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The Determinants of Financial Derivatives Use in the United Kingdom Life Insurance Industry

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THE DETERMINANTS OF FINANCIAL DERIVATIVES USE IN THE UNITED KINGDOM LIFE INSURANCE INDUSTRY

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Abstract

This paper examines the determinants of financial derivatives use in the United Kingdom (UK) life insurance industry. We estimate a probit regression model and a Heckman two-stage sample selection regression model using a sample of 88 UK life insurers in 1995. Our results indicate that the propensity to use derivative instruments is positively related to a firm's size, leverage and international links, and negatively related to the extent of reinsurance. We also find that mutual life insurance firms have a greater propensity to use derivatives than proprietary firms. The positive relation with leverage and the negative relation with reinsurance support the hypothesis that UK life insurers use derivatives to offset risk, rather than as a speculative means of income generation.

1. Introduction

Life insurance firms may use financial derivatives either as part of a risk management strategy or as a means of income generation. On the one hand, researchers have acknowledged the importance of financial derivatives in alleviating the effects of volatile interest rates and exchange rates on the asset values of insurance firms. Such hedging activities can ensure the survival of those entities in increasingly competitive environments (*e.g.* see Hoyt, 1989a, 1989b; Wilson and Hollman, 1995; Colquitt and Hoyt, 1996, 1997; Cummins *et al*, 1997; Hentschel and Smith, 1997).[1] On the other hand, Cummins *et al* (1997) have also reported that managers in insurance firms may be tempted to avoid external scrutiny and use financial derivatives to enhance reported annual earnings rather than to transfer risk and that speculative activity of this kind may increase the risk of insolvency.

Financial derivatives include such instruments as futures, options and invariably swaps, which can either be traded on public exchanges or treated as over-the-counter transactions.[2] The growth in derivatives trading has greatly expanded managerial opportunities to manage risks and enhance the value of insurance companies and other firms operating in the financial services sector, such as banks (Sinkey and Carter, 1997). Indeed, the importance of derivatives to the insurance industry is underpinned by Cummins *et al* (1997) who report that in the United States (US), at the end of 1994, some 286 life and property-casualty insurers held derivatives valued at approximately $418 billion. However, as Colquitt and Hoyt (1996, p. 149) observe, shareholders, policyholders, industry regulators and others with a direct interest in the operational performance of the insurance industry have " . . . come to recognize not only the benefits of derivatives trading . . . but also the potential misuse and abuse . . .". Hentschel and Smith (1997) share this view and consider that a better understanding of the reasons for participation in financial derivative markets by the insurance industry can help to improve the management and control of such instruments. Moreover, Hoyt (1989a, 1989b) points out that as the value of long-term insurance contracts, particularly those with guaranteed returns, is sensitive to interest rate fluctuations and inflation, it is likely that the use of derivatives would be more appropriate to life insurance firms rather than general insurers. Cummins *et al* (1997) provide evidence from the US insurance market to substantiate this claim (see section

2). In the present study, we focus on the UK life insurance industry and seek to isolate those factors which explain both the decision to employ financial derivatives and the extent of that usage by firms operating in that industry.[3]

This paper contributes to the growing literature on the use of derivatives in the financial services sector in five principal regards. First, the study could contribute insights into the motives underlying insurance firms' activities in financial derivative markets and as such be of interest to industry regulators, ratings agencies, actuaries and others concerned about the potential misuse of derivatives and the adverse implications which that might have for the future solvency of insurance firms. Second, the study could be of relevance to those parties that contribute to the current and future capital needs of insurance firms. For instance, a relation between derivatives usage and firm-specific characteristics, such as size and organizational form, could help policyholders and shareholders to better assess financial risks and thus make more informed insurance and investment decisions. Third, a comprehensive analysis of the utilization of derivatives has not previously been carried out in the UK insurance sector. Therefore, the results of this study could be used to compare and evaluate the results reported in studies carried out elsewhere, notably in the US insurance markets (*e.g.* Hoyt, 1989a; Colquitt and Hoyt, 1996, 1997; Cummins *et al*, 1997). Fourth, our study extends the existing literature by testing the influence of organizational operations (*e.g.* in overseas markets) on the decision to use derivatives. This factor has not been examined in other derivatives research concerned with insurance markets. Fifth, by focusing on the life insurance industry, our research project is able to control for the potentially confounding effects that differences in reporting practices, industry regulations and investment opportunities could have in wider studies (*e.g.*, see Staking and Babbel, 1995, p. 702).

The remainder of the paper is structured as follows. The next section provides background information on the use of financial derivatives by US and UK insurance firms and explains the importance of derivatives to life insurers. Section 3 discusses the determinants of derivative use derived from the corporate finance literature. Section 4 describes the research design, including the sources of data, the models employed and measurement of the variables. Section 5 analyses the results, while the final section concludes the paper.

2. Background

Financial derivatives comprise various types of contracts ranging from the more usual futures, options and swaps, to other more complex forms, such as exotic instruments. Cummins *et al* (1997) found that, in the US insurance industry, roughly half of the total number of derivative instruments used by insurers in 1994 were swaps, although the value of these was relatively low at $29 billion. The most important derivatives used by US insurers in value terms were options amounting to roughly $224 billion at the end of 1994. In contrast, few exotic forms of derivative instruments appear to have been used by US insurers. The number of derivative users were split evenly between life (144 firms) and property-casualty insurance users (142 firms), although at the end of 1994, life insurers accounted for approximately 90 per cent of the $418 billion total value of insurer derivative positions. This evidence suggests that financial derivative markets are more important to life insurers than to property-casualty insurers and supports the contention of Hoyt (1989a, 1989b), which we highlighted earlier.

In the UK, the Insurance Companies Regulations (1994) require insurers to report details of the number, type and value of derivative contracts on the new Form 13A of their annual solvency returns, which they file with the Department of Trade and Industry (DTI) (Gallen and Kipling, 1996). From this source, we ascertained that in 1995, 67 out of a population of approximately 270 UK life insurers reported the use of derivative instruments with a total notional (*i.e.* face) value of £809.5 million. It appears that the most common forms of derivative instruments used by UK life insurers are option contracts, particularly those involving the exchange of equities. In 1995, the asset values of these contracts was £362.9 million. Under the 1994 regulations UK-based insurers should not use financial derivatives for speculatory purposes. Rather such instruments may only be used for improved risk management purposes and to minimize investment risks. Indeed, the derivative positions adopted by UK life insurers should be monitored by appointed actuaries and the Department of Trade and Industry in their monitoring of annual corporate solvency (Gallen and Kipling, 1997). Some direction regarding the actuarial treatment of financial derivatives is also provided by the UK actuarial profession in its 1996 Guidance Note No. 25 on Investment Derivatives Instruments. However, because of the lack of transparency in the UK associated with the accounting for financial derivatives and their disclosure in annual reports (Accounting Standards Board, 1997), there is scope for life insurers to speculate on derivatives markets and for such trading to remain undetected.

Although UK life insurance firms appear to participate in financial derivative markets to a lesser degree than US life insurance firms, the amounts involved are not trivial and appear to be increasing. Currently, life insurance firms in the UK generate domestic annual premiums of approximately £47 billion (Association of British Insurers, 1996). This makes the UK the third largest provider of long-term insurance business in Europe (after France and Germany) and one of the major life insurance markets in the world (with the US and Japan being the two leading markets respectively). As in the US, many UK life insurers (*e.g.* Axa Sun Life, Standard Life) are multinational enterprises and thus likely to have large positions in foreign securities and/or large amounts of assets held by overseas-based subsidiaries. Such exposure to foreign exchange volatility means that derivative-based hedging strategies are likely to be attractive to many firms in the UK life insurance industry both now and in the future. This means that the economic incentives for derivatives usage reported in the US life insurance industry by Colquitt and Hoyt (1996, 1997), Cummins *et al* (1997) and others, is expected to be equally germane to the UK life insurance industry, thereby facilitating comparison and evaluation of empirical results across the two jurisdictions. Along with the US, the UK is now one of the few major insurance centres to publish statistics on derivatives usage. These attributes therefore make the UK life insurance industry an interesting and useful environment within which to conduct our research.

3. Theoretical framework

Colquitt and Hoyt (1996) consider that insurance firms will employ derivatives for various reasons. For example, they contend that although shareholders may be able to diversify financial risks cost-efficiently by holding balanced portfolios of investments, managers are less efficient bearers of such risks. Oldfield and Santomero (1997) suggest two reasons why managers are inefficient at diversifying risks: first, their personal wealth is limited; and second, they have a concentrated and non-transferable human capital stake in the firm (*e.g.* accumulated business knowledge).

The inability of managers to bear risks efficiently increases the prospects of insolvency and generates costs of financial distress (*e.g.* lost orders, higher cost of capital and so on). As a result, the owners of insurance firms will have to compensate their managers for bearing increased risks by giving them more attractive compensation packages (Kleffner and Doherty, 1996). By shifting risk to the financial derivative markets, owners of firms can mitigate such agency costs and reduce the prospects of bankruptcy. Furthermore, Hentschel and Smith (1997) point out that the continued ability of insurers to meet the fixed claims of policyholders is a matter of fundamental importance to both current and future generations of customers. They argue that reducing the probability of financial distress enables insurance firms to improve their reputations for prudent management and increase the average level of premiums that policyholders are willing to pay, thereby generating appropriable rents and reducing their future market cost of capital.

However, as Colquitt and Hoyt (1997, p. 650) report, regulators " . . . have come to recognize not only the benefits of derivatives trading by insurers but also the potential misuse and abuse that could accompany an unregulated use of these financial instruments." Indeed, in 1994, the US Hawaiian-based Equity Life Company lost US $90 million in trading bond futures, thereby giving substance to public concerns as to the need for the sound management and internal and external control of derivatives for the sake of life insurer solvency and the future protection of shareholders' and policyholders' claims.

In spite of the possibility that financial derivatives could be used by insurers for speculative rather than risk management/risk transfer purposes, Colquitt and Hoyt (1996, p. 152) acknowledge that speculation can have benefits in that " . . . by increasing participation in the futures market . . . [speculators] . . . provide hedgers with a more liquid market in which to hedge . . . ". Hentschel and Smith (1997) further argue that because most prior studies report empirical relations between the managerial demand for risk transfer through derivatives and firm-specific characteristics (such as leverage), speculative motives are likely to be subordinate to the hedging incentives of insurance firms. Nonetheless, the fact that derivatives can be used for both hedging and income enhancement purposes further underscores the need for academics, industry regulators and others to obtain deeper insights into what motivates the decision to use derivatives in the life insurance industry.

Prior studies reported in the corporate finance literature (*e.g.* Smith and Stulz, 1985; Froot, Scharfstein and Stein, 1993; Nance *et al*, 1993) contend that the use of derivatives to hedge financial risks can also be influenced by environmental factors, notably taxation rules. For example, Froot *et al* (1993) report that under the progressive tax codes that characterize most developed countries, like the UK and US, the taxation schedule for most firms will follow a convex function of reported earnings and that as a result, hedging through the use of derivatives can substantially alleviate cash flow volatilities and thus reduce the expected taxes of firms. Nance *et al* (1993) add that the existence of tax shields, such as loss carry forward provisions and foreign tax credits, enhances the convexity of the effective taxation schedule of most firms and further contributes to the managerial incentives to use hedging instruments in order to increase the traded value of firms. However, to our knowledge, there is no empirical evidence that firms in the USA or the UK actually use derivatives in this way in an attempt to minimise their tax liabilities.

To sum up, modern corporate finance theory suggests that managers actively use derivatives to alleviate market imperfections and reduce firm-specific exposure to financial risks which could create high volatility in firm cash flows and result in a reduction in shareholder value. Prior studies reported in the academic literature (*e.g.* Froot *et al*, 1993; Nance *et al*, 1993) have found that the extent to which hedging vehicles are employed varies according to the organizational characteristics of firms, features which themselves reflect the underlying agency cost relationships in firms and the response of managers to environmental phenomena, such as the effects of a progressive corporate tax code. Colquitt and Hoyt (1997) also examine the extent of derivatives use in relation to the corporate characteristics of US life insurance firms. Drawing a framework from this literature, we now consider five possible determinants of the use and financial extent of derivatives by life insurance firms: firm size; the risk of insolvency; organizational form; taxation status; and the extent of overseas business.

Firm Size

Jensen and Meckling (1976) and Zahra and Pearce (1989), among others, argue that as firms get bigger and their operations become more complex, information asymmetries between the various contracting groups worsen. As a result, agency costs (*e.g.* screening and monitoring expenditures) increase in order to prevent opportunistic behaviour by managers and enable *ex post* contractual realignment, if necessary. For instance, Zahra and Pearce (1989, p. 294) report that " . . . as firms become bigger, the control function becomes vital. Large organizational size is often associated with complex operations that require careful integration . . . [and close monitoring] . . . ". Cummins *et al* (1997) contend that as shareholders are expected to be better able than managers to diversify risks by holding mixed asset portfolios, the existence of hedging through financial derivative markets is likely to be a manifestation of the attenuated agency problems found in large firms. Nance *et al* (1993) also suggest that hedging could be a convenient mechanism by which agency incentive conflicts inside large firms can be mitigated. They state (p. 270) that to reduce agency costs, the firm must assure contracting groups “. . . that wealth transfers will not take place, either via restrictive covenants . . .or hedging . . . ". One example of a prospective agency incentive conflict inside firms is the under-investment problem whereby shareholders will be disinclined to invest in positive net present value projects (*e.g.* the re-building of plant and machinery after an environmental disaster) because the benefits of such investment will accrue to debtholders rather than themselves.

Smith and Stulz (1985) also contend that large firms are expected to use derivatives more than small firms because they can realize informational and scale economies from the activity. Large firms are also likely to have sufficient resources to train and employ personnel with expertise in the management and use of derivatives, whereas small firms are unlikely to have access to such specialist managerial skills (Hoyt, 1989a). Furthermore, large firms are expected to utilize derivatives to a greater extent than smaller firms because they are likely to engage in a wider variety of activities (Sinkey and Carter, 1997). However, other researchers (*e.g.* Nance *et al*, 1993) suggest that the empirical relation between hedging and firm size may be negative rather than positive. One reason for this is that small firms have higher exposure to prospective bankruptcy than large firms and so will use derivatives to hedge the risk of incurring the costs of financial distress. However, the vast body of empirical evidence from the insurance industry (*e.g.* Hoyt, 1989a, Colquitt and Hoyt, 1996, 1997; Cummins *et al,* 1997) supports a positive relation between firm size and the use of derivatives.[4]

Risk of insolvency

On the assumption that risk minimization through hedging is the main motive for derivative use by life insurance firms, we might expect to find a positive link between the use of derivatives and the risk of insolvency. There are a number of proxy variables that might be used as indicators of the risk of insolvency. We consider the following three: leverage, asset-liability mismatch and the extent of re-insurance.

(a) Leverage Agency theory-based studies, such as Jensen and Meckling (1976) and Smith and Warner (1979), among others, contend that increased leverage in firms induces high agency costs for suppliers of debt capital. For instance, when a firm's capital structure comprises debt, contractual covenants, such as those restricting the substitution of collaterized assets for those over which debtholders do not have a claim (*i.e.* me-first rules), have to be written so that debtholders are protected against a dilution of their rights to regular repayments of principal and interest. A highly leveraged posture also increases the expected costs of financial distress for firms and raises the possibility of bankruptcy. Colquitt and Hoyt (1997, p. 655) report that in the life insurance industry an operative " . . . with a higher probability of insolvency would benefit more from a decrease in the variance of firm value than would an insurer with a lower probability of insolvency. Therefore, the higher an insurer's leverage, the more likely it is to use derivatives . . . " . Staking and Babbel (1995) add that highly leveraged insurance firms will hedge in order to protect their corporate franchise value from losses arising from financial distress. For instance, they state (p. 698) that because ". . . the franchise is valuable, and this value may be lost in the event of insolvency or financial distress, the insurer will expend resources to protect it." Moreover, managerial action to control leverage and mitigate the risk of financial distress through the use of financial derivatives could have advantageous signalling effects for prospective investors and policyholders of insurance firms (*e.g.* by providing surety as to the entity's future as a going concern).

In contrast, Sinkey and Carter (1997) point out that in the financial services sector, industry regulators may prohibit highly leveraged (low equity financed) firms from participating in derivative markets because they perceive that involvement in new financial management activities is risky and thus a threat to future corporate solvency. However, most of the relevant academic literature does not support this contention. For example, Mayers and Smith (1987) and Nance *et al* (1993) report that the higher expected probability of financial distress associated with increased leverage enhances the under-investment incentive in firms and that this problem can be alleviated by hedging vehicles, such as derivative instruments and/or insurance. This reasoning therefore suggests that highly leveraged life insurers are more likely to use derivatives than lowly leveraged life insurers. De Marzo and Duffie (1995) also propose that hedging may be used by highly leveraged firms to signal to the capital markets positive information concerning future solvency, managerial ability and prospectively sound financial performance. Such signals may not only mitigate the possible costs of financial distress, but also reduce the future market cost of capital. However, the empirical evidence concerning the relation between hedging and capital structure has been mixed. For example, in their cross-sectional US-based study, Nance *et al* (1993) do not find evidence to support a positive linkage between hedging and leverage. However, studies from the life insurance industry (*e.g.* Colquitt and Hoyt, 1996, 1997) are more supportive of a hypothesized direct relation between derivative usage and firms' leverage. As a consequence, we predict a positive relation between the use and extent of financial derivatives by life insurers and their leverage.

(b) Asset-Liability Mismatch One way to measure firms' vulnerability to financial risks would be to examine the duration of their assets and liabilities (Sinkey and Carter, 1997). Indeed, several researchers (*e.g.* Hoyt, 1989b, Colquitt and Hoyt, 1996, 1997; Cummins *et al*, 1997; Santomero and Babbel, 1997) consider that because of the long-term nature of life insurance policies and the various fixed and flexible options that they contain (*e.g.* guaranteed returns or flexible premium terms), managers (notably actuaries) in life insurance firms have to take cognisance of the need to match the actuarial value and maturity of liabilities with their underlying assets. Over the long term, the value of life insurers' assets is particularly sensitive, being subject to the possibility of dilution by the combined effects of inflation, interest rate movements and

foreign exchange rate fluctuations which can increase the costs of financial distress. Such a prospective situation requires that actuaries in life insurance firms will routinely attempt to hedge balance sheet duration gaps (a process called immunization). In addition, the persistency of life insurance policies could be adversely affected by macro-economic factors, such as a severe economic recession. In other words, the default risk associated with life insurance business-in-force may be greater than that expected by the actuaries in their *ex ante* pricing of life insurance products. Indeed, Santomero and Babbel (1997, p. 246) report that in recent years many US-based life insurers " . . . feel that they do not have enough reliable data on which to specify the relation of lapses and policy surrenders to interest movements." Therefore, life insurers that match closely the duration of their assets and liabilities are expected to have less need for hedging through financial derivatives compared with those life insurance firms that mis-match their assets and liabilities. Prior studies (*e.g.* Cummins *et al,* 1997) also cite evidence supporting this contention.

(c) Reinsurance Adams (1996) finds that reinsurance is an important mechanism for alleviating the risk-bearing problem in New Zealand-based life insurers. Cummins *et al* (1997) also consider reinsurance to be a long-established mechanism in the insurance industry for hedging against unanticipated underwriting losses and financial risks, such as interest rate exposure. Therefore, reinsurance can help to alleviate the financing strain associated with the writing of new business (*e.g.* due to high up-front sales commissions) and reduce the volatilities in the operational cash flows of life insurance firms. Under this perspective the level of reinsurance held by life insurers is expected to substitute for economic hedging through the use of financial derivatives. Indeed, Joseph and Hewins (1997, p. 164) state that " . . . a firm that employs hedging substitutes is likely to hedge less . . . ". Alternatively, the extent to which life insurance firms utilize reinsurance could reflect managements' predisposition for and experience of hedging techniques. This reasoning suggests that the empirical relation between the use of derivatives and reinsurance could be complementary rather than substitutive (Colquitt and Hoyt, 1997). However, Nance *et al* (1993, p., 281) contend that whereas " . . . management [in insurance firms] . . . should be familiar with reinsurance since it is a normal component of their business. . .[such] familiarity is less likely for the financial hedging instruments." Their analysis therefore implies an inverse linkage

between derivative usage in life insurance firms and the level of reinsurance. Cooper (1996, p. 15) also supports this view when she states that in the life insurance industry derivatives enable firms

“. . . to hedge exposure within a tranche of risk in much the same way as by effecting . . . reinsurance”. Moreover, the empirical evidence cited by Cummins *et al* (1997) in the US property-casualty insurance industry supports a predicted substitutive relation between derivative usage and reinsurance. Therefore, we hypothesize a substitutive relation between the use and extent of financial derivatives and the amount of reinsurance.

Organizational Form

Adams (1995) employs the managerial-discretion hypothesis of Mayers and Smith (1981) to demonstrate that the balance sheet structure of life insurance firms varies according to organizational form, that is, the mutual (*i.e.* policyholder) versus proprietary or stock (*i.e.* shareholder) form of ownership. Such an analysis implies that organizational form could be an important determinant of variability in the use of derivatives among firms in the life insurance industry. For example, Cummins *et al* (1997, p. 29) argue that the managerial-discretion hypothesis " . . . suggests that stocks are expected to engage in more OBS [off-balance sheet] activity than mutuals because stocks are more likely to be involved in complex and/or risky lines of business that give rise to hedging." Indeed, evidence from the US insurance industry (*e.g.* Mayers and Smith, 1988) indicates that stock insurers tend to assume higher levels of financial risk than mutual insurers. Mutual insurers are, however, largely controlled by risk-averse managers with little direct monitoring from policyholders and, unlike stock insurers, they do not have equity capital to cushion against adverse economic shocks. Furthermore, the shareholdings of stock insurers could be well-diversified compared with policyholders (Kleffner and Doherty, 1996), suggesting that the owners will be indifferent to the transference of risks through the use of hedging instruments (Colquitt and Hoyt, 1997)[5]. Other commentators (*e.g.* Ralfe, 1996) further consider that the transaction costs associated with derivatives (*e.g.* trading and management costs) could exceed the benefits of derivatives usage and actually dilute shareholder value. Colquitt and Hoyt (1997, p. 657) also note that as “. . . the interests of the owners and fixed claimants are more closely aligned [in mutuals] because the policyholders 'own' the company . . . stock firms are less likely than mutual firms to participate in . . . hedging activity". Furthermore, as non-listed companies, mutuals (unlike stock insurers) are not subject to the discipline of the market for corporate control. Managers in mutuals could, therefore, have more freedom to counteract any reduction in reserves (*e.g.* as the result of imprudent investment) by the use of financial derivatives than their counterparts in stock firms. For these reasons, the managers of mutuals could be more inclined to hedge than their counterparts in stock insurance firms.

However, the managerial-discretion hypothesis contends that compared with the disparate policyholder-owners of mutuals the relatively more closely-held owners of stock insurers will be motivated to grant their managers more discretion over activity choice decisions, such as hedging, because they can more effectively mitigate the risk of aberrant managerial behaviour through increased monitoring and control. Froot *et al* (1993) also consider that shareholders could benefit from hedging if they are prohibited from diversifying their interests cost-efficiently as a result of market imperfections (*e.g.* transactions costs and information asymmetries). Additionally, managers in stock life insurance firms could be partially remunerated by stock option schemes and as a result, they could be motivated to use derivatives to control variations in firm value and enhance their economic utility (*e.g.* see Smith and Stulz, 1985). Moreover, most of the empirical evidence from the US insurance markets indicates that stock insurers tend to engage in derivatives trading to a greater extent than mutuals. We would tend to expect, therefore, that in the UK life insurance industry stock companies are more likely to utilize derivatives more than mutuals and to a much greater degree.

Taxation

Several researchers, such as Smith and Stulz (1985) and Nance *et al* (1993), have hypothesized that entities with a convex tax schedule could reduce their tax liabilities, and thus increase the traded value of the corporation by reducing the volatility of annual reported taxable earnings. Indeed, Nance *et al* (1993) find evidence in the US corporate sector to suggest that firms that hedge have larger investment tax credits and tax carryforwards and more pre-tax income in the convex region of the tax schedule than firms that do not use hedging instruments. Kleffner and Doherty (1996), Hoyt and Khang (1997), among others, also argue that tax shields, such as investment tax credits and tax loss carry forward provisions, provide additional incentives for managers of firms to reduce the variance of taxable earnings by means of hedging devices such as financial derivatives. Although the taxation assessment procedure for UK-based life insurers is complex and unique (Sole, 1996), their general taxation status could thus be an important determinant of the managerial decision to participate in financial derivatives markets (Colquitt and Hoyt, 1997). Sinkey and Carter (1997) hold a similar view from their analysis of derivatives usage in the US banking sector. For instance, they state (pp. 60-61) that ". . . if hedging [through derivatives] increases the value of the banking firm, it does so by reducing expected costs associated with taxes . . .". As a result, we consider that managers of life insurance firms with higher taxation liabilities are more likely to decide to use derivatives and employ them to a much greater extent than life insurers with lower taxation liabilities.

Overseas Business

Whilst the diversification of business operations overseas can help to reduce corporate risks (Brealey and Myers, 1996), the substitutive effect, if any, of such investment is unclear from the literature. Most researchers, however, suggest that the relation between off-balance sheet hedging (*e.g.* through the use of derivatives) and multinational operations is complementary. For example, Joseph and Hewins (1997) contend that the multinational versus domestic operating status of firms is an important influence on the managerial decision to participate in financial derivative markets. For instance, they state (p. 164) that the geographical focus of business activities could be important as multinationals are " . . . likely to hedge as it could be beneficial in protecting the competitive position of a firm which trades across borders." Berkman and Bradbury (1996, p. 8) make a similar observation when they state that “ . . . firms with overseas subsidiaries are more likely to use derivatives to manage foreign currency exposures”. Thus, we would expect to find that multinational life insurance firms, foreign-owned life insurers and those firms that sell life insurance products across international borders are likely to have a greater propensity to use derivatives than purely domestic life insurance firms.

4. Research design

We turn now to an empirical investigation of the determinants of derivatives use in the UK life insurance industry. Lack of appropriate data on the duration of assets and liabilities prevented us from including a suitable proxy for the mismatch of assets and liabilities among the explanatory variables.[6] Also, the proxy variable available to measure each company's taxation status (*i.e.* taxation divided by income after expenses) was highly insignificant in all regressions and so has been excluded from the model.[7] To examine the derivative choice decision in UK life insurers we first estimate a dummy dependent variable probit model, with firm size, leverage, reinsurance, organizational form and international links as independent variables. Second, to evaluate the extent of financial derivatives usage by UK life insurance firms, we estimate a Heckman two-stage selection regression model. We used the Heckman two-stage model because ordinary least squares (OLS) estimators do not satisfactorily control for the qualitative difference between the zero-limit observations and continuous data that characterize the financial measurement of our dependent variable (e.g., see Colquitt and Hoyt, p. 651).

Sample data of UK-based life insurance firms (n = 88) were obtained at random from the Thesys insurance company database for 1995. The data are based on insurers' statutory returns that are filed each year with the DTI (Form 13A)[8]. As Gallen and Kipling (1996) point out, these statutory filings require insurance firms to give details of derivative instruments used, including whether the derivatives are asset or liability-based contracts, their particular classification (*e.g.* options, futures) and whether they are fixed-income securities, equities, property or other derivative-type contracts. The financial derivatives are recorded at their year-end closed-out positions and valued, whenever possible, on a marked-to-market basis.

The *probit model* to be estimated, with *n* observations and *m* independent variables, may be written as:

$$d_j^* = b_0 + \sum_i b_i X_{ij} + e_j \qquad j = 1, . . . , n, \ \ i = 1, . . . , m.$$

where $b_0, b_1, . . . , b_m$ are the parameters to be estimated and e_j is a disturbance term assumed to be normally distributed with zero mean and a constant variance equal to one. The latent variable, d_j^*, is not observed: the observed dummy variable, d_j, is set equal to one for life insurance firms which use derivatives and equal to zero otherwise. In the model, d_j equals one when $d_j^* > 0$ and is zero otherwise.

The *Heckman two-stage model* to be estimated is expressed as:

$$D_j = g_0 + \sum_i g_i X_{ij} + g_m M_j + u_j \qquad j = 1, . . . , n, \ \ i = 1, . . . , m.$$

where D_j is the extent of derivatives use by life insurance firms, measured by the natural logarithm of the total notional value of all derivative contracts held at the end of the year, and M_j is the inverse Mills ratio derived from the probit model. The error term u_j is assumed to have an expected value of zero and a constant variance.

The independent variables (X_{ij}) are as follows:

Firm Size (X_{1j}): As in Cummins *et al* (1997), firm size was measured by the natural logarithm of total assets. The logarithmic transformation of the variable mitigates the risk that our results may be confounded by extreme values in the data set and helps to eliminate heteroskedasticity in the disturbances.

Leverage (X_{2j}): Leverage was proxied by the ratio of the total actuarial value of long-term liabilities to total assets. This enables comparable measures to be calculated for both mutual and stock life insurance firms.

Reinsurance (X_{3j}): Following Cummins *et el* (1997), the extent of reinsurance was measured by the ratio of ceded reinsurance premiums written for the year to total annual gross premiums written.

Organizational Form (*X_{4j}*): As in Adams (1996), organizational form is represented by a dummy variable, which is set equal to one for a stock life insurer and 0 for a mutual life insurer.

International Links (*X_{5j}*): To capture the effects of international links, a further dummy variable is included which is set equal to one for multinationals, foreign-owned firms and those firms that earn a majority proportion of their annual premiums from cross-border sales. The dummy variable is set equal to zero for purely domestic companies.

5. Results

Descriptive statistics and correlation coefficients

The means, standard deviations, and minimum and maximum values of the variables included in the study are shown in Table 1 for the 88 life insurance companies in the sample, with separate data given for users and non-users of derivatives. The table also shows a Pearson correlation coefficient matrix for these variables and the variance-inflation factors (VIFs) for the independent variables to test for multicollinearity. It can be seen from the table that 57 per cent of the sample used derivatives during 1995 and that the companies included in the sample varied substantially in the extent of their holdings of derivatives, their size, leverage and in their use of reinsurance. With respect to organizational form, 70 per cent of the sample firms were stock life insurers companies, with the other 30 per cent being mutuals. Also, 44 per cent of the firms in our sample had international links of various kinds, while the remaining 56 per cent were essentially domestic-only life insurance firms. On average, the users of derivatives in our sample were larger firms with slightly more leverage and less reinsurance compared with the non-users of derivatives. Also, as expected, a bigger proportion of the users of derivatives had international links (59 per cent, compared with just 24 per cent of the non-users), but a surprisingly large proportion of the non-users in the sample were stock companies (81 per cent, compared with just 63 per cent of the users).

TABLE 1

Descriptive Statistics, Correlation Coefficients and Variance-Inflation Factors

This table shows the means, standard deviations and maximum and minimum values of the variables used in the study for users and non-users of derivatives, together with a matrix of correlation coefficients and variance-inflation factors for the independent variables.

Descriptive statistics

	Mean	***Standard deviation***	***Minimum***	***Maximum***
Total sample				
Derivative dummy (Der)	*0.57*	*0.49*	*0*	*1*
Log of derivative use (Ld)	*8.75*	*1.83*	*2.94*	*12.28*
Log of assets (Las)	*13.49*	*2.76*	*5.58*	*17.45*
Leverage (Lev)	*0.88*	*0.13*	*0.14*	*1.04*
Reinsurance (Rein)	*0.12*	*0.17*	*0*	*0.83*
Organizational form (Org)	*0.70*	*0.46*	*0*	*1*
International links (Int)	*0.44*	*0.50*	*0*	*1*
Users of derivatives				
Log of assets	*15.06*	*1.20*	*12.84*	*17.45*
Leverage	*0.89*	*0.90*	*0.67*	*1.00*
Reinsurance	*0.09*	*0.12*	*0*	*0.52*
Organizational form	*0.63*	*0.49*	*0*	*1*
International links	*0.59*	*0.50*	*0*	*1*
Non-users of derivatives				
Log of assets	*11.31*	*2.83*	*5.58*	*16.00*
Leverage	*0.87*	*0.16*	*0.14*	*1.04*
Reinsurance	*0.16*	*0.23*	*0*	*0.83*
Organizational form	*0.81*	*0.40*	*0*	*1*
International links	*0.24*	*0.44*	*0*	*1*

Pearson correlation coefficient matrix

	Der	*Ld*	*Las*	*Lev*	*Rein*	*Org*
Las	*0.65***	*0.26***				
Lev	*0.17*	*-0.08*	*0.09*			
Rein	*-0.19**	*0.05*	*-0.24***	*-0.03*		
Org	*-0.21***	*0.23***	*-0.19**	*0.32***	*0.03*	
Int	*0.36***	*0.09*	*0.39***	*-0.02*	*-0.09*	*-0.07*

** Significantly different from zero at the 0.05 level (two-tailed test)
* Significantly different from zero at the 0.1 level (two-tailed test)

Variance-inflation factors

Las 1.32 Lev 1.14 Rein 1.06 Form 1.18 Int 1.19

The bivariate correlation coefficients indicate that, as expected, the derivatives use dummy variable is positively and significantly correlated with firm size and the international links dummy, both at the 0.05 level in two-tailed tests. The correlation with leverage is positive, but insignificant. There is also evidence of negative correlation between the derivatives use dummy and the extent of reinsurance (significant at the 0.1 level) and between the derivatives use dummy and the organizational form dummy (significant at the 0.05 level). The extent of derivatives use variable is positively correlated with firm size and the organizational form dummy, but is not significantly correlated with any other independent variable.

The correlation coefficients between pairs of independent variables are generally low (all less than 0.40), which suggests that problems with multicollinearity are unlikely. However, collinearity can be present between more than two independent variables: to test for this, we computed VIFs by regressing each independent variable in turn on all the others and then calculating $1/(1 - R^2)$, as recommended by Belsley *et al* (1980). All the calculated VIFs are less than 2, so we can be reasonably confident that multicollinearity is not a problem in this study.

Regression results

The 'derivatives use' equation was estimated as a univariate binomial probit model and a number of additional diagnostic statistics were calculated. The parameter estimates and test statistics which resulted from the estimation are shown in Table 2.

The estimated coefficients have expected signs, with the exception of b_4 (the coefficient of the organizational form dummy), which is negative. The estimates of b_0 (the intercept), b_1 (the coefficient of firm size), b_2 (the coefficient of leverage) and b_4 (the coefficient of organizational form) are all significantly different from zero at the 0.05 level (in one-tailed tests) and the estimates of b_3 and b_5 (the coefficients of reinsurance and the international links dummy) are significantly different from zero at the 0.1 level (in one-tailed tests).

Table 2
Regression Results

This table shows the probit parameter estimates for the derivatives use equation using data from a sample of 88 UK life insurance companies. A set of diagnostic statistics is also shown.

Parameter[1]	*Estimate*[2]	*t-value*
b_0	-14.26^{**}	-3.30
b_1	0.76^{**}	3.78
b_2	5.00^{**}	2.05
b_3	-1.85^{*}	-1.58
b_4	-0.83^{**}	-1.69
b_5	0.49^{*}	1.31

Test statistics

c^2 = 58.89 *(Reject hypothesis that all parameters are zero)*

Pseudo-R^2 = 0.87

LM test: c^2 = 6.72 *(Cannot reject hypothesis of homoskedasticity)*

Predicted and actual values of the dependent variable:

		Predicted		***Totals***
Actual		**0**	**1**	
	0	27	11	38
	1	7	43	50
Totals		34	54	88

Notes

1. ***b_0 is the constant; b_1 is the coefficient of the log of assets; b_2 is the coefficient of leverage; b_3 is the coefficient of reinsurance; b_4 is the coefficient of organizational form; b_5 is the coefficient of international links.***

2. ***** = significantly different from zero at the 0.05 level (one-tailed test).***
**** = significantly different from zero at the 0.1 level (one-tailed test).***

The test statistics include a χ^2 statistic for testing the null hypothesis that the regression coefficients (excluding the intercept) are all zero. The χ^2 value of 58.81 allows us to reject this hypothesis. A second χ^2 statistic is calculated in a Lagrange Multiplier (LM) test of homoskedasticity which compares the estimated model with an alternative model which allows for heteroskedasticity in the disturbances. The calculated χ^2 value of 6.72 (critical value = 11.1 at the 0.05 level) means that we cannot reject the hypothesis of homoskedasticity on this evidence. The pseudo-R^2 value, calculated using a formula suggested by Zavoina and McElvey (1975), is 0.87 which indicates a reasonably good fit.[9]

Finally, Table 2 gives a cross-tabulation of the actual and predicted values of the derivatives use dummy variable. It can be seen that the model correctly predicts the use or non-use of derivatives in 70 out of the 88 cases, with 43 out of the 50 users of derivatives correctly predicted.

Following the procedure of Colquitt and Hoyt (1997, p. 664), the extent of derivatives use equation was estimated using Heckman's two-stage procedure.[10] The parameter estimates and test statistics are summarised in Table 3. When all of the independent variables were included in the model (including the inverse Mills ratio from the probit model[11]), only two had t-values greater than one. A stepwise experimental procedure to eliminate insignificant variables was employed, therefore, and this resulted in four of the variables being excluded from the regression. Of the six independent variables included in the model, only firm size and organizational form have any significant influence on the extent of derivative holdings by the life insurance firms in our sample. In this model, the coefficient of determination is quite low (0.15), but the results of the LM test do not allow us to reject the hypothesis of homoskedasticity.

Implications of the results

We are now able to consider the implications of the regression results for the determination of derivatives use by UK life insurers.

Firm size In the probit model, the estimate of the coefficient of the logarithm of total assets (b_1) is positive, as expected, and statistically significant at the 0.05 level (one-tailed test). Thus, there is strong evidence to support the hypothesis that larger life insurance firms have a greater propensity to use derivatives than smaller life insurance firms. This may be because larger firms use hedging to mitigate their agency incentive conflicts, and/or because they can gain more from informational and/or scale economies. It is also likely that larger firms will be able to employ specialized personnel and so be able to ensure that " . . . those who have responsibility for the control of derivative instruments are sufficiently independent of the day-to-day operators to ensure effective control" (Department of Trade and Industry, 1996, Insurance Companies Regulations, Prudential Guidance Note, 1994/6, Annex C). Our finding of a positive link between the propensity to use derivatives and firm size is also consistent with the findings of previous US studies of the life insurance industry, such as Cummins *et al* (1997) and Colquitt and Hoyt (1997).

In the Heckman two-stage model (with the insignificant variables, including the inverse Mills ratio coefficient, excluded), the estimate of γ_1 is positive and significantly greater than zero at the 0.05 level. The estimate, equal to 0.49, represents the elasticity of derivative holdings with respect to firm size. As the estimate is less than one, it suggests that as derivatives-using firms grow, their holdings of derivatives also grow but at a slower rate. This may be because larger firms tend to employ a wider range of risk management techniques than smaller firms. For example, large life insurers may be better able to engage in corporate risk management by modifying their operating and financing strategies (Berkman and Bradbury, 1996).

Table 3

Heckman Two-Stage Regression Results

This table shows the Heckman parameter estimates for the derivatives use equation using data from a sample of 88 UK life insurance companies. A set of diagnostic statistics is also shown.

Parameter[1]	*Estimate*[2]	*t-value*[3]	*Estimate*	*t-value*
g_0	-5.12	-0.34	0.66	0.16
g_1	0.79	1.05	0.49**	1.89
g_2	1.02	0.23	-	-
g_3	-0.35	-0.02	-	-
g_4	0.90	1.17	1.09**	2.08
g_5	0.20	0.32	-	-
g_m	1.38	0.53	-	-

Test statistics

Mean of dependent variable:	8.75	
S.d. of dependent variable:	*1.83*	
Standard error of regression:	*1.72*	
LM test:		*2.16*
F statistic:	*4.99*	
R-squared:	*0.15*	

Notes

1. ***g_0 is the constant; g_1 is the coefficient of the log of assets; g_2 is the coefficient of leverage; g_3 is the coefficient of reinsurance; g_4 is the coefficient of organizational form; g_5 is the coefficient of international links; g_m is the coefficient of the inverse Mills ratio.***

2. ***** = significantly different from zero at the 0.05 level (one-tailed test).***
**** = significantly different from zero at the 0.1 level (one-tailed test).***

3. ***All standard errors of the estimates are heteroskedastic-consistent.***

Risk of insolvency Two variables were included as proxies for the risk of insolvency: leverage and reinsurance. If hedging against risk were the main motive for derivatives use by life insurance firms, we would expect to find a positive relation between the propensity to use derivatives and leverage and a negative relation between the propensity to use derivatives and the extent of reinsurance.

In the probit model, the estimate of the coefficient of leverage (b_2) is indeed positive and significant at the 0.05 level (one-tailed test). This result is consistent with the findings of Colquitt and Hoyt (1997) and supports the view that life insurance firms with higher leverage, and therefore a higher probability of bankruptcy, will have a greater propensity to hedge. Furthermore, the use of financial derivatives could enable highly leveraged life insurers to maximize firm value by writing new business without altering the level of assumed financial risk for existing policyholders. Indeed, Staking and Babbel (1995, p. 698) point out that in some jurisdictions, such as some states in the US, insurance ". . . cannot be underwritten unless the insurer obtains a minimum grade from one of the rating agencies. If such business is valuable, hedging will be undertaken . . .". In the probit model, the estimate of the coefficient of reinsurance (b_3) also has its expected sign (negative), but can only be regarded as significant at the 0.1 level in a one-tailed test. Thus, we have some evidence to support the findings of Cummins *et al.*'s (1997) analysis from the US property-casualty insurance industry that there is a substitutive relation between derivatives use and the extent of reinsurance in life insurance firms. Nonetheless, our results are contrary to those reported by Cummins *et al. (1997)* and Colquitt and Hoyt (1997) in the US life insurance industry where a complementary relation between the propensity to use financial derivatives and the amount of reinsurance was found.

Furthermore, in the Heckman two-stage model, neither leverage nor reinsurance has a significant influence on the extent of derivative holdings. Thus, although these variables influence the *decision* to hold derivatives, they have little or no effect on the value of derivatives held in our sample.

Organizational form The estimate of the coefficient of the organizational form dummy variable (b_4) is negative in the probit model, so our expectation that stock life insurance firms would have a greater propensity to use derivatives more than mutuals is not supported. However, the alternative views, expressed by Kleffner and Doherty (1996) and Ralfe (1996), which suggest that mutual life insurance companies will have a greater propensity to use hedging instruments, does receive some support from our results: the coefficient estimate is significantly less than zero at the 0.05 level in a one-tailed test. This is a result, therefore, that lends support to the view, such as that expressed by Colquitt and Hoyt (1997), that the managers in mutuals tend to be more risk-averse and, given their lack of equity capital to help them deal with adverse economic conditions, will have a stronger inclination than stock insurance firms to use derivative instruments as part of their risk management strategies.

Apparently contrary to our results, however, Colquitt and Hoyt (1997) found a positive relation between the propensity to hedge and an organizational form dummy for US life insurers, although in the same model they found a negative relation between the propensity to hedge and an interaction term, defined as the product of firm size and the organizational form dummy. They concluded (p. 663) that this supported the view, expressed originally in Mayers and Smith (1981), that " . . . as stock firms become large, they tend to behave more like mutuals" (p. 18).[12] However, when we included the same interaction term in our model, it proved to be insignificant, with a t-value of -0.3.

In the Heckman two-stage model, the estimate of the coefficient of the organizational form dummy variable is positive and significant at the 0.05 level. This suggests that, of those life insurance firms in our sample which held derivatives, the stock firms tend to have larger holdings than mutuals.

To investigate further the link between derivatives use and organizational form, two chi-squared independence tests were conducted. In a test of independence between organizational form (mutual or stock) and use or non-use of derivatives, a chi-squared value of 11.2 was calculated. As the critical value is 3.84 at the 0.05 level of significance, we can reject the hypothesis of independence. Only 26.9 per cent of the mutual companies in the sample were non-users, compared with 58.1 per cent of stock companies, so this result suggests that the mutual life insurance companies in our sample have a greater propensity to use derivative instruments than the stock life insurance companies (a result supported by the probit regression results). The second chi-squared test investigated a possible link between the organizational form of the companies that used derivatives and the types of derivative instruments used (futures, options or ‘other’ forms). The calculated chi-squared value of 0.23 (with a critical value of 5.98) suggests that no such link exists.

International links As expected, in the probit model, the coefficient of the international links dummy variable is positive, but only significant at the 0.1 level in a one-tailed test. This provides some support for the view expressed by Joseph and Hewins (1997) that multinational life insurance firms, foreign-owned firms and those with cross-border life insurance sales are more likely to use derivative instruments than purely domestic life insurance firms. However, in the Heckman two-stage model, the international links dummy does not have a significant influence on the extent of derivative holdings in our sample. This finding is consistent with that of Berkman and Bradbury (1996) in their study of derivatives use in the New Zealand corporate sector.

6. Conclusions

In this study, we have investigated the determinants of derivatives use and the financial extent of that use by UK life insurers. Drawing on modern corporate finance theory and similar recent studies relating to the US insurance industry, we first discussed the possible relation between the use of derivative instruments and a number of firm-specific characteristics: firm size, leverage, asset-liability mismatch, reinsurance, organizational form, taxation status and international links. In the empirical study, we included five of these as explanatory variables in both a probit and a Heckman two-stage model. Consistent with our prior expectations, the results of the probit regression, suggest that the propensity to use derivatives is positively influenced by a firm’s size, leverage and international links, and negatively influenced by the extent of reinsurance. The inverse relation between the propensity to use derivatives and reinsurance was contrary to that reported in the US life insurance industry by Cummins *et al*. (1997) and Colquitt and Hoyt (1997). We also found that mutual life insurance firms have a greater propensity to use derivatives than stock life insurance firms, a finding which is again different to that observed in US-based studies (*e.g.* Cummins *et al*, 1997). The positive link with leverage and the negative link with reinsurance lend support to the hypothesis that UK life insurers use derivative instruments as part of a risk management strategy, rather than as a speculative means of income generation. A further implication of our results is that if ‘capital-poor’ mutual life insurance companies in the UK are using derivatives as a substitute for capital, then this may call for tighter external monitoring of the systems of internal control in these firms.

The results of the Heckman two-stage regression suggest that the extent of derivatives use is positively related to firm size (though with an elasticity less than one), and that stock life insurance firms (that use derivatives) have larger holdings of derivatives than mutual firms. But we found no significant relation between the extent of derivative holdings and leverage, reinsurance or the international links dummy variable.

Data limitations forced us to exclude two possible independent variables from the model. Finding appropriate measures of the mismatch between asset and liability duration and the taxation status of UK life insurers, and then including them in a ‘derivatives use’ regression model, would be an interesting future research project. A further possible limitation of the study is that the data used cover only a single year and may therefore be affected by short-term fluctuations in derivatives usage. As more data becomes available, a panel data study of derivatives use may provide more robust evidence. In spite of these omissions, we feel that the evidence reported here provides some useful insights into the determination of derivatives use in the UK life insurance industry, which will hopefully inspire other researchers to investigate the topic further.

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End-notes

[1] Wilson and Hollman (1996, p. 252) report that derivatives are ". . . financial arrangements whose value is linked to, or derived from, the change in value of some underlying security, commodity, index, rate or other financial measure or asset".

[2] A future is a forward contract that is traded on an exchange and which commits the holder to buy or sell an asset at a specific price at some future date. An option is a contract that gives the buyer the right to buy or sell an asset at a given price on or before a specified date. A swap is a contract by which the parties exchange cash flows that are linked to a liability or asset. Commonly, swaps include interest rate and currency contracts. Currency swaps involve the exchange of the principal sum as well as income streams. Additionally, the swap market is over-the-counter and not exchange-traded. A problem with valuing derivative positions is that over-the-counter contracts have no observable market values and are sometimes therefore 'valued' at exercise price or nominal value. This may considerably overestimate the likely settlement of differences. Similarly, the value of an option contract is much less than its exercise price, but the latter may be used for putting a 'value' on option positions, especially for over-the-counter contracts. This problem should be borne in mind in interpreting the derivative values for the USA and the UK quoted in the paper.

[3] Although the UK's Insurance Companies (Amendment) Regulations (1994) require greater disclosure of derivatives use for solvency monitoring purposes, there are no explicit restrictions on the use of derivatives for income enhancement. However, the 1994 regulations do attempt to reduce opportunities for the speculative use of derivatives by insurance firms. As mentioned in section 2, the use of appointed actuaries to monitor and report on the financial condition of UK life insurers each year is one corporate governance mechanism that aims to alleviate the risk of speculation through financial derivatives.

4 Another possible reason for a positive link between the use of derivatives and firm size is that large firms are likely to have a comparative advantage in the fixed rate market, but are likely to have a fair proportion of floating rate sensitive assets. They can use their comparative advantage by borrowing fixed and swapping some of this into floating rate debt.

[5] In general, policyholders are not only less diversified than shareholders but they are also tied-in to policies by prohibitive surrender terms. As a result, policyholders " . . . cannot cancel past coverages and obtain refunds if they perceive that the riskiness of the insurer is increasing . . .". (Staking and Babbel, 1995, p. 692). Thus, the insured is inhibited from effectively controlling for a reduction in insurer quality by canceling the insurance policy in the way that a depositor could withdraw or sell his/her investments

in a company.

6 The data available from the insurance companies' DTI annual returns do not permit the average duration of assets and liabilities to be estimated. Measuring the asset-liability mismatch by taking the difference between long-term assets and long-term liabilities (scaled by total assets), as used by Colquitt and Hoyt (1997), does not in our view provide a satisfactory proxy variable. This is because the accounting values of assets/liabilities reported by UK life insurers in the DTI resturns do not always enable one to determine the mix of assets/liabilities of various duration that are held by such firms. In any case, such a measure would be very similar to our leverage proxy.

7 Other prior US-based insurance industry studies, such as Colquitt and Hoyt (1997) and Cummins *et al* (1997), also report that the taxation variable does not explain derivatives use by firms. It is possible that the unique taxation base used in the insurance industry could be confounding the empirical results. Santomero (1995, p. 4) adds that to the extent that ". . . significant discretion exists in tax reporting, tax considerations may not motivate actual decision-making (on hedging) nearly as much as . . . theory suggests".

8 The Thesys database is not comprehensive. For example, it excludes insurers which are no longer writing new business due to solvency problems. Our sample (n = 88) represents roughly one-third of the total number of UK-registered life insurance firms (N = 270 approx.). Our data also excludes friendly societies, reinsurers and pensions funds as they do not write much direct life insurance business.

9 Zavoina and McElvey (1975) suggest the following pseudo-R^2 measure for the probit model:

$$R^2 = \frac{\text{var}\left(y_f\right)}{1+\text{var}\left(y_f\right)}$$

where $y_f = E[y^*½y]$.

10 A tobit regression would be an alternative to the Heckman two-stage procedure. However, when we ran a tobit regression, the results were not substantially different from those obtained from the Heckman method and so are not reported. In addition, in Colquitt and Hoyt (1997), the estimates of the bias parameters obtained from the Heckman two-stage regression were not significant, so that their derivatives use models were actually estimated by ordinary least squares.

11 The inverse Mills ratio is the expectation of the residual obtained from estimating the probit model.

11 As a result of the accumulation of reserves over many years, several mutuals operating in established insurance markets, such as the UK and the US, are

large firms. For example, the UK’s second largest life insurer, Standard Life, is a mutual form of organization with approximately £25 billion of assets in 1994.