

DERIVATIVE HEDGING AND INSURER SOLVENCY: EVIDENCE FROM TAIWAN

ABSTRACT

Using company-level panel data (2001-2003), this paper empirically examines whether Taiwanese insurers' use of derivatives for hedging purposes is significantly related to their solvency (as measured by solvency ratio). Contrary to the public's perception that firms with derivative programs have a higher level of solvency if derivatives are employed for hedging purposes, our results indicate that insurers' derivative hedging generally is not associated with solvency. Derivative hedgers have solvency that is similar to nonhedgers.

JEL classification: C3; G32; M41

Keywords: Derivative use; Insurer solvency; Hedging

INTRODUCTION

According to Modigliani and Miller's propositions, derivative hedging should be irrelevant in a frictionless world with full information and complete markets, and without tax, cost of transaction and financial distress. In the real world, however, imperfections exist in capital markets and Modigliani and Miller's propositions do not completely hold. Some previous studies suggest that hedging creates value for firms (e.g., Allayannis and Weston, 2001; Carter, Roger and Simkins, 2006). It is the public's perception that firms which have derivative programs for hedging purposes are expected to be less likely to go bankrupt than those which do not.

Wide use of derivative securities in recent decade has generated several studies concerning the relation between the use of derivatives and firm risk. The empirical evidence is inconclusive. For instance, Koski and Pontiff (1999) and Hentschel and Kothari (2001) do not find a relation between derivative use and corporate risk, while Tufano (1996) and Guay (1999) document a positive relation between derivative use and risk reduction. As far as the authors understand, there is little, if any, research investigating the relationship between derivative hedging and insolvency risk in the context of insurance.

Derivative markets were originally introduced to eliminate risk for commodities.

According to the EU Insurance Directive, however, derivatives are used by insurers to cover technical provisions where they were affected for the purposes of efficient portfolio management or risk reduction, and thus to increase insurer solvency. As described in the United Kingdom Prudential Source Book for Insurers (Financial Services Authority, 2008), derivatives are regarded as being held for the purpose of efficient portfolio management if the insurer reasonably believe that the derivatives enable the insurer to generate additional capital/income, reduce tax/investment cost, or acquire/dispose of rights, while derivatives held for the purpose of reducing investment risk if they can reduce any aspect of investment risk without significantly increasing any other element of that risk. As such, derivatives in insurance can be used for hedging or nonhedging purposes.

Under the Taiwanese ‘Guidance Note on Derivative Transactions by Insurers’ issued by the Financial Supervisory Commission, all authorized insurers carrying on insurance business in Taiwan can only employ derivatives to hedge risks rather than speculate on market price movements. The aim of allowing insurers to engage in derivative hedging is to enable insurers to alleviate the impact of risks on its financial health and thus to increase solvency. As discussed later in this section, the problem of endogeneity may exist in the analysis. Jin and Jorion (2006) propose three criteria for selecting an ideal sample to examine the issue on hedging premium. First, the sample

is obtained from a single industry. Second, financial exposure is important for firms in the sample. Third, these firms have a huge variety of hedging ratios. These criteria can also be applied to this study investigating the relationship between derivative hedging and insolvency risk. In this analysis, our sample is limited to insurance firms which are exposed to market risks to a great extent and have diverse hedging programs. Our insurance sample largely satisfies the criteria proposed by Jin and Jorion (2006). We adopt a single industry setting in which risk exposures are more likely to be similar across firms to test the relation between derivative hedging and insurer solvency.¹

The Taiwanese insurance regulator only permits insurers to use derivatives for hedging purposes for fear that derivatives might be employed for speculative purposes to the detriment of solvency. Derivative use, if not properly controlled, could increase, rather than reduce risk. We examine whether the insolvency risk of an insurer decreases with the use of derivatives. If the insurer uses derivatives for hedging purposes, as required by the regulator, the insolvency risk faced by the insurer should be reduced and, thus, its solvency improved. Conversely, if derivatives are used for income enhancement, the risk might be increased and the solvency reduced.

Surprisingly, little is known about the linkage between derivative hedging and

¹ The single-industry approach has recently been used in assessing the effect of hedging on firm value. See Jin and Jorion (2006) and Carter, Rogers and Simkins (2006).

firm solvency in insurance. This paper seeks to address this gap in the literature by investigating the association between insurer solvency and the use of derivatives for hedging purposes.

Prior literature on risk management suggests that corporate hedging is aimed at achieving shareholder value maximization (Smith and Stulz, 1985; Froot, Scharfstein, and Stein, 1993; Tufano, 1996). Using off-balance-sheet instruments for hedging reduces insolvency risk and volatility of firm value, and accordingly increases the expected utility of shareholders. On the other hand, greater insolvency risk could motivate more hedging activities with derivatives. Thus, we cannot rule out the possibility that both risk and derivative utilization might be endogenously or simultaneously determined by certain corporate characteristics. If there exists endogeneity in regressions, our coefficient estimates from the ordinary least squares (OLS) regression would be inconsistent (Maddala, 2001). As described previously, Jin and Jorion (2006) argue that selecting firms within the same industry is instrumental in alleviating the endogeneity problem. In our analysis, the sample is limited to insurance firms. To further and formally address this problem, we test for endogeneity using the Hausman test devised by Wu (1973) to identify whether two stage least squares could be applied to improve consistency in the estimation process. We carry out this before examining the effect of derivative hedging on insolvency risk. In the

empirical analysis, we use the solvency ratio to measure insolvency risk. The higher the solvency ratio, the lower the insolvency risk. The findings suggest that derivative use does not seem to affect solvency for the insurance industry, implying that derivative use by insurers does not decrease or increase insurer solvency.

The remainder of the paper is organized as follows. In the next section, we discuss the related literature. In Section 3, we describe the sample, variables and methodology employed in this study. Section 4 presents the results while the last section concludes and provides some policy implications.

RELATED LITERATURE

Corporate hedging studies can be broadly classified into two categories. The first is to identify the determinants of decisions on derivative use. The decisions include whether to participate in the derivative markets and the extent to which derivatives are used. Determinants studies (e.g., Nance et al., 1993; Colquitt and Hoyt, 1997; Hardwick and Adams, 1999; Cummins, Phillips, and Smith, 2001; De Ceuster et al., 2003) generally base their hypotheses on the shareholder value maximization argument and the managerial incentives theory. These studies find that several firm-specific factors such as size, growth option, and liquidity are potentially related

to participation and extent decisions on derivative use. Another strand of research is to examine the effect of derivative use on risk (e.g. Guay, 1999; Hentschel and Kothari, 2001; Yang et al., 2006), firm value (e.g. Allayannis and Weston, 2001; Jin and Jorion, 2006; Carter, Rogers and Simkins, 2006), or asymmetric information (e.g., Dadalt, Gay, and Nam, 2002). Previous studies show mixed results concerning the linkage between derivative usage on firm risk. Analyzing a sample of 679 domestic equity mutual funds, Koski and Pontiff (1999) find no differences in risk between derivative users and nonusers. Hentschel and Kothari (2001) find that the riskiness of a firm is not associated with its derivative use for both financial and non-financial firms. Bali, Hume and Martell (2007) use the data on non-financial firms from 1995 through 2001 to examine the relation between interest rate, currency and commodity derivatives and their corresponding risk exposures. In their research, little evidence is found to support the view that derivative use reduces the impact of price movements on firms. Conversely, it is argued that managers can better perform risk management through hedging, decrease insurer insolvency risk, and thus increase solvency. Guay (1999) documents that entity risk declines following derivative use. Using a sample of 99 bank holding companies, Venkatachalam (1996) shows that derivative contracts are employed by these banks to reduce risk. Sinkey and Carter (2000) find that banks with a higher probability of bankruptcy have a propensity to employ derivatives to hedge.

In this case, the likelihood of insolvency determines the extent of derivatives employed and the level of bankruptcy risk decreases due to derivative use. Atkins, Carter and Simpson (2007) find that the higher level of currency risk a bank faces, the more currency derivatives the bank uses for hedging purposes, implying that a negative relation exists between currency risk and bank risk. Allayannis and Ofek (2001) find empirical support for financial firms' use of foreign currency derivatives for hedging purposes. Yang et al. (2006) argue that capital market participants generally perceive that banks use derivatives to hedge risk. Thus, if firms mainly use derivatives to hedge these movements, then we would expect that the use of derivatives should reduce risk exposures. In sum, prior research of this strand is limited to the management of capital markets risk for financial and non-financial firms. It is unclear whether the hedging premium exists for insolvency risk or within the insurance industry. This study helps shed light on these questions by examining the relation derivative hedging and the level of insolvency risk for insurers.

Prior studies (e.g., Guay, 1999; Hentschel and Kothari, 2001) employ various measures entailing market value of the company to proxy firm risk. Due to the fact that most insurers in Taiwan are not listed firms, however, the absence of information on daily market prices makes unavailable the information on market value. We, therefore, cannot measure the effects of derivative use on market risk measures. This

work is important as maintaining solvency is the most important task of insurers and no research has been carried out to examine the relation between derivative use and insolvency risk/solvency. We conduct this research to fill in the gap in the literature. In this analysis, the solvency ratio (book value of equity expressed as a percentage of net premiums written) is used as an indicator of insurer insolvency risk.

RESEARCH DESIGN

The Sample

We obtain data on notional amount of derivative contracts and insurer characteristics, taken mostly from the year books and annual financial reports provided by the Taiwan Insurance Institute, a think tank of insurance in Taiwan. The data are verified and supplemented using company annual reports. Annual data for life and non-life insurers from 2001 through 2003 are collected. As shown in Table 1, 94 and 90 per cent of life and non-life insurers in business respectively are included in the sample. All large insurers in terms of total assets and gross premiums written also are included. Thus, our sample is representative of the whole insurance industry.

(Insert Table 1 about here)

Figures 1 and 2 show that the number of derivatives users increases in proportion to

the derivatives they held during the period 2001-2003. Figure 3 indicates that, albeit with slight growth in the derivatives holdings of the non-life insurance sector, the relative proportions seem to remain constant over the period.

(Insert Figures 1-3 about here)

It is worth mentioning that insurers in Taiwan can only carry out derivative transactions for hedging purposes in accordance with ‘Guidance Note on Derivative Transactions by Insurers’ issued by the Financial Supervisory Commission of Taiwan. According to these regulations, insurers must clearly disclose their derivative use and the risk exposures to be hedged in their financial statements, making possible this study on the relation between derivative hedging and solvency.

Control Variables

As regards the control variables, we follow Guay (1999) and Hentschel and Kothari (2001) in using leverage (LEVER) and the book value of common equity (EBV). Since most Taiwanese insurers are not publicly traded companies, we use book values, instead of market values that are used in Guay (1999) and Hentschel and Kothari (2001). Leverage is introduced to account for the fact that an insurer’s capital structure may be related to its solvency. Insurers with excessive leverage are relatively likely to become insolvent (Shiu, 2005). We use a leverage variable defined as the

book value of liability over the book value of equity. The book value of common equity is introduced to account for the influence of cushion considerations. A number of insurer characteristics also are included in the regressions to avoid omitted variables bias, since past research has suggested the importance these considerations. These variables include degree of concentration of premiums (HERFP), interest rate risk exposure (MISAST and MISLIA), foreign exchange rate risk (FX), growth opportunity (GROWTH), reinsurance dependence (REINS), net interest margin (NIM), and the sale of investment-linked insurance (INV) (life insurance only). All these variables are considered in theory to be related to insurer solvency. The definitions of control variables are described in Table 2 and their hypothesized relationship with solvency discussed below. We calculate the Herfindahl index of net premiums written to reflect the concentration of product mix. Both interest rate and currency risks are included as control variables to account for the effects of these two major market risks on insurer solvency. A measure of the growth opportunity is included to control for changes in solvency unrelated to derivative usage. The rationale for this measure is that insurers with more growth opportunities are expected to perform better and thus have a relatively low likelihood of insolvency and a high level of solvency. Previous evidence (e.g., Garven and Lamm-Tennant, 2003; Cole and McCullough, 2006) suggests that the purchase of reinsurance can substitute for

capital. Insurers with more reinsurance are less likely to become insolvent. We use reinsurance ceded over the sum of direct premiums and reinsurance assumed as a proxy. We also include net interest margin as one of the control variables because it may be related to solvency. For life insurers, we control for the sale of investment-linked insurance products since insurers selling such products are highly exposed to capital markets risk as well as return.

(Insert Table 2 about here)

Methodology

To assess the effect of derivative use on insurer solvency, we estimate the following model using panel estimation techniques:

$$Solvency_{i,t} = f(Derivative\ Use_{i,t}, CV_{i,t}) + \nu_i + \varepsilon_{i,t}$$

where $Solvency_{it}$ is the solvency ratio of insurer i at time t . $Derivative\ Use_{it}$ is a dummy variable (user=1; nonuser=0) to represent the participation decision on derivative use or a continuous variable (proxied by the balance of quarter-end notional value of derivatives instruments scaled by total assets of the insurer) to represent the extent decision. CV_{it} refers to the set of control variables which are related to insurer solvency based on the literature reviewed. ν_i accounts for individual effects and $\varepsilon_{i,t}$ is an error term. Besides, since the regressions involve multiple years, we also

include yearly dummies, which are not reported here.

EMPIRICAL RESULTS

Hausman tests of endogeneity

Before considering the impact of derivatives activities on the risk profile of an insurer in the next subsection, we should beware of the likelihood that our analysis may suffer from the problem of endogeneity. Since the risk faced and the derivatives held by the firm may be simultaneously determined, endogeneity could be an econometric issue. If this is the case, the classical OLS assumption that explanatory variables are exogenous and uncorrelated with the error term would be violated. The coefficient estimates obtained from OLS regressions would then be biased and inconsistent (Maddala, 2001). To test for endogeneity, a Hausman test with the null of no endogeneity is performed.

The first step in conducting a Hausman test is to find appropriate instrumental variables which are uncorrelated with the error term (the first requirement) but associated with the proxy variables of derivative utilization (the second requirement). There is no universally recognized approach to testing the validity of available instruments. A Pearson correlation test is utilized here. The possible candidates for

instruments are the significant variables obtained from the literature (specifically Shiu, Adams, Shin (2008)) on determinants of decision on derivative use. We employ a Pearson correlation test to investigate the relationships between derivative usage and the chosen variables, and between these variables and the error term. Those satisfying both requirements are selected as instrumental variables for the Hausman test. The results of the correlation and Hausman tests are presented in Panels A (for the life insurance sector) and B (for the non-life insurance sector) of Table 3.

(Insert Table 3 about here)

In addition, any explanatory variables (other than the proxy for derivative use) that are not correlated with the error term are also included as instruments. This is to satisfy the order condition for identification, which requires that there are at least as many instruments as there are coefficients in the model. None of these variables are significantly related to the error term (results available on request).

The life insurance results indicate that derivative usage is not endogenously determined and accordingly it is not necessary to employ the instrumental variable estimation, such as the two stage least squares approach, in the analysis. However, for the non-life sector, there is no qualified instrumental variable, as reported in Panel B of Table 3. As suggested by Maddala (2001), it is difficult in practice to find appropriate instruments. The results obtained from the instrumental variable

estimation, if a poor instrument is used, are worse than those from the OLS specification. The findings reported in Panels A and B of Table 3 produce no evidence that insurer risk and derivative holdings are endogenously determined, so the two stage least squares approach is inappropriate in our study.

Univariate Analysis

In this section, we test the hypothesis, which is whether derivative user firms have the same solvency as nonuser firms. Univariate results are presented in Table 4. Panels A and B of this table reports the means and variances of solvency ratio respectively for derivative users and nonusers for the life and non-life sectors. To examine whether there is any statistical difference in the means and variances between users and nonusers, we conduct equality tests. With a view to confirming the robustness of the results, two tests are conducted for both statistics, i.e., mean and variance. The equality test results can also be found in Table 4. The results from this table display no statistically significant difference in solvency ratios between users and nonusers.

(Insert Table 4 about here)

Multivariate Regressions

We now examine whether firm solvency is affected by derivative activities measured by the participation decision and the participation extent. Other firm characteristics significantly influencing risk are also reported below. The results of the

participation models are illustrated in Tables V (Life) and VI (Non-life), whereas those of the usage extent decision models are shown in Tables VII (Life) and VIII (Non-life). It should be noted that not all explanatory variables are included in all the models. We start with a simple model by regressing our dependent variable (i.e. solvency) on the derivative use variable (Specification I). In the second step, we add to these basic regressions a set of control variables (Specification II), as discussed above. In the final stage of the analysis, we remove the derivative use variable from Specification II for robustness check (specification III). In each specification, we estimate ordinary least squares (OLS), and one-factor fixed-effects (FE) and random-effects (RE) regression models. On these regressions, we perform Lagrange Multiplier (LM) and Hausman tests to determine the most appropriate model. The LM test is employed to examine the relative efficiency of the heterogeneous panel data models (one-factor FE/RE models) against the homogeneous pooled OLS estimation. If the LM test statistic is greater than the critical chi-squared value, this suggests that the panel data models are more appropriate than the OLS specification. If the computed LM test statistic argues in favor of panel data models, the Hausman specification test is then to check for efficiency and bias in the estimation of coefficients obtained using the FE specification by demeaning or the RE specification based on a generalized least squared estimation procedure. If the Hausman test

statistic is greater than the critical chi-squared value, this suggests that the FE model is more suitable than the RE model (Hausman, 1978). The results of LM and Hausman tests are presented at the bottom of Tables V, VI, VII, and VIII, suggesting the most appropriate models for Specifications II and III of the participation and extent models for both sectors are one-factor RE models. As regards Specification I, the pooled OLS models are superior to the panel data models in life insurance, while the one-factor RE models are better than the OLS/FE models in non-life insurance. To examine the effects of the inclusion and exclusion of the derivative usage variable, an adjusted R^2 for the OLS and fixed-effects models is reported. No adjusted R^2 is reported for the random-effects models.

In this paper, we use solvency ratio (SR) measured by the ratio of book value of equity to net premiums written to evaluate whether the financial health of insurers is affected by off-balance-sheet activities. In one sense, a firm with higher solvency ratio is regarded as one with lower insolvency risk. For robustness checks, we also use the ratio of book value of equity to gross premiums written. The tenor of the results is quantitatively unchanged.

Effects of the Decision to Use Derivatives

The proxy for insurer solvency is regressed on the participation decision (assigned

1 if there is a quarter-end derivatives position) and several firm characteristics. The univariate results and other results, in Tables 5 and 6, show that the participation variable (PAR) is not significantly related to solvency.

(Insert Tables 5 and 6 about here)

The explanatory power, measured by the adjusted R^2 , for the OLS and fixed-effects models, increases from specifications I to II. However, the results for specifications II to III are mixed. In the life insurance sector, the adjusted R^2 increases from specifications I through III, while in the non-life sector, the adjusted R^2 declines slightly from specifications II to III. The consistently rising adjusted R^2 in the life sector shows that the explanatory power can be improved by removing the PAR variable, suggesting that derivative participation has no significant effect on firm solvency. For non-life insurance, the explanatory power decreases slightly from specifications II to III. The overall evidence provides support for the previous finding that the decision to participate in derivative activities is not important in interpreting the variation of solvency.

Effects of the Extent of Derivative Usage

Tables 7 and 8 present the results concerning the participation extent of the solvency models. The solvency is regressed on the level of derivative use measured

by quarter-end notional value of the derivatives position and other firm characteristics.

The life sector results for the extent model reveal that derivative holdings have insignificant association with insurer solvency. It is noted, however, that a negative and significant relationship between derivative utilization and solvency ratio exists in non-life insurance, indicating that non-life insurers actively participating in derivative transactions could suffer from a higher likelihood of insolvency. One of the possible explanations is that if a non-life insurer uses derivatives for hedging purposes, it can operate at a lower solvency margin. In one sense, this type of explanation is consistent with Leland (1998) argument that hedging allows firms to take on more debt.

(Insert Tables 7 and 8 about here)

As regards the explanatory power, Table 7 shows that the adjusted R^2 for the life sector is enhanced from specifications I through III, implying that the extent usage is not related to firm solvency. The lack of association between derivative activities and solvency in the life sector is consistent with the findings of Hentschel and Kothari (2001) that derivative holdings of both financial and non-financial firms have no influence on their return volatility. Table 8 presents that, for the non-life insurance sector, the adjusted R^2 reduces from specifications II to III. The incremental power is possibly attributable to the marginal effect of derivative holdings. This finding suggests that non-life insurers using derivative contracts expose themselves to

decreased solvency.

CONCLUSION

Mounting evidence on the benefits of derivative use highlights the need for financial firms as well as non-financial firms to use derivatives to shift risks. Most prior studies on derivative use, e.g., Cummins, Phillips, and Smith (1997), Sinkey and Carter (2000), and Cummins, Phillips, and Smith (2001), focus on its determinants. Few studies, such as Guay (1999), Hentschel and Kothari (2001), and Yang et al. (2006), examine the relationship between the use of derivatives and firm risk. To our knowledge, there is no research investigating the impact of derivative usage on firm insolvency risk/solvency in the context of insurance. In this paper, we provide an empirical analysis on derivative use for hedging purposes and solvency of insurers in Taiwan. Our data on derivative hedging allow us to examine this issue.

This paper investigates the differences in solvency across life and non-life insurers. Using three years of data, we examine whether the differences in solvency across insurers can be systematically explained by derivative participation/extent, while controlling a number of insurer characteristics. We pay particular attention to separate the effect of derivative participation on solvency from that of derivative extent. In this study, the results from the univariate analysis are consistent with those from

multivariate regressions. Our results allow us to draw the following main conclusion.

Derivative holdings of insurers generally have no significant relationship with solvency. Nevertheless, it is worth noting that a negative and significant relationship between derivatives utilization and solvency ratio is documented in the non-life insurance sector.

We consider that our research findings have important implications for the regulator. Derivative hedging was originally aimed at increasing insurer solvency. The empirical absence of higher level of solvency following derivative hedging suggests that this aim apparently is not achieved.

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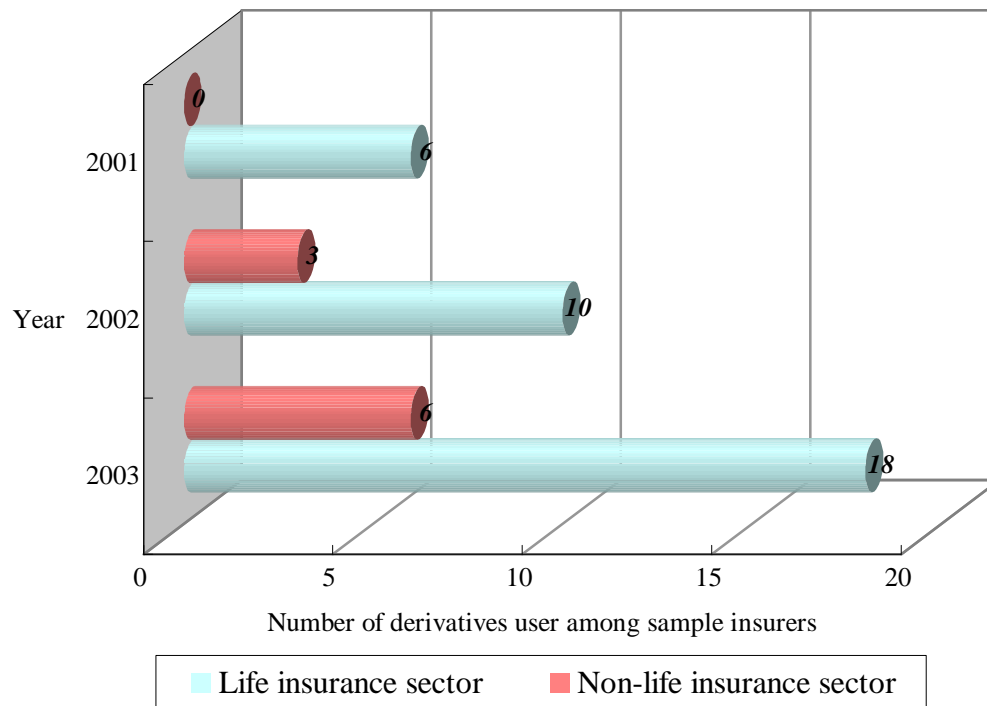


Figure 1. Number of derivatives participants in our sample

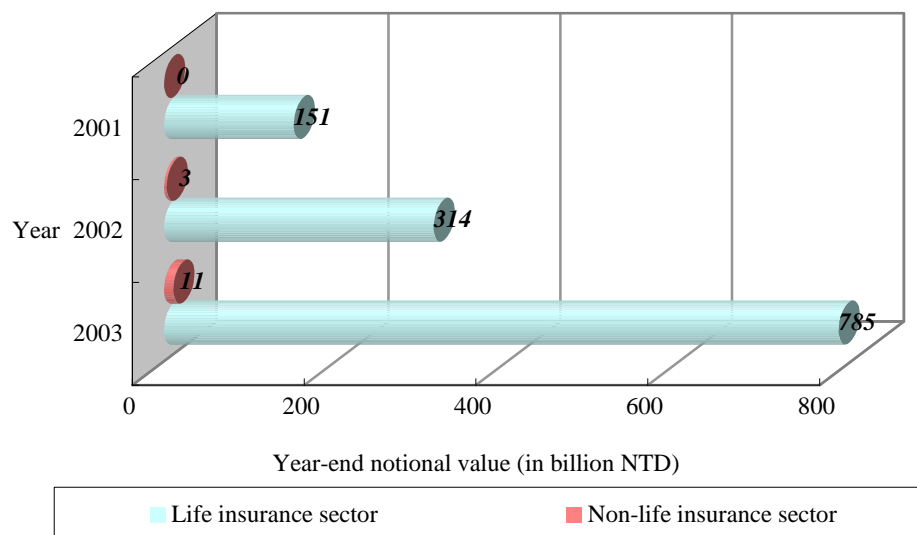


Figure 2. End-of-year derivatives positions of life and non-life insurers

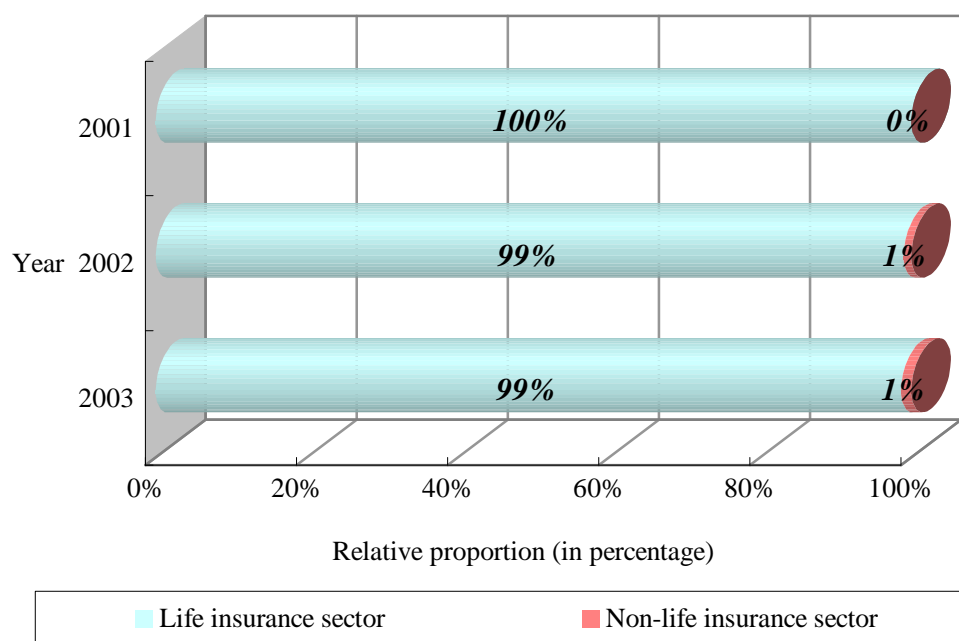


Figure 3. The relative proportions of derivatives holdings in life and non-life insurance sectors

TABLE 1**Number of Life and Non-Life Insurers**

	Number of insurers			
	2001	2002	2003	Total number of firms
Life insurers included in the sample	27 (93%)	28 (100%)	24 (89%)	79 (94%)
Life insurers in business	29	28	27	84
Non-life insurers included in the sample	23 (82%)	24 (89%)	24 (100%)	71 (90%)
Non-life insurers in business	28	27	24	79

Note. The percentages in parentheses represent the ratio of number of insurers included in the sample to number of insurers in business.

TABLE 2
Variables and their Definitions

Variable	Definition
Dependent Variable	
SR	Ratio of book value of equity to net premiums written
Independent Variables	
PAR	Participation decision: 1 for derivative users, 0 otherwise.
EXT	Extent decision: the balance of quarter-end notional value of derivative instruments scaled by total assets of the firm
LEVER	book value of liability deflated by book value of equity
EBV	book value of common equity
HERFP	Herfindahl index of net premiums written. Suppose X consists of M components where each component denotes x_k and $k = 1, 2, 3, \dots, M$. The Herfindahl index is computed as $\sum_{k=1}^M (x_k/X)^2$ to measure the concentration of X .
MISAST	Mismatch where non-current assets outweigh non-current liabilities scaled by book value of firm
MISLIA	Mismatch where non-current liabilities outweigh non-current assets scaled by book value of firm
FX	Total amount of foreign investment scaled by book value of firm
GROWTH	Cash reinvestment ratio multiplied by return on equity
REINS	Ratio of reinsurance ceded to the sum of direct premiums written and reinsurance assumed
NIM	Net interest margin
INV	Value of underlying assets represented by investment-linked insurance deflated by gross written premiums [for life sector only]

TABLE 3
Hausman Test of Endogeneity

Panel A: Life Insurance Sector

	Determinants of Derivatives Usage			Testing for Correlation
	FX	CR	DOMESTIC	Hausman Test
	Correlation Coefficient [<i>p</i> -value]	Correlation Coefficient [<i>p</i> -value]	Correlation Coefficient [<i>p</i> -value]	<i>t</i> -ratio [<i>p</i> -value]
Correlated with Derivatives				
EXT	0.5850 *** [0.0000]	0.3640 *** [0.0010]	0.3450 *** [0.0020]	
Uncorrelated with Disturbance of each equation				
SR	0.0000 [1.0000]	0.1360 [0.2370]	-0.0260 [0.8210]	-0.2981 [0.7666]

Note: FX = total amount of foreign investment scaled by book value of firm; CR = current ratio; DOMESTIC = 1 if domestic insurer, 0 otherwise; EXT = year-end balance of derivatives holdings scaled by book value of firms; SR = the ratio of solvency margin to premium income. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel B: Non-Life Insurance Sector

	Determinants of Derivatives Usage		
	REINS	FX	IR
	Correlation Coefficient [<i>p</i> -value]	Correlation Coefficient [<i>p</i> -value]	Correlation Coefficient [<i>p</i> -value]
Correlated with Derivatives			
EXT	-0.0630 [0.6010]	0.2880 ** [0.0140]	0.0320 [0.7910]
Uncorrelated with Disturbance of each equation			
SR	0.6500 *** [0.0000]	0.8010 *** [0.0000]	-0.1160 [0.3440]

Note: REINS = ratio of reinsurance ceded to the sum of direct premiums written and reinsurance assumed; FX = total amount of foreign investment scaled by book value of firm; IR = discrepancy between interest income and cost scaled by total asset; SR = the ratio of solvency margin to premium income. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

TABLE 4

Equality Tests of Means, Medians, and Variances of Solvency Ratio

Panel A: Test for Equality of Means of Solvency Ratio

<i>Risk Measures</i>	Overall			Users			Nonusers			Tests equality of mean			
	<i>N</i>	Mean	Std. Dev.	<i>N</i>	Mean	Std. Dev.	<i>N</i>	Mean	Std. Dev.	t-test [<i>p</i> -value]	Anova F-statistic [<i>p</i> -value]		
Life insurance sector													
SR	81	0.2064	0.1935	35	0.1972	0.1532	46	0.2133	0.2207	0.3689	[0.7132]	0.1361	[0.7132]
Non-life insurance sector													
SR	71	0.7420	0.9595	9	0.6008	0.4756	62	0.7626	1.0117	0.4700	[0.6398]	0.2209	[0.6398]

Panel B: Test for Equality of Variances of Solvency Ratio

<i>Risk Measures</i>	Overall		Users		Nonusers		Tests equality of variance			
	<i>N</i>	Std. Dev.	<i>N</i>	Std. Dev.	<i>N</i>	Std. Dev.	Levene [<i>p</i> -value]	Brown-Forsythe [<i>p</i> -value]		
Life insurance sector										
SR	81	0.1935	35	0.1532	46	0.2207	1.7970	[0.1839]	1.1717	[0.2823]
Non-life insurance sector										
SR	71	0.9595	9	0.4756	62	1.0117	0.5319	[0.4683]	0.2971	[0.5874]

Note. SR = ratio of book value of equity to net premiums written.

* Statistically significant at less than 0.10.

** Statistically significant at less than 0.05.

*** Statistically significant at less than 0.01.

TABLE 5
Participation Model for Life Insurance Sector

Variable	I		II		III	
	OLS Model		Heteroscedasticity Adjusted RE Model		Heteroscedasticity Adjusted RE Model	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Constant	0.2133	0.0000 ^{**}	0.0695	0.3863	0.0697	0.3808
PAR	-0.0037	0.9335	-0.0107	0.7935		
LEVER			-0.0021	0.1992	-0.0021	0.1820
EBV			0.0024	0.0632 [*]	0.0024	0.0635 [*]
HERFP			0.1934	0.0895 [*]	0.1896	0.0922 [*]
MISAST			0.0168	0.0000 ^{**}	0.0169	0.0000 [*]
MISLIA			0.0001	0.9067	0.0002	0.8698
GROWTH			0.0007	0.4821	0.0007	0.4724
REINS			0.0022	0.2792	0.0023	0.2659
NIM			-0.1375	0.2912 ^{**}	-0.1382	0.2832 ^{**}
INV			0.0020	0.0000 [*]	0.0020	0.0000 [*]
FX			-0.0184	0.9380	-0.0459	0.8281
Number of observations		79		77		77
OLS adjusted R ²		-0.0129		0.4932		0.5009
FEM adjusted R ²		0.1538		0.6941		0.7019
F test		0.0100 [0.9336]				
LM test		1.3100 [0.2519]		4.8000 ^{**} [0.0284]		4.7600 ^{**} [0.0292]
Hausman test		1.5300 [0.2166]		0.0000 [1.0000]		0.0000 [1.0000]
White test		0.9570 [0.3310]		5.1012 [*] [0.0000]		5.4278 [*] [0.0000]

Note: The numbers in the parentheses are p-values; OLS = ordinary least squares model; REM = one-factor random-effects model; PAR = 1 for derivatives users, 0 otherwise; LEVER = book value of liability deflated by book value of equity; EBV = book value of common equity; HERFP = Herfindahl index reflecting concentration of various type of net premiums written; MISAST = mismatch where non-current assets outweigh non-current liabilities scaled by book value of firm; MISLIA = mismatch where non-current liabilities outweigh non-current assets scaled by book value of firm; GROWTH = cash reinvestment ratio multiplied by return on equity; REINS = ratio of reinsurance ceded to the sum of direct premiums written and reinsurance assumed; NIM = net interest margin; INV = value of underlying asset invested by premiums of investment linked insurance; FX = total amount of foreign investment scaled by book value of firm.

^{*} Significant at the 10 per cent level.

^{**} Significant at the 5 per cent level.

^{***} Significant at the 1 per cent level.

TABLE 6
Participation Model for Non-Life Insurance Sector

Variable	I		II		III	
	RE Model		Heteroscedasticity Adjusted RE Model		Heteroscedasticity Adjusted RE Model	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Constant	0.7649	0.0000 ***	0.0202	0.9550	-0.0780	0.8251
PAR	-0.1641	0.6269	-0.2524	0.2091		
LEVER			-0.0044	0.2763	-0.0047	0.2408
EBV			-0.0243	0.0151 **	-0.0279	0.0036 ***
HERFP			0.8904	0.0715 *	0.9918	0.0419 **
MISAST			0.0105	0.0002 ***	0.0103	0.0003 ***
MISLIA			-0.0038	0.3565	-0.0035	0.4015
GROWTH			-0.0148	0.2325	-0.0146	0.2443
REINS			0.0092	0.0283 **	0.0106	0.0082 ***
FX			0.0717	0.0000 ***	0.0675	0.0000 ***
NIM			-0.0242	0.4803	-0.0178	0.5995
Number of observations		71		68		68
OLS adjusted R ²		-0.0113		0.7408		0.7404
FEM adjusted R ²		0.2980		0.8749		0.8706
LM test		7.1200 ***		12.4700 ***		11.9200 ***
		[0.0076]		[0.0004]		[0.0006]
Hausman test		0.0000		0.0000		0.0000
		[0.9996]		[1.0000]		[1.0000]
White test		0.2237		1.7296 *		1.8735 **
		[0.6378]		[0.0639]		[0.0421]

Note: The numbers in the parentheses are p-values; REM = one-factor random-effects model; PAR = 1 for derivatives users, 0 otherwise; LEVER = book value of liability deflated by book value of equity; EBV = book value of common equity; HERFP = Herfindahl index reflecting concentration of various type of net premiums written; MISAST = mismatch where non-current assets outweigh non-current liabilities scaled by book value of firm; MISLIA = mismatch where non-current liabilities outweigh non-current assets scaled by book value of firm; GROWTH = cash reinvestment ratio multiplied by return on equity; REINS = ratio of reinsurance ceded to the sum of direct premiums written and reinsurance assumed; FX = total amount of foreign investment scaled by book value of firm; NIM = net interest margin.

* Significant at the 10 per cent level.

** Significant at the 5 per cent level.

*** Significant at the 1 per cent level.

TABLE 7
Extent Model for Life Insurance Sector

Variable	I		II		III	
	OLS Model		Heteroscedasticity Adjusted RE Model		Heteroscedasticity Adjusted RE Model	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Constant	0.2097	0.0000 ^{**}	0.0699	0.3811	0.0697	0.3808
EXT	0.0516	0.8253	-0.0148	0.9379		
LEVER			-0.0021	0.1810	-0.0021	0.1820
EBV			0.0024	0.0646 [*]	0.0024	0.0635 [*]
HERFP			0.1887	0.0987 [*]	0.1896	0.0922 [*]
MISAST			0.0169	0.0000 ^{**}	0.0169	0.0000 [*]
MISLIA			0.0002	0.8714	0.0002	0.8698
GROWTH			0.0007	0.4785	0.0007	0.4724
REINS			0.0023	0.2662	0.0023	0.2659
NIM			-0.1378	0.2862 ^{**}	-0.1382	0.2832 ^{**}
INV			0.0020	0.0000 [*]	0.0020	0.0000 [*]
FX			-0.0350	0.8894	-0.0459	0.8281
Number of observations		79		77		77
OLS adjusted R ²		-0.0123		0.4989		0.5009
FEM adjusted R ²		0.1366		0.6998		0.7019
F test		0.0500 [0.8254]				
LM test		1.3200 [0.2511]		3.2600 [*] [0.0710]		4.7600 ^{**} [0.0292]
Hausman test		0.4100 [0.5240]		0.0000 [1.0000]		0.0000 [1.0000]
White test		0.5485 [0.5801]		4.8845 [*] [0.0000]		5.4278 [*] [0.0000]

Note: The numbers in the parentheses are p-values; OLS = ordinary least squares model; REM = one-factor random-effects model; EXT = the balance of year-end notional value of derivatives instruments scaled by total assets of the firm; LEVER = book value of liability deflated by book value of equity; EBV = book value of common equity; HERFP = Herfindahl index reflecting concentration of various type of net premiums written; MISAST = mismatch where non-current assets outweigh non-current liabilities scaled by book value of firm; MISLIA = mismatch where non-current liabilities outweigh non-current assets scaled by book value of firm; GROWTH = cash reinvestment ratio multiplied by return on equity; REINS = ratio of reinsurance ceded to the sum of direct premiums written and reinsurance assumed; NIM = net interest margin; INV = value of underlying asset

invested by premiums of investment linked insurance; FX = total amount of foreign investment scaled by book value of firm.

* Significant at the 10 per cent level.

** Significant at the 5 per cent level.

*** Significant at the 1 per cent level.

TABLE 8
Extent Model for Non-Life Insurance Sector

Variable	I		II		III	
	RE Model		Heteroscedasticity Adjusted RE Model		Heteroscedasticity Adjusted RE Model	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Constant	0.7537	0.0000 **	0.4134	0.2365	-0.0780	0.8251
EXT	-1.0294	0.7551	-6.7685	0.0002 **		
LEVER			-0.0030	0.4409	-0.0047	0.2408
EBV			-0.0231	0.0098 *	-0.0279	0.0036 *
HERFP			0.7730	0.0968 *	0.9918	0.0419 **
MISAST			0.0107	0.0001 *	0.0103	0.0003 *
MISLIA			-0.0071	0.0743 *	-0.0035	0.4015
GROWTH			-0.0164	0.1516	-0.0146	0.2443
REINS			0.0025	0.5600	0.0106	0.0082 *
FX			0.0927	0.0000 **	0.0675	0.0000 **
NIM			-0.0484	0.1436	-0.0178	0.5995
Number of observations		71		68		68
OLS adjusted R ²		-0.0138		0.7687		0.7404
FEM adjusted R ²		0.2973		0.8968		0.8706
F test						
LM test		7.1500 **		16.8700 **		11.9200 **
		[0.0075]		[0.0000]		[0.0006]

Hausman test	0.0300 [0.867 8]	0.0000 [1.0000]	0.0000 [1.0000]
White test	0.0704 [0.932 1]	1.6492 * [0.0801]	1.8735 ** [0.0421]

Note: The numbers in the parentheses are p-values; REM = one-factor random-effects model; EXT = the balance of year-end notional value of derivatives instruments scaled by total assets of the firm; LEVER = book value of liability deflated by book value of equity; EBV = book value of common equity; HERFP = Herfindahl index reflecting concentration of various type of net premiums written; MISAST = mismatch where non-current assets outweigh non-current liabilities scaled by book value of firm; MISLIA = mismatch where non-current liabilities outweigh non-current assets scaled by book value of firm; GROWTH = cash reinvestment ratio multiplied by return on equity; REINS = ratio of reinsurance ceded to the sum of direct premiums written and reinsurance assumed; FX = total amount of foreign investment scaled by book value of firm; NIM = net interest margin.

* Significant at the 10 per cent level.

** Significant at the 5 per cent level.

*** Significant at the 1 per cent level.