What Motivates Insurers to Use Internal and External Reinsurance? Evidence from the United Kingdom Life Insurance Industry

Yung-Ming Shiu
Professor, Department of Risk Management and Insurance,
Research Fellow, Risk and Insurance Research Center, College of Commerce
National Chengchi University, Taiwan
64, Sec. 2, Zhi-Nan Road, Wen-Shan District, Taipei 11605, Taiwan
Tel: +886-2-29393091 ext. 81014
Fax: +886-2-29393864
Email: yungming@nccu.edu.tw

Ching-Yuan Hsiao
PhD Candidate, Department of Risk Management and Insurance,
National Chengchi University, Taiwan
64, Sec. 2, Zhi-Nan Road, Wen-Shan District, Taipei 11605, Taiwan
Tel: +886-2-29393091 ext. 89072
Fax: +886-2-29393864
Email: 101358503@nccu.edu.tw

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ABSTRACT

We examine the effects of insurer's business mix on reinsurance usage by employing the model of Cragg (1971) to analyze the reinsurance decisions made between 2005 and 2014 by insurers in the UK life insurance industry. Our findings reveal a positive (negative) correlation between with-profit (unit-linked) business and reinsurance, which indicate that insurers write risky product risk have greater reinsurance demand. Then we separate reinsurance into internal and external reinsurance and conduct further analysis. We find that insurers writing more with-profit business appear to use more internal reinsurance, implying that internal reinsurance could be more cost effective for those reinsurance transactions relating to more complex business.

Keywords: Finite risk paradigm; Risk-bearing hypothesis; Transaction cost economics (TCE); Internal reinsurance; External reinsurance.

JEL Classification: G22; G32

1. INTRODUCTION

In insurance industry, the characteristics of an insurer's business mix could influence various financing decisions. Several studies on insurer's capital structure have provided the theoretical framework and empirical evidence that insurer's business mix could play important role in capital holding (e.g. Cummins and Sommer, 1996; Baranoff and Sager, 2002, 2003; Baranoff, Papadopoulos and Sager, 2007). Since reinsurance could be considered as a substitute of capital, the theories and evidence of these studies could also provide implications for the relationship between insurer's business mix and reinsurance usage. In insurance literature, several studies also indicate that the insurers which underwrite more risky business tend to reinsure more (e.g. Adams, 1996; Kader, Adams and Mouratidis, 2010). Nevertheless, the majority of the studies on reinsurance usage do not extensively discuss and examine how the characteristics of business mix on reinsurance decisions. In addition, to the best of our knowledge, with one notable exception of Powell and Sommer (2007), very little effort appears to have been placed into differentiating between internal and external reinsurance and carrying out separate examinations of their determinants.

Our aim in the present study is twofold. Firstly, we analyze how the characteristics of insurer's business mix affect its demand for reinsurance. Secondly, we separate reinsurance use into internal can external reinsurance and investigate how the

characteristics of insurer's business mix influence the choice between internal and external reinsurance. In the UK life insurance industry, with-profit products are considered to be a more risky than other lines of business for insurers since they have to ensure that the proposed benefits and bonus payments for their with-profit policyholders are fair, they must also make sure that the bonus distribution plans for the with-profit policies are affordable and sustainable, so as to ensure the continuing solvency of the firm. For policyholders and other external stakeholders of insurers, with-profits products could be also considered as structurally complex product since the management of this type of products involves greater discretion by insurer. Such management discretion could further introduce more uncertainties in underwriting results. In contrast, unit-linked products tend to be less risky and complex for insurers since policyholders bear the investment risk and insurers do not need to exercise discretion in bonus distribution.

In our study, we expect that insurer's business mix affect the reinsurance use decisions by the following ways. First, we conjecture that insurers with more with-profit products are associated with greater reinsurance usage due to greater product risk. According to *finite risk paradigm* proposed by previous studies (e.g. Cummins and sommer, 1996; Baranoff and Sager, 2002, 2003), insurers tend to limit their overall risk level to avoid the costs related to insolvency. Thus, insurers with greater product risk

tend to hold more capital to limit overall risk. In reinsurance literature, *risk-bearing hypothesis* proposed by Adams (1996) postulates that insurers which are more likely to become insolvent tend to use more reinsurance to mitigate the impact of large losses. This hypothesis also suggests that insurers with higher risk from business operation tend to reinsure more to reduce insolvency risk. Since with-profit products are considered as more risky insurance products in the present study, we expect that insurers which underwrite more with-profit products have increased demand for reinsurance. In contrast, insurers with more unit-linked products could use less reinsurance duo to the less risky nature of these types of products.

Second, we argue that greater use of internal reinsurance will be found among firms with greater proportions of with-profit business due to the increased transaction uncertainties arise from greater product complexity. According to transaction cost economics (TCE) developed by Willamson (1979, 1981, 1991a), transactions that involve assets with greater complexity and idiosyncrasies could suffer exacerbated information asymmetry among the participating parties and greater contractual uncertainties. In several studies on capital structure, equity and bond are considered as two governance forms for the contractual relationship between funds providers and recipients from the perspective of TCE theory. Williamson (1988, 1991b) and Kochhar (1996) suggest equity instrument is more suitable for the firms with more complex and

idiosyncratic business portfolio due to the information advantage for stockholders to monitor managerial decisions and flexible payment schedule for firms. With regard to the choice between internal and external reinsurance, Doherty and Smetters (2005) suggest that affiliated reinsurer could be more effective in monitoring insurer's potential moral hazard behaviors due to lower degree of information asymmetry. In contrast, non-affiliated reinsurer could experience greater difficulty in monitoring insurer and thus tend to impose price control as the mechanism to limit insurer's opportunistic behavior. Based on TCE theory and the work of Doherty and Smetters (2005), we conjecture that insurers which underwrite more with-profit products tend experience increased information asymmetry between reinsurer and could be more subject to price control mechanism in reinsurance contracts due to the complex and uncertain natures of with-profit business. To save reinsurance transaction costs arise from the characteristics of with-profit business, these insurers may tend to use more internal reinsurance.

We employ the Cragg (1971) model to analyze reinsurance decisions, with the sample adopted for our study comprising of a 2005-2014 database on UK life insurers. Our main results are summarized as follows. First, insurers carrying more with-profit business are associated with greater demand for reinsurance. Consistent with finite risk paradigm, insurers that underwrite more risky products tend to use more reinsurance to limit overall insolvency risk. Second, parts of our results indicate that insurers which have

more with-profit business use more amount of internal reinsurance. These results suggest that the reinsurance transactions relating to the business with greater complexity and uncertainty tend to be organized within an insurance group to reduce the costs associated with of the reinsurance activities,

Our main research make contribution to literature by extending the empirical studies on the determinants of reinsurance usage and the prior studies which analyze capital structure decisions based on finite risk paradigm and TCE theory. Specifically, we discuss and analyze how the characteristics of the insurer's business mix are related to insurer's risk profile and demand for reinsurance. Then we further discuss how these characteristics contribute to the cost difference between internal and external reinsurance and the choice between these two types of reinsurance made by insurers. In short, we provide empirical evidence on the linkage between characteristics of insurance products and reinsurance decisions.

The main differences between our study and the work of Powell and Sommer (2007) are summarized as follows. First, we analyze both the participation and volume decisions of internal and external reinsurance; the focus in Powell and Sommer (2007) was on analyzing the costs and structural differences in the determinants of the volume of internal and external reinsurance usage; however, in the present study, in addition to reinsurance volume decisions, we further analyze the internal and external reinsurance participation

decisions made by the parties. Secondly, we analyze reinsurance usage decisions in the context of the UK life insurance industry, as opposed to the non-life insurance industry. In the majority of the prior related studies, including Powell and Sommer (2007), reinsurance decisions were primarily investigated within the context of the non-life insurance industry; however, we argue that reinsurance may also be considered to be an important instrument for the transfer of risk within the life insurance industry based upon the numbers of insurers participating in reinsurance transactions and the total volume of reinsurance usage within the insurance sector as a whole.

The remainder of this paper is organized as follows. Section 2 provides a review of the related literature on how the characteristics of business mix affect insurer's reinsurance usage and develops our research hypotheses. A brief description of the data sample and research methodology adopted for our study are provided in Section 3, followed in Section 4 by the presentation of our empirical estimations and results. Finally, the conclusions drawn from this study are presented in Section 5.

2. HYPOTHESES DEVELOPMENT

In this section, we discuss how the characteristics of insurer's business mix influence the demand for reinsurance and the choice between internal and external reinsurance based on related studies in the context of the UK life insurance industry. As several studies on reinsurance demand suggest that reinsurance could be considered as

a capital structure decision it reduces financial leverage of insurer (e.g. Garven and Lamm-Tennant, 2003; Powell and Sommer, 2007), we review relevant capital structure and reinsurance literature in this section. After reviewing these studies, we propose our research hypotheses.

2.1 Product Risk and Reinsurance Decisions

The risk arise from insurance products could affect insurer's financing decisions. In insurance literature, finite risk paradigm suggests a positive relationship between insurer's product risk and capital holding. The work of Cummins and Sommer (1996) utilizes option model to analyze insurance pricing and solvency and finds a positive association between insurer's overall riskiness arise from its asset and liability portfolio and capital holding, which indicates that insurers tend to have a target insolvency risk level. They suggest the following reasons for insurer to limit overall risk instead of pursuing excessive risk-taking. First, insurers may want to avoid the costs associated with intensified regulation and bankruptcy. Second, policyholders could demand for greater solvency level of insurers since they are averse to insurers' insolvency risk. Third, managers may tend to select more conservative strategies because their compensation depends on insurers' survival. Therefore, based on finite risk paradigm, insurers with more risky business portfolio are associated with more conservative financing decisions and vice versa.

After the work of Cummins and Sommer (1996), several studies further find supports for finite risk paradigm. For instance, Shim (2010), Mankaı̈ and Belgacem (2015) use asset-liability volatility to capture the overall riskiness of insurer's asset and liability portfolio and find a positive relationship between insurer's risk and capital holding. Some studies further separate insurer's overall risk into asset and product risk, which refer to the risk from holding risky invested assets and underwriting risky lines of business respectively, and analyze the interrelation between these types of risk and capital structure. Baranoff and Sager, (2003), Baranoff et al. (2007), Cheng and Weiss (2013) find that both asset and product risk are associated with greater capital holding. Although a few studies find mixed results (e.g. Baranoff and Sager, 2002; Lin, Lai and Powers, 2014), the majority of previous studies find empirical supports for finite risk paradigm. In reinsurance literature, several studies suggest that reinsurance could be considered as a capital structure decision it reduces financial leverage of insurer (e.g. Garven and Lamm-Tennant, 2003; Powell and Sommer, 2007). Thus, we argue that finite risk paradigm could imply positive relationship between insurer's product risk and reinsurance use.

In insurance literature, several studies also indicate insurer's business mix could affect insurer's reinsurance demand. According to risk-bearing hypothesis proposed by Adams (1996), insurers which are more subject to insolvency risk tend to use

reinsurance to enhance their risk-bearing efficiency. Insurers with higher underwriting risk could face greater insolvency risk and thus have increased demand for reinsurance. With regard to the related empirical studies, Adams (1996) and Kader et al. (2010) measure underwriting risk as the variance of loss ratio and the ratio of claims to premiums earned respectively. These studies find that underwriting risk positively affect reinsurance use, which support risk-bearing hypothesis. Based on risk-bearing hypothesis and related empirical evidence, insurers with more risky product written could be exposed to greater underwriting risk and thus have increased demand for reinsurance.

In the UK life insurance industry, with-profit products could be considered as more risky products because insurers could face several competing issues in managing these products and have a considerable amount of discretion available to them. For instance, they must carefully determine their bonus distribution plans to ensure that policyholders are treated fairly whilst also ensuring the solvency of the firm (O'Brien, 2011). Given the particular features of with-profit products, insurers that fail to prudentially manage their with-profit products could easily encounter deterioration in their solvency position. Unit-linked products, in contrast, are far less complicated for insurers. In their management of unit-linked contracts, insurers do not generally have to establish bonus distribution plans or exercise any significant discretion. Therefore, we consider the

proportion of with-profit and unit-linked business as the proxies for high and low product risk in our study. Based on finite risk paradigm and risk-bearing hypothesis, we anticipate that higher product risk is associated with greater reinsurance usage and vice versa. Our hypotheses are stated as follows:

Hypothesis 1a: *Insurers underwriting more risky line of business will use more reinsurance.*

Hypothesis 1b: *Insurers underwriting less risky line of business will have a lower demand for reinsurance.*

2.2 Business Mix and Product Complexity

The complexity of firms' business could influence the choices of financing instruments. According to the studies on capital structure based upon TCE theory, Williamson (1988, 1991b) and Kochhar (1996) considered debt and equity financing to be governance forms in the contractual relationship between fund providers and recipients. Based on TCE theory, equity could be considered as an "internalized governance form" because the stockholders own the firms and monitor in firms' management decisions. Therefore, stockholders could have more information advantage in monitoring firms' decisions and activities. In addition, firms with more sophisticated or idiosyncratic assets or investment could have more unstable cash flows and thus prefer to equity financing. Under debt contract, firms could be forced to go bankrupt when they are unable to follow compulsory payments schedule imposed by debtholders. In contrast,

firms could face more flexible payments schedule under equity financing contract. This characteristic could provide elasticity for the firms with greater cash flow volatility. In short, the reduced information asymmetry between fund providers and recipients and the elasticity of payment schedule make equity instrument less costly for the firms with more investment in complex and idiosyncratic assets.

Numerous studies within the finance and management literature have provided empirical support for the notion that where the investments of a firm have complexity, the firm will tend to use equity financing essentially to avoid the greater costs of debt financing. Titman and Wessel (1988), for instance, found that firms with a higher degree of product uniqueness were associated with lower debt financing, whilst Vicente-Lorente (2001) suggested that the strategic resources of a firm that were capable of generating abnormal returns tended to be unique, non-tradable and difficult to imitate, with these features of the firm's strategic resources raising the level of specificity and opacity. Lenders will tend to be less willing to provide funds to firms with more strategic resources, essentially because they have very little information on the cash flows generated by these strategic resources and could also incur significant losses in the event of bankruptcy; thus, firms with more strategic resources tend to have limited borrowing capacity. O'Brien, David, Yoshikawa and Delios (2014) argued that the utilization performance of the firm's strategic resources in new business lines could lead to the firm being faced with non-

trivial uncertainty. When firms attempt to diversify into new business, equity financing may be preferable since it provides managers with a higher degree of flexibility and forbearance to leverage the firm's resources and capabilities. Their results revealed that firms that were shielded from the more rigid governance of debt financing tended to have higher diversification returns. Furthermore, other studies investigating debt capacity also provide support for the notion that firms with less specific assets, or a greater capacity for the redeployment of their assets, are associated with lower debt financing costs and greater leverage (Benmelech and Bergman, 2009; Campello and Giambona, 2013).

In insurance and reinsurance literature, several studies suggest that the degree of information asymmetry between reinsurer and insurer is lower (Doherty and Smetters, 2005; Powell and Sommer, 2007). For instance, Doherty and Smetters (2005) contend that affiliated reinsurers tend to utilize monitoring as the method to control insurers' potential moral hazard problems. In contrast, non-affiliated reinsurers tend to use loss sensitive premiums to limit insurers' moral hazard due to greater difficulty in monitoring insurers. In more recent literature, Cole, He, McCullough, Semykina and Sommer (2011) further find that affiliated reinsurance usage negatively affect insurer's risk-taking, which suggests that affiliated reinsurers are more effective in limiting insurers' risk-taking behaviors. These studies indicate that affiliated reinsurers could have more advantage in limit insurer's opportunistic behavior and thus tend not to use price control mechanism

in a reinsurance contract.

When the reinsurance business offered by an insurer is more complex, the cost differences between internal and external reinsurance could be greater for the following reasons. First, the information asymmetry between unaffiliated insurers and reinsurers could be exacerbated. This situation makes non-affiliated reinsurers more difficult to monitor insurers' potential opportunistic behavior. Second, the underwriting performance of complex insurance products could be more uncertain. To deal with such uncertainty, non-affiliated reinsurers may need to impose price control on insurers. Thus, insurers may tend to transfer their premiums written in more complex lines of business to affiliated reinsurer to reduce the cost associated with product complexity. Based on TCE theory and related reinsurance literature, we argue that insurers which underwrite more complex business tend to use more internal reinsurance and less external reinsurance.

In the UK life insurance industry, with-profit products could be considered as structurally complex products which involve nontrivial uncertainty due to the substantial degree of managerial discretion in deciding bonus distribution. In contrast, other types of products could be regarded as less complex products since these products do not involve discretion on bonus plan. Therefore, we proxy the proportion of with-profit as product complexity. Based on the discussions above, we propose the following hypotheses:

Hypothesis 2a: *Product complexity positively affect internal reinsurance use.*

Hypothesis 2b: *Product complexity negatively affect external reinsurance use.*

3. DATA AND METHODOLOGY

3.1 Data

Our dataset on UK life insurers was obtained from the Synthesys database, and since records on internal reinsurance transactions are not available in the database until the year 2005, our sample period covers the years 2005 to 2014. In our study, we investigate the following three reinsurance decisions: total, internal and external reinsurance. Following the majority of previous studies (e.g. Adams, Hardwick and Zou, 2008; Kader et al., 2010; Shiu, 2011), Total reinsurance is defined as the ratio of reinsurance premiums ceded to reinsurers to direct premiums written. Then we follow Powell and Sommer (2007) to define internal (external) reinsurance as the ratio of reinsurance premiums ceded to affiliates (non-affiliates) to all direct premiums written.

Several data selection criteria were applied in this study. First, we included only those insurers that were affiliated with at least one life insurer simply because only these insurers would have had the use of internal reinsurance available to them. Second, we excluded all observations with non-logical values, such as non-positive premiums written (Cole and McCullough, 2006). Third, those insurers with an internal or external reinsurance value above 1 or below 0 were excluded from the sample, since such values would tend to indicate extraordinary operating characteristics for these insurers

(Mayers and Smith, 1990; Shiu, 2011).[1] Finally, all reinsurers were excluded from the sample. Our resultant sample after applying these criteria provided us with a total of 921 firm/year observations.

3.2 Research Design

Our investigation in this study involves the examinations of the participation and volume decisions made by insurers relating to total, internal and external reinsurance. Since the volumes of reinsurance are censored at 0 and 1, using an ordinary least square (OLS) estimation could result in biased and inconsistent coefficients; we therefore analyze the reinsurance participation and volume decisions made by insurers based upon the model of Cragg (1971). This model is considered appropriate for our empirical analysis essentially because the factors affecting reinsurance participation decisions could differ from those affecting reinsurance volume decisions. We estimate the following equations for both participation and volume decisions of total, internal and external reinsurance:

$$\begin{aligned} \textit{Reinsurance Participation}_{i,t} = f(&\textit{With-profit business}_{i,t-1}, \\ &\textit{Unit-linked business}_{i,t-1} + \textit{Control variables set}_{i,t-1}) + \varepsilon_{i,t}, \end{aligned} \tag{1}$$

$$\begin{aligned} \textit{Reinsurance Volume}_{i,t} = f(&\textit{With-profit business}_{i,t-1}, \\ &\textit{Unit-linked business}_{i,t-1} + \textit{Control variables set}_{i,t-1}) + \varepsilon_{i,t}, \end{aligned} \tag{2}$$

[1] According to Mayers and Smith (1990), a negative value for the reinsurance ratio may be attributable to premium returns by the reinsurer. If the ratio exceeds 1, this could indicate that the insurer decided to discontinue writing new business but ceded the premiums in force at that time to the reinsurer.

where the subscript i (t) refers to insurer i (year t); *With-profit business* (*Unit-linked business*) refers to the overall proportion of with-profit (unit-linked) business; the *Control variables set* includes all of the control variables identified; and $\varepsilon_{i,t}$ denotes the error term.

In addition to our main analysis, we further conduct additional analysis for the subsamples of the insurers which use at least one type of reinsurance and the insurers which use both internal and external reinsurance. Specifically, we investigate the effect of business mix variables on the relative amount of internal reinsurance use for these two subsamples. The regression for this analysis is constructed as follows:

$$\begin{aligned} Proportion\ of\ Internal\ Reinsurance_{i,t} = f\,(&With\text{-}profit\ business_{i,t-1},\\ &Unit\text{-}linked\ business_{i,t-1} + Control\ variables\ set_{i,t-1}) + \varepsilon_{i,t}\,, \end{aligned} \tag{3}$$

In equation (3), proportion of internal reinsurance refers to the ratio of internal reinsurance use to total reinsurance usage. In this analysis, we want to examine the effect of business mix variables on the choice between internal and external reinsurance in more granular way. Because the dependent variable is censored at 0 and 1, we use Tobit model to estimate equation (3).

Before our empirical analysis, we also test for potential endogeneity between the business mix variables (with-profit and unit-linked business) and the reinsurance decision variables. The procedure of endogeneity test is described as follows. First, we identify

additional instrumental variables that do not appear in the control variables set for the business mix variables.[2] Then we perform Sargan (1958) and Basmann (1960) over-identifying tests to test the validity of the instrumental variables. The statistics of Sargan and Basmann tests are chi-square distributed and the null hypothesis is that the over-identifying restrictions and instrumental variables are valid. In second stage, we then use the instrumental variables which pass the over-identifying tests to perform the endogeneity test. Specifically, we perform both Durbin (1954) and Wu-Hausman (Wu 1974; Hausman 1978) tests in this stage. The null hypothesis of endogeneity test is that business variables are exogenous. The results of over-identifying and endogeneity tests are shown in table 1. Our results indeed suggest that the null hypothesis that our instrumental variables are valid is not rejected and business mix and reinsurance variables are endogenous. Therefore, we employ a 2SLS estimation method to estimate the fitted values of the business variables and then replace the actual values of the business variables with the fitted values of these variables shown in Equation (1) to (3) for our empirical analysis.

<Table 1 is inserted about here>

3.3 Control variables

[2] The candidates for the instrumental variables in this study were the proportion of assets backing with-profit business, the proportion of assets backing linked business, the proportion of assets backing property-linked business, the proportion of assets backing index-linked business and the proportion of assets backing non-linked business, as well as the proportion of investment in a range of assets (stocks, bonds, mortgages and real estate) to total admissible assets.

In this sub-section, we briefly explain the control variables in Equation (1) to (3). The definitions of all of the variables used in this study are summarized in Table 2.

<Table 2 is inserted about here>

Our control variables are described as follows. First, we include loss ratio as a control variable to capture the effect of underwriting performance on the demand for reinsurance. Loss ratio is measured in the present study as the annual losses of the insurer divided by the total premiums written. To capture the effect of financial distress costs on reinsurance demand, we include firm size and free assets ratio as explanatory variables. Based on previous studies (e.g. Adams, 1996; Adams et al., 2008), firm size is measured as the natural logarithm of the annual total admissible assets. Free assets ratio is considered as our inverse measure of leverage. We follow Adams et al. (2008) and Kader et al. (2010) to calculate the free assets ratio by first of all calculating the ratio of total long-term assets to total long-term reserves and other liabilities, and then subtracting the regulatory required solvency margin from the ratio calculated in the first step. To consider the effect of access to external capital markets on reinsurance decisions, we include a publicly-traded and organization form dummy variables. Following Powell and Sommer (2007), publicly-traded variable takes the value of 1 if the insurer is a publicly-traded company; otherwise 0. The dummy variable of organization form takes the value of 1 for stock insurers; otherwise 0.

The usage of derivatives instrument could influence the overall riskiness of insurer and thus effect reinsurance use decisions. In the present study, we follow Shiu (2011) to indicate the use of derivatives by insurers using a dummy variable which takes the value of 1 if the insurer uses derivatives; otherwise 0. To control the effect of business concentration on insurer's risk profile and the demand for reinsurance, we include line of business concentration as an explanatory variable. In the present study, we define business concentration as the Herfindahl index of reserves based upon lines of business. Insurers with higher liquidity levels will have sufficient cash resources to meet any claims payments. To consider the effect of liquidity on reinsurance use, we include cash holdings as a control variable, which is measured as the ratio of cash to total admissible assets.

To address the tax related incentive to use reinsurance, we include tax convexity and marginal tax rates as control variables in our study, Following Adams et al. (2008), tax convexity is measured as the excess of the marginal tax rate over the effective tax rate. We follow Adams et al. (2008) and Shiu (2011) to measure the marginal tax rate as the top statutory rate, if the net operating loss in the prior year was equal to zero and the pre-tax earnings in the current year were greater than zero; otherwise 0.

4. EMPIRICAL RESULTS

4.1 Descriptive Statistics

Since some of our control variables, such as the free assets ratio and the marginal tax rate, were found to have extreme values, we winsorized the sample by substituting the values of the observations below the 1th percentile with the 1th percentile, and those above the 99th percentile with the 99th percentile. The descriptive statistics of all of the variables used in this study are presented in Table 3.

<Table 3 is inserted about here>

As the table shows, 80.24 per cent of insurers use at least one type of reinsurance in our sample, suggesting that reinsurance could be a prevailing risk management instrument in the UK life insurance sector. The respective participation rates for internal and external reinsurance usage are 30.84 per cent and 76.33 per cent, which indicates that more insurers cede premiums to other non-affiliated reinsurers. The life insurers in our sample are found to have reinsured an average of 8.94 per cent of their gross premiums with affiliates, and 10.87 per cent with non-affiliates, with an average proportion of with-profit (unit-linked) business of 5.82 per cent (57.85 per cent). These results together suggest that most UK life insurers, at least those in our sample, are generally found to have higher proportions of unit-linked business than with-profit business.

The correlation coefficients on all of the variables used in our study are presented in Table 4, from which we can see that the proportion of with-profit business has a

positive correlation, at the 1 per cent significance level, with all reinsurance participation variables. This result may indicate that insurers with higher proportions of with-profit business have a greater demand for reinsurance. As regards the volume of reinsurance usage, the proportion of with-profit business is found to be positively correlated with total and internal reinsurance, whereas negatively correlated with external reinsurance.

<Table 4 is inserted about here>

These results are consistent with our anticipated finding that insurers with a higher proportion of with-profit business may tend to use more internal reinsurance than external reinsurance due to the increased costs arising from the exacerbated information asymmetry problem. In contrast, unit-linked business is found in the present study to be negatively related to all reinsurance variables, thereby suggesting that that insurers with a higher proportion of unit-linked business have a lower demand for reinsurance due to lower product risk.

The reinsurance activities of our sample of observations over the years 2005 to 2014 are reported in Table 5, which shows that the use of reinsurance is common in the UK life insurance industry over the entire sample period. Specifically, the participation rate of reinsurance consistently remain at the level of around 80 per cent.

<Table 5 is inserted about here>

Details on the total amount of reinsurance premiums ceded by insurers in our 2005-2014 sample are provided in Table 6, which reveals a general decline since 2008 in the total amount of internal reinsurance. In contrast, the amount of external reinsurance demonstrates a general increasing trend throughout our sample period. These statistics may be attributable to the effects of the financial crisis which occurred in 2008. As a result of the financial crisis, many insurers incurred significant losses and may have been unable to assume reinsurance premiums from other affiliated insurers; thus, they may have increased their dependence on non-affiliated reinsurers in response to the reduced underwriting capacity of their affiliates.

<Table 6 is inserted about here>

Table 7 reports the mean difference test results on all of the explanatory variables between the sub-samples of insurers using: (i) only internal reinsurance; and (ii) only external reinsurance. The table reveals differences between the control variables for the two sub-samples at conventional significance levels; for example, we find that insurers using only internal reinsurance have greater loss ratio, a higher free assets ratio, a higher propensity for the use of derivatives and more concentrated business. Nevertheless, we can find no significant differences in the business variables between the two sub-samples.

<Table 7 is inserted about here>

5.2 Multivariate Analysis

Before conducting our analysis, we calculate the 'variance inflation factors' (VIFs) of the explanatory variables. The unreported results reveal that all of the VIF values are below 10, thereby indicating that the potential problem of multicollinearity is not severe in the present study; we can therefore confidently use the business and control variables for our regression analyses (Gujarati, 1995).

The multivariate analysis results are reported in Table 8, with column (1) to (6) reporting the Cragg (1971) Tobit regression results for reinsurance participation and volume decisions, and column (7) and (8) reporting the regressions on the proportion of internal reinsurance by analyzing the following two subsamples: the insurers which use any types of reinsurance and the insurers that use both internal and external reinsurance. According to columns (1) and (2), with-profit business variable exerts positive effects on the both participation and volume of total reinsurance. In contrast, with-profit business has negative effect on the volume of total reinsurance. These results are consistent with Hypotheses 1a and 1b, indicating that higher (lower) product risk is associated with more (less) demand for reinsurance.

<Table 8 is inserted about here>

Columns (3) and (4) of table 8 show that with- profit business has positive effects on both the participation and volume of internal reinsurance usage, thereby indicating

that insurers with more with-profit business tend to participate in, and use more, internal reinsurance. The results reported in Table 8 therefore provide support for our Hypothesis 2a; that is, the amount of more complex business written leads to greater demand for internal insurance usage. Nevertheless, in the external reinsurance usage results, the effect of with-profit business on external reinsurance participation is both positive and significant; thus, Hypothesis 2b is not supported in the present study. Taken the result of total reinsurance participation together, with-profit business positively affect all reinsurance participation decisions, which indicates that insurers with more risky product risk tend to use reinsurance to mitigate potential impact of underwriting losses.

With regard to the coefficient on the proportion of unit-linked business, unit-linked business had a negative effect on the volume of internal reinsurance and the participation in external reinsurance. Nevertheless, unit-linked business positively affect the participation of internal reinsurance. Taken these results together, insurers with more unit-linked business may have more access to internal reinsurance. However, unit-linked business is generally associated with lower demand for reinsurance.

The results of the analysis of Cragg's model reported in Table 8 provide general support for the notion that an insurer's business mix could have significant effects on reinsurance demand. The positive and significant coefficients on with-profit business suggest that the amount risky products written by insurers is associated with increased

reinsurance demand. Finite risk paradigm and risk-bearing hypothesis are generally supported in our study. Furthermore, business mix also influences the types of reinsurance transactions in which they tend to engage. When insurers wish to transfer part of their with-profit business premiums to reinsurers, the reinsurance transactions could become more costly as a result of the exacerbated information asymmetry between the insurer and the reinsurer; thus, internal reinsurance transactions within an insurance group to reduce transaction costs.

Turing to the additional analysis on the relative usage of internal reinsurance, column (7) of table 8 shows that with-profit positively affect the relative amount of internal reinsurance use. In column (8) of table 8, the coefficient on unit-linked business is negative and significant, which indicates that the proportion of unit-linked business is associated with less internal reinsurance. These results are generally consistent with the main analysis of Cragg's model and provide additional support for hypothesis 2a, which postulates that insurers which underwrite more complex products tend to use internal reinsurance.

Turning to the results of the other control variables in Table 8, we find that firm size is negative and significant in most column, which is consistent with the notion that smaller insurers have higher insolvency risk and thus have greater reinsurance demand. Contrary to our expectations, the coefficient on free assets ratio is found to be

significantly positive in column (3) of Table 8. A possible explanation for this result is that insurers with more financial resources are able to access internal reinsurance.

The coefficients on derivatives usage are found to be positive and significant in column (1) to (3) of Table 8, thereby indicating that derivatives and reinsurance may be regarded as risk-management complements. The coefficient on line-of-business concentration variable is positive and significant in column (1), suggesting that less diversified insurers tend to use reinsurance to mitigate potential large loss. Cash holding is found to be negatively related to reinsurance use, implying that insurers with higher liquidity could be less likely to become insolvent and thus have less reinsurance demand.

Column (3) of Table 8 reveals that tax convexity has a negative effect on total reinsurance volume. The argument that insurers purchase reinsurance when facing higher tax convexity to reduce expected tax payment proposed by Adams et al. (2008) is not supported. The negative coefficient on the marginal tax rate variable in column suggests that insurers faced with higher marginal tax rates will tend to use less reinsurance, which supports for the income level enhancement argument proposed by Adams et al. (2008).

4.3 Checks for Robustness

In order to check whether our main results may differ as a result of extreme values of the variables, we rerun the regressions using non-winsorized samples. Based on the results reported in table 9, the effects of business mix variables on reinsurance decisions

remain generally unchanged. In addition, we also carry out an additional check to determine whether our results could vary based upon the features of the life and pension insurance products. Within the life insurance industry, insurers issuing more life insurance products are more exposed to mortality risk, whereas insurers with more pension business may be exposed to longevity risk. To test whether our main results are affected by the nature of the life and pension business, we retrieve those observations with positive values of reserves in life (pension) business and use these as our life (pension) sub-sample.

<Table 9 is inserted about here>

The life and pension sub-samples are analyzed by calculating reinsurance usage, business mix and underwriting risk, along with the line-of-business concentration variable based upon the premiums written, losses incurred and reserves in life (pension) business (as opposed to using the aggregate values of premiums written, losses and reserves). The remaining control variables are calculated as described in Table 1. The unreported results show that the with-profit business variable continues to have positive effects on both participation and volume decisions relating to internal reinsurance when using the separate life and pension sub-samples in our empirical analysis.

We further conduct additional tests in the present study to determine whether there were any structural changes to our main results over the sample period. A Bank of

England inflation report published in 2012 found that UK interest rates fell significantly after the 2008 financial crisis, resulting in UK insurers being faced with a low interest-rate environment. According to Berends et al. (2013), a low interest-rate environment poses a significant threat to the insurance sector since it can lead to increased bond prices and considerably lower investment returns for insurers.

Furthermore, the interest rate level faced by insurers can affect the development of the alternative capital markets, such as catastrophe bonds and collateralized reinsurance. According to a global insurance market report (IAIS, 2014), the high yield of the alternative capital markets, relative to a low-yield environment, boosts the development of the alternative capital markets, ultimately placing pressure on reinsurers; in other words, as opposed to reinsurance, insurers may tend to use alternative capital when faced with a low interest-rate environment. There is, therefore, considerable doubt that our results would have been structurally changed as a result of the 2008 financial crisis.

For our robustness checks, we divide our sample into two sub-samples based upon the pre- and post-financial crisis periods, and then separately analyze the effects of the business variables on reinsurance usage; we refer to the sub-sample comprising of 2005-2008 (2009-2014) observations as the pre-crisis (post-crisis) sub-sample. The unreported results suggest that the effects of business mix variables on insurers'

reinsurance decisions do not structurally change from pre-crisis to post-crisis period.

5. CONCLUSIONS

We set out in this study to examine the effects of insurer's business mix on reinsurance usage decisions. Based upon the use of the Cragg (1971) model for our analysis of a 2005-2014 sample of UK life insurers, we find the following two main results. First, a higher proportion of with-profit business has a positive association with overall reinsurance usage, which suggests that more risky products underwritten by insurer is associated with greater reinsurance use. This result supports the finite risk paradigm and risk-bearing hypothesis which indicate insurer's tendency to limit its overall risk. Second, we find that higher proportion of with-profit business positively affect the amount of internal reinsurance use, indicating that insurers may prefer to transfer premiums associated with greater complexity to affiliated reinsurer. Our main results are generally found to be robust under various specifications in our empirical analyses.

Our results may have the following implications. First, insurer's product risk arise from its business mix could play important role in reinsurance demand. To limit insolvency risk and increase insurer's risk-bearing ability, higher product risk could motivate insurer to use reinsurance. Second, the complexity of insurance product could increase the information asymmetry between reinsurer and insurer and introduce more uncertainties in reinsurance contract performance. These situations could further

increase the cost difference between internal and external reinsurance and the likelihood for non-affiliated reinsurer to impose price control mechanism on the insurer which has deteriorated underwriting result. For these reasons, insurers may prefer to transfer their sophisticated business to affiliated reinsurers in order to avoid the high transaction costs associated with the external reinsurance markets. When deciding how to allocate their reinsurance underwriting capacity, insurance groups may give a higher priority to taking on more of the sophisticated business written by their subsidiaries.

The main limitation of our research is the lack of availability of data. Although we were able to obtain data on the total amount of reinsurance premiums ceded, we did not have access to any data on the respective amounts of reinsurance premiums that are ceded to the insurers or reinsurers. In addition, the information provided by the database did not enable us to distinguish between the types of reinsurance treaties purchased by the insurers. Future studies may therefore attempt to carry out an examination of the determinants affecting the decisions made by the insurers or reinsurers on the respective amounts of reinsurance premiums that are ceded. We also suggest that future studies could investigate whether internal and external reinsurance decisions vary in terms of the type of reinsurance treaty.

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Table 1 Over-identifying and Endogeneity Tests

Dependent Variable	Column (1): Total Reinsurance Participation	Column (2): Total Reinsurance Volume.	Column (3): Internal Reinsurance Participation	Column (4): Internal Reinsurance Volume.	Column (5): External Reinsurance Participation	Column (6): External Reinsurance Volume.	Column (7): Proportion of Internal Reinsurance	Column (8): Proportion of Internal Reinsurance
Panel A: Over-identifying Test								
Sargen Statistic	2.3870	0.2913	1.5814	0.1142	0.7808	0.4547	0.0846	0.8778
Basmann Statistic	2.3513	0.2862	1.5562	0.1122	0.7676	0.4468	0.0827	0.8300
Panel B: Endogeneity Test								
Durbin Statistic	44.3178***	230.9110***	31.7043***	220.9350***	16.6967***	30.9063***	17.0640***	13.2158***
Wu-Hausman Statistic	23.0420***	160.8550***	16.2060***	151.1590***	8.3669***	15.7813***	8.5611***	6.5564***

Notes:

[a] In column (7), we use the subsample consisting of the insurers which use any types of reinsurance; in column (8), we use the subsample which only includes the observations that have both internal and external reinsurance usage.

[b] *** indicates statistical significance at the 1% level; ** indicates statistical significance at the 5% level; and * indicates statistical significance at the 10% level.

Table 2 Variable definitions

Variables	Definitions	Source
1. Dependent Variables		
reinsurance participation	Variable taking the value of 1 if the insurer has used reinsurance; otherwise 0.	Specified by authors
Internal reinsurance participation	Variable taking the value of 1 if the insurer has used internal reinsurance; otherwise 0.	Specified by authors
External reinsurance participation	Variable taking the value of 1 if the insurer has used external reinsurance; otherwise 0.	Specified by authors
Reinsurance volume	Ratio of premiums ceded to direct premiums written.	Adams et al. (2008), Kader et al. (2010), Shiu (2011)
Internal reinsurance volume	Ratio of premiums ceded to affiliates to direct premiums written.	Powell and Sommer (2007)
External reinsurance volume	Ratio of premiums ceded to non-affiliates to direct premiums written.	Powell and Sommer (2007)
2. Business Mix		
With-profits business	Proportion of reserves in accumulated with- profit contracts.	Synthesys Database
Unit-linked business	Proportion of reserves in unit-linked contracts	Synthesys Database
3. Control Variables		
Loss ratio	Insurance losses divided by total premiums written.	Specified by authors
Firm size	Natural logarithm of the annual total admissible assets of the insurer.	Adams (1996), Adams et al. (2008)
Free assets ratio	Ratio of long-term assets to total long-term reserves and other liabilities, minus the regulatory required solvency margin.	Adams et al. (2008), Kader et al. (2010)
Publicly traded	Variable taking the value of 1 if the insurer is a publicly-traded company; otherwise 0.	Powell and Sommer (2007)
Organizational form	Variable taking the value of 1 if the insurer is a stock insurer; otherwise 0.	Kader et al. (2010)
Derivatives	Variable taking the value of 1 if the insurer uses derivatives; otherwise 0.	Shiu (2011)
Line-of-business concentration	Herfindahl line-of-business concentration index.	Cole and McCullough (2006), Shiu (2011)
Cash holdings	Total cash holdings divided by total assets.	Specified by authors
Tax convexity	Excess of the marginal tax rate over the effective tax rate.	Adams et al. (2008), Kader et al. (2010), Shiu (2011)
Marginal tax rate	Top statutory rate if the prior year net operating loss was equal to 0 and the current year taxable income is greater than 0; otherwise 0.	Adams et al. (2008), Kader et al. (2010), Shiu (2011)

Table 3 Descriptive statistics[a]

Variables[b]	Mean	Median	S.D.	Min	Max
Reinsurance Participation	0.8024	1.0000	0.3984	0.0000	1.0000
Internal reinsurance participation	0.3084	0.0000	0.4621	0.0000	1.0000
External reinsurance participation	0.7633	1.0000	0.4253	0.0000	1.0000
Reinsurance Volume	0.1979	0.0709	0.2708	0.0000	1.0000
Internal reinsurance volume	0.0894	0.0000	0.2272	0.0000	1.0000
External reinsurance volume	0.1087	0.0217	0.1806	0.0000	0.9053
With-profit business	0.0582	0.0000	0.1379	0.0000	0.8178
Unit-linked business	0.5785	0.6881	0.3907	0.0000	1.0000
Loss ratio	2.1209	0.9276	8.2455	0.0000	110.3349
Firm size	14.5781	14.6744	2.1543	9.1310	18.6658
Free assets ratio	19.7786	7.0800	49.9506	0.0200	386.6900
Publicly traded	0.3898	0.0000	0.4880	0.0000	1.0000
Organizational form	0.8295	1.0000	0.3762	0.0000	1.0000
Derivatives	0.3963	0.0000	0.4894	0.0000	1.0000
Line-of-business concentration	0.7776	0.8240	0.2239	0.3338	1.0000
Cash holdings	0.0623	0.0114	0.1444	0.0000	0.7669
Tax convexity	0.1054	0.0646	0.5093	-1.1794	3.7619
Marginal tax rate	0.1245	0.1900	0.0966	0.0000	0.2100

Notes:

[a] The descriptive statistics reported here are based upon the winsorized sample.

[b] Descriptions of all of the variables are provided in Table 2.

Table 4 Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	0.3628***																
3	0.3314***	0.3956***															
4	0.1954***	0.7489***	0.5897***														
5	0.8912***	0.1921***	0.1727***	-0.0371													
6	0.2989***	0.5617***	-0.1433***	-0.1249***	0.3354***												
7	0.1809***	0.0249	0.1965***	0.1384***	0.1814***	-0.1328***											
8	-0.1642***	-0.1214***	-0.0383	-0.1124***	-0.1537***	-0.0422	- 0.3326***										
9	-0.1589***	-0.0690*	-0.0284	-0.0177	0.1517***	-0.0815	-0.0149	-0.0100									
10	0.0556*	-0.0682*	0.3055***	0.0853***	0.0958***	-0.2038***	0.1286***	0.3562***	0.0858***								
11	0.0936***	0.3202***	0.0928***	0.3520***	-0.0814**	0.0368	-0.0344	-0.2527***	-0.0350	-0.3769***							
12	-0.0227	0.0549*	0.2039***	0.1529***	-0.0263	-0.1053***	0.0138	0.2813***	0.0809**	0.3325***	-0.0279						
13	-0.0799**	0.0933***	0.1776***	0.0484	-0.0554*	0.0797**	-0.2750***	0.1961***	0.0345	0.2489***	-0.1297***	0.2557***					
14	0.2460***	0.1794***	0.4155***	0.2628***	0.2110***	-0.0569*	0.2754***	-0.2154***	0.0401	0.4746***	0.0781**	0.1080***	0.0131				
15	-0.3538***	-0.1297***	-0.3397***	-0.2029**	-0.3656***	0.0554*	-0.5197***	0.2748***	0.0037	-0.2636***	0.1085***	-0.0538	0.2486***	-0.5912***			
16	0.0158	0.0222	-0.1292***	-0.0249	0.0166	0.0642*	0.0477	-0.4336***	-0.0533	-0.4775***	0.2802***	-0.1431***	-0.0160	-0.1507***	0.1509***		
17	0.0697*	-0.0351	0.0420	-0.0190	0.0852**	-0.0282	0.0585	-0.0583	-0.0133	-0.0050	-0.0163	-0.0125	0.0261	0.0108	-0.0002	0.0291	
18	-0.1433***	-0.1274***	-0.1475***	-0.1059***	-0.1694***	-0.0606*	-0.1372***	0.1332***	0.0441	-0.0985***	0.0229	-0.0444	-0.1027***	-0.1773***	0.1563***	-0.0244	-0.0911**

Notes:

[a] The numbers 1 to 18 on the x/y axis refer to the following variables. 1: Total reinsurance participation; 2: Total reinsurance volume; 3: Internal reinsurance participation; 2: External reinsurance participation; 4: Internal reinsurance volume; 5: External reinsurance participation; 6: External reinsurance volume; 7: With-profits business; 8: Unit-linked business; 9:Loss ratio; 10: Firm size; 11: Free assets ratio; 12: Publicly-traded; 13: Organization form; 14: Derivatives; 15: Business concentration; 16: Cash holdings; 17: Tax convexity; 18: Marginal tax rate. Descriptions of all of the variables are provided in Table 1.

[b] *** indicates statistical significance at the 1% level; ** indicates statistical significance at the 5% level; and * indicates statistical significance at the 10% level.

Table 5 Reinsurance activities, 2005-2014

Year	Reinsurance Transactions*									
	Model (1) Internal Only		Model (2) External Only		Model (3) Internal and External		Model (4) Neither		Model (5) Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
2005	7	5.83	62	51.67	28	23.33	23	19.17	120	13.03
2006	5	4.31	60	51.72	29	25.00	22	18.97	116	12.60
2007	3	3.09	47	48.45	26	26.80	21	21.65	97	10.53
2008	3	3.06	45	45.92	29	29.59	21	21.43	98	10.64
2009	4	4.12	46	47.42	28	28.87	19	19.59	97	10.53
2010	4	4.00	46	46.00	32	32.00	18	18.00	100	10.86
2011	3	3.75	37	46.25	24	30.00	16	20.00	80	8.69
2012	2	2.63	39	51.32	21	27.63	14	18.42	76	8.25
2013	3	4.29	37	52.86	15	21.43	15	21.43	70	7.60
2014	2	2.99	36	53.73	16	23.88	13	19.40	67	7.27
Totals	36	3.91	455	49.40	248	26.93	182	19.76	921	100.00

Note: * the percentages shown in Models (1) to (4) represent the proportion of the observations of each type of reinsurance activity in the current year to the total number of observations in the current year; the percentages shown in Model (5) represent the proportion of observations in the current year to the total number of observations in the full sample.

Table 6 einsurance transactions, 2005 to 2014

Year	Reinsurance Transactions					
	Internal		External		Totals	
	Amount[a]	Ratio[b]	Amount[a]	Ratio[b]	Amount[a]	Ratio[b]
2005	24,057.64	0.1601	5,399.53	0.0359	29,457.17	0.1960
2006	27,621.85	0.1345	5,443.13	0.0265	33,064.98	0.1610
2007	23,434,29	0.1020	7,439.31	0.0324	30,873.61	0.1344
2008	31,132.67	0.1783	13,790.36	0.0790	44,923.04	0.2573
2009	19,833.42	0.1270	10,180.61	0.0652	30,014,03	0.1921
2010	20,921.33	0.1362	10,826.55	0.0705	31,747.89	0.2067
2011	14,445.35	0.1161	10,599.95	0.0852	25,045.30	0.2013
2012	12,261.83	0.0685	13,926.24	0.0777	26,188.07	0.1462
2013	7,863.49	0.0543	14,363.52	0.0991	22,227.00	0.1534
2014	7,631.30	0.0535	18,818.81	0.1318	26,450.12	0.1853
Totals	189,203.19	0.1139	110,788.00	0.0667	299,991.19	0.1806

Notes:

[a] 'Amount' refers to the amount of reinsurance ceded for each year (in GBP million).

[b] 'Ratio' refers to the number of ceded premiums for each year to the total number of premiums written.

Table 7 Univariate analysis of internal and external reinsurance usage

Variables	Internal Reinsurance User (N = 36)			External Reinsurance User (N = 455)			t-statistics (a–b)	Mann-Whitney U-Test
	Mean (a)	S.D.	Median	Mean (b)	S.D.	Median		
With-profit business	0.0402	0.1075	0.0000	0.0530	0.1443	0.0000	–0.5203	–1.0170
Unit-linked business	0.5779	0.4340	0.7398	0.5408	0.4013	0.5809	0.5309	0.0690
Underwriting risk	2.3741	2.2230	1.8387	1.2842	1.7374	0.8961	3.5421***	3.3330***
Firm size	13.5542	1.9611	13.5961	14.0600	2.0960	14.2752	–1.3991	-1.2180
Free assets ratio	111.5869	144.4105	68.1300	19.21382	43.7478	7.6700	9.3308***	3.3870***
Publicly traded	0.4167	0.5000	0.0000	0.2879	0.4533	0.0000	1.6280	1.6250
Organizational form	0.7500	0.4392	1.0000	0.7429	0.4375	1.0000	0.0943	0.0940
Derivatives	0.5000	0.5071	0.5000	0.3033	0.4602	0.0000	2.4501**	2.4380***
Line-of-business concentration	0.8607	0.2099	0.9851	0.7848	0.2103	0.8203	2.0839**	2.4920**
Cash holdings	0.0595	0.1783	0.0038	0.0816	0.1648	0.0189	–0.7715	-3.3280***
Tax convexity	0.0039	0.1350	–0.0291	0.1144	0.5043	0.1334	-1.2716	-3.1570***
Marginal tax rate	0.1585	0.0822	0.2000	0.1273	0.0959	0.1900	1.8325*	1.7600*

Note: *** indicates statistical significance at the 1% level; ** indicates statistical significance at the 5% level; and * indicates statistical significance at the 10% level.

Table 8 Multivariate regression results (winsorized sample)

Variables	Total Reinsurance		Internal Reinsurance		External Reinsurance		Reinsurance User	
	Column (1): Participation	Column (2): Volume	Column (3): Participation	Column (4): Volume	Column (5): Participation	Column (6): Volume	Column (7): Reinsurance user	Column (8): Both user
	(N=921)		(N=921)		(N=921)		(N=739)	(N=248)
Constant	2.0399***	1.1801**	-0.4537	2.9797**	2.6608***	4.1591	-0.1953	1.1591***
With-Profit Business	33.4549***	27.0398***	8.7085***	6.8199***	7.3310***	-15.1788	10.7658***	-0.5751
Unit-Linked Business	0.3044	-1.1401***	0.6104**	-1.2442***	-0.7953***	0.1316	0.3935	-0.4794***
Loss Ratio	-0.0197**	-0.0680**	-0.0089**	-0.0711*	-0.0829	-0.7433	0.0189	-0.0256
Firm Size	-0.5301***	-0.5777***	-0.0592	-0.2048**	-0.0769	-1.0054*	-0.1393**	0.0072
Free Assets Ratio	-0.0032	-0.0031***	0.0037***	0.0015	-0.0038**	-0.0037	0.0021*	0.0003
Publicly-Traded	-0.2223	0.1567	0.0266	0.0652	-0.0806	-0.4142	-0.0880	0.0768
Organization Form	0.3275	0.2685	-0.2222	-0.6049*	0.4044*	5.0155	-0.3346	0.1072
Derivatives	0.9539***	0.9582***	0.8954***	0.3201	-0.0272	1.4506	0.5014***	-0.1582*
Line-of-Business Concentration	6.6004***	7.1647***	0.1075	0.1932	-0.4581	1.8242	2.0097**	-0.5481
Cash Holding	-2.6481***	-3.7466***	-1.0122*	-0.1783	-0.7324	-5.7297*	-1.4983**	-0.0456
Tax Convexity	-0.1564	-0.5333***	0.0276	-0.2377	0.2446*	-0.6535	-0.1110	-0.0164
Marginal Tax Rates	-1.1559*	-0.3644	-0.9112	-0.5064	-1.2983**	1.8305	0.1203	0.2875
Pseudo Likelihood Ratio	45.4283		-204.3063		290.7502			
Log Pseudo Likelihood							377.0568	274.6195

Notes:

[a] The dependent variable in the column (7) and (8) is the proportion of internal reinsurance use to total reinsurance use.

[b] *** indicates statistical significance at the 1% level; ** indicates statistical significance at the 5% level; and * indicates statistical significance at the 10% level.

Table 9 Multivariate regression results (non-winsorized sample)

Variables	Total Reinsurance		Internal Reinsurance		External Reinsurance		Reinsurance User	
	Column (1): Participation	Column (2): Volume	Column (3): Participation	Column (4): Volume	Column (5): Participation	Column (6): Volume	Column (7): Reinsurance user	Column (8): Both user
	(N=921)		(N=921)		(N=921)		(N=739)	(N=248)
Constant	1.5211***	0.3760	-0.2927	2.3907**	2.1608***	4.4533	-0.0139**	1.1438***
With-Profit Business	32.9275***	27.0457***	9.4523***	6.8280***	6.3900**	-21.9982	11.1159***	-0.7669
Unit-Linked Business	0.4164	-1.2615***	0.6433***	-1.1343***	-0.7539***	-0.1074	0.4857*	-0.4802***
Loss Ratio	-0.0032	-0.0003***	-0.0019	-0.0001***	0.0002***	-0.3415*	-0.0003	-0.0244
Firm Size	-0.4968***	-0.5299***	-0.0795*	-0.1679***	-0.0432	-1.1008*	-0.1545***	0.0123
Free Assets Ratio	-0.0007	-0.0012***	0.0018**	0.0015	-0.0014**	-0.0014	0.0009	0.0005
Publicly-Traded	-0.2653*	0.1858	0.0216	0.0648	-0.0907	-0.2604	-0.1145	0.0849
Organization Form	0.4239*	0.2201	-0.3100	-0.6702**	0.5257**	5.4727	-0.3859*	0.1050
Derivatives	0.8824***	0.7943***	0.9235***	0.1882	-0.1125***	1.5147	0.5341***	-0.1613*
Line-of-Business Concentration	6.3758***	7.2105***	0.3368	0.1590	-0.7351**	1.6072	2.0600***	-0.6246
Cash Holding	-2.4207***	-3.5202***	-0.8445*	0.5188	-0.5170**	-7.0501**	-1.3038**	0.0243
Tax Convexity	-0.0006	-0.1051***	0.0069	-0.0428	0.0318	-0.2254*	-0.0055	-0.0003
Marginal Tax Rates	-1.1197*	-0.4060	-0.9540*	-0.8752	-1.5375***	1.7212	0.1287	0.3023
Pseudo Likelihood Ratio	35.0250		-204.1161		273.4921			
Log Pseudo Likelihood							357.8159	271.5529

Notes:

[a] The dependent variable in the column (7) and (8) is the proportion of internal reinsurance use to total reinsurance use.

[b] *** indicates statistical significance at the 1% level; ** indicates statistical significance at the 5% level; and * indicates statistical significance at the 10% level.