PRICING OF INSURANCE RISK

1998 GENERAL INSURANCE CONVENTION
AND
ASTIN COLLOQUIUM

GLASGOW, SCOTLAND: 7-10 OCTOBER 1998

Contents

1. Introduction and Summary

1.1 *Introduction*

This paper develops an approach and presents some evidence as to the pricing of life and property/casualty reinsurance treaties allowing for risk. A key aspect of the study was to see whether the empirical and theoretical findings of modern financial theory apply to reinsurance pricing.

1.2 *Summary of Results*

Given the nature of reinsurance business, the main topic considered relates to the assessment of the return required to cover risks accepted.

The results may be briefly summarised as follows:

- Premiums charged can and should cover and allow for a number of elements of cost, including obvious costs such as for expected claims and expenses, as well as capital costs, and charges to reflect the various risks which are incurred.
- Modern portfolio theory draws a major distinction between risks which are systematic, that is are related to economy-wide factors of major concern to investors and consumers, and other risks which are more random in character. A substantial charge may be required for bearing systematic risk whereas only a modest premium, or no premium at all, is needed for unsystematic factors.
- The results of the various analyses summarised in this paper generally support the findings of modern portfolio theory - the premium required for bearing non systematic reinsurance claims risk ("insurance" or "reinsurance" risk) is relatively small compared with prior expectations - no more than say 1½% of premiums charged for a typical reinsurance product line. Also consistent with the results would be a 0% insurance risk charge, as suggested by standard CAPM.
- The argument for little or no premium for insurance and other risk factors is enhanced because risk is often shared with the insured. A large loss is often followed by substantial premium increases, leading to no net loss for shareholders.
- For property catastrophe reinsurance, the total appraisal value of the reinsurer is potentially at risk and an additional premium may be required to cover bankruptcy costs.

- The analyses set out support the application of fairly substantial charges for the use of capital and to cover a number of risk factors. These risks are sales risk (the risk that even if claims levels were known with certainty, profitability would vary according to the stage of the business or underwriting cycle) and inflation risk (because claim payments are often expressed in real rather than nominal monetary terms).
- Within the overall framework, individual treaties can have more or less risk than typical for their line of business, and a framework for rating to allow for these individual risks is recommended.

A discussion of inflation risk is set out in section 2.3; sales risk is discussed further in section 3.1; the cost of capital is considered in detail in sections 2.5 and 4.3.

The pricing formula suggested is:

P = $C1 + E + (C + S + R \times R1 \times R2 \times R3 \times R4)/(1-t)$ where

P   is the minimum premium required for the treaty

C1   is the present value of expected future claims under the treaty, assessed using the risk-free rate. It also includes expected losses in total company shareholder value arising from any catastrophe loss experience as discussed in section 8.

E   is the level of marginal expenses and commissions under the treaty

C   is a charge for the use of capital, assessed as 1% of the amount of capital employed, for business written in the UK

S   is the charge required for sales risk, taken as 1% of premiums written

R   is a charge for insurance risk, assessed as in between 0% and 1% of premiums for each 20% standard deviation in operating ratio for the line of business

R1   are individual treaty risk factors, each set at 0.5, 1.0 or 2.0 depending on

to R4   whether the treaty has a low, medium or high risk level compared with typical levels for the line of business. The risk factors are described in section 3.

t   is the rate of corporation tax, 31%.

In practice, in the absence of a model which demonstrates the marginal impact of individual treaty risk on capital requirements, factors R1 to R4 could also be applied to C, the cost of capital. In the formula, it has been assumed that insurance risk is unsystematic (not correlated to economy wide factors); a higher risk charge may be required for lines of business for which claims costs are correlated to economy wide factors.

114

For life business the result of applying the above formula will typically result in a need to charge minimum premiums such that pre-tax profitability is equal to 1.7% of the value of future premiums. This is based on using a discount rate equal to 1% pa higher than the yield on long-term government bonds.

2. *The Risk Return Relationship*

This section examines the relationship between risk and return, and explores the non-insurance specific aspects of risk, and the returns required from bearing different types of risk.

The conclusions reached in this section are:

(i)   Property/casualty business is probably subject to systematic risk, as evidenced by the existence of an underwriting cycle, with expected losses varying over time ("sales risk")

(ii) To the extent that claim payments are not associated with economy-wide systematic risk factors they should be valued using a risk free rate of interest. This conclusion is modified if a premium is required for unsystematic risk as in (iii)

(iii) A first indication is that the reward required for carrying unsystematic risk is no more than 0.05% of additional premium for each 1% of standard deviation in the operating ratio for any given line of business.

2.1   *Systematic Risk*

Markowitz noted in 1952 that diversified portfolio investors, when deciding whether to invest in a share, are interested primarily in the contribution that the share will make to the overall risk of their portfolio rather than riskiness of the share taken in isolation. Only the systematic component of risk is of concern - under the standard Capital Asset Pricing Model (CAPM) this is measured by beta or the responsiveness to common market or economy wide factors. For example, the probability and expected cost of a flood at an industrial plant should be taken into account in the future cash flows, which are used to value a company. However, flood risk is likely to be uncorrelated to economy wide factors and consequently should not affect the choice of discount rate used in valuing the cash flows. The contribution to risk made by unsystematic risk (such as of flooding) diminishes rapidly towards zero as the number of shares in a portfolio increases, to the extent that this risk is not correlated to the main (systematic) risk factors.

To the extent that a company prices its products to provide a margin in respect of unsystematic risk, a portfolio investor will achieve superior portfolio risk adjusted returns in respect of that company's shares. This superior return results in fresh capital being drawn to the industry, driving product prices down towards the level at which unsystematic risk is not rewarded. The theory has stood the test of time and has important ramifications for pricing and valuation. As noted in section 2.4, standard CAPM is not exactly true and an element of reward for unsystematic may be appropriate.

2.2 *Reward for Systematic Risk*

A standard finding, based on research using data over many decades in many countries is that the expected return on equities is some 5% pa higher than the risk-free rate, typically measured by the return on treasury bill investments. The standard deviation of equity portfolio returns is of the order of 15% pa.

In broad terms, each 1% pa of systematic standard deviation risk borne corresponds to an additional return requirement of 0.3% pa (= 5/15).

Systematic risk factors which have been identified as possibly contributing to an additional return requirement include stock market levels, the real rate of interest, inflation, GDP and consumption growth, and the difference between high and low grade corporate bond yields.

It is important to note here that investment in insurance company shares does carry significant systematic risk, if shareholders' capital is invested primarily in stocks and bonds rather than treasury bills, and if there is a component of goodwill value correlated with the business cycle. The underwriting cycle is likely to be related to the economy wide business cycle (and therefore connected with systematic risk). Expected loss and expense ratios at point of sale may vary with the cycle ("sales risk") and subsequent claims ratios may also vary. This issue of whether the underlying insurance business cycle carries systematic risk is explored further in section 8.

Given the high variability of property/casualty returns, even a relatively small correlation with economy wide factors could result in a significant risk return requirement for this business.

How should systematic risk be incorporated into premium charged? As discussed in section 3.1, to the extent that expected loss and expense ratios at point of sale vary with the business cycle, a (positive or negative) profit margin should be built in to reflect systematic sales risk. If, for example, claims ratios subsequently increase during recessions, (negative systematic risk) a low discount rate should be used to value claim payments. The systematic risk is negative because whereas equity prices typically decline prior to a recession, claims may increase. The use of a low discount rate results in an increase in the estimate of the value of future claim payments, and lower shareholder value.

2.3 *Inflation Risk and the Risk-Free Rate*

Even if other systematic risk factors are relatively small, inflation risk may be pertinent.

There is some evidence for the existence of a positive term premium, i.e. that the yield on long term bonds exceeds the expected return on treasury bills. A typical assumption is for the term premium to equal approximately 1% pa. It is possible that the term premium is associated with inflation risk.

This is because in contrast to long-term bonds, treasury bills are not subject to inflation risk (the market price is broadly unaffected by changes in expected inflation).

To the extent that systematic risk is very small, and claim payments increase in line with inflation, they need to be discounted using the expected treasury bill rate rather than the yield on long-term bonds, that is at say 1% pa less than the long-term bond yield. This is because the appropriate asset strategy for minimising risk is the use of index-linked bonds or treasury bills, rather than long-term bonds denominated in nominal terms. Use of this strategy reduces the risk that an increase in inflationary expectations will result in an increase in claims with no corresponding increase in asset value.

The adjustment required to allow for unsystematic risk is considered next.

2.4 *Reward for Unsystematic Risk*

In practice, empirical and theoretical work in relation to CAPM supports the use of a small premium to cover the unsystematic component of equity returns. Under the zero beta version of CAPM, the implied return on an asset with zero beta (zero systematic risk) is computed. There is some, limited, evidence that zero beta assets would provide returns of the order of 1% pa higher than that of a risk-free Treasury bill. Since the level of unsystematic risk in any individual share corresponds to a standard deviation of the order of 20% pa, one possible interpretation is that the reward required for each 1% pa of unsystematic standard deviation risk is an additional return of 0.05% pa. With this interpretation, the reward required for a line of property/casualty business with operating ratio standard deviation of 10% would be 0.5% of written premiums (since the operating ratio is expressed as a proportion of premiums and is typically of the order of 100%). Although these results are before tax, for ease of presentation this paper assumes that the premium is an after-tax amount.

2.5 *Capital, Cost of Capital and Risk*

When factors such as tax and management efficiency are disregarded, holding additional capital has no associated cost to shareholders. For example, in the derivatives markets, traded option writers are required to put up sufficient capital to ensure that they will meet their potential obligations. Within reasonable limits, the amount of capital ("margin") required does not influence the option price. For an insurer this strict parallel does not apply, and capital costs in practice are discussed further in section 4.3.

Once the cost of capital has been established, appraisal values can be computed for alternative levels of capitalisation to establish optimal capital levels. The marginal additional level of capital required to write any particular line of business could also be established. To the extent that a company chooses to hold in excess of marginal requirements, there is an apportionment issue (as there is with overhead costs) which, however, need not impact on decision-making.

3. Risk Factors and Pricing Methodology

There are a variety of risks involved with the decision to sell insurance business and with the acceptance of an insurance contract. Once these have been assessed the minimum price required for any given treaty could be gauged.

The conclusions from this section are that:

- A methodology should be developed to gauge the present values of future premium and claim payments, so that individual treaties can be priced.
- Premiums should be set to at least cover sales risk, the cost of capital and insurance risk.
- The insurance risk charge should be set on a line of business basis and adjusted according to whether the individual risk factors R1 to R4, discussed below, for a particular treaty are favourable or unfavourable.
- In practice, premiums will be set in accordance with market conditions from time to time, with excess profit targeted at cycle peaks and non recovery of overhead costs during cycle troughs.

Insurance risk and the cost of capital are considered further in the remaining sections of this paper.

The key to a successful business is accurate estimation and appropriate decision making in regard to factors such as pricing trends relative to competitor behaviour, claims costs, allocation of expenses between marginal versus overhead and between the different aspects of a company's activities, and allowing for adverse selection. The methodology outlined here is not a substitute for implementation of an economic value added framework to allow for these high level issues.

3.1 *Sale of Insurance Business*

In order to establish an insurance company and generate future profitable sales, investment is needed to create the required infrastructure and to generate reputation and market share. This investment is subject to risk because future profit may not be generated. In other words, it does not suffice to compensate shareholders for insurance risk borne; sales risk also needs to be covered by means of specific profit objectives. Under CAPM, if expected profit at the point of sale varies according to economy wide factors, the systematic component of this variability needs to be rewarded. For the sake of illustration, it is assumed here that sales risk has an associated cost of 1% of premiums written (post tax).

3.2 *Direct Insurance Risk Factors*

Risks faced when an insurance contract is accepted include:

- *Individual Policy Random Claim Amount and Frequency Fluctuations (Factor D1)*

Typically, the standard deviation of the claims distributions for any particular policy is extremely high. A modest charge for individual policy random (that is, unsystematic) risk could be considered, although the primary focus is more properly at the line of business level and charging for the contribution to line of business risk. To the extent that policy risk is correlated with line of business risk, a greater emphasis should be placed on individual policy risk.

- *Anti Selection (Factor D2)*

Although the expected claims cost calculation will allow for a normal level of adverse selection, a higher charge is appropriate if a policy carries a higher adverse selection risk. In principle, a range of likely expected costs could be calculated for alternative rating factors and a higher premium charged for policies with a higher maximum expected loss.

- *Uncertainty in Claim Distribution Parameters (Factor D3)*

The parameters of the individual policy claim amount and frequency distributions are not known with certainty. A charge could be applied dependent on the differences, between the upper bounds and most likely levels, of the mean and maximum of the claim amount and claim frequency distributions.

- *Deterioration in Claims Distribution Parameters over Time (Factor D4)*

A level of assumed improvement or deterioration will be built into the premium calculation but a loading could be applied for volatility in this trend, and for the possibility that line of business experience could be significantly worse than expected.

These risk factors need to be considered not just in computing the mean or mode of the underlying distributions. They also need to be considered when determining what profit loading should be applied to cover risk.

There is a trade-off between the cost of obtaining and processing information and the degree of rating accuracy obtained. A pragmatic approach is required when selecting which of the risk factors D1 to D4 are to be taken into account for any particular policy to be priced.

3.3 *Reinsurance Risk Pricing*

Risk factors for reinsurance business can be classified into the same four categories as for direct business. The corresponding factors for reinsurance are R1 to R4.

Often, the standard deviations of the claims amount and frequency for an individual treaty (Factor R1) will be much less than for an individual direct policy, but higher than for the particular line of business to which the treaty relates. In the absence of detailed treaty by treaty data, it is not possible to accurately set a value for each of the risk factors R1 to R4. However, a realistic approach to pricing would be as follows:

•   *Assess expected value of claims costs*

In the absence of systematic risk, the present value of best estimate claims costs should be obtained by discounting using the risk-free rate, for example 1% pa less than the government bond yield. So, if Dutch long-term bonds are yielding 6% pa, claim payments under a Dutch treaty would be discounted using a 5% pa rate (1% pa lower because of the existence of a term premium). Claim payments should be projected allowing for best estimate patterns of payment, for inflation (using the risk-free rate less say 3% pa to allow for real rates of interest) and for claims cost escalation (the rate at which claims costs increase faster than the rate of consumer price inflation). To the extent that patterns are similar for all treaties within a line of business, some rules of thumb could be established in place of making a detailed projection for each treaty quotation. For non-symmetric distributions, for example if claims in excess of a specified amount are to be paid, the best estimate needs to take account of the shape of the distribution.

If there is some evidence that claims increase during recessionary periods, that is claims are subject to negative systematic risk, a lower rate of discount should be used.

The potential cost of any additional loss in shareholder value arising in the event of an accumulation of catastrophe losses should also be included, as discussed in section 8.

It should be noted that the "expected value" of the claims costs is not an "economic value" since the latter will also reflect the additional risk adjustment discussed below.

•   *Assess value of premiums, expenses and other costs*

The expected value of all other cash flows including marginal head office expenses need to be assessed. If a proportion of the assets backing the claims reserves are non-interest bearing, an adjustment should be made, for example by discounting the claims payments using a lower rate of interest. Since liabilities need to be assessed accurately and appropriately, this adjustment should only be made to claims payments (as distinct from shareholder assets) if the non-interest bearing assets relate to the reinsurance treaties in force.

- *Assess risk factors*

To take a pragmatic approach, individual treaty risk factors R1 to R4 could, for example, be classified into three categories "low", "medium", or "high" relative to the typical level for treaties accepted for that line of business. A value of 1 would be assigned to each of the four factors for a treaty, which was deemed to possess a typical level of each risk factor for its class. A low risk rating can be assigned the value 0.5 and a high relative risk rating is assigned 2.0. These values are at present arbitrarily set, pending a closer examination of the relative risk/return tradeoffs for various classes of business.

- *Assess insurance profit target*

Let the risk reward required for a particular line of business be equal to r, expressed as a proportion of premiums written, P. For example, r could equal 1% of premiums. The charge for any individual treaty is then $R = R1 \times R2 \times R3 \times R4 \times r \times P$, where each of R1 to R4 have values 0.5, 1.0 or 2.0 as discussed above.

3.4 *Premium Requirement*

The premium quoted should be not less than:

P	=	$Cl + E + (C + S + R)/(1 - t)$, where
Cl	=	present value of future expected claims
E	=	marginal expense, commission or other costs
C	=	cost of capital, depending on the minimum marginal amount of capital allocated to the treaty
S	=	profit required to cover sales risk
R	=	risk charge as discussed above
t	=	rate of corporation tax.

123

4. Historic Profitability in the UK

In this section the historic profitability of the UK direct property/casualty market by line of business is examined, in order to provide an indication of the profit required to compensate for insurance risk.

The preliminary conclusion reached is that insurance risks and sales risks together require a premium loading of no more than 1½%. Within this, the premium required for insurance risk is gauged at no more than ½% of premiums written, compared with a standard deviation in operating ratios of approximately 10% as noted in section 4.4. It is not possible to assess a lower bound since the nature of the relationship between insurer/insured in the direct market could allow for an element of profit to reflect lack of knowledge or other factors on the part of the insured.

4.1 *Calendar Year Combined Ratios*

The following table sets out approximate historic profitability for the UK by line of business, for the eighteen-year period from 1976 (including estimated profitability for 1993).

Approximate Historic Profitability and Risk 1976 - 1993

	Combined Ratio[*] %	Business Mix (1991) %	Post Tax Insurance Profit %	Standard Deviation of Combined Ratio %
Property Damage	105	33	0	6
Motor Vehicle	108	31	1½	6
General Liability	120	7	2	8½
Accident and Health	96	12	4	2
Pecuniary Loss	n/a	8	n/a	n/a
MAT	n/a	9	n/a	n/a
Total	107	100	1½	5

[*]   ABI statistics.

Post tax insurance profit was calculated assuming an interest yield of 10% pa and assuming a tax rate of 35%.

For motor vehicle, the underwriting loss over the period 1960 to 1993 based on ABI statistics was 5%, leading to a post tax insurance profit of 2% assuming an interest yield of 8½% for this period.

4.2 *Analysis of Results*

Reserve strengthening is not likely to have materially affected the calendar year results for the property damage and motor lines. However, for general liability, reserve strengthening in the years 1989 to 1992 was substantial - of the order of 15% of premiums in each of 1991 and 1992. If it is assumed that this class has been affected by unanticipated reserve strengthening of 50% during the 18 year period, the average combined ratio would have been 117.5% rather than 120.3% and the post tax insurance profit would have been approximately 3½% of premiums. For the industry as a whole, reserve strengthening is unlikely to have been a significant factor overall.

Rating is free of regulatory constraints in the UK and so this is not a feature that is likely to have distorted results. Property insurance was subject to a tariff system up to the early 1970s but not during the period analysed. However, this class was subject to a number of adverse catastrophe losses, in 1982, 1987 and in 1990/91. It is possible that profitability for the period analysed is below (or above) equilibrium levels. Accident and health business is subject to somewhat limited competitive pressures and the results for this class may not provide a reliable indicator of required profitability.

The pecuniary loss line showed exceptionally large losses for the period since 1990. It is not clear what level of underlying profitability may be appropriate for this line.

Insurance after-tax profit ratios of 2% of premiums, (3½% for general liability), are broadly consistent with the following "equilibrium" combined ratios, based on expected risk-free rates of interest in the future of 7% pa, and a tax rate of 31% and historic claim payment patterns.

Equilibrium Combined Ratios

	Post Tax Insurance Profit %	Equilibrium Combined Ratio %
Property Damage	2	100
Motor Vehicle	2	104
General Liability	3½	110
Accident and Health	2	101
Pecuniary Loss	2	n/a
MAT	2	n/a
Total	2	102

A part of the insurance profit requirement may be attributable to the cost of capital rather than insurance risk or other factors and this is considered next.

4.3 *Cost of Capital*

Leaving aside the question of insurance and sales risk, the holding of capital may result in tax, expense or other costs to shareholders. The 'other' category results from the risk that spare capital will be used inefficiently, for example by an aggressive drive for market share. Investment management expenses are assumed to be included within the combined ratio.

For capital up to the level of the minimum required by the market to write insurance business, there is generally no question of inefficient use. The capital is typically invested in traded securities expected to achieve an investment return commensurate with their risk. Cost relative to the earned rate results from tax treatment.

It may be useful to describe in general terms how investment income and gains are taxed in the UK. Dividends from UK equity shares are paid net. A typical basic rate investor pays no further tax on the dividend he receives, and also pays no tax on the capital growth of his equity holdings, because of personal tax exemptions and also the indexation allowance. A pension fund investor also pays no tax on capital growth or on the net dividends received. For an insurance company investor, income and gains covered by insurance losses are not taxed. Income and gains representing shareholder' profit are fully taxed. Investment income and gains other than UK dividend income are taxed at 31%; tax credits on the UK dividend income are not recoverable.

For both the pension fund and the basic rate taxpayer, the treatment of dividends received by the insurance company and paid out in the form of dividends is tax neutral. For every 80 of net dividend (corresponding to a gross dividend of 100) received by the insurer, the net dividend received by the pension fund investor is 80 and by the basic rate taxpayer is also 80, just as for direct investments. In respect of capital gains on the underlying investment, the insurance company is assumed here to retain this capital gain for the purpose of financing future growth in business volumes. For 100 of capital gain, the insurer pays 31 of tax; no further tax is paid by either the pension fund or the basic rate taxpayer.

The tax effect of holding UK equities within an insurance company rather than via direct investment is illustrated in the following table. The equity dividend yield is assumed to equal 3% pa and capital growth is projected at 9% pa.

Tax Cost of Holding Equities in an Insurance Company

	Direct Investment		Insurance Company Holding	
	Pension Fund Investor % pa	Basic Rate Tax Payer % pa	Pension Fund Investor % pa	Basic Rate Tax Payer % pa
Dividend Yield	2.4	2.4	2.4	2.4
Capital Growth	9.0	9.0	6.2	6.2
Total	11.4	11.4	8.6	8.6

In the example, returns on an equity investment held via an insurance company are nearly 3% lower than on equities held directly, both for the pension fund and basic rate taxpayer investors. However, equity risk is also reduced since the effect of a fall in market prices will be offset by a reduction in capital gains tax paid by the insurer. If the equity risk premium is 6% pa relative to treasury bills, the after tax risk premium is reduced by 2% pa to 4% pa. The net effect is a cost of capital of approximately 1% pa, that is the difference between the 3% pa tax cost of indirect investment and the 2% pa reduction in the risk premium required because of the effect of capital gains tax on equity risk. In terms of value a 1% pa cost is equivalent to valuing solvency capital at approximately 75% of market value. For example, using a dividend growth model, the value of a direct holding in equities for a pension fund investor is 3/(0.12 - .09) = 100 whereas an indirect holding is worth 3/(0.10 - .06) = 75. The numerator is the dividend yield and the divisor is the discount rate requirement less future net capital growth. The discount rate requirement is 12% for the direct holding and only 10% for the indirect holding because, for the latter, the impact of capital gains tax reduces investment risk, as outlined at the beginning of this paragraph.

The tax effect of holding fixed interest assets within an insurance company rather than via direct investment can be illustrated as follows:

Tax Cost of Holding Gilts in an Insurance Company

	Direct Investment		Insurance Company Holding	
	Pension Fund Investor % pa	Basic Rate Taxpayer % pa	Pension Fund Investor % pa	Basic Rate Taxpayer % pa
Investment income	6.0	4.5	4.1	4.1

The basic rate taxpayer pays 25% tax on the income leading to a net yield of 4.5% on a direct holding. For the indirect holding, the insurance company pays 31% tax on 6%, leading to a net dividend payment of 4.1%.

From the table, it can be seen that returns on a gilt held via an insurance company are between 0.4% and 1.9%pa lower than on gilts held directly. This cost is equivalent to valuing solvency capital at between 70% and 90% of market value.

For capital held in excess of the minimum market requirement, there is a tax cost, of the order of 1% pa, as illustrated in the two examples provided above. In addition, shareholders are subject to the risk that capital will not be used efficiently. It is not possible to quantify this risk in general terms - the cost will vary from time to time according to the individual circumstances of each insurer and the level of capital at risk. It will also vary according to where the capital is held -a lower cost would apply in some countries than in others. For the sake of illustration the overall cost of holding excess solvency capital is assumed to equal 3% pa, equivalent to valuing this capital at approximately 60% of face value.

4.4 *Non-Invested Assets*

Non-invested assets can amount to typically 5% of reserves for direct insurance business, equivalent to 0.35% of insurance profit for a product line with reserves equal to one times premiums. This cost is most easily allowed for by reducing the rate of interest used to value claims by 5%.

4.5 *Minimum Solvency Capital Requirements*

Assumptions as to minimum capital levels are required in order to analyse profitability. The following table suggests reasonable levels of requirement for each line of business.

Minimum Capital Requirements in the UK

	Total Capital Including Reserving Strength %	Solvency Margin Requirement %	Standard Deviation of Combined Ratio %
Property Damage	50	45	16
Motor Vehicle	25	20	8
General Liability	35	25	10
Accident and Health	15	10	6
Pecuniary Loss	50	40	20
MAT	25	20	8
Total	35	30	11

In the table it is assumed that solvency margin market requirements are set by multi-line insurers so that allowance is made for the probability that adverse results in one line will sometimes be offset by better results in other lines. The requirements assume that the capital is invested primarily in equities, so that the need to allow for fluctuations in equity values has been taken into account. A realistic retrocession programme is also assumed. The standard deviation of the combined ratios assume no smoothing of results, and assume an accident year basis (and therefore these ratios differ from the ratios shown in the earlier table of this section). The indicative standard deviations were calculated from an analysis of claim payments data for the UK market, based on DTI returns for the period 1982 to 1992.

4.5 *Premium Required for Insurance Risk*

The insurance profit ratios set out in section 4.2 can be adjusted to remove cost of capital effects discussed in section 4.3 to obtain an estimate of profits required to cover insurance risks.

Return Requirement for Insurance Risk

	Assumed Post Tax Insurance Profit %	Assessed Cost of Capital %	Assumed Sales Risk Margin %	Assessed Cost of Non Invested Assets %	Derived Insurance Risk Profit %
Property Damage	2.0	0.5	1.0	0.2	0.3
Motor Vehicle	2.0	0.2	1.0	0.4	0.4
General Liability	3.5	0.3	1.0	0.8	1.4
Accident and Health	2.0	0.1	1.0	0.2	0.7
Pecuniary Loss	2.0	0.5	1.0	0.5	0.0
MAT ¯	2.0	0.3	1.0	0.4	0.3
Total	2.1	0.4	1.0	0.3	0.4

In the table, the profit requirement to cover insurance risk has been assessed as the balancing item once the cost of capital, sale risk and non-invested asset cost margins have been deducted from the assumed level of post tax insurance profit. There is a considerable level of uncertainty regarding any individual figure for the insurance risk profit requirement and it is the total rather than the individual figures, which should be given most weight.

It should be noted that profit margins may be required not just to cover risk but also may arise as a result of market strength and the cost of market entry. Further, the insurer has some pricing advantages relative to the insured in the direct market and therefore may achieve some profit on this account. For these reasons, the level of profit should represent an upper bound on the return required for risk borne.

5. Reinsurance Profitability in the UK

An analysis of the LIRMA statistics for London market reinsurance for the period 1982 to 1992 showed that, for almost all years, for almost all lines of business, insurance losses were made, even taking into account investment income. Typically, the losses for each line were substantial.

The conclusion from the analysis is that data for the London market, for these years, contributes no information as to required profitability for reinsurance business. The lack of profitability does, to some extent, support the conclusion that the required profit to compensate shareholders for insurance or reinsurance risk borne is small.

6. UK Share Price Analysis

This section considers what information as to property/casualty risk and return can be gleaned from an analysis of share price return data.

The section reports the results of three separate analyses. Firstly it is noted that composite sector total returns have broadly equalled the returns on UK equities generally. This result leads to the conclusion that the level of insurance and sales profit achieved since 1970 has been of the order of 1½% of premiums, consistent with the result obtained in section 4. In the second analysis, it is noted that beta ratios for the composite sector are typically equal to approximately 1.0, consistent with their strategy of investing approximately 100% of their capital in equities. The result is a suggestion that insurance and sales risk has at most only a small systematic component or that profitability of new business is small. The final analysis is this section notes that the observed tendency for the sector to trade at a discount to appraisal value over the period 1982 to 1992 is not inconsistent with a modest return requirement in respect of insurance and sales risk.

The conclusions from this section are generally supportive of the results set out elsewhere in this paper that the reward required for insurance risk is modest. Further work would be needed in order to draw more definitive conclusions.

6.1 *Composite Sector Historic Returns*

Over the period 1.1.70 to 1.1.94, the composite insurance share price index under-performed the FT All Share index by approximately 20%. However, the sector has been on a yield premium to the All Share index so that on a total return basis, the sector has matched the equity markets.

This similarity of total return corresponds to the tendency for the composites to invest of the order of 100% of shareholders funds in equities. Any additional return achieved by their insurance activities has been broadly offset by the cost of holding assets through an insurance company rather than directly. Given the high degree of capitalisation targeted by the composites during this twenty-four year period, the cost of capital is likely to have been closer to the 2% pa rather than the 1% pa level discussed in section 4. Since capital to premium ratios have been in the range of 50% to 100%, this analysis suggests that insurance and sales profit achieved in the 24-year period was of the order of 1½% of premiums. This result is likely to be an amalgam of better than market equilibrium performance in the UK, where the composites have traditionally had a competitive expense advantage, poor performance overseas where, for many operations, no competitive advantage exists, and poor performance in the reinsurance markets, as discussed in section 5.

6.2 *Composite Sector Risk*

Beta ratios for the composite sector companies are typically equal to approximately 1.0. It is possible to back out the insurance sales or insurance beta so that the systematic component of insurance business risk can be gauged. Since solvency capital is broadly backed by investment in equities, a first indication for the insurance business beta is zero, given the observed beta of 1.0. At this stage, no closer analysis of implied sales or insurance risk is made.

6.3 *Fundamental Analysis*

During the period 1982 to 1992, the composites traded at varying discounts to appraisal value as estimated by James Capel.

Composite Sector Market Prices Compared with Appraisal Values[1]

	Percent
1982	46
1983	50
1984	51
1985	57
1986	65
1987	71
1988	66
1989	66
1990	75
1991	83
1992	64
Average	63

[1] Estimates from James Capel.

The James Capel appraisal value estimates provide some support for the proposition that shareholders' funds should be stated at a significant discount to allow for the tax cost and inefficiencies resulting from holding surplus capital, as discussed in section 4. Assuming that not all of the discount of 37% is to be attributed to these sources, a part or all of the insurance profit of 2% of premiums (gross of tax) built in to the James Capel appraisal value calculations represents not value added but compensation for insurance and sales risks borne.

133

7. Reinsurance Profitability in the USA

This section considers historic profitability of the US reinsurance industry, with a view to providing further evidence as to the trade-off between risk and return. It should be noted that no detailed analysis of claim payment patterns was undertaken and therefore the results from this section provide indicative rather than conclusive evidence as to historic profitability.

The conclusions from this section are that the US reinsurance industry was inadequately profitable over the period 1970 to 1993. Insurance profit for the period was of the order of 1½% of premiums once the effect of inflation risk is taken into account. Allowing for a cost of sales risk of 1% of premiums and the tax cost of capital, which equates to approximately 2% of premiums, the overall result needed to be 1½% higher in order to break even with no reward for insurance risk. Adverse profitability in the years 1983 to 1985 contributes to the overall poor result - profitability would have been 2% higher if these years had not existed.

These conclusions can also be turned around to determine the level of insurance profit required to achieve adequate profitability. For example, if it is assumed that the US reinsurance industry is twice as risky as UK direct for which a ½% cost of insurance risk is an upper bound, a 6% insurance profit is required (as shown in section 7.3). The equivalent Best's quoted figure would be approximately 7% (because of the effect of inflation risk). Given the historic pattern of actual results (between -3% and 10% if the three lean years are excluded), a profit of much more than this figure of 7% appears an unlikely goal for this market. To conclude, the historic evidence points to little or no requirement to price for unsystematic risk (that is, the historic evidence is broadly consistent with the return requirement implied by CAPM).

7.1 Historic Profitability Data

The following table presents data for the US reinsurance industry (RAA, Best's and S&P data combined).

US Reinsurance Profitability Data

	Premiums $bn	Operating Ratio %	Solvency Ratio %	Expense Ratio %	Insurance Profit %	Total Investment Income %	Net Income %	Reserves/ Premiums %
1980	4.6	104.6	67	28.5	5.9	n/a	n/a	n/a
1981	4.9	105.7	69	30.9	4.5	n/a	n/a	n/a
1982	5.2	109.0	76	31.3	-1.3	n/a	n/a	n/a
1983	5.5	114.1	78	32.1	-6.4	n/a	n/a	n/a
1984	6.1	127.1	63	30.6	-22.2	n/a	n/a	150
1985	7.8	119.0	59	28.5	-7.0	15.6	(2.7)	144
1986	11.4	103.0	66	26.1	0.4	13.7	7.6	130
1987	11.7	103.0	75	27.0	-2.6	16.6	10.3	157
1988	10.6	103.0	95	26.3	10.0	21.8	14.5	194
1989	10.3	107.4	116	30.4	1.3	24.8	12.5	221
1990	10.71	106.1	113	30.6	4.6	25.2	14.9	n/a
1991	11.48	106.5	113	31.2	10.1	24.4	16.6	n/a
1992	11.98	117.4	108	31.6	0.0*	n/a	n/a	n/a
1993	14.10	107.3	104	30.8	10.0*	n/a	n/a	n/a
Average	-	109.5	86	29.7	0.5	-	-	-
Standard Deviation	-	7.2	-	-	8.6	-	-	-

*   Estimated

The column headed operating ratio consists of RAA data and may overstate profitability if exits from the industry are not fully taken into account in this database. The Best's data for insurance profit, including allocated interest, is probably more representative of profitability for the period. The average insurance profit over the period 1977 to 1993 is estimated to equal approximately 1%. Conning & Company reports an average operating ratio of 101% for the period 1970 to 1976. Combining this data with the Best's data suggests an average insurance profit for the period 1970 to 1993 of approximately 3%.

7.2 *Capital and Cost of Capital for US Reinsurers*

There is some tax cost to holding capital in a US reinsurer because dividends and capital gains achieved on this capital are taxed both within the company and again in the hands of stockholders when distributed. No detailed study of the tax cost has been made but a figure of 2% pa has been used in this paper, for the sake of illustration. Based on a capital to premium ratio of 100%, this equates to a cost of capital equal to 2% of premiums.

7.3 *Analysis of Required Insurance Profit*

The following table illustrates the required level of insurance profit, based on alternative views on the pre-tax profit required to compensate shareholders for insurance risk.

Illustrative Required Insurance Profit, % Premiums

Compensation for Insurance Risk	0	1	2
Cost of capital	2	2	2
Sales risk	1	1	1
Tax on above	1½	2	2½
Required Insurance Profit	4½	6	7½

8. Property Catastrophe Reinsurance Pricing

This section considers the price required to cover property catastrophe risks. The results set out in this section are inconclusive but suggest that the profit required for property catastrophe risk is relatively modest. Based on a 50% standard deviation in operating ratio, the available data would not rule out an average insurance risk profit requirement of 2% or 3% of premiums. In addition, a substantial premium may be required in order to compensate shareholders for the possibility that adverse catastrophe experience may result in the reinsurer ceasing to write business and to a loss of profitable business opportunities for the future. More detailed analysis is required to validate these conclusions.

8.1 *Analysis of Quoted Catastrophe Reinsurers*

There are a number of quoted property catastrophe reinsurers in the US and Bermuda. Generally, these writers maintain a capital base of 2.0 or more times written premiums.

The Bermudan entities operate in a tax favourable environment. It appears reasonable to assume that these companies have no cost of capital relative to direct investment. By comparison, the cost of capital for a specialist US property catastrophe reinsurer could, for example, be equal to 1.5% pa, that is 3% of premiums, based on a 2:1 capital ratio.

The following table shows the level of achieved profitability for selected specialist property catastrophe reinsurers for the years 1994 and 1995. This is measured by the combined ratio, that is the sum of expenses expressed as a proportion of written premiums and losses expressed as a proportion of earned premiums.

Profitability of Specialist Property Catastrophe Reinsurers

	1995 Net Written Premiums	Combined Ratio	
		1994	1995
	$m	%	%
IPC Holdings	104	59.2	52.0
La Salle Re[1]	198	78.4	59.0
Mid Ocean Ltd[2]	435	80.8	71.6
Renaissance Re	290	60.1	52.0
Unweighted Average		69.6	58.7

[1] *1995: nine months to 30 September*
[2] *Year to 31 October*

Depending on the type of business, some catastrophe insurance providers have achieved even lower combined ratios.

The following table provides estimates of the post-tax profit required for insurance risk, based on a combined ratio of 82% and also on ratios of 87% and 95%.

Loading for Insurance Risk (Percent of Net Written Premiums)

Combined Ratio	82	87	95
Premium	100	100	100
Claims and Expenses	(82)	(87)	(95)
Interest on Reserves	2	2	2
Cost of Capital	(4)	(4)	(4)
Sales Risk	(1)	(1)	(1)
Tax	(5)	(3)	(1)
Profit for Insurance Risk	10	7	1

8.2   *Long Run Profitability*

There is of course a considerable degree of uncertainty as to the "true" underlying mean of the catastrophe loss distribution. The figures shown in section 4.1 may not allow for the possibility of occasional large losses - the period from 1993 has seen only relatively modest losses compared with the exceptional losses emerging in 1992 as a result of Hurricane Andrew.

A brief recap of some salient features of the last fifteen years may be useful:

- A decade of price erosion was followed by a period of price explosion, between 1989 and 1993. The period since 1994 has witnessed price erosion, with prices some 25% off their peak. Standard & Poor's suggest that reductions of 5-10% are in prospect for 1997.
- The period 1980 to 1988 saw relatively few catastrophes affecting the reinsurance market (six) compared with well over 20 in the period from 1989.
- Massive underwriting losses in the period 1989 to 1992 led to the withdrawal of some 50 out of the 145 companies, which were participants in the market in 1990.

The high variability of catastrophe losses means that it is difficult to assess the underlying mean. For example, the number of hurricanes over the thirty-year period to 1989 was lower than the long-term average since 1909. Also, there is some evidence of an increasing trend of catastrophe losses over the period since 1949. Some studies have suggested that catastrophe business was very profitable during the period up to 1989 but the question must arise as to whether this was because there were fewer than expected claims.

The quoted specialist property reinsurers currently trade at a little above book value, perhaps reflecting expectations of high profitability in the short term and a return to required profitability in the longer term. It may also reflect a comparative cost and cost of capital advantage relative to traditional reinsurance providers.

8.3   *Analysis of Profitability*

Specialist catastrophe insurers have been achieving combined ratios of 50% to 80% since 1993, reflecting the explosion in pricing during the period 1989 to 1993. In part, these margins may reflect the market practice of attempting to recoup catastrophe losses from subsequent years' business - a form of financial reinsurance.

Taking account of the continuing trend towards price erosion, and the possibility of occasional large losses, a combined ratio of, for example, of the order of 80% or 90% may represent a truer picture of long run average profitability. Based on a tax rate of 30% in the hands of the ultimate investor, these combined ratios correspond to insurance profitability equal to 10% of premiums written (15% less 30% tax).

To illustrate this further, this level of profitability would be broadly consistent with the current market pricing of Renaissance Re, which trades at a premium to book value equal to approximately 50% of net written premiums - a multiple of 5 times assumed long run insurance profitability. A multiple of 10 times would imply long run profitability of 5% of premiums written and a long run combined ratio of 93%.

Given that most existing reinsurers pay tax on their investment income receipts and on insurance profit, and may have a higher level of administration expenses than their Bermudan counterparts, there is little evidence of substantial over pricing of catastrophe reinsurance by the reinsurance markets.

Arguably, an over emphasis when pricing on total rather than systematic risk may contribute towards some inefficiency and opportunity for the capital markets.

This analysis suggests that capital market/Bermuda market solutions may be important, because of the potential for cost efficiencies and because, as discussed previously, there is no need for a cost of capital adjustment. Further it is possible that the 'market' is factoring a gradual trend towards more efficient pricing as a result of these potential developments.

8.4   *Pricing Behaviour*

Although the reinsurance markets respond rapidly to changing market fundamentals, the speed of response is likely to further increase in the event that/as an active traded (listed or OTC) market in catastrophe risk develops.

A feature of the current market is periods of relatively low prices if there have been no catastrophe events for a period of years and high prices in the two or three years following a claim, as reinsurers attempt to recover profitability. This feature results from barriers to entry since otherwise new entrants could take advantage of attractive pricing following a catastrophic event. The development of the Bermudan markets with a relatively liquid capital base could help to break these barriers. The development of a traded market could further help to stablilise prices closer to equilibrium levels.

8.5   *Analysis of Best's Data*

The following table summarises loss ratios for various lines of business for US professional reinsurers:

Pure Loss Ratios

	Average 1986 to 1992	Average 1988 to 1992
Excess monoline property	n/a	81.7
Commercial multi-peril	64.5	68.7
Homeowners multi-peril	72.9	80.7
Average of above	68.7	77.0
Total reinsurance	73.2	72.6

These ratios exclude expenses of perhaps 25% of premiums, leading to combined ratios in the range of 90% to 105% during this period. It should be noted, however, that this period includes the adverse experience of 1989 to 1992.

The results of this analysis support the use of combined ratios closer to 95% rather than the 82% set out in section 8.1 and suggest that the profit required for property catastrophe risk is relatively modest.

8.6 *Corporate Solvency Issues*

Writing of property catastrophe reinsurance creates the possibility that a few large catastrophe losses within the space of a few years may eliminate the capital base of a monoline reinsurer, or create a significant dent in capital for a multiline company. In turn, this could result in the company ceasing to write business, possibly just at the time when pricing recovers and profit margins are high. In other words, the writing of property catastrophe business gives rise not only to an expected claims cost but also to some expected loss of profitable future business opportunities and to potential bankruptcy costs. These costs need to be included in the premium charged to the insurer.

The appropriate charge for the possibility that profitable future business opportunities will be lost will depend on how important such opportunities are to the reinsurer, as well as the probability of a heavy catastrophe experience and the volume of catastrophe business in the reinsurer's portfolio.

These effects disappear in the event that the insurer holds a sufficient amount of capital and, for catastrophe business written through the capital markets, the level of capital at risk is clearly defined. This effect may not, therefore, lead to a relative advantage or disadvantage for traditional reinsurance versus the capital markets alternatives.

Some anecdotal evidence that cannot be attributed suggests that reinsurers may require a charge of the order of 15% to 25% of premiums written as compensation for this expected cost.

8.7 *Beta Analysis*

The Bermudan property insurance companies have fairly high beta ratios, of the order of 0.6, even though they have little or no investment in shares. Based on a market capitalisation/book value of 1.5:1, and assuming that the assets and existing liabilities have no systematic risk, the beta ratio attributable to new business value alone is 1.8. The suggestion is that the property catastrophe insurance business cycle is heavily geared to systematic economy wide factors. The implication is that premiums rise or claims payments decline during a rising equity market. An alternative explanation which should not be dismissed is that a major component of the equity risk premium relates to catastrophe risk and that this is linked to property catastrophe risk losses.

9. Life Reinsurance Pricing

This section sets out a pricing formula for life reinsurance business.

Given the relatively low level of risk charge implied by the analyses undertaken in previous sections of this paper, and the modest level of risk for life reinsurance business compared with property/casualty reinsurance, little or no risk loading is required. However, there is a cost of capital and a cost of sales risk, and both need to be factored into treaty pricing and profit testing.

The overall conclusion, for UK level term assurance, is that premiums should be set such that pre-tax profitability is equal to 1.7% of the value of future premiums, based on a discount rate 1% pa higher than the long-term government bond yield.

9.1 Pricing Formula

The minimum premiums for a life reinsurance treaty can be defined in exactly the same way as for a property/casualty treaty, as:

P   = Value of expected future expenses (assessed using a risk free-rate), E

+   Present value of expected claims (assessed using a bond yield), C1

+   Sales risk cost (1% of the present value of premiums), S

+   Insurance risk cost (risk factor loading times standard deviation of actual to expected claims ratio times the present value of expected claims), R

+   Cost of capital (present value of the tax cost of holding capital during the life the treaty), C.

If a profit-test system is used to assess premium rates, the approach could be as follows:

Set target profitability equal to 1% of the present value of future premiums (the sales risk cost) and build into the profit-test cash flows:

- expected future expenses (including a 1% pa addition to expected inflation, because of inflation risk)
- expected future claims increased to allow for the insurance risk cost. Where guarantees are given, the expected cost of meeting the guarantee also needs to be included
- target surplus (say 125% of the EC solvency margin)
- statutory reserves
- interest on reserves, target surplus and cash flows based on long-term government bond yields
- tax of 8% of I-E and 25% of profit
- discounting based on the yield on long-term government bonds (no higher since the allowance for risk is included in the projected claims).

142

In addition, a charge is required to cover the cost of capital, based on the difference in profitability between discounting at the net earned rate (the bond yield less 8% tax) and discounting at this rate but allowing for an investment return equal to 1% pa less than the net earned rate. Since the 1% pa cost of capital adjustment is an after tax figure, the charge for capital should not be reduced by the 25% tax rate.

Expected claims would allow for the probability that any rate guarantees may bite as a result of random or other stochastic fluctuations in mortality and morbidity rates. The increase to the level of expected claims to allow for insurance risk would likely be small. For example, if a 1½% pre-tax cost is associated with a standard deviation of 20% as suggested in section 2 of this paper, and if the standard deviation of expected claims was 5%, the claims would be multiplied by 1.0038 (1+ 5/20 x .015) to allow for insurance risk. As noted in section 3, this loading of 0.0038 (i.e., 0.4% of claims) should be increased or reduced if a treaty has an unduly high or low level of risk factors (R1 to R4) compared with typical risk levels for the line of business.

9.2 *Conclusion*

We examined the results of a few sample profit-tests for level term assurance and noted that the effect on profitability of a 1% pa increase in the discount rate exceeds the effect of the assessed cost of capital. Based on this finding, the overall conclusion is that premiums should be set such that post-tax profitability is equal to 1% of premiums plus 0.4% of claims, based on a discount rate 1% pa higher than the yield on long-term government bonds. With a claims ratio of say 60%, required after tax profitability would be 1¼% (1% + 0.6 x 0.4%) of the value of premiums, say 1.7% pre-tax. It is then straightforward to convert to an equivalent minimum internal rate of return (based on zero profitability at outset) although this rate will vary according to product characteristics, such as duration.

10. Conclusions and Recommendations

This section summarises the principal findings from this study and draws attention to areas where further work would be desirable.

10.1 *Conclusions*

The overall conclusions from the analyses which were undertaken in the course of preparing this paper are as follows:

- **Cost of Capital Charge, C**

Treaty premiums should allow for a cost of capital equal to approximately 1% pa in excess of the investment return achieved on direct investment. For capital held in a corporate entity in the USA the cost of capital is assessed at approximately 2% pa. For a company writing business in Bermuda, this cost is zero.

- **Sales Risk Charge, S**

There is some risk associated with the selling process, perhaps connected with the underwriting cycle. Even if claims costs could be predicted accurately, loss ratios may vary over time. This risk is related to the volume of business sold and for the purposes of this paper it has been assumed that a 1% after tax loading to premiums should be made to compensate shareholders.

- **Inflation Risk Charge, I**

Since non-life claims costs are typically denominated in real rather than nominal monetary terms they should be discounted using a risk-free (expected treasury bill or index-linked gilt) yield rather than the yield on longer-dated government bonds. For the purposes of this paper it has been assumed that a charge of 1% pa is appropriate.

- **Insurance Risk Charge, R**

Once charges for capital, sales risk and inflation risks are taken into account, there was little evidence of a substantial premium requirement for insurance risk. A reasonable upper bound allowance for such risk would be to incorporate a margin of 1% additional premium for each 20% of standard deviation in operating ratios. The levels of total capital required for each line of business are, for the purposes of illustration assumed to be broadly proportional to the standard deviation of operating ratios. For this reason, the allowance for insurance risk equates to an increase in the cost of capital of 1¼% pa (assuming that the average standard deviation of operating ratios for reinsurance business is 20% and the

144

capital requirement is 80% of premiums). A lower bound for the insurance risk charge would be nil, as suggested by standard CAPM.

- **Individual Treaty Risk, R1 to R4**

As suggested in section 3, some treaties will be more or less risky than others in the same line of business. It was suggested that treaties could be given four risk factor weightings, Factors R1 to R4, each factor being classified as "low", "medium" or "high" risk relative to the typical level for that line. Factor R1 relates to the standard deviation of the claims distribution; Factor R2 to adverse selection risk, Factor R3 to uncertainty in the underlying parameters of the claims distribution and Factor R4 to the extent to which claims experience may deteriorate over time. Each factor would be assigned a value 0.5, 1.0 or 2.0 and the four factors multiplied together to obtain an overall risk weighting for the treaty. This weighting would be applied to the insurance risk charge so that higher premiums and expected profits would apply for treaties with higher risk.

In fact, since low risk treaties require less capital than higher risk treaties, factors R1 to R4 could also be applied to the cost of capital charge. Whilst not theoretically robust this may be a not unreasonable approach in the absence of an investigation as to the marginal impact on total capital requirements of individual treaty risk.

- **Tax**

It should be noted that all of the costs, of capital, sales risk and insurance risk are after tax and need to be grossed-up at 31% to allow for UK corporation tax prior to being loaded into the premium rate.

The premium quoted, P, should be not less than the sum of the expected value of claims, C1, expenses E, the cost of capital charge C, the sales risk charge S and the charge for insurance risk.

$P \geq C1 + E + (C + S + R \times R1 \times R2 \times R3 \times R4)/(1-0.31)$.

For life business, the result of applying the above formula to level term assurance is to require minimum premiums such that pre-tax profitability is equal to 1.7% of the present value of future premiums, based on a discount rate 1% pa higher than the yield on long-term government bonds.

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