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Reinsurance and Capital Structure: Evidence From the United Kingdom Non-Life Insurance Industry

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Abstract

Using a data set consisting of statutory returns of U.K. non-life insurers from 1985 to 2002, I find that insurers with higher leverage tend to purchase more reinsurance, and insurers with higher reinsurance dependence tend to have a higher level of debt. My results are consistent with the expected bankruptcy costs argument, agency costs theory, risk-bearing hypothesis, and renting capital hypothesis. I also find that the impact of leverage on reinsurance will be weaker for insurers that use more derivatives than those that use less. Moreover, high levels of derivative use increase the leverage gains attributable to reinsurance.

Introduction

According to Modigliani and Miller (1958), reinsurance and financing decisions are irrelevant in a world of perfect capital markets. Why then would insurers buy reinsurance? The primary reason is that in reality the markets are imperfect. Insurers usually take out reinsurance cover to provide protection against catastrophic losses, mitigate policyholders' concerns about insurer insolvency, enhance the insurer's ability to bear risk, and reduce expected tax liability. In a similar line of argument, based on incentives to make value-maximizing decisions, the demand for capital structure change arises due to capital market frictions. The capital structure literature (e.g., Titman and Wessels, 1988) has suggested that firms actually have a target debt ratio, which is influenced by several factors such as size, and profitability.

MacMinn (1987) and Plantin (2006) have argued that reinsurance and capital structure might be jointly determined. To my knowledge, the current study is the first research using panel data on a sample of 350 U.K. non-life insurers to simultaneously examine the impact of leverage on reinsurance and the reverse causation from reinsurance to capital structure. Specifically, I construct a two-equation structural model and employ a two-stage least squares (2SLS) regression to estimate it. Prior studies (e.g., Graham and Rogers, 2002; Dionne and Triki, 2004; Aunon-Nerin and Ehling, 2008; Zou and Adams, 2008; Bartram, Brown, and Fehle, 2009) use the simultaneous equations to

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examine the relation between derivative/insurance hedging and the debt ratio. Unlike their study, I investigate the relation between reinsurance hedging and leverage. Moreover, I estimate the model using the fixed effect vector decomposition (FEVD) approach proposed by Plümper and Troeger (2007) in order to address the problems of estimating time-invariant/rarely changing variables.

The motivation for this research is twofold. First, since research on the reverse causality from reinsurance to leverage has never been conducted, this current study aims to fill in the gap in the literature. The second motivation is that insurers, unlike other ordinary business firms, not only use derivatives to hedge their investment risk but also use reinsurance to hedge underwriting risk. Most of previous studies (e.g., Graham and Rogers, 2002; Aunon-Nerin and Ehling, 2008; Bartram, Brown, and Fehle, 2009) find that high leverage increases derivative/insurance hedging and that hedging has a significant positive effect on leverage. Dionne and Triki (2004), however, find that leverage has a positive effect on hedging, but firms do not necessarily hedge to increase their debt capacity. Zou and Adams (2008) show that property insurance expands firms' debt capacity, whereas leverage alone does not result in the purchase of more property insurance. The empirical evidence on the relation between hedging and leverage varies. In my research, I wish to examine whether similar relations exist between reinsurance hedging and capital structure.

Consistent with the *expected bankruptcy costs argument*, the *agency costs theory*, and the *risk-bearing hypothesis*, I find that leverage exerts a positive influence on reinsurance purchases. I also find evidence to support the *renting capital hypothesis*, in that higher leverage is associated with more reinsurance purchases. Further, I document the moderating impacts of derivative use on the two-way relation between reinsurance and leverage. I find that the impact of leverage on reinsurance will be weaker for insurers that use more derivatives than those that use less. I also find that high levels of derivative use increase the leverage gains attributable to reinsurance.

The article proceeds as follows. The following section provides background information on reinsurance and capital structure for U.K. non-life insurers. Next, I introduce the related theories, define my testable predictions, then discuss the methodology and empirical framework employed. The data source, variables and their measures are described in the subsequent section, and an empirical analysis of the estimation results are provided thereafter. The robustness checks are conducted in the penultimate section, whereas the last section offers my concluding remarks.

INSTITUTIONAL BACKGROUND

According to Swiss Reinsurance Company (2003, pp. 34–35), in 2002 the U.K. non-life insurance industry generated annual premiums of £51.31 billion (US$77.03 billion), ranking first in the Europe and third in the world. There have been several legislative changes in the United Kingdom during the analysis period 1985–2002. Before the Financial Services and Markets Act of 2000 came into force and the Financial Services Authority (FSA) officially assumed legal responsibility for the supervision of insurers in 2001, the main statutes governing U.K. insurers' reporting on their financial condition were the Insurance Company Act of 1982, the Insurance Companies Regulation of 1994, and the Insurance Companies (Accounts and Statements) Regulation of 1996. These statutes were then repealed and replaced by the Interim Prudential Sourcebook for Insurers (INSPRU) in the FSA's Handbook of Rules and Guidance. For practical reasons, however, most of relevant provisions in the INSPRU and previous regulations remained the same (Philpott, 2009). Since the changes in legislation have not significantly affected how insurers function over the analysis period, the associated potentially confounding effects are minimized. Moreover, the U.K. insurance markets are generally considered to be less regulated than those in other jurisdictions (Wang, 2002). Although the U.K. insurance regulator required non-life insurers to report information on the reinsurance arrangements in force, there were no particular requirements or restrictions, which may influence my examination of the relation between reinsurance and capital structure. Therefore, my empirical results are unlikely to be confounded by institutional factors that are beyond the control of managers of insurers.

According to the U.K. Companies Act, prior to authorization a public insurer requires a minimum paid-up capital of £50,000 as a buffer fund. Moreover, an insurer transacting insurance in the United Kingdom must maintain its margin of solvency above the level of the statutory required minimum margin. The required solvency margin is the highest of the figures calculated under two methods. The first method, also known as the premiums method, involves calculation of 18 percent of gross premiums written for a financial year, whereas the second method, also known as the claims method, involves calculation of 26 percent of average incurred claims over the last 3 years (Bannister, 1997, p. 43). These two methods are stated in Forms 11 (General business: Calculation of required margin of solvency—first method), and 12 (General business: Calculation of required margin of solvency—second method, and statement of required minimum margin) of the FSA statutory returns. An insurer generally is considered to have the solvency problem if the value of its assets allocated toward required minimum margin is less than required minimum margin. The availability of data on solvency margin provides an opportunity to test Chen, Hamwi, and Hudson's (2001) argument in the U.K. non-life insurance sector that a less solvent insurer tends to use more reinsurance. Moreover, it is also possible to examine how an insurer's solvency affects its debt decision.

U.K. insurers have to file annual returns with the FSA (which at the time was the Department of Trade and Industry). Non-life insurers, also known as general insurers, disclose their information on equity and solvency in Forms 11 and 12, whereas disclosing information on reinsurance in Form 24 (General business (underwriting year accounting): Analysis of premiums, claims, and expenses). The capital and reinsurance data used in this research are mainly drawn from these forms.

HYPOTHESES DEVELOPMENT

Effects of Leverage on Reinsurance

The effects of leverage on reinsurance purchases can be investigated from several aspects.[1] According to the expected bankruptcy costs argument, highly leveraged insurers are exposed to a higher likelihood of insolvency and thus higher expected bankruptcy costs. Reinsurance purchases may protect the insurer from unexpected huge losses and therefore reduce the probability of insolvency. If the insurer is highly

[1] In this section, I focus on theories and evidence from prior studies on the effects of leverage on reinsurance purchases by insurers, rather than on insurance purchases by noninsurance firms.

leveraged, it would be difficult to raise required capital in the financial markets at a low cost. This insurer would thus tend to purchase more reinsurance to supplement capital deficiency in order to maintain solvency at an acceptable level.

The agency costs theory also suggests a positive relation between leverage and reinsurance. Policyholders, like debt holders in ordinary firms, and stockholders in insurers have conflicting interests, which impose agency or informational asymmetry costs on the firm. Managers of a levered insurer with a significant probability of bankruptcy would tend to reject positive net present value (NPV) projects, especially those that may involve high-expected losses, thus causing the underinvestment problem. The reason for this is that policyholders have a prior claim on company cash flows, whereas stockholders have the residual claim, and the benefits of undertaking positive NPV projects may only accrue to policyholders. The purchase of reinsurance by insurers may alleviate this problem by transferring to the reinsurer the risk of incurring huge losses. Adams (1996) further proposes the risk-bearing hypothesis, which postulates that insurers tend to reinsure more to alleviate the risk of a catastrophic loss as their leverage gets closer to solvency constraints.

Prior research evidence, excluding that in Cole and McCullough (2006), is consistent with the expected bankruptcy costs argument, the agency costs theory, and the risk-bearing hypothesis, that is, that reinsurance purchases are positively associated with leverage.[2] Hoerger, Sloan, and Hassan (1990) find that the surplus to premium ratio (an inverse measure of leverage) has a negative effect on the amount of reinsurance, supporting the view that reinsurance increases with debt ratio. Adams (1996) argues that the amount of reinsurance is likely to be greater in insurers with higher leverage reaching solvency constraints. Garven and Lamm-Tennant (2003) show that the demand for reinsurance is positively related to insurer leverage. Shortridge and Avila (2004) argue that the shareholders' equity to total premiums earned ratio is negatively related to the use of reinsurance, implying that an insurer with higher leverage needs more reinsurance. Powell and Sommer (2007) further provide evidence that leverage has a positive impact on both internal and external reinsurance. Unlike prior studies, Adams, Hardwick, and Zou (2008) investigate the factors affecting the incremental use of reinsurance, instead of the level of reinsurance use. They also report that insurers with higher leverage tend to purchase more reinsurance.

Effects of Reinsurance on Leverage

Under the renting capital hypothesis, insurers with a higher level of reinsurance choose higher debt ratios because reinsurance reduces the strain on the insurer's capital. Reinsurance effectively serving as a substitute to some degree for equity capital (Adiel, 1996) can increase a ceding insurer's surplus (Chen, Hamwi, and Hudson, 2001). The risk management and finance literature (Graham and Rogers, 2002; Aunon-Nerin and Ehling, 2008; Zou and Adams, 2008; Bartram, Brown, and Fehle, 2009) indicates that derivative/insurance hedging expands a firm's debt capacity. Reinsurance can affect the solvency margin in the regulatory returns by reducing solvency requirements and can then be regarded as one form of off-balance-sheet capital.

[2]Cole and McCullough (2006) document no significant relation between the overall demand for reinsurance and leverage. However, they find that insurers with lower leverage are associated with the use of foreign reinsurance.

Since ceding insurance to the reinsurer can be considered as the insurer renting capital from the reinsurer, the cost of reinsurance (reinsurance premium) is actually the cost of renting capital. If the cost of reinsurance is less than the cost of financing from other sources, such as debt and equity, the insurer would rely more on reinsurance. Thus, insurers may acquire reinsurance to underwrite risks larger than those normally accepted. This would increase the direct premiums written, and then the debt ratio accordingly, all else being equal.

THE METHODOLOGY AND EMPIRICAL FRAMEWORK

As discussed earlier, an insurer's capital structure may have an impact on its utilization of reinsurance and the reverse causality from reinsurance to capital structure may exist. The dual causality requires the application of a simultaneous equation model that accounts for two-way causation between variables.[3] Therefore, I construct a two-equation simultaneous equations model and estimate it by 2SLS. This model is constructed as follows:

$$REINS_{i,t} = f_1(LEV_{i,t}, CV_{1,i,t-1}) + e_{1i,t} \tag{1}$$

$$LEV_{i,t} = f_2(REINS_{i,t}, CV_{2,i,t-1}) + e_{2i,t}, \tag{2}$$

where $REINS_{i,t}$denotes the purchase of reinsurance of insurer i in year t; $LEV_{i,t}$ represents the leverage of insurer i in year t. CV_1 and CV_2 are two different sets of control variables that are identified based on the theoretical arguments and empirical evidence.[4] To correct for the problem of endogeneity, lags are utilized for the control variables.[5] CV_1 and CV_2 are both uncorrelated with the error terms $e_{1i,t}$ and $e_{2i,t}$, respectively. $e_{1i,t}$ and $e_{2i,t}$ are structural errors and may be correlated with each other. The instrumental variables consist of all the exogenous variables appearing in Equations (1) and (2).

My procedure for specifying the two equations satisfies both the order and rank conditions.[6] The order condition, which is a necessary and sufficient condition for the equations to be identified, is met because CV_1 and CV_2 contain different exogenous variables, meaning that exclusion restrictions have been imposed on the two-equation

[3]Econometrics texts such as Wooldridge (2006, p. 557) argue that an explanatory variable which is determined simultaneously with the dependent variable is generally correlated with the error term. If the explanatory variable is correlated with the error term due to simultaneity, the use of an ordinary least squares (OLS) regression would suffer from the simultaneity bias and lead to inconsistency.

[4]I rely on the reinsurance and capital structure literature (such as Hoerger, Sloan, and Hassan, 1990; Adams, 1996; Chen, Hamwi, and Hudson, 2001; Garven and Lamm-Tennant, 2003; Shortridge and Avila, 2004; Cole and McCullough, 2006; Titman and Wessels, 1988; Kayhan and Titman, 2007) to identify the possible control variables.

[5]I conduct a test for endogeneity suggested by Hausman (1978) for the control variables. See also Wooldridge (2006, pp. 532–533) for the details. The unreported results show that the problem of endogeneity exists. I therefore use lagged values for the control variables to correct for that problem (Cole and McCullough, 2006).

[6]See Wooldridge (2006) and Greene (2008) for the procedure for identifying and estimating a structural model using the method of 2SLS.

structural model. The rank condition is also satisfied because at least one of the exogenous variables excluded from Equation (1) has a nonzero coefficient in Equation (2), and vice versa.

Since my control variables include time-invariant and rarely changing variables, I also estimate the model using the FEVD approach of Plümper and Troeger (2007).[7] This approach is used to address the problems of estimating time-invariant and rarely changing variables in panel data analysis with unit effects.

DATA AND VARIABLES

Data

This study employs an unbalanced sample of yearly based panel database of U.K. non-life insurers over the period 1985 to 2002. The data for insurer-specific variables are computed using U.K. regulatory returns from the data set of SynThesys Non-Life provided by Standard & Poor's. The number of firms in this data set is originally 360. However, since this article focuses on non-life insurers' simultaneity in financing and reinsurance decisions, I exclude firms whose reinsurance assumed account for more than 75 percent of total premium written (Cole and McCullough, 2006; Powell and Sommer, 2007). Moreover, group-affiliated insurers are also excluded since their reinsurance decisions are arguably different from those of unaffiliated insurers, as the former can be regarded as transactions in internal capital markets (Mayers and Smith, 1990; Garven and Lamm-Tennant, 2003; Powell and Sommer, 2007).[8] I then exclude insurers with nonpositive total admissible assets for the years in which they have nonpositive total admissible assets. I further exclude insurers with negative net earned premiums written in any of the six lines of business, including accident and health, motor, marine aviation and transport, property, third-party liability, and miscellaneous and pecuniary loss. Moreover, insurers without any net earned premiums written in all of the six lines are excluded from the sample. I exclude insurers reporting a value outside the range of zero and one for the reinsurance variable because they represent extraordinary operating characteristics.[9] In addition, the use of lagged values for most of the explanatory variables leads to the loss of one more year's data. Finally, because this article is only focused on the U.K. non-life insurance market, firms submitting global returns are excluded from this research. The final sample

[7] The time-invariant and rarely changing variables include the organizational form variable in Equation (1), and the derivative dummy in Equations (1) and (2).

[8] My data include only two firms, Brit Insurance Ltd. and Royal and Sun Alliance Insurance PLC, which were publicly traded on the London Stock Exchange during the analysis period. Both of them are group-affiliated insurers and therefore removed from the sample. Since listed insurers have access to equity markets, their demand for reinsurance and debt decisions may be different. In earlier tests, I also included the listed dummy (1 for listed firms; 0 for nonlisted firms) as an additional explanatory variable. However, its estimated coefficients were insignificant. Since dropping it does not qualitatively affect the results of the other explanatory variables, I do not include it in the models reported further.

[9] As explained in Mayers and Smith (1990, p. 24), the reinsurance ratio is not necessarily bounded by zero and one due to temporal mismatches in income flows. Following Powell and Sommer (2007, p. 183) and Adams, Hardwick and Zou (2008, p. 109), I exclude the observations outside this range that account for less than 1 percent (16 observations) of the sample. For a robustness test, I include these observations and rerun the analysis. The results remain qualitatively unchanged.

includes 143 insurers and 1,857 insurer-year observations. In addition, this study is relatively unlikely to be subject to survivorship bias, as my data set includes all of the insurers, which existed during the period 1985 to 2002 and filed complete returns, even if they failed to survive until the end of the period.

As stated previously, the FSA officially became the insurance regulator in 2001. Nevertheless, the relevant provisions mostly remained unchanged during the period of my analysis.[10] Thus, the possibility of confounding effects arising from major legislative changes on the empirical results is reduced.

Dependent Variables

Reinsurance and leverage are the dependent variables in Equations (1) and (2), respectively. Since some non-life insurers may assume reinsurance business from other direct insurers, I measure the reinsurance variable as the ratio of reinsurance premiums ceded to direct business written plus reinsurance assumed.[11] The leverage variable is defined as the ratio of direct premiums written to surplus.[12]

Control Variables

Prior research on reinsurance and capital structure suggests several factors that may affect the dependent variables reinsurance in Equation (1) and leverage in Equation (2). The effects of these factors on the dependent variables are examined as follows and a list of variables and their definitions are described in Table 1.[13]

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[10]Major legislative changes in the supervision of insurers started from December 31, 2004 when the Integrated Prudential Sourcebook was implemented. The forms and the content of regulatory returns prescribed in this Sourcebook are slightly different from those prescribed in the previous legislations.

[11]This definition of reinsurance activity is also used in Mayers and Smith (1990), Garven and Lamm-Tennant (2003), Cole and McCullough (2006), and Powell and Sommer (2007). In addition, we use the proxy used in Hoerger, Sloan, and Hassan (1990), who measure reinsurance activity as the ratio of the difference between the amount of premiums ceded by the insurer to other firms and the amount of premiums assumed by the insurer from other firms to gross premiums written. Mayers and Smith argue that such a proxy, which treats reinsurance assumed as simply the negative of reinsurance ceded, is not appropriate for the purpose of measuring reinsurance activity. The tenor of the results is qualitatively unchanged, and the basic results are not affected by using as the proxy for reinsurance activity the ratio of total reinsurance ceded to gross premiums written, without considering the premiums assumed by the insurer from other firms. This is possibly due in part to the small number of insurers that assume insurance business from other companies.

[12]An alternative proxy, the ratio of total liabilities to surplus, for the leverage also is employed to examine the sensitivity of my empirical results. I find that this substitute gives qualitatively the same results except the organization form variable that become insignificant at the 0.1 level in the 2SLS model.

[13]Mayers and Smith (1990) and Shortridge and Avila (2004) suggest that ownership type/structure is a potential factor affecting the reinsurance decision. They argue that the more diversified the owners' portfolios, the less the reinsurance purchases. Berger, Ofek, and Yermack (1997) also argue that ownership affects capital structure through monitoring. Lack of appropriate data on ownership type/structure prevented me from controlling for the ownership type/structure variables. To the best of my knowledge, the existing databases of ownership for U.K. firms are only for listed companies, such as *Hemscott Company Guru—Academic Edition*. However, the data set used in my study, SynThesys Non-Life, only includes very few

TABLE 1
Description of Variables

Variable	Description
Endogenous variables	
Reinsurance	The ratio of reinsurance premiums ceded to direct business written plus reinsurance assumed
Leverage	The ratio of direct premiums written to surplus
Explanatory variables	
Dependent variable (−1)	The lagged dependent variable by 1 year
Firm size	The natural logarithm of total admissible assets, deflated using the RPI (inflation) into 1985 prices
Claims volatility	The natural logarithm of the absolute value of the coefficient of variation of the sum of net claims incurred and claims management costs incurred up to the preceding year
Growth opportunities	Change in natural logarithm of total admissible assets
Business mix: accident and health, motor, marine aviation and transport, property, third-party liability, miscellaneous and pecuniary loss	The proportions of net earned premiums written in each of the six lines of business, namely: accident and health, motor, marine aviation and transport, property, third-party liability, and miscellaneous and pecuniary loss
Line-of-business concentration	A Herfindahl index of line-of-business concentration using premiums written in line of business by the insurer
Solvency	The solvency margin expressed as a percentage of the premium income
Tax convexity	The excess of marginal tax rate (= top rate if prior year's net operating loss = 0 and current year's taxable income > 0; = 0 otherwise) over the annual effective tax rate (= total tax expense/annual taxable income)
Marginal tax rates	Top rate if prior year's net operating loss is 0 and current year's taxable income is greater than 0; 0 otherwise
Derivative dummy	1 for derivative users; 0 for nonusers
Organizational form	1 for stock insurers; 0 for mutual insurers
Profitability	The ratio of pretax profit to surplus
Earning volatility	The natural logarithm of the absolute value of the coefficient of variation of pretax profit up to the preceding year

Control Variables in Reinsurance Equation (1)

Firm Size. Warner (1977) indicates that financial distress costs do not increase proportionately with firm size. Thus, small insurers would benefit more than large insurers from reinsurance hedging. Moreover, small insurers do not have economies of scale and scope, and have higher financing costs when raising external funds, suggesting

listed insurers. Specifically, SynThesys Non-Life contains 360 U.K. insurers. Only two (Brit Insurance Ltd. and Royal and Sun Alliance Insurance PLC) of them were publicly traded on the London Stock Exchange during the analysis period. As noted earlier, these two listed firms in my data set are removed because they are group-affiliated insurers.

that smaller insurers depend more on reinsurance use. Prior studies (e.g., Hoerger, Sloan, and Hassan, 1990; Adams, 1996; Powell and Sommer, 2007) document that reinsurance is negatively related to insurer size. The same result would be expected here. I measure firm size as the natural logarithm of total admissible assets deflated into 1994 prices using the U.K. RPI (inflation).[14]

Claims Volatility. Reinsurance can be used to stabilize underwriting profits. Consistent with Hoerger, Sloan, and Hassan (1990), I expect that increases in claims volatility are likely to lead to more reinsurance. Following Graham and Smith (1999), Graham and Rogers (2002), and Adams, Hardwick, and Zou (2008), I measure claims volatility on a rolling basis as the natural logarithm of the absolute value of the coefficient of variation of the sum of net claims incurred and claims management costs incurred up to the preceding year.[15]

Business Mix. Previous research on reinsurance (e.g., Shortridge and Avila, 2004; Cole and McCullough, 2006) considers the effects of lines of business on reinsurance to reflect risk differences across lines. I measure the proportions of net earned premiums written in each of the following six lines: accident and health, motor, marine aviation and transport, property, third-party liability, and miscellaneous and pecuniary loss. I do not make any predictions on the sign of these variables.

Line-of-Business Concentration. Insurers with high business concentration carry a high earnings risk, thereby needing more reinsurance. However, another line of argument is that insurers that are more concentrated in terms of business mix could specialize in and may underwrite less volatile lines of business. For these reasons, the net impact of business concentration on the demand for reinsurance is thus indeterminate. I use a line-of-business Herfindahl index to proxy line-of-business concentration.

Organizational Form. Organizational form affects insurers' decisions on reinsurance purchases for several reasons. First, managers/stockholders of stock insurers have incentives to underinvest, and the use of reinsurance can alleviate this problem. Adams (1996) finds that stock insurers use more reinsurance than mutual insurers. Second, mutual companies have relatively limited sources to obtain new capital from financial markets compared to stock companies, and thus tend to need more reinsurance. Thus, the relation between reinsurance and organizational form is an empirical

[14]If I use total admitted assets without the logarithmic transformation or the natural logarithm of annual premium income to proxy for firm size, the main conclusions on the relation between reinsurance and leverage remain the same. Findings for other variables are similar.

[15]I also use a sample-period-invariant proxy for claims volatility, measured as the standard deviation of the first annual differences of the sum of net claims incurred and claims management costs incurred divided by mean annual direct premiums written. This variable remains insignificant across my models. The results on other variables are qualitatively unaffected except the line-of-business concentration variable in the 2SLS model. This variable becomes insignificant at the 0.1 level.

question. Organization form is a dummy variable labeled 1 for a stock insurer and 0 for a mutual insurer.

Growth Opportunities. Insurers with better investment opportunities are likely to purchase more reinsurance to reduce the risk of an unexpected catastrophic loss that may force the firm to either raise costly external capital or simply give up the investment project. To measure this variable, it would be best to employ the data on market-to-book ratio or R&D expenses. However, due to data unavailability, I utilize change in logarithm of total admissible assets (Frank and Goyal, 2009).

Solvency. A less solvent insurer is likely to use more reinsurance due to difficulty in raising funds at a low cost in the capital markets (Chen, Hamwi, and Hudson, 2001). I measure insurer solvency as the solvency margin expressed as a percentage of the premium income (Daykin, Pentikäinen, Pesonen, 1994, p. 383).

Tax Convexity. When facing convex tax schedules, insurers can purchase reinsurance to reduce their expected tax liability by lowering their pretax income volatility. Graham and Rogers (2002) and Adams, Hardwick, and Zou (2008) find no support for the income volatility reduction argument. Despite the insignificant empirical results, I still include the tax convexity variable in my models due to its theoretical importance. Following Adams, Hardwick, and Zou, I define this variable as the excess of marginal tax rate (defined below) over the annual effective tax rate (total tax expense/annual taxable income).

Marginal Tax Rates. Since reinsurance can enhance insurers' current earnings, insurers with a higher marginal tax rate will purchase less reinsurance to decrease expected tax liabilities (Adams, Hardwick, and Zou, 2008). Thus, I predict a negative relation between reinsurance and marginal tax rates. The marginal tax rate is set equal to top rate if prior year's net operating loss is 0 and current year's taxable income is greater than 0, and 0 otherwise.

Derivative Dummy. Insurers use both derivatives and reinsurance to hedge risks. Derivatives could serve as a substitute for reinsurance hedging or they might be complements.[16] Following Colquitt and Hoyt (1997), a derivative dummy variable is labeled 1 for a derivative user and 0 for a nonuser.[17]

[16]Colquitt and Hoyt (1997) find a positive relation between reinsurance and year-end derivative participation. However, they find an insignificant relation between reinsurance and the extent of derivative hedging. Cummins, Phillips, and Smith (2001) find that the reinsurance variable is negative and statistically significant at the 0.1 level in the non-life insurer within-year derivative participation regression, while it is insignificant for life insurers. They also document a significantly positive relation between reinsurance and year-end derivative positions for both life and non-life insurers.

[17]I collect derivative data from Form 17 of the U.K. regulatory returns. The insurer is classified as a derivative user if it has nonzero year-end derivative position or if derivatives are open at the end of the previous year.

Interaction Between Leverage and Derivative Use. As argued earlier, leverage increases reinsurance purchases. Insurers using more derivatives have less need to use reinsurance to reduce bankruptcy and/or agency costs that result from leverage. Thus, I predict that the positive effect of leverage on reinsurance decreases when the insurer uses more derivatives. To investigate the moderating role of derivative use on the leverage–reinsurance relation, I include a variable that interacts the leverage variable with the derivative use variable. Derivative use is proxied by the balance of year-end notional value of derivatives instruments scaled by total admissible assets.[18]

Control Variables in Leverage Equation (2)

Firm Size. The trade-off theory predicts larger firms are in a better position to hold less capital because they generally have less volatile cash flows and are more diversified (Frank and Goyal, 2009). However, the pecking order theory predicts a negative relation between leverage and firm size. Thus, the relation is an empirical question.

Business Mix. Insurers' investment portfolios are determined by the nature of their product portfolios. Both portfolios are the main ingredients of two sides of the insurer's balance sheet. I expect that an insurer's business mix has a significant influence on its capital structure.

Profitability. The pecking order theory suggests that firms decrease their level of debt if internal funds are available, and thus, profitable firms would have a lower debt ratio (Titman and Wessels, 1988; Frank and Goyal, 2009). However, firms that are more profitable have lower expected bankruptcy costs and find interest tax benefits of debt more valuable, suggesting more profitable firms use more debt. Overall, the net effect of profitability on leverage is indeterminate. I use the ratio of pretax profit to surplus to proxy the profitability variable.

Earning Volatility. Bradley, Jarrell, and Kim (1984) argue that a firm's debt ratio is negatively related to its volatility of earnings. The rationale is that a firm with volatile earnings has difficulty in accessing external funds at a relatively low cost. Following Graham and Rogers (2002) and Adams, Hardwick, and Zou (2008), I calculate the earning volatility variable on a rolling basis as the natural logarithm of the absolute value of the coefficient of variation of pretax profit up to the preceding year.[19]

Growth Opportunities. Firms with more growth opportunities face more debt-related agency problems and the associated costs are likely to be higher for these firms

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[18] In order to mitigate high levels of collinearity between the interaction term and its component parts, I mean center leverage and derivative use and then calculate the product term using the mean-centered scores (Cronbach, 1987; Jaccard and Turrisi, 2003).

[19] The earning volatility variable remains insignificant in the 2SLS model but becomes significant at the 0.01 level in the FEVD model when a sample-period invariant measure (the standard deviation of the first difference in annual pretax profit over the period 1985–2002 divided by the mean value of total admissible assets over the same time period) is used. The results on other variables remain qualitatively unchanged.

(Frank and Goyal, 2009). Thus, debt level is expected to be negatively related to growth opportunities.

Solvency. Solvent insurers have relatively easy access to market capital and may use more debt to take advantage of interest tax shields. Thus, I expect a positive relation between leverage and solvency.

Tax Convexity. The trade-off theory suggests that firms use more debt to enjoy higher interest tax shields when tax rates are higher. Thus, I expect that insurers facing a high level of tax convexity are likely to issue more debt.

Marginal Tax Rates. Graham (1996) highlights the importance of a firm's marginal tax rate in its debt policy. He argues that firms facing a higher level of marginal tax rates issue more debt. As a result, I expect a positive relation between leverage and marginal tax rates.

Derivative Dummy. Lin and Smith (2007) find that derivative participation leads to a significant increase in leverage. They argue that derivative hedging allows firms to increase their debt capacity by reducing the probability of financial distress. Thus, insurers that use derivatives are expected to issue more debt than those that do not.

Interaction Between Reinsurance and Derivative Use. Insurers may use both reinsurance and derivatives to hedge risks. I have argued that these risk management activities allow insurers to issue more debt. The level of leverage may be also affected by the interaction of both reinsurance and derivative use. Thus, I create an additional variable to measure the possible effect by interacting an insurer's reinsurance multiplicatively with derivative use.[20]

EMPIRICAL RESULTS

Univariate Analysis

Table 2 presents the descriptive statistics for the variables used in the study. Reinsurance has a mean of 0.31259 and a standard deviation of 0.25504, whereas leverage has a mean of 1.93345 and a standard deviation of 1.49371. The mean value for the claims volatility variable is −0.24200 in my sample, which is higher than the reported mean of –0.35 in the less risky U.K. life insurance industry (see Adams, Hardwick, and Zou, 2008). Another interesting finding is that the values for the business mix variables range from 0 to 1, suggesting that in addition to multiline insurance firms, I have insurers specializing in any of these six types of insurance in my sample.

In untabulated results of the Pearson correlation coefficient matrix, I find that, consistent with my expectations, reinsurance is positively correlated with the leverage with a correlation coefficient of 0.10, statistically significant at the 0.01 level. Overall, the absolute values for the correlation coefficients between pairs of explanatory variables

[20]I also mean center reinsurance and derivative use to reduce the problem of multicollinearity.

TABLE 2
Descriptive Statistics

Variable	Min	Max	Mean	Median	SD	CV
Reinsurance	0.00007	1.00000	0.31259	0.25953	0.25504	0.81588
Leverage	0.00018	9.75282	1.93345	1.62633	1.49371	0.77256
Firm size	1.99989	14.08526	9.73100	9.69206	1.75894	0.18076
Claims volatility	−3.76161	2.33909	−0.24200	−0.24805	0.45785	−1.89195
Growth opportunities	−0.48834	0.98716	0.09499	0.07420	0.21449	2.25807
Accident and health	0	1	0.10050	0	0.24810	2.46852
Motor	0	1	0.11801	0	0.27632	2.34145
Marine aviation and transport	0	1	0.16398	0	0.35453	2.16211
Property	0	1	0.24540	0.01510	0.34040	1.38710
Third-party liability	0	1	0.08420	0	0.20086	2.38565
Miscellaneous and pecuniary loss	0	1	0.17456	0.00570	0.31906	1.82780
Line-of-business concentration	0.17440	1	0.78007	0.80601	0.41503	0.53204
Solvency	0	0.50844	0.15866	0.14955	0.08694	0.54798
Tax convexity	−0.95442	0.97952	0.16503	0.09698	0.17051	1.03322
Marginal tax rates	0	0.35000	0.22092	0.31000	0.15534	0.70314
Derivative dummy	0	1	0.03488	0	0.18354	5.26152
Organization form	0	1	0.86883	1	0.33768	0.38866
Profitability	−0.98565	0.96843	0.20236	0.15519	0.18381	0.90834
Earning volatility	−0.49946	0.97491	0.11267	0.08600	0.34576	3.06871

are generally modest. None of these exceeds 0.35, except the correlation coefficient value of –0.59 between leverage and solvency.[21] I also calculate the variance inflation factor (VIF) values for each explanatory variable. The calculated VIF values are

[21] I also try a solvency dummy denoting whether an insurer has the solvency problem (solvency dummy = 1 if the insurer's value of assets allocated toward required minimum margin is greater than required minimum margin; 0 otherwise). For both the 2SLS and FEVD models, the estimated coefficients on this dummy are insignificant at the 0.1 level (probably because the dummy variable is a less sensitive measure than the continuous solvency variable, proxied by the ratio of solvency margin to premium income). Moreover, using the dummy variable does not qualitatively affect the results on other variables. According to Studenmund (2001, p. 259), multicollinearity does not always reduce the *t*-statistics enough to make them insignificant, and a remedy for multicollinearity should be considered only if the consequences cause insignificant *t*-statistics. In the current case, although the continuous solvency measure and leverage have a high correlation, for the 2SLS model the coefficient on the solvency variable is negative and significant at the 0.1 level, as shown in Table 3. Therefore, I to use the continuous solvency measure in my models.

TABLE 3
Effects of Leverage on Reinsurance

Dependent Variable = Reinsurance

Independent Variable	Expected Sign	2SLS Coefficient	2SLS Standard Error	FEVD Coefficient	FEVD Standard Error
Constant		−162.65894	37.22778***	−172.80821	44.98227***
Leverage	+	1.25151	0.20029***	0.79847	0.02682***
Firm size	−	−0.01356	0.04685	0.00804	0.04324
Claims volatility	+	−0.00060	0.01908	0.00385	0.01455
Accident and health	±	0.00961	0.25782	−0.05914	0.03154*
Motor	±	−0.10573	0.44613	0.31672	0.07521***
Marine aviation and transport	±	0.04534	0.26155	−0.07418	0.03020**
Property	±	0.02743	0.15157	−0.03017	0.03348
Third-party liability	±	−0.10672	0.18124	−0.08282	0.03659**
Miscellaneous and pecuniary loss	±	0.20570	0.39869	0.06018	0.07858
Line-of-business concentration	±	−0.12935	0.06699*	−0.08669	0.05397
Organization form	±	0.21535	0.12988*	0.05206	0.02772*
Growth opportunities	+	0.14568	0.04362***	0.08270	0.04138**
Tax convexity	+	−0.00856	0.01980	−0.03224	0.01862
Marginal tax rates	−	−0.15971	0.06318**	−0.04408	0.04318
Solvency	−	−0.17851	0.10334*	0.04524	0.04367
Derivative dummy	±	−0.06286	0.03008**	−0.12621	0.02319***
Leverage × derivative use	−	−0.12288	0.03478***	−0.10215	0.04578**
Adjusted R^2		0.73042		0.79973	
F-value		296.82***		411.98***	

Note: ***, **, and * represent statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

less than 10, suggesting that problems associated with multicollinearity are relatively unlikely in my analysis (Gujarati, 1995).

Multivariate Analysis

For expositional convenience, I first report the results for Equation (1), followed by those for Equation (2). These results are generally consistent with those of prior research and support most of hypotheses discussed previously. Under different regression models, the parameter estimates on each independent variable and associated standard errors, which are robust to heteroskedasticity, are reported.

Results for Equation (1)

Table 3 shows the results for Equation (1). *F*-tests for the overall statistical goodness of fit of both 2SLS and FEVD models are significant at the 0.01 level, confirming that the fitted models are better than a null model without explanatory variables. The adjusted R^2 for both models are 0.73042 and 0.79973, respectively. Consistent with my predictions and the univariate results presented earlier, both models show that leverage has significantly positive effects on reinsurance purchases at the 0.01 level, which supports the view that insurers with higher leverage use more reinsurance. This evidence is consistent with the expected bankruptcy costs argument, the agency costs theory, and the risk-bearing hypothesis. My finding is in line with that of Hoerger, Sloan, and Hassan (1990), Adams (1996), Garven and Lamm-Tennant (2003), Shortridge and Avila (2004), Powell and Sommer (2007), and Adams, Hardwick, and Zou (2008), who find strong support for the prediction that the demand for reinsurance is positively related to leverage. However, this evidence conflicts with Cole and McCullough (2006). In addition, it is worth noting that my finding of a positive effect of leverage on reinsurance hedging is similar to Graham and Rogers (2002), Aunon-Nerin and Ehling (2008), and Bartram, Brown, and Fehle (2009), who find that high debt ratios lead to a high extent of derivative/insurance hedging.

In both the 2SLS and FEVD models, the coefficients of growth opportunities are positive and highly significant. This suggests that increases in growth opportunities are likely to lead more reinsurance. The significantly negative coefficients on the derivative dummy variable in both models support the proposition that derivatives serve as a substitute for reinsurance. Insurers using derivatives to reduce their investment risk and so reduce the overall risk have less need to use reinsurance to hedge underwriting risk. I also find a significant negative relation in both models between reinsurance and the interaction between leverage and derivative use, suggesting that the impact of leverage on reinsurance will be weaker for insurers that use more derivatives than those that use less.

In line with Adams (1996), I find that the organizational form variable is positive and weakly significant in both models, suggesting that stock insurers reinsure more than mutual insurers. This is consistent with the *agency costs theory*, which postulates that stock insurers tend to use more reinsurance than mutual insurers to mitigate the underinvestment incentive problem among residual claimants.

In the 2SLS model, the estimated coefficients on the line-of-business concentration, marginal tax rates and solvency are negative and statistically significant. These findings are consistent with the view that decreases in product concentration, marginal tax rates, and solvency are likely to lead to more reinsurance.

I find that four out of six business mix variables are significant at least at the 0.1 level for the FEVD model, indicating that the extent of reinsurance use is possibly driven by the classes or lines of products sold by insurers. This evidence provides some support for the view that insurers would consider risk differences across business lines when making reinsurance decisions.

Results for Equation (2)

Table 4 presents the estimated results for Equation (2). F-tests for both 2SLS and FEVD models are significant at the 0.01 level and the adjusted R^2s are 0.75059 and 0.82607, respectively.

TABLE 4
Effects of Reinsurance on Leverage

Dependent Variable = Leverage

Independent Variable	Expected Sign	2SLS Coefficient	2SLS Standard Error	FEVD Coefficient	FEVD Standard Error
Constant		195.28295	35.66456***	97.35373	35.69763***
Reinsurance	+	1.07663	0.06104***	0.67715	0.02766***
Firm size	±	−0.02942	0.03832	0.00195	0.03924
Accident and health	±	0.03604	0.24280	−0.03342	0.02778
Motor	±	−0.20797	0.38771	0.10564	0.07584
Marine aviation and transport	±	0.03198	0.24323	0.05997	0.02739**
Property	±	0.07513	0.14139	−0.02383	0.01802
Third-party liability	±	0.10547	0.17188	0.06605	0.05371
Miscellaneous and pecuniary loss	±	−0.05826	0.37262	−0.13571	0.06337**
Profitability	±	−0.02556	0.01836	0.01530	0.01637
Earning volatility	−	0.00408	0.01466	−0.00887	0.01139
Growth opportunities	−	−0.10981	0.03048***	−0.12401	0.04112***
Tax convexity	+	0.03645	0.01706**	−0.00387	0.01351
Marginal tax rates	+	0.07938	0.03521**	0.15784	0.04255***
Solvency	+	0.04345	0.04481	0.21087	0.04482***
Derivative dummy	+	0.04034	0.02658	0.09538	0.02259***
Reinsurance × derivative use	±	0.12374	0.03332***	0.09074	0.03706**
Adjusted R^2		0.75059		0.82607	
F-value		350.09***		519.52***	

Note: ***, **, and * represent statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

As expected, reinsurance has statistically significantly positive effects on leverage in both models at the 0.01 level, supporting the renting capital hypothesis within the range of my data. This finding is consistent with the view that insurers with higher reinsurance dependence hold a higher level of leverage. This is possibly because higher reinsurance allows the insurer to have a lower (higher) capital (debt) ratio for a given level of solvency, as some of the capital needed can be rented from reinsurers. My findings of the reverse causality from reinsurance hedging to leverage are similar to the results of Graham and Rogers (2002), Aunon-Nerin and Ehling (2008), Zou and Adams (2008), and Bartram, Brown, and Fehle (2009), who find that derivative/insurance hedging increases the debt ratio.

Turning to the control variables, the growth opportunities variable is negative and statistically significant at the 0.01 level in both the 2SLS and FEVD models. This evidence supports the view of the trade-off theory and is in accord with Frank and Goyal (2009), who find that firms with more growth options have lower leverage. The significantly positive coefficients on the marginal tax rates variable in both models support the proposition that firms facing a higher level of marginal tax rates are likely to issue more debt (Graham, 1996). I find that the coefficients for the interaction between reinsurance and derivative use are positive and highly significant in both models. This suggests that an insurer's derivative use moderates the relation between reinsurance and leverage in such a way that high levels of derivative use increase the leverage gains attributable to reinsurance.

The tax convexity and solvency variables are positive and statistically significant in the 2SLS and FEVD models, respectively. These findings are consistent with the view that increases in tax convexity and solvency are likely to result in higher leverage in order to take advantage of interest tax shields. In the FEVD model, I document a positive relation between derivative dummy and leverage, suggesting that insurers that use derivatives have higher leverage than those that do not. I also find evidence indicating that business mix has an influence on the debt level.

ROBUSTNESS CHECKS AND SENSITIVITY TESTS

Alternative Regression Specifications

In the empirical results section, I only consider the linear relation between reinsurance and leverage. In order to allow for nonlinearity, I use the quadratic specifications of leverage and reinsurance, that is, the leverage squared and reinsurance squared in Equations (1) and (2), respectively. In the unreported reinsurance regressions, I find that reinsurance is still positively and significantly (at the 0.01 level) related to leverage when leverage squared is added. The coefficients on the squared term of leverage are negative and significant at the 0.01 level. The latter relationship suggests a curvilinear relationship, and combined, these two relationships denote a potential inverted-U shaped relationship between reinsurance and leverage. In the leverage regressions, I find that the estimated coefficients on reinsurance remain positive and significant at the 0.05 level when reinsurance squared is added but that those on reinsurance squared are insignificant. Taken together, it appears that the nonlinear effect of reinsurance on leverage does not exist.

In practice, immediate adjustment of reinsurance purchases/capital structure may be relatively unlikely. Reinsurance purchases/leverage one period prior may have an effect on the current reinsurance purchases/leverage. Since my sample consists of panel data, I estimate a dynamic panel data model with the FEVD specification, including a lagged dependent variable as a regressor in the regressions. When lagged reinsurance is included in Equation (1), the estimated coefficient on leverage remains positive and significant at the 0.01 level. The lagged reinsurance has a positive sign and is statistically significant at the 0.01 level, suggesting that reinsurance purchases 1 year back have a positive influence on the current reinsurance purchases. When lagged leverage is added in Equation (2), I find that reinsurance is still positive and significant at the 0.01 level. The lagged leverage is significant at the 0.05 level and it has a negative sign, suggesting evidence of a negative association between an insurer's current and prior debt ratios.

Extreme Values

Examining the coefficients of variation reported in Table 2 reveals that there might be some extreme values in my explanatory variables. To better understand the sensitivity of my results to outliers, I therefore exclude them, observation by observation, from my regressions. The observations that are excluded are roughly less than the 0.5th percentile and greater than the 99.5th percentile.[22] I find my main results are unaffected by outliers. I also winsorize the sample by setting the data below the 0.5th percentile to the 0.5th percentile, and data above the 99.5th percentile to the 99.5th percentile. The robustness of my analysis is further confirmed.

CONCLUSIONS

In this article, I test the effects of capital structure on reinsurance purchases and the reverse causality between reinsurance purchases on capital structure using the regulatory returns data on the U.K. non-life insurers from 1985 to 2002. Consistent with the expected bankruptcy costs argument, the agency costs theory, and the risk-bearing hypothesis, I find that insurers with a higher level of leverage tend to reinsure to a greater extent to reduce the probability of insolvency and mitigate the agency costs problem arising between policyholders and stockholders. Moreover, I document the reverse causality from reinsurance to capital structure. In line with the renting capital hypothesis, I find that insurers purchasing more reinsurance would have higher leverage, possibly because reinsurance purchases, like renting capital from reinsurers, increase the insurer's surplus, allowing the insurer to write more new policies, thereby increasing their leverage but maintaining a certain level of solvency. Taken together, my evidence suggests that leverage positively affects reinsurance, and vice versa. A highly leveraged insurer has a higher probability of insolvency, thereby having difficulty in obtaining the capital needed from the capital markets at a low cost. On the one hand, an insurer with higher level of debt is likely to purchase more reinsurance to rent the capital needed from reinsurers. On the other hand, renting capital permits the insurer to further expand its debt capacity by underwriting more risks without increasing its insolvency risk. To sum up, I have argued that a highly leveraged insurer would tend to purchase more reinsurance, and with more reinsurance it would be able to maintain a higher level of debt without significantly increasing its insolvency risk.

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