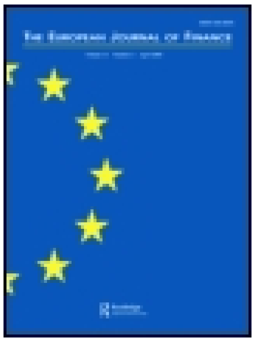

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Risk management and the cost of equity: evidence from the United Kingdom's non-life insurance market

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ABSTRACT
We investigate the effect of risk management (reinsurance) on the corporate cost of equity using panel data drawn from the United Kingdom's (UK) non-life insurance industry. Our results show that use of reinsurance lowers the cost of equity but that the relation is non-linear. We find that the rate of reduction declines as the level of premiums ceded relative to total gross premiums written increases. We also find that the reinsurance-cost of equity relation is moderated by the risk of financial distress/bankruptcy. This moderating relation is robust to the use of three alternative measures of financial distress and bankruptcy risk.

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1. Introduction

This paper examines whether the use of reinsurance – a common and widely reported risk management technique in the insurance industry – has an effect on cost of equity (discount rate) of non-life (property-casualty) insurers operating in the United Kingdom (UK). Examining the factors that influence the corporate cost of equity is a salient issue as it reflects investors' trade-off between risk and return over investment decisions and it is a crucial component of discount rate in companies' capital budgeting decisions (Easley and O'Hara, 2004). The cost of equity is also an important variable as it is used in corporate valuation, the setting of managerial performance targets, and the regulation of rates of return (O'Hanlon and Steele, 2000). Indeed, prior empirical studies have demonstrated a direct empirical linkage between risk management and the cost of equity. For instance, Gay, Lin and Smith (2011) find the cost of equity for the users of derivatives is lower than that of non-users. Bartram, Brown and Conrad (2011) also find a negative relation between the use of financial derivatives and, both, total and systematic risks. In the same vein, Disatnik, Duchin and Schmidt (2013) show that corporate hedging makes access to external funding more cost-effective. There is, however, a lack of evidence on the effect of risk management on the cost of equity of financial intermediaries, such as banks and insurers, which are usually excluded from cross-industry studies due to their unique (e.g., highly levered) financial structure, opaque systems of accounting, and active risk-trading/risk-bearing activities (e.g., see Larsen and Resutek, 2017). The present study therefore contributes to the finance literature by providing empirical evidence on the cost of equity-risk management nexus within the insurance industry, and also identifies a channel through which this relation manifests itself in capital markets.

One strand of the finance literature suggests that the risk management function affects the cost of equity through its impact on financial distress and default risk, but the empirical evidence is mixed. On the one hand, Dichev (1998) and Campbell, Hilscher and Szilagi (2008) report that default risk and realized stock returns are negatively related, which suggests that the cost of equity capital decreases with a rise in default risk. On the other hand, Vassalou and Xing (2004) and Chava and Purnanandam (2010) show that default risk is systematic, and so equity investors will tend to demand above market average returns for bearing this risk. Therefore, in theory,

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risk management can reduce the cost of equity by reducing the default risk. This study analyses the cost of equity, probability of default and reinsurance nexus in order to establish the channel through which reinsurance affects the cost of equity. We calculate firm-level equity risk premia using a novel method, which combines the full information beta method of Kaplan and Peterson (1998) with the non-parametric method of equity beta estimation of Wen et al., (2008).

To explore the risk premium–risk management relation, we adopt a panel data modelling approach to analyze UK non-life insurance industry data from 1985 to 2010. Specifically, we first use fixed-effects regression to obtain baseline estimates, and then to explore the channel through which reinsurance-cost of equity relation manifests itself, we employ Chava and Jarrow's (2004) logit model to calculate the probability of default of insurers. Our results show that use of reinsurance lowers the cost of equity, but that the rate of reduction declines as the level of premiums ceded relative to total gross premiums written increases. This finding supports Froot's (2007) contention that risk management is a value-added activity, but that its efficiency diminishes as the associated hedging costs rise relative to the magnitude of the loss being mitigated. We also find that the reinsurance-cost of equity relation is moderated by the effect reinsurance has on the risk of financial distress/bankruptcy.

Our research contributes potentially important insights on the interplay between the cost of capital and reinsurance that might be useful for insurance industry stakeholders, including shareholders, policyholders, and industry regulators. The study also highlights the effect of risk management, including the use of indemnity hedges, such as commercial insurance, on the cost of equity in cross-industry contexts. This is particularly germane given that insurance consumption is significant across industrial sectors of most developed economies (Lin, Lin, and Zou 2012). In this sense, we expect the results of the present study to have broader appeal beyond the financial services sector. Additionally, the present study estimates the risk management-cost of equity relation for both publicly listed and non-publicly listed insurers – the latter being under-represented in previous cost of capital studies (e.g. see Abudy, Benninga, and Shust 2016).

The remainder of our paper is organized as follows. Section 2 provides institutional background information on the UK's non-life insurance market and justifies the UK as a domain within which to focus the study. Section 3 reviews the related risk management literature and develops the research hypotheses. Section 4 describes the research design employed, including a description of the data, description of the model, and definition of the variables. Section 5 discusses the empirical results, while section 6 concludes the paper.

2. Institutional background

According to Swiss Re (2018), the UK's non-life insurance market is the fifth largest in the world, comprising 275 active domestically-owned and foreign-owned companies, subsidiaries and branches of varying size, ownership structure, and product-mix, and currently generates approximately £72 billion (US$93 billion) in gross annual premiums.[1] In addition, 94 active syndicates at the Lloyd's of London insurance market currently underwrite direct non-life premiums of roughly £35.5 billion (US$46 billion) per annum, primarily in property and casualty insurance (Lloyd's of London 2018).

During the period covered by our study (1985 to 2010), the UK's insurance industry witnessed regulatory changes leading to the adoption of a risk principles-based approach to solvency. However, insurance regulation in the UK has been a 'lighter touch' system compared with the risk-based capital solvency requirements prevailing in the United States (US) (Veprauskaite and Adams, 2018). For example, the evolution of the UK's regulatory regime has tended not to intervene in any major way with the insurance industry's capability to innovate and introduce new products in the market, and raise equity on cost-effective terms. The effect of this difference in regulatory approach could be interesting in terms of comparing the results of this study with similar US-focused research (e.g. Wen et al., 2008). Moreover, the UK insurance market operates under a unitary (homogenous) regulatory regime. Again, this situation contrasts with the US insurance market where solvency surveillance is the responsibility of the state-based regulators. Standards issued by the National Association of Insurance Commissioners (NAIC) are used in the US to coordinate regulation activity between states. However, as these standards are not mandatory, there are some regulatory differences between states – for example, in terms of reinsurance requirements (Cummins and Phillips, 2009). Moreover, US-based insurers are subject to premium rate regulation on certain business lines, such as motor insurance, which is not the case in the UK (Nelson, 2000). Thus, the premiums charged by insurers in the UK's non-life insurance market are governed mainly by market competition and not regulatory intervention. These attributes of the UK's non-life insurance market facilitate potentially 'cleaner' tests of the hypotheses put forward in this study.

Another important institutional aspect of the UK's non-life insurance sector is its accounting and financial reporting practices. During our period of analysis (1985 to 2010), non-life insurers in the UK were required to produce their annual accounts in accordance with UK generally accepted accounting principles (GAAP) or since 2005 International Financial Reporting Standard (IFRS) 4, which intend to present a 'true and fair' view of the financial condition of the company. These set of accounts are also used for calculating the tax liability of the insurers, and value assets and liabilities at, or close to, their 'fair' market values. However, this accounting treatment can induce volatility in period earnings, claim reserves, tax liabilities, and capital adequacy calculations (Post et al., 2007). The amount recoverable under a reinsurance treaty is, however, independent of common valuation parameters, such as interest rates. Hence, reinsurance can be instrumental in reducing volatility induced by mark-to-market accounting and variations in the use of discretionary reserve accruals across accounting periods (Veprauskaite and Adams, 2018). Moreover, unlike in the US, the supply of reinsurance in the UK insurance market is not distorted by discriminatory rules that penalize insurers with higher capital maintenance requirements, and hence, higher costs of capital, if they use foreign reinsurers (Cole and McCullough, 2006). This institutional attribute of using UK insurance industry data further helps us to avoid potentially confounding effects and enables more direct tests of hypotheses to be carried out. Therefore, UK's non-life insurance market is well-suited to the conduct of this research.

3. Related literature and hypotheses development

During the past three decades, the increasing frequency and severity of environmental perils, such as hurricanes, earthquakes, and floods, have resulted in wide-scale economic losses around the globe. For instance, Low (2019) reports that in 2018 the global insurance industry suffered insured losses of US$ 80bn, which is significantly higher than the 30-year average of US$ 41billion. Not only this, past few years have also witnessed an increasing contribution from weather related events to total annual losses. This trend of rising losses from catastrophes has serious implications for the insurance industry, as it can undermine the capital adequacy of insurers to service the claims of existing customers and to underwrite new business at competitive premiums (Froot, 1999). This situation could threaten investors' contractual benefits as it implies an increase in insurers' insolvency risk, and a decrease in their future profitability. According to Jean-Baptiste and Santomero (2000), these concerns have resulted in an increased interest amongst managers, reinsurers, regulators, and others in better understanding the risk management and pricing techniques employed by the insurance industry, and their implications for firm value. For non-life insurers, an improved understanding of risk-bearing and risk-financing is particularly important due to the increased potential for the geographical and product-market concentration of insurable risks (Froot and O'Connell, 2008).

Prior studies propose several reasons for corporate risk management. According to Smith and Stulz (1985), tax shield benefits, lower costs of financial distress/bankruptcy, and a reduced probability of underinvestment following a loss event are amongst the key benefits of corporate hedging in imperfect capital markets. Leland (1998) adds that the value of the debt-based tax shields and the realization of investment options can be increased by enhancing debt capacity through hedging. Zou and Adams (2008) come to similar conclusions regarding the role of commercial property insurance in lowering corporate debt costs and increasing debt capacity. Risk management studies commonly assume that if financial markets are imperfect then external financing is costlier than internally generated funds. Froot (2007, p. 273) states that '… most financial policy decisions, whether they concern capital structure, dividends, capital allocation, capital budgeting, or investment and hedging policies, revolve around the benefits and costs of a corporation holding risk'. Similarly, Smith and Stulz (1985) show that risk management (hedging) is an element of overall corporate financing policy. Therefore, risk management and financing decisions are intertwined. Though the risk-return trade-off is (or should be) the basis of strategic decision-making, the impact of risk management on firm risk and traded value is still a contested issue in the academic literature.

3.1. Risk management and value creation

In perfect markets, corporate risk management, including the purchase of insurance, is redundant as shareholders can efficiently diversify firm-specific risks by holding balanced portfolios of investments (Choi, Mao, and Upadhyay, 2013). However, in their influential work on the modern theory of corporate insurance, Mayers and Smith (1982) argue that risk management adds value to a firm if it allows them to mitigate the frictional costs arising in imperfect markets. For example, a firm facing increased costs of financial distress and/or bankruptcy is more likely to incur agency problems (e.g. asset-stripping) that benefit the immediate economic utility of managers rather than the economic interests of shareholders and creditors. Prudent risk management (e.g. via restrictive insurance covenants and direct monitoring by insurers) can mitigate agency incentive conflicts and lower the cost of external finance, thus promoting investments in value-enhancing projects. According to Doherty (2000, p. 9) '… hedging complements other sources of financing, internal and external, to replace destroyed assets and new investments'. Such reasoning has given rise to a sizable body of literature that links corporate financing decisions to risk management (e.g., see DeMarzo and Duffie, 1995; Froot, 2007; Froot, Scharfstein, and Stein, 1993). However, most of the empirical evidence to date relates to the use of financial derivatives by non-financial firms – instruments that unlike indemnity-based reinsurance contracts can concomitantly be used for both hedging and speculation purposes (Aunon-Nerin and Ehling, 2008).

Nance, Smith and Smithson (1993, p. 267) define corporate hedging as '… the use of off-balance-sheet instruments – forwards, futures, swaps, and options – to reduce the volatility of firm value'. Reinsurance, however, is intrinsically different from other financial hedges (e.g., derivative instruments) in at least five key regards. First, reinsurance is well accounted for in the financial statements submitted to its regulator by an insurer as claims recoverable from reinsurers are counted as one of the 'admissible' assets used to determine capital adequacy. This makes reinsurance well-integrated with the capital structure of an insurer. The second reason that makes reinsurance different from financial derivatives is that, as an indemnity contract, reinsurance involves the transfer of 'downside' risks making it a pure hedge instrument, which cannot be used for 'upside' speculative purposes (Aunon-Nerin and Ehling, 2008). Campello et al., (2011) note that firms may opt out of their hedging positions once they have secured sufficient capital from lenders. Third, derivatives contracts can be imperfect hedges of underlying risks (i.e. they can suffer from basis risk) (Doherty, 2000) However, this problem does not apply to indemnity reinsurance. The fourth difference between reinsurance and other financial hedges is that as an indemnity contract assuming an offsetting financial position is not possible with a reinsurance contract (treaty). Fifth, reinsurance treaties often provide ancillary advisory services, such as the pricing of emerging or unusual risks, and/or claims handling. These 'real services' can also provide added-value for the shareholders and policyholders of insurance firms (Doherty, 2000).

3.2. Reinsurance and the cost of equity

Sharfman and Fernando (2008) suggest that in the context of a firm's standing in capital markets, the link between risk management and the cost of equity is a fundamental strategic issue. The structural relation between business risk and cost of external funding is a key issue for regulated entities such as insurers, as their investment opportunity sets are often constrained by regulations. Risk and capital management are further intertwined for insurers because they are statutorily mandated to meet minimum capital requirements (Upreti and Adams 2015). There are several reasons for reinsurance to have an effect on the cost of equity of an insurer. For example, reinsurance, being a leverage-neutral post-loss financing mechanism,[2] enables primary insurers to mitigate the adverse effects of rising losses such as the increased risks of financial distress and/or bankruptcy (Doherty and Lamm-Tennant 2009). Doherty and Tinic (1981) further suggest that reinsurance reduces the probability of ruin for direct insurance writers. Similarly, Stulz (1996) argues that by reducing the downside financial distress/bankruptcy risks, risk management (reinsurance) can reduce the cost of equity along with increasing corporate debt capacity.

Froot and O'Connell (2008) also note that reinsurance is important because compared with equity investors, the disparate policyholder-customers of insurance firms are less efficient at diversifying risk. As a result, reinsurance provides policyholders with fixed claims on future cash flows with the certainty of indemnification in the event of an insured loss. Doherty and Tinic (1981) observe that insured parties by definition are risk-averse and unable to cost-efficiently diversify away their insurable risks in capital markets. Therefore, exposure to financial distress/bankruptcy will subject an insurer to reduced new business growth, and hence, loss of profitability, as well as an increase in the market cost of capital. Reinsurance not only provides protection against the adverse effects of financial distress, but also generates 'tax shield' benefits by stabilizing period earnings and reducing marginal rates of taxation (Abdul-Kader, Adams and Mouratidis, 2010). According to Modigliani and Miller (1963), such tax shields can reduce the rate at which cost of equity increases with the increase in leverage. So, the decision to reinsure can also be viewed as a financing (capital structure) choice decision that provides insurance firms with a form of 'synthetic equity' that protects them against severe loss events (e.g. catastrophes) that can have systematic effects on capital markets (Garven and Lamm-Tennant, 2003). It is so because major catastrophes (e.g. a tsunami in Japan or a terror attack in New York) have global effects on financial markets and make access to external capital more expensive. The situation is even more challenging for the insurance industry because it pays substantial amounts to cover claims arising from such events, depleting its capital reserves to cover future losses. In such a scenario, reinsurance enables insurers to protect their risk capital and to access external financing at favourable rates owing to their better risk profile. The foregoing analysis therefore implies that:

H1: Other things being equal, reinsured insurers have a lower cost of equity than non-reinsured insurers.

Since there are many ways through which reinsurance affects the cost of equity, a framework is required to analyze this relation. Froot, Scharfstein, and Stein (1993) provide a framework for analyzing risk management decisions in terms of market frictions and the impact of financing policy on firms' investment decisions. They argue that cash flow volatility can be costly for shareholders as it increases equity risk, and that by stabilizing cash flows following unexpected shock events, risk management techniques (reinsurance) enhances the value of (insurance) firms by enabling managers to realize positive net present value (NPV) projects in their firms' investment opportunity sets. Plantin (2006) argues that because of reinsurers' close contractual relations with direct insurers and their regular monitoring of insurers' underwriting and claims settlement systems, reinsurance can serve as an important signalling device to investors, policyholders, regulators, and others as to insurers' future financial condition. Shimpi (2002) further contends that the contingent capital properties of (re)insurance can help lower annual combined loss ratios (i.e. claims plus expenses including commissions as a proportion of net premiums written) as well as reduce the required level of retained equity capital. The implied market signalling benefits of reinsurance as a risk assurance device can, therefore, help direct insurance writers to reduce their equity cost of capital.

Froot and O'Connell (2008) point out, however, that holding too much equity in insurance firms is not only unproductively expensive for investors, but it also increases the risk of resource misuse and excessive perquisite consumption by managers. In other words, the frictional costs of capital in insurance firms can arise from agency incentive conflicts between management, owners, and fixed claimants (policyholders) (Laux and Muermann, 2010). Laux and Muermann (2010) further argue that as stock insurance firms invariably raise equity prior to selling policies, competition in insurance markets limits the amount of equity capital that can be raised at a cost that maximizes their expected returns on investment. However, as contingent capital, reinsurance can relax equity limits and help optimize the allocation of capital in insurance firms in a way that financially benefits shareholders (e.g., see also Froot, 2007). Moreover, reinsurance can become economically advantageous to a direct insurance writer in the face of information asymmetries and agency problems such as the underinvestment and asset substitution incentives which if left unchecked could raise the risk of financial ruin, and therefore, increase insurers' costs of capital (Garven and MacMinn, 1993).

Though there are many ways in which reinsurance can affect the cost of equity, the functional form of the relation is unclear. There are several reasons for the complexity of reinsurance-cost of equity relation. For example, Froot (2001) finds that due to market frictions (e.g. information asymmetries and agency costs) the price of catastrophe reinsurance coverage in the US property-liability insurance market often exceeds the actuarial value of expected losses. Froot and O'Connell (2008) also argue that reinsurance purchased in excess of the optimal level required by the insurer, can result in 'deadweight costs' because of transaction costs, such as reinsurers' expenses and profit loadings. Similarly, Schrand and Unal (1998) also argue that because of the transaction costs involved, the hedging (reinsurance) of core risks can have a deleterious effect on firm value. In a cross-industry context, Gray, Koh, and Tong (2009) argue that a firm's equity cost of capital is expected to be positively related to non-diversifiable information risk. Risk management through reinsurance could also increase the agency cost risk that entrenched managers in insurance firms could denude firm value by allowing them to bypass close monitoring of financiers and invest in negative net present value (NPV) 'pet' projects and/or engage in moral hazard behaviour (e.g., see Tufano, 1998).

Such reasoning implies that reinsurance can increase the value of an insurer by reducing the cost of equity capital rather than increasing the future expected cash flows. Therefore, it can be argued that reinsurance, if purchased in excess of the optimal level required by the insurer, can result in 'deadweight costs' because of the transaction costs and a reinsurer's expense and profit loadings (Froot and O'Connell 2008). The foregoing analysis also suggests that if the benefits of risk hedging via reinsurance outweigh the costs, then purchasing reinsurance should lead to a reduction in the cost of equity. However, as the proportion of ceded premiums increases, its capacity to lower the cost of equity decreases owing to increase in costs associated with reinsurance. As a pure risk management device reinsurance is expected to always lower the risk of an insurer, but at relatively high cession rates increasing costs make it less effective in reducing the cost of equity. This suggests that the relation between the cost of equity and reinsurance is likely to be non-linear. Therefore, our second hypothesis is:

H2: Other things being equal, insurers' costs of equity decreases non-linearly as the level of reinsurance increases.

3.3. Reinsurance and the probability of default

An important reason for purchase of reinsurance is to reduce financial distress/bankruptcy risks and avoid regulatory intervention in the event of a severe loss (Hoerger, Sloan and Hassan 1990). Not only this, Upreti and Adams (2015) find that the management of underwriting risks through reinsurance is vital for insurers to compete effectively in product-markets of their specialization. Survey evidence provided by Wakker, Thaler and Tversky (1997) also suggests that the policyholder-customers of insurance firms expect deep (and disproportionate) reductions in the premium paid for an insurance policy for any increase in insurers' probability of default. As a consequence, reinsurance becomes more important as an post loss financing mechanism due to these regulatory and operational considerations. According to the trade-off theory of capital structure, the probability of ruin directly effects the cost of capital of a firm. For example, Li, Lockwood and Miao (2017) find that higher default probabilities are associated with lower stock returns and higher equity costs of capital because the managers of highly leveraged financially distressed firms are likely to engage in risk-shifting behaviour, such as overinvestment in wealth destroying projects. Vassalou and Xing (2004) further find that debt default risk and its link with the equity cost of capital is intimately related to the size and book-to-market (BM) characteristics of a firm. Hence, by reducing the probability of financial distress and/or bankruptcy, reinsurance not only enables insurers to maintain business operations and increase product-market share, but also reduce their market costs of equity. Consequently:

H3: Other things being equal, reinsurance reduces the insolvency risk of insurers.

4. Data and research design

4.1. Data

The data used in this study are derived from two sources. First, we use – the annual statutory solvency returns covered by *Standard & Poor's SynThesys* UK non-life insurance companies' database for the 26 years 1985 to 2010. This period, which covered variable macroeconomic conditions, represents the earliest and latest years for which financial data were available at the time the study was carried out. The *SynThesys* database does not provide consolidated returns of group companies as regulations require independently operating and reporting insurers to file their returns individually, rather than on the basis of group membership. In selecting our sample, we excluded very small insurers (e.g. local mutual fire insurance and professional indemnity pools), closed funds in 'run-off', and public sector insurance arrangements as they do not directly and/or actively write much, if any, ongoing insurance business. Additionally, not all firm-year cases in the *SynThesys* database are usable (e.g. as a result of missing values). Therefore, we imposed certain selection restrictions to derive a usable panel sample – for example, accounting values for premiums retained and total assets had to be complete and non-negative for firm/year observations. This 'filtering procedure' also required that the return on assets be greater than – 1 for a firm-year to be included in the sample. Moreover, to preserve the longitudinal (panel) structure of the dataset, only insurance firms with two or more years of data are included in the sample. Applying these procedures thus resulted in an unbalanced, but cross-sectionally representative (e.g., in terms of size, financial structure, and product-mix), panel sample of 397 insurance firms (5,427 data points) that operated in the UK between 1985 and 2010. Second, our study also used the *Thomson Reuters Datastream* database to collect data necessary for calculating the cost of equity. Specifically, data on the Financial Times Stock Exchange (FTSE) Non-Life Insurance Index were used to calculate returns for the UK non-life insurance sector, whereas the FTSE All Share Index was used for calculating the market return.[3]

4.2. Cost of equity estimation

There are various techniques for calculating the cost of the equity of a firm of which variants of the capital asset pricing model (CAPM) and Fama and French's (1997) three-factor (FF3F) model are the most common (Gregory and Michou, 2009); however, their application is often constrained by the availability of requisite data. The extant academic literature reports that market-based accounting methods provide the most accurate estimates of the cost of equity as these estimates tend to correspond well with market risk proxies (e.g., see Botosan and Plumlee, 2005). Since these techniques are by definition market-based, they are useful only for publicly quoted firms for which long-run earnings and/or dividend forecast data are available for estimating the equity cost of capital. However, insurance firms listed on the LSE, and/or other major stock exchanges represent only a small proportion of the UK non-life insurance market (i.e. 27 out of 701 UK licensed insurance firms in 2010).[4] Results obtained using a sample of only 27 firms would not be generalizable, therefore, precluding the use of market-based accounting methods for determining the cost of equity. Accordingly, the Rubinstein-Leland (R-L) model, a technique based on asset pricing theory was selected for the estimating cost of equity in the present study.

The R-L model, attributed to Rubinstein (1976) and Leland (1999), assumes the log-normality of market returns, but it does not make any distributional assumptions regarding share returns. Wen et al., (2008) apply the R-L model to US property-liability insurers, and report that the R-L model, being distribution-free, provides better estimates of portfolio returns for insurers with highly skewed returns, and/or portfolios of small size. Even though the R-L model is a market-data based technique, Cummins and Phillips (2005) demonstrate that the R-L model can be effectively applied to non-listed firms (including mutual insurers) if it is used in conjunction with the 'full information beta' (FIB) technology as described in Kaplan and Peterson (1998).[5] Consequently, this technique does not impose severe limitations on the data in terms of organizational form or the listing status of the insurance firm – a quality that is desirable in the context of the present study. Indeed, Cummins and Phillips (2005, p. 447) state that the '… FIB methodology produces cost of capital estimates that reflect the line of business composition of the firm'. Therefore, we estimate industry-level betas for each of six main lines of non-life insurance business written by insurers as the first step of the FIB procedure.[6] Cummins and Phillips (2005) further explain that in arbitrage-free markets, firm value can be considered as the sum of the values of a firm's assets across its main lines of business (i.e. the so-called value additivity property). As a result, an insurance firm's overall CAPM market beta ($\beta_{i,t}$) is the sum of the beta coefficients across business lines weighted according to their proportionate contribution to the firm's market value. Cummins and Phillips (2005) further note that the 'sum-beta' CAPM is particularly appropriate for firms operating in the property-casualty insurance industry. This is because on average, the stock returns of insurers are more sensitive to financial distress risks (higher equity costs of capital) than stock returns in general. As a result, insurance firms tend to engage in less frequent share trading, and hence, less susceptible to equity market price volatilities, than more risk-taking (e.g. high technology) firms.[7] The 'sum-beta' CAPM model is specified as:

$$\boldsymbol{\beta_{i,t}} = \sum_{\boldsymbol{j}=1}^{6} \boldsymbol{\beta_j \omega_{ijt}} + \epsilon_{it} \qquad (1)$$

In Equation (1) above, ω_{ijt} represents the weight of by-line business premiums written by insurance firm '*i*' in year '*t*' as a proportion of annual gross premiums written by the firm in that year; β_j represents the beta of each line of business; and ϵ_{it} is a random error term for firm '*i*'. Since individual business lines are not traded in the market, the traded value of individual business lines is not known. Therefore, following Kaplan and Peterson (1998), we use premium income (sales data) for six lines of business at the industry and firm-level to proxy for the relative weight of each line at the industry-level and firm-level respectively. The assumption is that weighted premiums are deemed a reasonable proxy for business participation as insurers invest net period income in assets and reinsure risks in proportion to liabilities reported at balance sheet date.

Within the FIB framework, the initial step using the R-L metric is to calculate an industry-level beta corresponding to each of the available monthly observations using the following equation:

$$\beta = \frac{Cov[R_i, -(1+R_m)^{-b}]}{Cov[R_m, -(1+R_m)^{-b}]}$$
$$\text{where, } b = \frac{1}{2} + \frac{E[\ln(1+R_m)] - \ln(1+R_f)}{Var[\ln(1+R_m)]} \tag{2}$$

The term '*b*' in equation (2) represents the degree of risk aversion.[8] Additionally, the three key inputs required for estimating equation (2) are: R_i – the return on a portfolio of non-life insurance companies; R_f – the return on the risk-free asset, and R_m – the return on the market portfolio. The proxies used for these three variables were obtained using data from *Datastream*. The FTSE-350 Non-life Insurance Index was used to proxy R_i, the average monthly return for the insurance industry. Data on this index are available from December 1985 onwards. Since the monthly returns on UK government Treasury bills of one month maturity precisely matches the duration of returns on the insurance industry index and the market index, it was used as a proxy for the risk-free rate R_f. Similarly, the return on the FTSE-All-Share Price Index is used to approximate the average monthly market return. It is important to note here that there is a mismatch of the duration of data available on the FTSE-350 Non-Life Insurance Index, which is based on data from December 1985 and the data available from the *SynThesys* database. Therefore, to avoid losing one year's data in the estimation, the bootstrap method utilizing the full sample of available returns was employed to estimate the yearly industry beta for each year from 1985 to 2010. In the next step of this procedure, using the yearly betas for individual firms, the risk premia for individual insurance firms for each year in the study period were calculated using equation (3) below:

$$RP_{i,t} = \beta_{i,t}(R_m - R_f) \tag{3}$$

The long-run average of the market risk premium used in the equation above as short-term estimates of the equity risk premium could be confounded by period-specific environmental (e.g. macroeconomic) events (Koller, Goedhart, and Wessels 2010). Therefore, to incorporate the long-run estimates of the equity risk premium, the risk premium of 5.23%, as reported in Kyriacou, Madsen and Mase (2006), is used as a proxy. Using the arithmetic mean, Kyriacou, Madsen and Mase (2006) calculate the historical risk premium using UK corporate data from the year 1900 to 2002. The yearly risk premia so calculated for each firm in the estimation sample thus serve as the dependent variable for testing hypotheses 2 and 3.

4.3. Variables

Since the cost of equity reflects investors' risk preferences (O'Hanlon and Steele, 2000), it can be influenced by various factors that have an effect on perceived market risk. In this context, the level of reinsurance can be a major factor in defining the riskiness and risk appetite of an insurer (Hoerger, Sloan and Hassan 1990). Since this research study aims to explain the effect of reinsurance on the cost of the equity of the insurers, the principal explanatory variables (i.e. the decision to reinsure and the extent of reinsurance) used in this research are derived from the premiums ceded to the reinsurers. To test the 'reinsurance participation' hypothesis, an indicator variable, named *REINID*, which takes value 1 if an insurance firm cedes premiums to a reinsurer, and 0 otherwise, is used. In the current study, 376 sample insurance firms (95% of the full panel sample) use reinsurance

Table 1. UK property-liability insurers, 1986–2010: definition of variables.

Variable	Represents	Description
$RP_{i,t}$	Equity Risk Premium	Annual equity risk premium for an insurer.
$REINS_{i,t}$	Level of reinsurance ceded	Amount of reinsurance premiums ceded in year *t* divided by the gross insurance premiums written in year *t*.
$LEV_{i,t}$	Leverage	Net provisions scaled by reported capital resources in year *t*
$LIQ_{i,t}$	Level of cash holdings	Ratio of cash (& cash equivalents) to total assets in year *t*.
$SIZE_{i,t}$	Firm size	Natural log of total assets in year *t*.
HINDX	Line of business Herfindahl-Hirschman Index	Sum of square of share of each line in a firm's annual premiums written.
$TLTA_{i,t}$	A measure of leverage	Ratio of annual total liability to annual total assets.
$NITA_{i,t}$	A measure of profitability	Ratio of annual net income to annual total assets.
$BPROB_{i,t}$	Probability of bankruptcy	Probability of bankruptcy of an insurer obtained using 'private firm model' of Chava and Jarrow (2004).
Altman Z	Altman *Z*-score	It is an inverse proxy for the probability of bankruptcy and is calculated as 6.56X1 + 3.26X2 + 6.72X3 + 1.05X4, where X1 to X3 respectively represent ratios of working capital, retained earnings and EBIT to total assets; whereas X4 is the ratio of the book values of equity and total liabilities.
Z-score	An inverse proxy for the probability of bankruptcy	(ROA + capital to asset ratio) divided by the standard deviation of ROA

This table presents the labels of the key variables used in the study together with their full description.

with approximately 93% of the firm-year observations (5,063 out of 5,427) reporting reinsurance data. To gauge the extent of reinsurance used by insurers relative to the gross premiums written at the total business level, the ratio of premiums ceded to gross premiums written (hereafter the 'reinsurance ratio') is employed. The variable label *REINS* denotes the reinsurance ratio given in Table 1 below.

Prior research studying the link between the cost of equity and firm risk characteristics (e.g. Botosan 1997; Botosan and Plumlee 2005; Gregory and Michou 2009) predicts a positive link between leverage (increased risk of financial distress/bankruptcy) and the equity cost of capital. This view is consistent with various theories of capital structure, such as trade-off theory. Following these studies, leverage (*LEV*) – net provisions scaled by total assets – is used here as an explanatory variable for the equity risk premium. Fama and French (1995) demonstrate that firm size is a significant factor in determining the risk premium demanded by investors. In Fama and French's (1997) three-factor (FF3F) model, firm size is predicted to be inversely related to the cost of equity because larger firms tend to have greater access to capital markets than smaller firms; plus, they are usually more diversified in terms of both their geographical scope of operations and product-markets. Botosan, Plumlee and Wen (2011) define firm size as the natural logarithm of the market value of the firm. However, this measure is not possible in this study as most of the firms in our panel sample (around 95% on average) are not publicly-traded entities. Therefore, the natural logarithm of the total assets is used to proxy for firm size. We consider that this is a reasonable proxy for firm size for two main reasons. First, during our period of analysis UK insurers were required by regulation to regularly (at least annually) mark their assets to 'fair' market values for statutory solvency monitoring and (under IFRS 4) for financial reporting purposes. Second, a large proportion of non-life insurers' assets are marketable (liquid) securities which are by necessity reported at, or close to, their tradable values.

Insurers, being financial intermediaries, face significant liquidity risks on their balance sheets (Borde, Chambliss and Madura 1994). Liquidity risks arise when insurers' investments (usually in marketable securities which are exposed to interest rate, market equity, and credit risks) are unable to meet an increased demand for liquidity in the aftermath of a major catastrophe. Borde, Chambliss and Madura (1994) report that liquidity has a positive and statistically significant relation with an insurer's risk, and that low liquidity levels could lead to a riskier investment strategy that promises greater than average market rates of return. To account for this possibility, the ratio of reported liquid assets (cash and cash equivalents) to total assets (*LIQ*), is used to measure liquidity risk. As *LIQ* is an inverse measure of liquidity risk, we expect this coefficient estimate to be negative.

Another important consideration in determining firm-level risk is the level of product-market diversification of the firm. For example, Cole and McCullough (2006, p.176) assert that '… differences in the lines of business sold affect a firm's investment opportunities, earnings volatility, and overall level of risk'. Huang et al., (2010) report that there is a significantly positive relation between the conditional idiosyncratic volatility estimated from monthly data and expected returns. Since a diversified insurance firm is likely to have lower return volatility, a Herfindahl index (*HINDX*) is used in this study to measure product diversification in accordance with prior insurance industry research (e.g., see Mayers and Smith, 1990). This variable (*HINDX*) is defined as the sum of squares of the premiums generated by individual lines of business as a proportion of the total premiums written at the total business level. In other words, for a firm 'i' operating in 'N' different lines of insurance in a given year 't', the Herfindahl index can be calculated as:

$$HINDX_{it} = \sum_{j=1}^{N} \left(\frac{GPW_{ijt}}{GPW_{it}} \right)^2 \text{ where } j \text{ represents the number of lines.} \tag{4}$$

An *HINDX* close to 0 represents a highly diversified company, whereas for a 'pure-play' company, this index is equal to 1. Since a diversified company is expected to be less risky, the cost of equity is expected be an increasing function of *HINDX*. On the other hand, Shim (2011) provides evidence that more product-focused insurers, on a risk adjusted basis, outperform the product-diversified insurers. Therefore, there can be a negative relation between the equity risk premium and the degree of product -line diversification.

4.4. Models

To test H1, which relates the cost of equity to the managerial decision to reinsure, the following model is specified:

$$RP_{it} = \beta REINID_{it} + \gamma LEV_{it} + \varphi SIZE_{it} + \rho LIQ_{it} + \theta HINDX_{it} + \varepsilon_{it} \tag{5}$$

Equation (5) is similar (but not identical) to the models used by Botosan and Plumlee (2005) and Botosan, Plumlee and Wen (2011) to compare the relative accuracy of the cost of equity estimates obtained using different techniques. The model in the Equation (4) above is based on the idea that the level of risk undertaken by investors must be priced in the cost of equity; hence, the factors that can affect this risk indicator must be accounted for in the model. All the variables in Equation (5) above are described in Table 1, while the last term ϵ_{it}, in the Equation (5) represents an error term that comprises unobserved firm-specific effects (e.g. between firm variations in managerial quality) (α_i); time-specific shocks (e.g. macroeconomic changes) (ν_t); and a random ('white noise') disturbance (η_{it}). That is:

$$\varepsilon_{it} = \alpha_i + \nu_t + \eta_{it} \tag{6}$$

In the presence of firm-specific effects, the ordinary least squares (OLS) estimator can be biased and inconsistent (Greene 2003). For instance, firm-effects can introduce a downward bias in estimates of standard errors, and may result in an upward bias in the magnitude of estimated t-statistics, which in turn leads to a statistical significance being assigned to variables that may not in actual fact be significant (Greene 2003). To control for firm-effects, we use the fixed-effects estimator, with standard errors corrected for clustering within firms to control for the downward bias in standard errors (Wooldridge 2002). This approach is consistent with the recommendations of Gormley and Matsa (2014) who argue that the fixed-effects estimator is more consistent than other common procedures, such as 'industry-adjusting' (demeaning), that are used for controlling unobserved heterogeneity. Moreover, we use year-dummies in our regressions to control for time-specific effects, including underwriting cycles.[9]

H2 predicts that the relation between the cost of equity of insurance firms and the extent of reinsurance will be non-linear. To capture non-linearity, we include an interaction term in our equation by first creating an indicator (dummy) variable based on the median value of reinsurance ratio (0.242), which takes the value 1 if reinsurance ratio is higher than the median, and 0 otherwise. Next, we interact this dummy variable with the reinsurance ratio variable to construct a variable *REINSINT* which captures the non-linearity of the slope between the observations above and below the median value of reinsurance ratio. This variable enters the regression equation along with the reinsurance ratio. The baseline model is given in Equation (7) below as:

$$RP_{it} = \beta_1 REINS_{it} + \beta_2 REINSINT_{it} + \gamma LEV_{it} + \varphi SIZE_{it} + \rho LIQ_{it} + \theta HINDX_{it} + \varepsilon_{it} \quad (7)$$

However, as reinsurance is a key element of the capital structure of insurance companies, there is the potential for endogeneity in the specified model (Cole and McCullough 2006). For example, a higher degree of corporate leverage could lead to a higher demand for reinsurance, which in turn increases the underwriting capacity of the insurer leading to a further increase in leverage. Eventually, this leverage-effect is likely to result in a higher cost of equity capital. Indeed, Shiu (2011) recognizes this potential endogeneity issue with reinsurance and controls for it using an instrumental variable (IV) approach. Therefore, we test for endogeneity using Durbin-Wu-Hausman test to establish whether, or not, an IV analysis is required.

4.5. Reinsurance and the probability of bankruptcy

In H_3, we propose that reinsurance lowers the cost of equity by reducing the probability of ruin. To test this we need to establish that the probability of bankruptcy is a key determinant of the cost of equity. Therefore, we employ the following model specified in Equation (10) below:

$$RP_{it} = \alpha_i + \lambda BPROB_{it} + \beta_1 REINS_{it} + \beta_2 REINSINT_{it} + \varphi SIZE_{it} + \rho LIQ_{it} + \theta HINDX_{it} + \varepsilon_{it} \quad (8)$$

We use both direct and inverse measures of the probability of bankruptcy. To directly measure the probability of bankruptcy, we use a model derived from the logit model proposed by Shumway (2001). This method uses a dummy (*BDUMMY*) as the dependent variable, which takes value 1 to indicate a bankrupt firm in a given year and 0 to indicate a solvent firm. Chava and Jarrow (2004) show that this model has superior forecasting performance compared with Altman's (1968) *z*-score model. We then follow the 'private firm model' of Chava and Jarrow (2004), which uses net income to total assets ratio (*NITA*) and total liability to total assets ratio (*TLTA*) as explanatory variables, which can mathematically be described in Equation (11) as:

$$BDUMMY_{i,t} = \alpha_i + TLTA_{i,t} + NITA_{i,t} + \varepsilon_{i,t} \quad (9)$$

To control for the potentially confounding effects of outliers in the data set, we winsorize these variables at the 1st and 99th percentiles at the left-hand and right-hand tails, respectively. Post-regression, we estimate the probability of bankruptcy, *BPROB*, for each firm using the logistic function. The predicted value is then used in Equation (10) above to test for relation between the probability of bankruptcy (*BPROB*) and the cost of equity. We expect to find a positive relation between the two, as predicted by the trade-off theory of capital structure (Hennessy and Whited, 2005). Since *TLTA*, a measure of leverage, is used as an explanatory variable for predicting probability of bankruptcy, we do not include *LEV* in Equation (10) in order to mitigate the risk of endogeneity. We then estimate the relation between reinsurance ratio and *BPROB* using Equation (12) below:

$$BPROB_{it} = \alpha_i + \beta REINS_{it} + \gamma LEV_{it} + \varphi SIZE_{it} + \rho LIQ_{it} + \theta HINDX_{it} + \varepsilon_{it} \quad (10)$$

Additionally, two alternative definitions of the *Z*-score are used as inverse measures of the probability of bankruptcy in this study. The first *Z*-score measure is based on the following equation from Altman (2013), suitable for non-manufacturing firms:

$$Altman\ Z_{it} = 6.56X1_{it} + 3.26X2_{it} + 6.72X3_{it} + 1.05X4_{it} \quad (11)$$

where variables X1 to X3 are defined as ratios of working capital; retained earnings; and earnings before interest and taxes (EBIT) to total assets respectively, while X4 is defined as the ratio of the book value of equity to book value of total liabilities. An alternative version of the *Z*-score is calculated as the sum of the return on assets (ROA) and the capital to asset ratio scaled by the standard deviation of ROA.[10] We predict the relation between reinsurance ratio and the probability of bankruptcy to be negative, i.e. that the purchase of reinsurance reduces the probability of ruin for insurance firms.

5. Empirical results

5.1. Descriptive statistics

Univariate statistics pertaining to the continuous variables in our panel sample are presented in Table 2.

The first main variable listed in Table 2 is the equity risk premium, *RP*, estimated using the R-L model. This variable denotes the excess return over the risk-free rate demanded by investors to invest in an insurance firm; relevant values range from a minimum of 4.63% to a maximum of 6.91% with a mean value of 5.65%. This variable is homogenously distributed over the entire panel sample as the median value of 5.67% is very close to the overall mean indicating a low level of skewness in the panel data set. A modest value of the overall standard deviation (0.52%) relative to the mean suggests that the variable shows a low degree of variability around the mean. This indicates that the insurers in our panel sample have similar business risk profiles. The second key variable listed in Table 2 is the reinsurance ratio, *REINS*, which ranges from a minimum of 0 to maximum of 1. The smaller this ratio, the lower the volume of premiums ceded to reinsurers relative to gross premiums written at the total business level. A high value of the ratio is equivalent to a high rate of outwards reinsurance, indicative of an insurer either closed to new business and in 'run-off' or in a state of financial distress. Given the aforementioned sampling procedure that we employed, most of the insurance firms in the estimation sample are expected to be 'going concerns', resulting in moderate values of reinsurance ratio. Nonetheless, there is a small minority of insurers left in the panel sample that have large values of the reinsurance ratio compared with the mean and median values of 0.32 and 0.26 respectively. Unlike the equity risk premium, the reinsurance ratio shows a higher variation relative to its mean with the standard deviation being 0.28.

Leverage (*LEV*) is the next relevant variable reported in Table 2, and ranges from 0 to 1617.5. This suggests the presence of both new entrants, and highly leveraged insurance firms in the panel data set. The overall standard deviation at 22.78 is several times the mean of 2.62 indicating substantial variation in leverage within the estimation sample, while a higher mean (2.62) than median figure (1.40) shows that the distribution of this variable is positively skewed. We winsorize *LEV* at the 1st and 99th percentile levels at both tails of the sample distribution to avoid the potentially confounding effects of extreme values (outliers) of this variable in our regression analysis. Post-winsorization, leverage (*WLEV*) has a mean of 2.12, which is closer to the median with substantial changes in the minimum and maximum values.

The variable representing insurance firm size (*SIZE*) given in Table 2 is, as noted earlier, calculated as the natural logarithm of total assets reported by an insurer in a year. Such a transformation serves two purposes. First, since the total assets of a firm in an industry are log-normally distributed, the logarithmic transformation results in a 'near' normally distributed variable. Second, the scaling of total assets is achieved by this transformation,

Table 2. UK property-liability insurers, 1986–2010: descriptive statistics.

Variable	MEAN	SD	MEDIAN	MIN	MAX	OBS	FIRMS	AVG. TIME
RP	5.655	0.520	5.665	4.629	6.915	5427	397	13.67
REINS	0.312	0.277	0.242	0.000	1.000	5427	397	13.67
REINSINT	0.264	0.311	0.000	0.000	1.000	5427	397	13.67
LEV	2.624	22.798	1.400	0.000	1617.500	5427	397	13.67
WLEV	2.122	2.966	1.400	0.007	24.670	5427	397	13.67
LIQ	0.757	0.186	0.795	0.002	1.625	5427	397	13.67
WLIQ	0.757	0.184	0.795	0.052	1.000	5427	397	13.67
SIZE	11.018	1.965	10.900	5.242	17.566	5427	397	13.67
HINDX	0.666	0.277	0.636	0.158	1.000	5427	397	13.67
BPROB	0.023	0.064	0.008	0.000	0.771	6821	455	14.99
TLTA	0.449	0.221	0.474	0.000	0.953	5427	397	13.67
WTLTA	0.449	0.221	0.474	0.004	0.953	5427	397	13.67
NITA	0.028	0.145	0.024	−2.857	3.929	5418	397	13.65
WNITA	0.026	0.100	0.024	−0.490	0.482	5418	397	13.65
Altman Z	4.264	1.429	4.167	−3.254	10.047	5418	397	13.65
Z-Score	11.136	12.070	8.960	−10.859	312.412	5418	397	13.65

This table reports the overall descriptive statistics of all variables defined in Table 1 for the entire period of analysis. Variables with prefix 'W' (e.g. *WLEV*) have been winsorized at the 1st and 99th percentiles at left and right tails, respectively.

which makes the results easier to interpret. The size of the firms in the estimation sample, measured using the log of monetary value of total assets, ranges from 5.70 (approximately £0.3 million) to 16.62 (£16.5 billion). Interestingly, the between and within-standard deviations in size are of similar magnitude at 6.54 and 6.27, respectively. This indicates that within-sample variation in firm size in a given year is of the same scale as the variation in the size of insurance firms over the full study period (1985 to 2010). The 'well-behaved' distribution of this variable is also reflected in qualitatively similar mean and median values at 11.02 and 10.9, respectively. In addition, the overall standard deviation of this variable at 1.96 suggests that this variable has little variation relative to its mean.

Liquidity, denoted by *LIQ* in Table 2, is another important variable used in this study, and reflects the level of cash and easily convertible cash equivalents in the asset mix of an insurer in a given year. This variable is bounded between 0 and 1 as it is not possible to have negative values of liquid assets or to have liquid assets greater in value than total assets in an accounting period. Again, to eliminate the potentially confounding effects of extreme values, *LIQ* is winsorized at the at 1st and 99th percentile levels at both tails. Post-winsorization, all values of this variable are within the aforementioned plausible range. Product diversification is listed in Table 2 as *HINDX*, and corresponds to the annual value of the Herfindahl index calculated for each insurance firm. About 54% (213 out of 397) of the insurance firms in the estimation sample conducted their business as mono-line companies (*HINDX* of 1) for at least one year during the study period. Similar, but relatively large magnitudes of the mean (0.66) and median (0.64) statistics, indicate that less diversified insurers are more prevalent in our data set. In other words, most insurers operating in the UK non-life insurance market tend to specialize in a few niche lines of business rather than diversifying across all potential product-markets. However, there are a few well diversified insurers in the estimation sample with the minimum value of *HINDX* being 0.16.

5.2. Multivariate results

H1 is tested using Equation (4) above. Panel A of Table 3 reports the relevant coefficient estimates and diagnostics, and they confirm the presence of both autocorrelation and heteroskedasticity in our dataset. To counter standard error bias, we follow the procedure in Driscoll and Kraay (1998), which controls for both arbitrary spatial and temporal dependence in panel data analyzed using the fixed-effects estimator. The coefficient estimate for *REINID*, which indicates the decision to reinsure or not, is negative and statistically significant ($p \leq 0.01$, 1-tailed). This result supports H1 that insurers utilizing reinsurance for risk management generally have smaller equity risk premiums (cost of equity) compared with insurers that do not purchase reinsurance. This observation therefore supports the view that reinsurance (risk management) can add value to insurance firms by enabling them to optimize capital structure, and so lower their equity cost of capital.

As expected, the winsorized value of leverage, *WLEV*, is positively and significantly related to the cost of equity. Specifically, *WLEV* has an estimated coefficient of 0.006 with a 1-tailed *p*-value of less than 0.05. This finding conforms to traditional theories of capital structure which suggest that the cost of equity is an increasing function of leverage, as increased indebtedness leads to increased frictional costs, such as costs associated with financial distress/bankruptcy, resulting in a higher equity risk premium (Chen and King, 2014). In accordance with what we predicted, Table 3 also shows that holding a relatively higher proportion of cash and cash equivalents in the asset mix reduces the equity risk premium of insurers. This result indicates that as highlighted in Laux and Muermann (2010), although insurance is primarily a solvency-focused business, liquidity risk, and its implications for the cost of capital is also an important strategic consideration for insurers. Table 3 however shows that firm size and degree of product diversification do not have a statistically significant effect on the equity risk premium, but the signs of these coefficient estimates are nevertheless in the predicted direction.

The test results for H2 are presented in Panel B of Table 3. They show that the coefficient estimate for *REINS* is negative and statistically significant (at $p \leq 0.01$, 1-tail); that is, reinsurance is associated with a lower equity risk premium. However, for insurers purchasing higher than the median level of reinsurance (approximately 24% of gross premiums written), the empirical relation is weaker compared with insurers that cede a lower proportion of premium underwritten to their reinsurance partners. In economic terms, this means that a one percent increase in premiums ceded is associated with nearly a 29 basis points drop in the equity risk premium; yet the drop tapers-off to 5 basis points for insurers ceding more than 24% of their gross premiums written. This suggests

Table 3. UK property-liability insurers, 1986–2010: fixed-effects estimates.

Panel A

			Two-tailed test		One-tailed test	
Variable	Coeff.	Robust Std. Error	*Z*	*p*-value	χ^2	*p*-value
REINID	−0.065	0.031	−2.05	0.04	4.22	0.02
WLEV	0.006	0.002	3.70	0.00	13.67	0.00
WLIQ	−0.066	0.038	−1.74	0.08	3.01	0.04
SIZE	−0.006	0.008	−0.74	0.46	0.55	0.23
HINDX	0.052	0.042	1.24	0.21	1.54	0.11
Year Dummies	Yes					
No. Observations	5427					
No. Firms	397					
Diagnostics	Wooldridge test for first order autocorrelation in panel data					
	F(1, 373)	208.389	*p*-value		0.00	
	Modified Wald test for group-wise heteroskedasticity					
	χ^2 (397)	3.9E + 34	*p*-value		0.00	
	Hausman test to choose between fixed and random effects estimation					
	χ^2 (30)	49.53	*p*-value		0.01	

Panel B

			Two-tailed test		One-tailed test	
Variable	Coeff.	Robust Std. Error	*Z*	*p*-value	χ^2	*p*-value
REINS	−0.287	0.077	−3.74	0.00	13.98	0.00
REINSINT	0.236	0.065	3.64	0.00	13.28	0.00
WLEV	0.006	0.002	3.64	0.00	13.21	0.00
WLIQ	−0.069	0.040	−1.74	0.08	3.03	0.04
SIZE	−0.009	0.008	−1.11	0.27	1.22	0.13
HINDX	0.052	0.042	1.25	0.21	1.56	0.11
Year Dummies	Yes					
No. Observations	5427					
No. Firms	397					
Diagnostics	Durbin-Wu-Hausman test for endogeneity of *REINS*					
	χ^2 (1)	1.10		*p*-value	0.29	
	Modified Wald test for group-wise heteroskedasticity					
	χ^2 (397)	1.2E+34		*p*-value	0.00	
	Hausman test to choose between fixed and random effects estimation					
	χ^2 (31)	57.26		*p*-value	0.00	

This table presents the results of the fixed-effects estimation that tests the effects of the reinsurance ratio on the annual risk premium of non-life insurers operating in the UK's non-life insurance market. Panel A reports the results of reinsurance participation decision and Panel B presents the results of the reinsurance volume decision. Also reported are the results of diagnostic tests to detect presence of heteroskedasticity and autocorrelation in panel data. All variables are as defined in Table 1. Both two-tailed and one-tailed test statistics for each explanatory variable have been reported in the table.

that the relation between the equity risk premium and the reinsurance ratio is negative but non-linear. It is well established that reinsurance can increase the underwriting capacity, and an increase in underwriting activity can result in a higher leverage (e.g. see Abdul-Kader, Adams and Mouratidis 2010). Moreover, reinsurance is costly, and so at relatively higher levels of cession rates reinsurance is less cost-effective in reducing the cost of equity capital. Nevertheless, this result accords with Bartram, Brown and Conrad (2011) who show that risk hedging can reduce both the total and systematic risks of firms. The Durbin-Wu-Hausman test reported in panel B of Table 3 shows that reinsurance-cost of equity relation is not endogenous, which obviates the need for additional regressions to treat endogeneity.[11]

There can be many channels through which reinsurance-cost of equity relation can manifest itself – one of which is to via the costs of financial distress/bankruptcy. The mediating-effects of financial distress/bankruptcy costs on the reinsurance-cost of equity relation are reported in Table 4. Panel A of Table 4 presents the results of a logit regression that employs the aforementioned 'private firm' model of Chava and Jarrow's (2004). Using this method, we derive estimates of each insurer's probability of bankruptcy using a logistic transformation, and running the estimates in a fixed-effects estimator using the model specified in Equation (10). The results obtained are reported in Panel B of Table 4, and they reveal that the predicted probability of bankruptcy is positively related

Table 4. UK property-liability insurers, 1986–2010: probability of bankruptcy and equity risk premium.

Panel A

Variable	Coeff.	Std. Error	Z	p-value
WTLTA	5.543	0.607	9.13	0.00
WNITA	−5.814	0.801	−7.26	0.00
CONSTANT	−7.327	0.460	−15.94	0.00
No. Observations	5529			
No. Firms	409			

Panel B

			Two-tailed test		One-tailed test	
Variable	Coeff.	Robust Std. Error	Z	p-value	χ^2	p-value
BPROB	0.243	0.107	2.27	0.02	5.16	0.01
REINS	−0.289	0.077	−3.75	0.00	14.06	0.00
REINSINT	0.238	0.065	3.67	0.00	13.50	0.00
WLIQ	−0.074	0.040	−1.85	0.07	3.41	0.03
SIZE	−0.007	0.008	−0.89	0.38	0.78	0.19
HINDX	0.053	0.042	1.25	0.21	1.56	0.11
Year Dummies	Yes					
No. Observations	5418					
No. Firms	397					

Panel C

			Two-tailed test		One-tailed test	
Variable	Coeff.	Robust Std. Error	Z	p-value	χ^2	p-value
REINS	−0.011	0.002	−4.96	0.00	24.64	0.00
WLEV	0.007	0.001	12.00	0.00	143.91	0.00
WLIQ	0.003	0.004	0.74	0.46	0.55	0.77
SIZE	0.000	0.001	0.12	0.91	0.01	0.55
HINDX	−0.009	0.003	−3.43	0.00	11.74	1.00
Year Dummies	Yes					
No. Observations	5418					
No. Firms	397					

Panel A presents the results of logit model of Chava and Jarrow (2004) used for predicting probability of bankruptcy. Panel B reports the fixed effects estimates of probability of bankruptcy on the equity risk premium. Panel C reports the results of fixed effects estimation of effect of reinsurance on probability of bankruptcy. Standard errors used in Panels B and C were obtained using the Driscoll and Kraay (1998) method. All variables are as defined in Table 1. Both two-tailed and one-tailed test statistics for each explanatory variable have been reported in the table.

to the equity risk premium. These findings support the trade-off theory of capital structure (e.g. Hennessy and Whited, 2005), which suggests that firm-level bankruptcy risk is priced in the financial markets. Although it can be argued that idiosyncratic risks, such as the risk of financial distress/bankruptcy, can be diversified away by investors, there is an increasing body of evidence that finds that default risk at firm-level is important. For example, Bartram, Brown and Stulz (2012, 1330) also state that '… idiosyncratic risk is important for the large numbers of investors who are imperfectly diversified'.

The other coefficient estimates reported in Panel B of Table 4 are similar to the results reported in Table 3, while the results reported in Panel C of Table 4 confirm that reinsurance is related to reduced probability of ruin. This suggests that reinsurance reduces the cost of equity by lowering the costs of financial distress/bankruptcy. Table 4, panel C also reports that the probability of financial distress/bankruptcy increases with leverage, whereas it decreases with the degree of product diversification. As with the equity risk premium, the results in Table 4 indicate that the size of the insurer does not have any statistically significant effect on the probability of ruin.

5.3. Robustness tests

To establish the consistency and reliability of the financial distress/bankruptcy risk channel through which reinsurance impacts the cost of equity, we conduct additional regression tests using two alternative definitions of the Z-score variable. These results are presented in Table 5.

Table 5. UK property-liability insurers, 1986–2010: equity risk premium and the *Z*-score.

Panel A				
Variable	Coeff.	Robust Std. Error	Coeff.	Robust Std. Error
Altman Z	−0.016∗∗ −2.54	0.006		
Z-score			−0.005∗∗ −2.36	0.002
REINS	−0.426∗∗∗ −4.47	0.095	−0.427∗∗∗ −4.47	0.095
REINSINT	0.33∗∗∗ 4.02	0.082	0.331∗∗∗ 4.01	0.082
WLEV	0.006∗ 1.8	0.004	0.005 1.51	0.003
WLIQ	0.038 0.8	0.047	0.044 0.93	0.047
SIZE	−0.011 −1.07	0.010	−0.012 −1.14	0.010
HINDX	0.004 0.08	0.050	0.001 0.02	0.050
Year Dummies	Yes		Yes	
No. Observations	5418		5418	
No. Firms	397		397	

Panel B				
	Altman *Z*-score		*Z*-score	
Variable	Coeff.	Robust Std. Error	Coeff.	Robust Std. Error
REINS	0.784∗∗∗ 5.93	0.132	2.549∗∗∗ 8.08	0.316
WLEV	−0.234∗∗∗ −7.48	0.031	−0.509∗∗∗ −7.05	0.072
WLIQ	0.794∗∗∗ 3.59	0.221	1.306∗∗ 2.42	0.541
SIZE	−0.061 −1.41	0.043	−0.056 −0.58	0.095
HINDX	0.131 0.78	0.169	1.075∗∗ 2.11	0.509
Year Dummies	Yes		Yes	
No. Observations	5418		5418	
No. Firms	397		397	

Panel A presents the results of fixed-effects regressions of the equity risk premium on the *Z*-score calculated using two alternative definitions. Both *Z*-score variables are inverse measures of the bankruptcy risk. Superscripts ∗; ∗∗ and ∗∗∗ denote statistical significance at 10%, 5% and 1% level respectively (two-tail). Panel B reports the fixed-effects results of regressing the *Z*-score on the reinsurance ratio and other variables. All variables are as defined in Table 1.

Table 5 corroborates the results obtained in Table 4 as both *Z*-scores (inverse measures of the probability of bankruptcy) in panel A have negative and statistically significant coefficients, suggesting that the risk premium decreases with increasing *Z*-score (lower bankruptcy risk). Additionally, reinsurance ratio is positively related to both measures of the *Z*-score as shown in panel B of Table 5, suggesting that use of reinsurance lowers the probability of financial distress and bankruptcy.

6. Conclusions

To summarize, we find that use of reinsurance (risk management) is associated with lower equity risk premium, but that the empirical relation between reinsurance and the equity risk premium is non-linear. As we predicted, a main explanatory variable – leverage – is also found to be positively related to the cost of equity across a majority of the estimations conducted in this study. In fact, it is well documented in the finance literature that leverage increases the risk default, and as a result, leads to an increase in the cost of equity. In line with expectations, insurers having more liquid assets relative to their stated total assets also tend to have a lower cost of equity, as higher liquidity levels improve investors' confidence that the insurance firm is relatively immune to unexpected losses to productive assets. However, a greater level of product-market diversification and larger firm size are found not to have a statistically significant and consistent effect on equity risk premium of insurers.

We conclude from our analysis that the use of optimal capital structure theory-based arguments best explain the use of reinsurance by non-life insurers. The empirical results obtained in this study support the contention (H1) that corporate users of reinsurance in the UK's relatively 'light touch' non-life insurance sector (e.g. at least as compared with the 'alien reinsurance' regime operating in the US) have a comparatively lower cost of equity than their counterparts without reinsurance. This could reflect that investors in the UK's non-life insurance market incorporate the risk reduction achieved by diversification through reinsurance in their return expectations. As predicted by the 'reinsurance volume decision' hypothesis (H2), our study finds that there is a non-linear relation between the extent of reinsurance use and the insurers' cost of equity. This result accords with the theoretical predictions which suggest that risk management can be a value-added activity, but that its efficiency diminishes as the associated costs rise relative to the magnitude of the loss being mitigated. We thus conclude that reinsurance is an important strategic instrument that insurers can use to optimize their capital structure in imperfect markets. We also observe that the equity risk premium has a positive link with the risks (costs) of financial distress/bankruptcy, but that reinsurance can reduce the equity risk premium by reducing the probability of ruin. Thus, a reduction in the costs of financial distress/bankruptcy is a key channel through which reinsurance reduces the cost of equity.

Many studies use financial derivatives to explain the impact of risk management on firm value. However, derivatives' data are not only 'noisy' and difficult to interpret, but may not be able to eliminate the risk exposure completely. In contrast, the current study focuses on reinsurance which is a pure hedge (indemnity) mechanism. This feature allows us to conduct a direct empirical test of the cost of equity-risk management relation. In this regard, the study provides a solid basis for further academic research on the role of corporate hedging, particularly the use of insurance, in influencing the market value of firms. To the best of our knowledge, the present study is the first to combine the full information beta method of Kaplan and Peterson (1998) with the non-parametric method of equity beta estimation described in Wen et al., (2008) to arrive at a firm-level equity risk premia. This is a novel technique for the cost of equity estimation that encompasses all organizational forms and accounts for all the 'moments' of the equity return distribution. This allows the cost of equity estimates to incorporate all the risk factors priced by investors while concomitantly optimizing sample size. As a result, our study also makes a prospectively useful methodological contribution to the literature.

We believe that the findings of this research provide useful insights for assessing an insurance firm's future profitability, riskiness, and market value. The empirical evidence provided by this study suggests that investors take account of reinsurance purchased in assessing risks associated with an insurer's business, and thus, in pricing its securities. Managers can also use this information to optimize corporate capital structure, and minimize the prospective cost of equity, and other frictional costs arising due to market imperfections. Moreover, an optimal reinsurance (risk management) policy can reduce the level of retained share capital that can maximize reported returns on invested capital. This insight could help policyholders and shareholders to make better-informed financial decisions, and assist industry regulators to design and develop capital maintenance rules. These attributes are potentially portable not only to other financial firms (e.g. banks) but also to non-financial firms that actively and routinely purchase insurance.

Notes

1. In 2016/17 there were 451 non-life insurers authorized to operate in the UK; however only approximately two-thirds of these entities actively underwrite and report insurance business. Non-active/non-reporting insurance operatives include a miscellany of structures, such as closed funds in run-off, 'brass plate' branches of European financial institutions with 'passport rights' to write (but not retain and report) business in the UK, and protection and indemnity pools that do not underwrite third party risks.
2. Since reinsurance is a binding contract, reinsurers will have to pay their share of losses irrespective of the level of financial leverage of the direct insurance writer. In contrast, increased leverage following a significant loss event will result in an increased risk of financial distress/bankruptcy, and therefore, a higher cost of capital for the primary insurer.
3. The FTSE-350 Non-life Insurance Index is a market-capitalization weighted index of all the companies in the non-life insurance sector of the FTSE 350 Index. The index was developed with a base value of 1,000 as of December 31, 1985. The FTSE-All-Share is a market-capitalization weighted index representing the performance of all eligible companies listed on the London Stock

Exchange's (LSE's) main market, that pass screening for firm size and liquidity. The FTSE-All-Share Index covers approximately 98% of the UK's total market capitalization.

4. A minority of the insurance firms included in our panel sample (e.g. Allianz) are quoted on the main stock exchanges based in the country of their respective parent companies (e.g. Germany). We treat corporate subsidiaries as stand-alone firms as they have to maintain the same capital maintenance standards under the UK's insurance industry solvency regulations.
5. Unlike the 'pure-play' approach commonly used for cost of equity estimation, which discards conglomerates, the FIB approach includes conglomerate as well as specialist firms to identify the impact of various lines of business on the cost of capital (Cummins and Phillips, 2005).
6. The six major lines of insurance business that are used in this study are: personal accident; motor insurance; property insurance; liability insurance; marine, aviation & transport insurance; and miscellaneous and financial loss. Together, these main lines comprise over 90% of annual premiums written in the UK insurance market over the period of analysis.
7. The average betas of insurance firms tend to be less than 1.0 - the market mean measure of systematic risk in portfolio theory (Cummins and Phillips, 2005).
8. Leland (1999) suggests that the degree of risk aversion of a representative investor can be viewed as the 'market price of risk', and can be estimated by dividing the market's instantaneous excess rate of return by the variance of the market's instantaneous rate of return. Accounting for the effects of firm-level human capital and the mean reversion character of stock index, Campbell (1996) estimates the value of risk aversion parameter 'b' to be 3.63. For simplicity, Wen et al., (2008) use the nearest integer value of 4 in their calculations; we do the same in this study.
9. The insurance underwriting cycle reflects temporal changes in premium rates, profits and capital capacity. The cycle begins after periods of large across-sector losses when premium rates rise, thereby, increasing profits, and attracting inflows of capital into the non-life insurance sector. In competitive insurance markets, such as the UK, increased capital capacity deflates prices thus reducing insurers' profitability.
10. We thank the anonymous referee for suggesting this definition of the Z-score.
11. Another commonly used test for endogeneity is the C-statistic, which is defined as the difference of two Sargan-Hansen statistic. Under the assumption of conditional homoskedasticity, this endogeneity test statistic is numerically equal to a Hausman test statistic (see Hayashi (2000), 233–234). With a test statistic of 2.25 (p-value of 0.13), the computed C-statistic test also accords with the result of the Durbin-Wu-Hausman test reported in panel B of Table 3.

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