2.98	-0.55	
	Parameter in variance of ε				**Parameter in variance of ε**		
Constant	3.59	16.39	***	Constant	2.63	9.74	***
	R and Z in variance of u				**R and Z in variance of u**		
SUP_RBC	3.80	7.10	***	SUP_RBC	2.96	4.69	***
NPW_GW	0.01	0.36		NPW_GW	-0.03	-0.05	
R1	-5.43	-1.39		R1	0.00	0.00	
R2	0.01	1.55		R2	0.02	1.64	

Notes:

*, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

CR: Total Costs+Loss Reserved+Unwritten Premium in million US$.

The dependent variable of the equation is lnCR, which equals CR with a parameter 0.09 in the Box-Cox transformation to adjust the wrong skewness..

lnQ1, lnQ2, lnP1, lnP2 and lnP3 are the natural logarithm of Q1, Q2, P1, P2, and P3, respectively. lnP1lnP2 is a second order item that equals the product of lnP1 and lnP2. All other second order items are denoted in the same way.

Q1: Investment related output quantity, i.e., Net investment income/Total Assets*100.

Q2: Underwriting related output quantity, i.e., Loss Incurred/Net Premium Written*100.

P1: (Dividend paid+change in treasury stocks)/surplus*100.

P2: Surplus in year 2003 /surplus in year 2002.

P3: Interest expenses/surplus.

R1: premium written of reinsurance.

R2: The notional amount of derivatives used.

SUP_RBC: Surplus of the company divided by RBC.

NPW_GW: the growth rate of net premium written in %.

$\lambda = \sigma_u / \sigma_\varepsilon$

$\sigma = \sqrt{\sigma_u^2 + \sigma_\varepsilon^2}$

7. Conclusions

This paper applies stochastic frontier approach to investigate the relationship between cost efficiency and the risk management mechanisms adopted by a group of property/liability insurance companies that include both organization forms of stock and mutual insurers for year 2003. Empirical results support the argument that for both stock and mutual insurers, the use of financial derivatives in managing investment risks can enhance the cost efficiency, while the use of reinsurance in managing underwriting risks cannot. The results are attributed to the fact that underwriting risks are categorized as core risks in insurance companies, and thus leaving the firm's exposure to such core risks instead of hedging them away can increase a firm's economic value (Scordis and Barrese, 2007).

On the other hand, the risk management tools do not influence the volatility of cost (in)efficiency, while the ratio of surplus to regulatory required capital (SUP_RBC) drives the variance of cost (in)efficiency of firms. Results suggest that holding a higher level of surplus compared to the regulatory required capital level unexpectedly increases the variance of cost inefficiency.

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