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CORPORATE DECISIONS IN GENERAL INSURANCE : BEYOND THE FRONTIER

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ABSTRACT

This paper shows how the powerful and flexible tool of stochastic modelling can be applied to a range of business decisions extending far beyond the asset allocation solutions that are common to many asset/liability modelling studies. The example used to demonstrate these techniques is a general insurance case study, but similar principles can be extended to many different business situations. At each stage of the analysis we consider the implications of modern financial theory on the management decision process together with a practical perspective on observed behaviour in the real world. Opportunities are taken to suggest directions in which further research may be of benefit to the actuarial profession.

KEYWORDS

Arbitrage Pricing Theory; Asset Liability Modelling; Capital Asset Pricing Model; Dividend Discount Model; Dynamic Financial Analysis; Efficient Frontier; Financial Economics; General Insurance; Modern Portfolio Theory; Risk; Investment Strategy; Systematic Risk

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1. INTRODUCTION

1.1 How should an insurer price for risk? This question has been asked many times; many solutions have been proposed. Four methods in widespread practical use are as follows.

1.1.1 *Premium principles.* The required loading for a given risk is assessed according to the distribution of cash flows from that risk. The required loadings are subject to various axioms, for example the premium should always lie above the expected loss and below the maximum loss. Depending upon the axioms chosen, various families of possible rules emerge.

1.1.2 *Risk adjusted capital/capital allocation.* The required profit for the

company is expressed as a return on capital. The capital for the business is then allocated between lines of business, usually according to the perceived relative threat to solvency. Profit targets for each business are then calculated as the return on capital target multiplied by the capital allocated.

1.1.3 *Efficient frontiers.* This approaches risk from a different angle, taking the available returns as inputs. The procedure is then to consider alternative mixes by volume, and assess whether these mixes are efficient in the sense of minimising risk for a given level of return. Turning this around, the actual mix by volume is optimal if the available returns on each line of business are proportional to the marginal risk incurred.

1.1.4 *Shareholder value.* The approach considers how shareholders value a company, and sets return targets with an aim to enhance shareholder value. This can be thought of as an efficient frontier approach, but the efficiency relates to the shareholder's own portfolio, of which the insurance company is a small part. This approach makes a key distinction between risk that shareholders can diversify (that is, specific risk) and the remainder (systematic risk) which is not diversifiable.

1.2 These four paradigms may seem to conflict. Practical implementations of these four approaches will often produce different answers. However, this is often due to inconsistent assumptions or methodologies. In this paper we implement these techniques for a simplified insurance company. We make use of a stochastic simulation model — a technique now known as 'dynamic financial analysis' (DFA). In doing this we are able to reconcile these different approaches.

1.3 DFA, also known as 'asset/liability modelling' (ALM), is a powerful and flexible tool for evaluating different strategies on a consistent basis. A very powerful technique for interpreting the DFA output is the so-called efficient frontier. The classic efficient frontier from modern portfolio theory helps investors choose between different portfolios of assets, typically by comparing the trade-off between expected returns and risk, as measured by the standard deviation of return. DFA extends this concept by calculating an asset-liability efficient frontier that captures a wider range of the different risks and rewards facing a general insurance company. In particular, the risk measure (likelihood of adverse outcomes) can vary with what management thinks is most important in any given set of circumstances. Typical risk measures might be ruin probability, probability of solvency impairment, or failure to meet a profit objective.

1.4 However, there is a pitfall for the unwary. A typical efficient frontier uses risk measures that mix together systematic and non-systematic risk. The distinction between these types of risks is essential if the shareholder perspective is to be taken into account. The user needs to treat them separately, or to know which is dominant.

1.5 In particular, extreme care needs to be taken with efficient frontiers for insurance companies if they are used to address strategic questions which include choices between different investment portfolios. They can produce results showing apparent benefits of diversification, which are shown to be false once the

concept of systematic risk has been factored into the equation. For example, the model can produce a result where the managers benefit (e.g. meet an objective) from taking more systematic risk. A knowledgeable shareholder would then require a higher return target, but only if he knows that this is going on.

1.6 The capital markets, where most of the practitioners of financial economics work, are characterised by high liquidity and high levels of public information. Systematic risk dominates, and the efficient frontier is not very useful.

1.7 However, in the insurance industry there are occasions when systematic risk is the dominant feature, and occasions when non-systematic risk dominates and the efficient frontier does come into play. Systematic risk dominates in investment decisions and in lines of business which are cyclical and related to the business cycle, e.g. creditor and mortgage indemnity guarantee business (MIG). Non-systematic risk and efficient frontiers are useful when taking decisions related to the purchase of reinsurance or targeting lines of business which are not strongly correlated to the business cycle.

1.8 This paper describes the problem of mixing systematic and non-systematic risk and their treatment, by means of worked examples. It will not deal at length with risk measures associated with insolvency, but will focus more on the example of a well-capitalised company, which wishes to manage its risk-reward profile so as to be competitive. We will illustrate the use of a DFA model, and provide an actual quantification of the risk-reward choices facing our example company.

1.9 In this paper we tackle two questions facing the same company, one asset-related, and the other liability-related (mix of business/reinsurance). Note that it is not the DFA model that provides the trap, rather it is the interpretation that the user puts on the output by using an efficient frontier that combines different types of risk. The key is to understand which tool to use in which circumstance.

2. Premium Principles and Capital Allocation

2.1 Premium principles represent the earliest attempt to load prices for risk. They are calculated on the basis that the premium for a risk should depend only on the probability distribution of that risk, and not on how it may relate to other risks. A number of formulae have been proposed. Goovaerts *et al.* (1983) describe eleven such rules.

2.2 Recently, more apparently scientific rationales have been developed for such formulae, based on capital allocation (see Hooker *et al.*, 1995). The idea is that capital has a cost, and risk in insurance business requires capital. The shareholders require a profit for each line of business, which can be expressed as a percentage of capital. If we can allocate capital according to risk, we then have an algorithm for allocating profit targets.

2.3 The algorithms are often hard to rationalise, because the theoretical cost of capital depends, not only on the business riskiness, but also on the capital base relative to which the return is measured. In theory, profit targets are virtually independent of the capital allocated. Without a robust theoretical framework, it is hard to achieve a consensus on how capital should be allocated in practice. The results of such exercises often end up resorting to premium principles in various guises, and so tend to be rather arbitrary. There are also numerous practical obstacles to allocating capital, including complications arising from the different stages of the product cycle (marketing, new business, unearned premiums, loss reserves) and interactions arising from overlapping generations. These issues are discussed in more detail in Ibeson *et al.* (1999).

3. CLASSIC/TRADITIONAL ALM – A SUMMARY

3.1 Over the course of the past decade, ALM has become a mainstream tool amongst the actuarial community. As greater computing power has been made available at the desk-top, the number of practitioners in this field has increased. Applications have been found across a wide range of actuarial activities, including life, pensions, general insurance and investment.

3.2 The underlying purpose of building a stochastic model is to aid understanding of the dynamics of a particular business problem. One of the cornerstones of the actuarial profession was, and is, an understanding of compound interest. This naturally led to the development of cash flow models, and it was a natural (though complex) next step to add a probability distribution around those deterministic cash flows to create a stochastic model.

3.3 Many papers have been written on the building of such models. It is not our objective in this paper to be unduly concerned over the type of model used — we are primarily concerned about the way in which output from a model is interpreted and business decisions made. Whether simple or extremely complex, the building of the model is generally the easy part. Understanding the output is the difficult part. The large number of variables typically used in a model means that the output is necessarily multi-dimensional. To analyse these data effectively and present the findings to senior colleagues in simple, easy-to-understand terms, represents a huge challenge to the modeller. It is probably fair to say that few can do this well.

3.4 One of the most common techniques used to present results is the efficient frontier. This is a technique borrowed from finance theory, where the problem was originally framed in terms of portfolio risk and return. It is common to define 'return' as the arithmetic mean of the surplus, and to define 'risk' as the corresponding standard deviation. Whatever definition of risk and return we wish to adopt, we can define an 'efficient' set of portfolios. In this context 'efficient' means that there is no portfolio that has a higher return for any given level of risk, or, conversely, no lower risk for a given level of return. The principle is

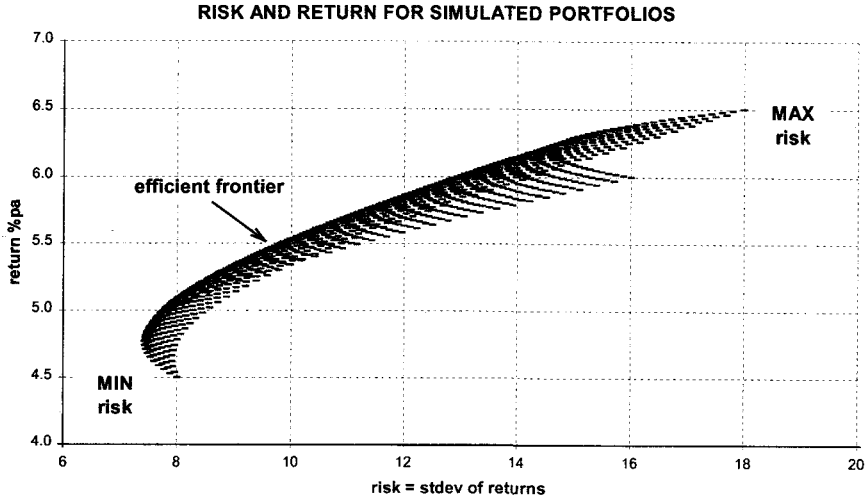

Figure 1. Efficient frontier measures of risk

illustrated in Figure 1, which shows the results for simulated portfolios using a simple problem with three asset classes — United Kingdom equities, overseas equities and U.K. bonds. The way in which portfolios cluster around the 'frontier' is a well observed phenomenon. For more examples, and a more detailed exposition, see Sweeney *et al.* (1998). In practice, this suggests that we need not be too concerned with finding the most efficient portfolio. Given the uncertainties surrounding any inputs to the model, we would generally be satisfied with a solution that lies close to the efficient frontier.

3.5 In passing, it is interesting to observe one of the features with this form of analysis. If we change our definition of 'return' or 'risk', then the shape of the 'frontier' may also change, and different strategies will look efficient. To illustrate this, we have revised the example above, but have defined risk to be the probability of negative real returns. Figure 2 shows how the shape of the feasible set and the frontier has changed.

3.6 Although selecting some tools from finance theory, the classical application of ALM tends to operate within a vacuum. For example, a pension fund is considered as an entity, in itself, rather than as part of an overall company balance sheet. In insurance work, the same misconception leads to definitions of risk (such as standard deviations) which fail to take account of the shareholders' ability to diversify. Whilst we recognise the difficulties of a more holistic approach, portfolio theory provides no way of optimising a 'sub-portfolio'. Treating part of a business as an isolated entity will give misleading results. Such approaches implicitly assume that the shareholder faces infinite costs of diversification, and therefore attribute any diversification within a company,

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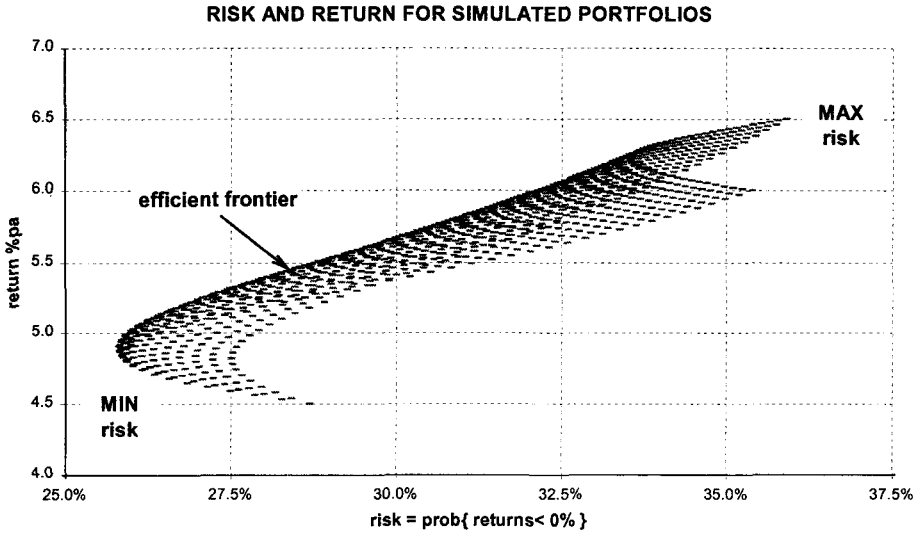

Figure 2. Efficient frontier using a downside measure of risk

whatever the cost, as a gain to shareholders. This plainly exaggerates the benefits of diversification.

3.7 To demonstrate the illusions that may be created by inappropriate use of ALM, consider the following example, drawn from the field of general insurance, of an insurer (MOTCO), currently a specialist in motor insurance.

3.8 There is a proposal to diversify into employers' liability and mortgage indemnity business by acquiring ELCO and MIGCO, respectively, creating a larger diversified general insurance company. A consulting actuary is hired to quantify the benefits of the business plan. Using the traditional ALM tools at his disposal, he uses the chart in Figure 3 to illustrate the benefits.

3.9 This shows very clearly the benefits of the diversification. By combining the companies we are effectively shifting the efficient frontier upwards to the left. Although the mean return on capital is simply the average of the component parts, the variability of returns on capital is diversified across the different businesses, and hence becomes lower than any of the underlying companies. The aggregate capital required to support the business is therefore less than the sum of the parts, hence surplus capital can be returned to the shareholders.

3.10 On the face of it, the analysis suggests that the diversification creates value for shareholders, while also improving credit risk for policyholders. However, there do not seem to be too many examples in history of a genuinely free lunch. Can these benefits be real — or are they just illusory? In reality, we observe a large number of specialist companies. Are these all missing a trick, or

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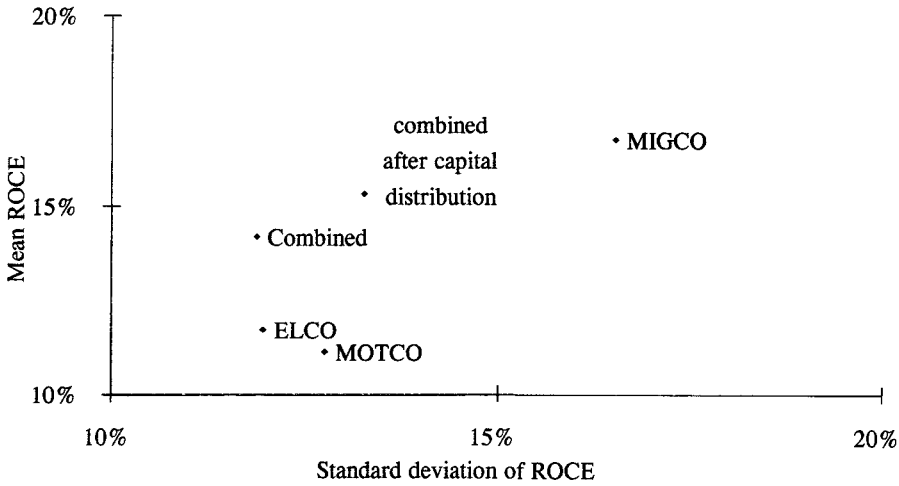

Figure 3. Benefits of the company merger measured in terms of return on capital employed (ROCE)

is there another dimension to the problem that we have missed? What would finance theory tell us about the benefits of the merger?

3.11 Advanced users of efficient frontiers can turn the problem around, designing optimal strategies. Under orthodox investment models the efficient frontier contains the 'market' portfolio of investments, and also various combinations of this investment with cash. For an explanation of why this happens, see Elton & Gruber (1981).

3.12 It follows that insurers may be able to reduce risk and increase expected return by moving their overall business towards the market portfolio. It is now common to see structured reinsurance deals that achieve this, for example by reducing the cedant's exposure to insurance risks and providing equity exposure in its place. Although this seems good from an efficient frontier perspective, in fact systematic risk has increased, so the cedant's shareholders are no better off. Furthermore, such strategies conflict with traditional rationales of why insurers exist. Once again we are led to question whether reducing risk and improving return necessarily creates shareholder value, or whether the apparent free lunches are illusory.

4. Financial Economics and the Role of Systematic Risk

4.1 Finance theory provides a number of models by which economists can estimate the value of cash flow streams. The chief intellectual hurdle to clear is an understanding of how to adjust for risk. One popular approach allows for risk by an adjustment to the discount rate. The value of a business is then determined by discounting the expected future profit stream to the current date. (In this context, 'profits' include capital flows and investment returns on existing capital backing the business.) This requires two components: the expected future cash flows; and the rate at which to discount these cash flows.

4.2 Note that this approach to valuation is the same as that used in a dividend discount model (DDM), a familiar tool that has historically been used by actuaries to value assets and liabilities. At any point in time the theoretical value (and hence the potential sale value) is the value of discounted future profits. However, actuarial theory has often been imprecise on where the discount rate comes from.

4.3 In a proprietary company the interest rate that needs to be used to discount the cash flows is the rate of return that shareholders expect (or require) to earn, on average, given the level of risk inherent in the cash flows. This required return is also known as the cost of equity.

4.4 However, shareholders can reduce their risk (i.e. diversify) by holding a basket of equities. In this way, the specific risk, which is unique to each equity, can be eliminated effectively. Therefore, shareholders will not get any extra expected return for taking diversifiable (or specific) risk. Even though some shareholders choose not to diversify, this does not mean that a risk premium is required for diversifiable risk. This is because diversified shareholders will outbid non-diversified shareholders in the purchase of non-diversified shares. What remains after diversification is market risk, otherwise known as systematic risk or non-diversifiable risk. This is the risk that earns an extra expected return, and so determines the cost of equity.

4.5 This insight is one of the fundamentals of the capital asset pricing model (CAPM). Although the theoretical development of the CAPM relies on a number of unrealistic assumptions, the resulting framework has proved sufficiently reliable to form a practical tool for measuring the risk/return trade-offs for differing investments. (However, it should be noted that the CAPM is less robust where a more detailed analysis of bond-type investments is required, or where multiple currencies are involved — in these circumstances a multi-factor approach such as arbitrage pricing theory is more useful.) A number of generalisations of the CAPM are now available, and the systematic/non-systematic risk distinction is fundamental to all of them. Traditional efficient frontier analysis does not recognise this distinction.

4.6 The systematic risk of a company's equity is conventionally measured by the company 'beta'. This shows the average responsiveness of the company's share price to changes in the overall market level. For example, a beta of 1.2

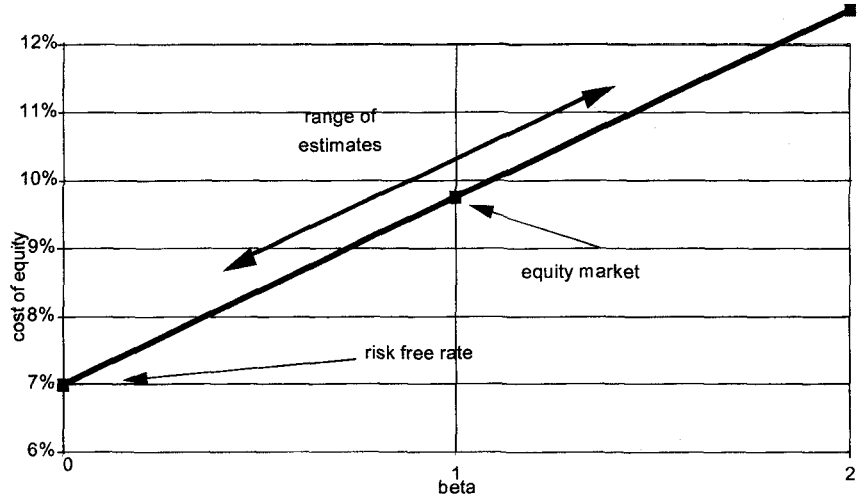

Figure 4. Capital market line

implies that, on average, when the market moves by 1% the company's share price will move by 1.2%. The beta depends on the correlation between returns on the company's shares and returns on the market, and on the relative volatilities of these returns.

4.7 Figure 4 shows an example of the 'capital market line' that results from CAPM. In order to construct such a line, assumptions need to be made for the risk-free rate and the market equity risk premium. The figure shows the cost of equity for each value of beta (i.e. for each level of systematic risk). By definition, the beta of the whole equity market is 1. The corresponding cost of equity is the risk-free rate plus the equity risk premium. Individual stocks offer different combinations of risk and return along the capital market line.

4.8 In order to estimate the cost of capital for a company, it is necessary to estimate the systematic risk, or beta, of the company's equity (see, for example, Copeland *et al.*, 1995). City analysts tend to use estimates of beta which are based on the historical behaviour of the share price relative to the market. This is essentially a top-down exercise; analysts have insufficient data to construct a risk model of a company's own cash flows.

4.9 However, in practice, partly because the nature of the risks faced by a company can change significantly over time (perhaps due to acquisitions or divestments), or because different strategies under consideration may involve different levels of risk to shareholders, a forward-looking or prospective measure is preferable. This can be carried out best from inside a company, where sufficient data and expertise may be available to adopt a bottom-up approach to cash flow modelling.

4.10 A prospective estimate of beta relies on an understanding of the core

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drivers of the business and how they relate to the equity market. Some form of modelling is therefore required. This can be done by projecting a range of economic scenarios, and evaluating the returns to the market and to the business within each scenario. The correlation between the market returns and the business returns and the volatility of each can then be used to estimate the beta of the business according to the formula:

$$\text{beta} = \text{correl}(\text{market}, \text{business}) \times \frac{\text{stdev}(\text{business})}{\text{stdev}(\text{market})}.$$

4.11 It is worth dwelling on some of the implications of this relationship. If an asset has a zero correlation with the market, then it has a beta of zero whatever the volatility of returns. Thus, in theory, one would only require to earn the risk free rate to make the asset attractive. Hence the excitement over so-called zero beta assets, such as catastrophe bonds, futures trading funds, commodities, etc. Any risk premium offered is theoretically very attractive. Such investments, whilst popular in the United States of America, have yet to make significant inroads into U.K. institutional portfolios.

4.12 These examples are interesting, because an insurer writing such catastrophe risks may appear to move away from the efficient frontier. By traditional measures this might be seen as a bad thing, but a deeper analysis, allowing for the cost of capital, could show that shareholder value has actually been created, because the insurance contract lies above the capital market line.

4.13 To understand the rationale, we have to look in more detail at why insurers are in business. In a pure CAPM world, there would be no need for financial institutions such as insurers or banks. Everyone would simply trade their risks in a huge market of equally informed participants. A major reason why this does not happen in practice is the importance of private information. Insurers have become expert in collecting, managing and using private information in underwriting decisions. Banks occupy a similar role in lending decisions.

4.14 As private information is, by definition, not generally available, it is to be expected that insurers could gain an economic rent from their specialist expertise in this area, particularly where there are additional barriers to new entrants. Competitive equilibrium arguments would not apply here, so projects utilising private information may lie above the capital market line, hence creating value for shareholders. This contrasts to the situation of market investments, where insurers are competing with billions of other investors, and there is little reason to believe that insurers enjoy any special information or other advantage.

4.15 Having digested some basic financial theory, we can now return to our merger problem set out in Section 3. The concept of systematic and non-systematic risk is the missing link that we were looking for! For each of the companies considered in the example, the risk profile is shown in Figure 5.

4.16 We can see that, in this context, while much of the risk of MOTCO and

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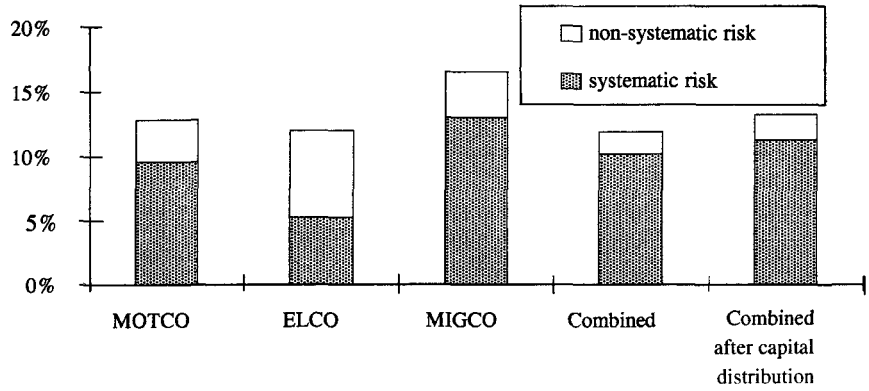

Figure 5. Systematic and non-systematic risk

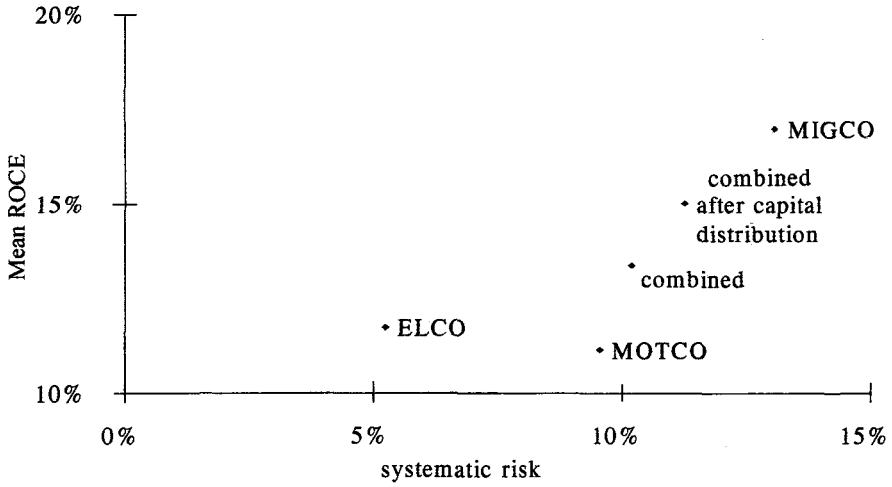

Figure 6. Systematic risk and return

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MIGCO is systematic, ELCO contains a large dose of non-systematic risk. While the merger results in diversification of non-systematic risk, the systematic risk is conserved. A more meaningful risk-return plot would show return against systematic risk, as in Figure 6.

4.17 Thus, without further management actions, shareholders will see little gain from the merger. The systematic risk of the merged company is just an average of the constituents, with no gain for diversification. All the apparent risk reduction is merely a reduction in non-systematic risk, which the shareholder would have diversified anyway. The systematic risk is not eliminated by the merger — in fact, it increases if capital is distributed, because the profits are more highly geared. The improvement in mean ROCE achieved by the merger is merely a fair compensation for the fact that the earnings have poorer quality. It is the same compensation as the shareholder would have got from gearing up his own portfolio. There is then, in theory, no overall gain to shareholders from the merger. This is one consequence of Modigliani-Miller's Nobel Prize winning irrelevance proposition (Modigliani & Miller, 1958). Bride & Lomax (1994) and Mehta (1992) both raise this issue in an insurance context.

4.18 Financial theory suggests that the merger does not create value of itself, while the same assets are still being held to meet the same liabilities. The merger can only create value if something economic changes as a result. For example, if the new company is better positioned to take advantage of profitable business opportunities, or is more efficient in using customer information than the individual entities, then value could be created. Perhaps the new entity has the resources to eliminate competitors. There may also be expense savings. Possibly management resources can be better employed.

4.19 In order for us to judge whether, in fact, value has been created, we need to model the expense savings, oligopoly profits, business opportunities and effectiveness of management resources. It is still unusual to see asset-liability studies which address these issues.

4.20 If we are to accept the above economic views, then there are profound implications for ALM studies. The key question here is how the theory is borne out in practice. It would seem unlikely that the shareholders have adequate information about a company upon which to make their portfolio choices. In practice, this is precisely the information that the managers of the business are searching for! It, therefore, cannot be well disseminated in the market. The separation of risk into the systematic and non-systematic components relies on estimated correlations between assets and liabilities; such correlations are notoriously difficult to estimate with any confidence. The extent to which individuals make rational portfolio choices is also open to debate. However, in practice there are a number of additional costs, including taxes, information costs and agency costs, which fall outside the scope of Modigliani-Miller's results. When these costs are taken into account in a DFA model, we no longer find that all capital strategies are equally attractive. Instead, we can use DFA to identify the optimal strategies that minimise the aggregate of these frictional costs.

5. Risk and Cost of Risk

5.1 Risk is not in itself a cost. As a result, reducing risk does not necessarily create shareholder value. As many of the risks borne by general insurers are non-systematic, we should see return targets only marginally in excess of the risk-free rate. This theory conflicts with the much higher rates conventionally used to profit test new products. Mehta (1998) demonstrates that the ex post returns achieved by general insurers are much closer to those predicted by CAPM than to the hurdle rates ostensibly used in pricing. In this section we consider how risks may manifest themselves as costs to an insurer. This provides a motivation for managing risks in terms of managing costs. It also puts risk on the same axis as returns. This is important, because it enables us to identify the appropriate amount to spend on risk management, that is, where the marginal £1 spent on risk management generates £1 in cost saving.

5.2 Insurers who write higher risk business may find that their share prices are more volatile. As a result, shareholders may demand a higher return—sometimes misleadingly called the cost of capital. This extra required return has to come from higher premiums, and can be thought of as a kind of risk cost. Indeed, in most corporate finance text books, this kind of risk cost is the first to be considered.

5.3 Financial theory suggests that not all sources of variability will result in higher required returns. A higher return will only be required to the extent that risk is systematic, that is, correlated to an investor's other wealth. Other risks can be eliminated by diversification within the shareholder's portfolio, and so do not require a risk premium. This realisation produces a number of insights into corporate policy, for example:

(a) The risk premium is not reduced by diversification. The portion of risk correlated to shareholders' other wealth is additive across lines of business.

(b) There is no free lunch for insurers switching from one asset class to another. This is because each asset class simply earns its required return to shareholders, so any gain in expected return is cancelled out by a higher shareholder required return.

(c) The required dollar return is not affected by the amount of capital allocated. This is because, if less capital is allocated, then the returns on a line of business are more geared, and so the percentage required return on capital goes up proportionately.

5.4 We will see that most of these statements are overly simplistic, because they take account only of systematic risk costs, and not other kinds of risk costs. Nevertheless, if the other risk costs are taken into account as cash flows, the systematic risk approach does provide a robust market-consistent way of valuing those cash flows. It is important to ensure that any economic model used for DFA is rich enough to support the systematic/non-systematic risk distinction.

5.5 It is reasonable to suppose that riskier lines of business require a

disproportionate amount of management time, because they are more significant for the insurer. This suggests that overhead expenses should be allocated in some way related to the risk. Furthermore, if an insurer is risky at the aggregate level, it becomes a less secure place to work, so that a risk premium must be loaded into salaries in order to attract and retain skilled staff. All of these observations contrast with common practice, which may allocate overhead expenses in proportion, for example, to premium income. A more accurate expense loading automatically provides a larger charge for more risky lines of business.

5.6 As pointed out by Jensen & Meckling (1976), shareholders incur agency costs when retaining managers to run companies for them. These agency costs are related to possible conflicts of interests between shareholders and managers. They are also reduced when shareholders can easily monitor managers.

5.7 The conflicts of interest are likely to be larger when more risk is involved. This is because managers inevitably bear some of the risk, but cannot diversify in the way that shareholders can. This creates an incentive for managers to spend resources on reducing non-systematic risk (for example, via purchase of reinsurance) in a way which is detrimental to shareholders' interests. It is also more difficult for shareholders to monitor managers of more risky businesses, because the amount of random noise makes it difficult for shareholders to distinguish between luck and skill. This makes it easier for managers to conceal their failings and to destroy shareholder value by stealth. All of these issues mean that risky businesses create a particularly high incidence of agency costs.

5.8 Companies have different levels of skill in different lines of business. A skilled underwriter will seek out information until he has a good understanding of risk exposure, conditions of cover, and possible claims that might result. However, in areas of expansion, for example emerging markets, it is not always cost effective to collect and analyse this information, or to spend resources recruiting and training specialist underwriters. This leaves the insurer open to adverse selection, and to more elementary blunders. This is another cost of risk, but in this context, risk is measured, not by variability or probability, but by the quality of information available to evaluate a risk.

5.9 We now move on to a less direct area of risk cost. Writing more risks usually increases the level of capital which an insurer optimally holds; but holding capital itself generates costs, which can be thought of indirectly as risk costs.

6. Capital and Cost of Capital

6.1 The amount of capital held by a company reflects several factors, including shareholder risk, tolerance, and regulatory and industrial constraints. These constraints might be thought of as dictating a minimum level of capital. In this section we discuss how an insurer can establish an optimal level of capital.

6.2 We have already discussed the way in which capital is a cost. In other

words, the profit available from insurance must be sufficient to justify to shareholders the amount of capital held. Some mechanism must be found for allocating these profit targets down to policy level. This goal can be re-expressed as an allocation of the capital itself.

6.3 Great care is required when discussing the cost of capital. In common parlance, the *cost of capital* is taken to mean the shareholders' required return on the capital that they have subscribed. If this cost of capital is used to evaluate a new project, we implicitly assume that the additional capital will be invested in the same way as existing projects. In other words, a marginal injection of capital will result in an increase in new business. In this context, the cost of capital includes, not just the cost of holding the capital, but also the cost of bearing all those extra risks assumed to be taken on once the new capital is in place.

6.4 It is sometimes more helpful to consider the *pure cost of capital*, that is the marginal cost of holding extra assets, with *no change* in the liabilities. This means that we have to allow for the fact that the injection improves, not only the expected profit (extra income from investment), but also the quality of earnings (ruin less likely because less gearing). On the other hand, the accounting return on capital has probably fallen as a result of the injection.

6.5 We can look at the required profit for a company before and after the injection of an additional £1 of capital. This can be expressed as the risk-free rate on £1 plus the pure cost of capital. In a perfect (Modigliani-Miller) world the pure cost of capital would be zero. However, in real life some investment income is double taxed. As discussed in ¶6.10, there may also be agency costs associated with managerial self-interest, which become more onerous as more funds are injected. This and other effects contribute to the pure cost of capital.

6.6 The size of pure cost of capital may vary according to how the funds are invested. For example, in the case of U.K. general insurers, the effect of double taxation is less severe for equities than for bonds, as the tax on capital gains can be deferred. On the other hand, equity investment may also increase agency costs, as the additional volatility creates a smokescreen, frustrating shareholder attempts to monitor managers.

6.7 We measure the cost of capital raising as a round-trip cost. This means that we consider the raising of capital via a rights issue, followed immediately by a dividend payment which restores the insurer to the situation prior to the rights issue; but the shareholder has not been restored to his former position — he is worse off because various third parties have taken a cut. The whole process may well trigger banking fees, dividend taxes and other forms of frictional cost. It will also consume a significant amount of management time. The sum total of these is the cost of raising capital.

6.8 In practice, the cost of raising capital depends on a number of other factors, most notably the state of the market and the state of the company concerned. If an insurer finds itself suddenly in difficulties and in need of capital, that capital will come at a high price. This price can be explained in terms of the *under-investment problem*. The problem arises because, when an impaired

company seeks new equity, some of the benefits accrue to policyholders and other creditors. However, there is no cost-effective way of contracting with these other beneficiaries to contribute to the cost of the new capital, so the new equity holders demand compensation for that part of their injection which benefits other parties. In contrast, well-planned capital injections to healthy companies, for example to finance future growth, may be far less costly.

6.9 Let us suppose that there were no cost to holding capital. Then it would be desirable to minimise future capital raising and distribution costs. The optimal strategy would be to raise a very large amount of capital in relation to the underlying business, so that the probability of future recourse to the markets is very slim indeed. In this context, DFA would be trivial, because the possibility of financial impairment would be more or less eliminated.

6.10 However, at such large levels of capitalisation, shareholders have little effective control over management. Managers can afford to ignore financial markets because they are unlikely to require subsequent favours from those markets. Such insurance enterprises are likely to be run for the benefit of management, not shareholders. This is an example of agency cost, that is, a capital holding cost. It explains why shareholders like companies to be lean and mean.

6.11 Now let us suppose that there are zero capital raising costs. Then optimal levels of capitalisation will be determined by other conditions, such as customer credit sensitivity or capital holding costs. In this case, the insurer should declare frequent dividends or make frequent rights issues, so that the capital remains close to the optimal level. There is a hint of this in some recent announcements from insurers, who claim that they have more capital than necessary, and use this to justify a redistribution to shareholders. It is to be hoped that this calculation of capital allows for the possible costs of asking for it back next year.

6.12 So far we have considered costs to shareholders. It is worth mentioning that company management may see these costs in a different light. One reason for this is that capital changes can play a role in signalling management competence to the market. Shareholders may question the competence of management if:

(a) dividends are cut suddenly;
(b) the company becomes impaired financially; and/or
(c) the company admits that it has little use for its capital, and hands some back.

6.13 In each of these cases, a possible shareholder reaction is to displace the existing management team. We should note that this eventuality is not necessarily costly to shareholders. Shareholders do not place a low value on variable dividends, but they do use it as information when considering alternative corporate structures. This contrasts to existing management, who view variability in dividends as personally costly, because they are averse to losing their jobs. This provides an incentive to existing management to smooth dividends and to

manufacture rhetoric claiming that existing capital resources are well managed. To the extent that DFA projects are commissioned by management (and not by shareholders), it is reasonable for DFA objectives to reflect management's preferences.

6.14 We have identified two different types of capital cost, and established that the optimal strategy is trivial if either of these costs is zero. We deduce that, if the problem is non-trivial, both of these costs must be significant. We would expect the magnitude of these costs to enter into the equation somewhere. Simplistic approaches, which do not take capital costs into account, cannot be expected to produce defensible capital solutions.

6.15 If these costs are an issue for DFA, we would also expect them to be relevant in profit tests. In practice, capital costs are seldom incorporated into profit tests explicitly, but, instead, are reflected implicitly in a higher hurdle rate of return. This phenomenon, which is not unique to insurance, explains the apparent confusion when economists seek to reconcile hurdle returns to models such as the CAPM. As noted by Lewin *et al.* (1994), the explanation for the high hurdle rates lies, not in any theory of risk and return, but in the observation that profit forecasts are often optimistic and neglect important costs. Other methods of risk loading, such as the use of premium principles or capital allocation, can similarly be rationalised as representing proxies for various costs which would not otherwise be taken into account.

6.16 In this section we have focused in some detail on the costs of capital. It is worth noting that holding capital also has some benefits. The most obvious reason for holding capital is that policyholders and regulators require it. Demonstrating capital resources is an important way of signalling intent to pay valid claims. This is valuable to customers, because other ways of reducing credit exposure (e.g. diversifying across insurers) are costly or otherwise impractical. The customer is, therefore, prepared to pay insurers to manage their own risks to reduce this cost.

6.17 Traditional ALM sets capital requirements by balancing return on capital employed against probability of ruin. We have shown that both of these measures contain significant shortcomings. We have now developed a new approach, in which optimal capital is determined by trading off frictional capital costs against the need to signal commitment to customers.

7. CONCLUSION

7.1 DFA is a powerful and flexible tool for modelling the effects of different strategies on the financial position of an insurance company. The efficient frontier is an intuitively appealing method for interpreting the output from a DFA model, showing the risk-reward trade-offs between different strategies in a systematic manner. However, the traditional risk measures, used, both those based on simple measures, such as standard deviation of return or probability that solvency drops

below a given level, and those based on more advanced ideas, such as expected policyholder deficit and dynamic programming, mix together systematic and non-systematic risk, and can lead to misleading conclusions.

7.2 If the systematic risk component is small, then the efficient frontier is a valuable tool for evaluating medium-term tactical choices between mixes of lines of business, or reinsurance purchase strategies; but when management evaluates changes in asset mix, or considers moving capital into or out of the industry, systematic risk becomes significant, and it is necessary to move beyond the understandings provided by the efficient frontier.

7.3 An understanding of the implications of financial economics is essential for the application of DFA in general insurance, otherwise false conclusions may be drawn regarding issues where investment strategies are involved. The actuarial profession has to embrace the techniques, and get more used to applying them in practice — it gives us opportunities, not just threats, and it gives us a framework within which to apply our professional judgement.

7.4 Actuaries need to ensure they do not get left behind in their understanding and application of financial economics — MBAs, merchant bankers and stockbroker analysts have moved ahead; but, when it comes to general insurance, we do have a strong position arising from some natural advantages: firstly, our training in statistics and the measurement of uncertainty; and secondly, our understanding of the nature of liabilities. In particular, the financial markets are used to dealing in hedged risk, but an underwriting operation is happy to set a price for accepting unhedged risk. Also, financial engineers may regard a liability as just a negative asset, but, for an insurance company, a liability is a service opportunity with an external customer, and so must be managed very differently from the assets.

7.5 Suppose that the finance director asks the question: "This DFA is all very well, but what does it have to do with me?" We would reply that, if he wants to examine questions such as how much capital he needs to run the business, how much reinsurance he should buy, what dividends he should pay, and how the answers change if he changes the mix of business, then he needs a framework such as provided by DFA.

7.6 We are now living in a world increasingly populated by MBA consultants selling shareholder value concepts to senior management. Finance theory is now the language of the boardroom. The tide will not turn back. Actuaries need to learn this language, and embrace the finance culture. If this is achieved, the actuarial profession will become significantly stronger. Only then can we realise the full potential of DFA to provide a framework to bring together finance and actuarial theory in one unified whole.

REFERENCES

BRIDE, M. & LOMAX, M.W. (1994), Valuation and corporate management in a non-life insurance company. *J.I.A.* **121**, 363-440.

COPELAND, T., KOLLER, T. & MURRIN, J. (1995). *Valuation: measuring and managing the value of companies*. Wiley.

ELTON, E.J. & GRUBER, M.J. (1981). *Modern portfolio theory and investment analysis*. Wiley.

GOOVAERTS, M., DE VYLDER, F. & HAEZENDONCK, J. (1983). *Insurance premiums*. North Holland, Amsterdam.

HOOKER, N. D., BULMER, J. R., COOPER, S. M., GREEN, P. A. G. & HINTON, P. H. (1995). Risk-based capital in general insurance. *B.A.J.* **2**, 265-323.

IBESON, D., CZERNUSZEWICZ, A., EABRY, M., KELSEY, R., MOSS, G., ORR, J., POLLACK, S., SAYERS, J., SMITH, A., WILLIAMSON, I. & WRIGHT, T. (1999). Preliminary report of the capital allocation working group. *General Insurance Convention*, Institute of Actuaries.

JENSEN, M. C. & MECKLING, W. H. (1976). Theory of the firm: management behaviour, agency costs and ownership structure. *Journal of Financial Economics*, October 1976, **3** No 4, 305-360.

LEWIN, C.G., CARNE, S.A., DE RIVAZ, N.F.C., HALL, R.E.G., MCKELVEY, K.J. & WILKIE, A.D. (1994). Capital projects. *B.A.J.* **1**, 155-330.

MEHTA, S.J.B. (1992). Allowing for asset, liability and business risk in the valuation of a life office. *J.I.A.* **119**, 385-455.

MEHTA, S.J.B. (1998). Pricing of insurance risk. *General Insurance Convention*, Institute of Actuaries.

MODIGLIANI, F. & MILLER, M. (1958). The cost of capital, corporation finance, and the theory of investment. *American Economic Review,* **48**, 261-297.

SWEENEY, J.C., SONLIN, S.M., CORRENTI, S. & WILLIAMS, A.P. (1998). Optimal insurance asset allocation in a multi-currency environment. In *Worldwide Asset and Liability Modelling*, edited by ZIEMBA, W.T. & MULVEY, J.M., Cambridge.

ABSTRACT OF THE DISCUSSION

Mr M. P. Cumberworth, F.I.A. (introducing the paper)**:** Although many may regard the paper as being largely theoretical, it was written from a very practical perspective. The paper examines the management processes associated with running a general insurance business, and aims to highlight techniques that can be used to enhance the quality of corporate decision making. There are two main themes running throughout the paper.

The first theme is concerned with stochastic modelling. Although this is an immensely powerful and flexible tool, to date its full potential has not yet been realised within the actuarial profession. The number of modelling practitioners is still small, and many asset/liability modelling studies have been concerned principally with deriving simple asset allocation results. The potential scope is much wider, and the profession needs more pioneers. Part of the problem is that much discussion within the profession has centred upon the merits of different asset models. Unfortunately, this has served to label stochastic modelling as 'difficult' and to frighten away senior management from using these techniques more widely. The reality is that there is a wide range of suitable asset models. It is important to be able to understand the inputs, but the real difficulty and the real skill is in interpreting the output! Our aim is to promote wider use of all forms of modelling.

The second theme concerns the use of financial economics, where actuaries still have much to learn. I am constantly amazed that the profession has such difficulty accepting the work of academics from outside the actuarial sphere. Meetings in this Hall have produced some astonishing debates. It is not acceptable to disregard nearly fifty years of finance theory just because there are some misgivings about Markowitz's seminal 1952 paper. Finance theory is now mainstream, and is the language of the City. This tide will not turn back. The culture of 'shareholder value' is currently being preached in boardrooms to senior management by Harvard MBAs. Actuaries are increasingly being sidelined in corporate decision making. At the very least, we must learn the language and understand the theories. If we cannot do this, then the profession runs the risk of being increasingly marginalised.

The paper combines these two themes, and examines both theory and practice. We aim to give practical insights to help others avoid some of the pitfalls. We show where finance theory is important, and, where possible, use examples to illustrate the decision processes. Although the paper has been written primarily to examine the particular needs of general insurers, many of the techniques can be used more widely in other forms of businesses. Above all, we aim to show the power and potential of combining both stochastic modelling and financial economics to enhance decision making at the corporate level.

Mr C. T. Pettengell, F.I.A. (opening the discussion)**:** The paper attempts a very difficult challenge: to bridge the world of financial economics to the world of non-life insurance or reinsurance. I now review the conclusions that I drew from the paper, discuss some real world observations, and make some suggestions for research.

The conclusions were quite difficult to identify, but I summarise my understanding of them as follows. First, the capital which is required in any non-life insurance or reinsurance company is driven by policyholder requirements, and viewed largely as a necessary evil from a shareholder's perspective. Normally shareholders are going to prefer less capital. Secondly, shareholders do not view all risks as equal, and critically distinguish between those that are systematic and those that are diversifiable. Shareholders will, indeed, value diversification of diversifiable insurance risk, but the value that they will ascribe to such diversification is likely to be less than that implied by a traditional asset/liability modelling approach, such as the one set out in the paper.

The value that they will ascribe from such diversification actually arises from the lower probability of ruin, which, therefore, lowers agency costs, capital raising costs and capital holding costs. This is, perhaps, most easily envisaged by considering the example in the paper, where the merger has happened, but no capital has been distributed. In this case the company has

the average return on equity (ROE) of the individual parts, but has a lower ROE variability, due to the pooling of diversifiable insurance risk. This does yield a lower probability of default and the associated reduction in capital raising and agency costs.

However, shareholders will not lower the discount rate for the earnings from this merged company, despite the fact that the variability of such earnings is lower. The reason for this is that the systematic variability for the merged company is just the average of the individual components.

More generally, the paper concludes that shareholders will measure the value of corporate decisions, such as diversification, or indeed merger and acquisitions, by the discounted value of the impacts that they have on the economics of the business — be they economies of scale, power of information, improved management capability, and so on. Crucially, the discount rate will depend solely upon the systematic risk that remains in the structure.

It occurs to me that this view is somewhat akin to that discussed in the last couple of years for capital projects appraisal. One of the findings in that work was that all effects cannot be summarised in one discount rate, and that it is important to allow for actual probabilities and economic costs to get a better value assessment.

I now move on to some real world observations, and begin with the role of the much maligned management, as set out in this paper. Firstly, neither I nor most managements with whom I have worked are trying to 'destroy shareholder value by stealth', as suggested in the paper. Management is required for shareholders to gain access to insurance risk, and should be better at allocating capital to different sources of insurance risk than a remote shareholder. If it is not, it had better watch out. Management is obviously, however, naturally non-diversified, and the value added that it delivers, in terms of accessing the insurance business and directing investments to more profitable sectors of insurance business, must exceed the agency costs that it brings. If not, management will disappear, and perhaps it is telling that management has not disappeared.

Shareholders want to assess their management. They would like the best management in the business, and so they do value smooth earnings to assist this assessment. Most investment analysts to whom I have spoken certainly do not act as diversified investors. To quote one: "I am more in the 'what have you done for me recently?' school". Indeed, I wonder if the authors could identify the fabled diversified investor.

One conclusion that will not come as a surprise to any management is that the key to merger and acquisition is evaluating the economic fundamentals of the resulting business, not something that might be suggested by an asset/liability modelling black box.

However, there is clearly real value in dynamic financial analysis, and I believe that it comes from an understanding of the real world drivers, the things that make the economics of the business different. Identification of these drivers helps management to adjust the mix of business, given different market prices, and adds their part of the value chain that shareholders employ them for in the first place.

I now consider what implications there are from the convergence of the banking and the insurance industries, and will speak about the evolution of CAT bonds and also movements into financial guarantees and credit wraps by insurers and reinsurers.

Regarding the evolution of CAT bonds, much less has been made of the zero beta of these assets, and, consequently, predictions have been made that the capital markets would undercut the reinsurance market for these risks.

The experience to-date is that this has not materialised. Indeed, the capital markets currently charge as much, if not more, than the traditional reinsurance market. This observation is not definitive, but it is interesting, and there are at least three reasons for it:

(1) The market is at an early stage of evolution in terms of the entrance of the broad scale capital markets, so, perhaps, the market pricing is not efficient yet.
(2) Investors place real value on the underwriting expertise of insurers or reinsurance.
(3) Not all investment fund managers act as diversified investors.

Considering the movement of insurers and reinsurers into financial guarantees and credit wraps, I wonder what people charge for the costs of risk — that is, beyond the expected losses for the costs of variability of the risk — for these deals. From what I have seen, I presume that many are pricing for volatility against an overall risk benchmark — that is, one including both systematic and non-systematic risk — rather than a more costly pure systematic benchmark, that I believe would be advocated by the authors.

I would consider a consistent valuation model for banks and insurance companies as the next logical step in the process. In a way, this would be taking financial economics back to the banking industry, where it originated.

One final real-world observation concerns the number of specialist companies. They certainly do exist, but I perceive that they are often ephemeral, unless there are structural reasons preventing their aggregation into more diversified companies. An example of this would be the evolution of mono-line CAT insurers. Here, I think that the real world values multi-line diversification of diversifiable insurance risk more highly than the clarity of the earnings that investment in a mono-line company would bring.

I suggest two areas for future research. First, I would like to see some more numbers; sample calculations of different assessment models — that is, the traditional asset/liability modelling approach compared with the approach suggested in the paper. Secondly, I would like to see some betas calculated for different lines of non-life business.

Mr D. E. A. Sanders, F.I.A.: I have three points that I wish to consider.

Optimisation

I agree that traditional asset/liability modelling and dynamic financial analysis methods should be used only as a guideline to setting capital. The authors conclude, in ¶6.17, that: "optimal capital is determined by trading off frictional capital costs against the need to signal commitment to customers." Considering this conclusion in the context of the United Kingdom market raises a number of issues. First, optimisation is not absolute, and needs to be measured relative to some desired objective and constraints. There is the seeking of a minimal solution to some function, which is the equivalent of finding the solution to some differential equation. The authors do not comment on the objectives or constraints. There is also difficulty in putting a measure on the 'signalling of customer commitment', which is, itself, a multi-dimensional facet. In the U.K. market there is legislation that protects the customer, for example the Policyholder Protection Act. Furthermore, annual accounting and scrutiny requirements give further protection. The policyholder has become more price sensitive, and places little value on any 'signal of commitment' by the insurers. In this market there appears to be little incentive for an insurer to raise capital in respect of personal lines business. Furthermore, the raising of capital in the Lloyd's market for some players has little frictional cost, which possibly explains its attraction relative to a fully capitalised London Market business. Signalling customer commitment, in practice, appears to be very much a side issue, and certainly not the driving force for raising capital.

Catastrophe bonds and zero beta assets

I have great difficulty with the concept of zero beta. First, if an asset is part of the market, then it must have some correlation with the market by its membership of the class. Thus, drawing a conclusion from a zero calculated correlation is just as bad as drawing a conclusion from highly correlated events. I am further concerned, because most catastrophes are modelled from distributions with unknown (possibly infinite) standard deviations. Thus, the product of a very low correlation and a very high standard deviation gives a positive non-zero beta, which, in the limit of the process, will still give a positive non-zero beta, and to assume that catastrophe bonds are zero beta assets will seriously misprice them, and, when a catastrophe happens, they will create real financial strain. As an example, consider the impact of a major Tokyo earthquake on the United States stock market, as assets are realised to meet the claims, and also as Japan's GNP tumbles.

Catastrophe bonds will perform in a similar way to international bonds when there are no very severe losses. When there are losses they will perform differently, depending on the extent of the loss, which may be limited to the loss of a year's interest in the case of, say, the Winterthur Bond, to a loss of capital in the very high risk hurricane and earthquake bonds. For most of the time the catastrophe bonds appear to trade like ordinary bonds, and this partial correlation appears to be confirmed by investigations.

The efficient frontier

In Section 4 the authors deal with the efficient frontier model, looking at three businesses: motor, employers' liability and mortgage indemnity. I now consider some issues, regarding two of the businesses, in setting value. Mortgage indemnity is a business where the insured has significantly more knowledge of the risks than the insurer. Since, as the authors correctly indicate, knowledge has value, does this place low value or worth on a mortgage indemnity business transacted distinct from the mortgage provider? I consider that it does. This would mean that any mortgage indemnity captive being set up would be difficult to sell, because the perceived value to any buyer would be significantly less than that to the mortgage provider. One of the problems of the 1990 mortgage indemnity fiasco was this lack of understanding of the market by insurers, and how it had been changed by the insureds. One may observe that many reinsurers are also in a very similar position in respect of the risks underwritten by their insureds.

The ability to diversify a portfolio, such as employers' liability, is very dependent on the size of the business. The representation, in Figure 6, of ELCO with a mean ROCE and systemic risk as a point is very simplistic. A better representation would be a spheroid or even a great amorphous blob. If an insurer wrote a small amount of employers' liability business, it could always back out of the risks, or change the niche market in which it is involved. This is the classical way of diversification and meeting the frontier — by rapidly changing the mix. A writer of a large volume of business has great difficulty in moving its position; CAPM models assume none of the real and practical restraints imposed on a major underwriter. One consequence of this is that, to diversify, one needs to break the business into smaller components, and manage these smaller components to achieve a better whole. The failure of big insurers to recognise this process gives smaller insurers an opportunity and an advantage. Thus, different size insurers have different perspectives of diversifiable risk and how to manage it. Arbitrage opportunities may exist, as a transient feature. This conclusion also leads automatically to a utility theory approach to the problem of diversification and capital. I would have liked to have seen the authors consider this type of issue, as it often leads to solutions from the classical theory of risk which support the more modern financial theory of risk.

Mr S. Christofides: The main issue here is the definition and quantification of risk and return in financial transactions. The paper rightly concentrates much of its comments, and warnings, on the need to differentiate between systematic and non-systematic risk. By the end of the paper every reader should be totally convinced of the validity of this argument.

This realisation is, in itself, sufficient justification for this paper. There is, in addition, a useful discussion on the use and limitations of efficient frontier techniques for risk-return evaluations where non-systematic risk is dominant, and the possible use of the CAPM where systematic risk dominates. These sections are useful summaries of these approaches, and could have been expanded to discuss the serious limitations of both approaches in any practical application in general insurance where the underlying results often have skewed distributions. In such cases standard deviations are simply not appropriate measures for risk, and much of the efficient frontier methodology is inappropriate. Skewness also causes problems with CAPM betas. This may contribute to the problem that one meets in practice when attempting to derive betas by class of business, where these values tend to be unstable over time. This problem was identified many years back by Professor David Cummins when, as I recall, this approach was being considered for U.S. rate filing purposes.

I now turn to the other thesis of this paper, that dynamic financial analysis (DFA) modelling offers the only realistic way of progressing these issues in developing our understanding of capital requirements as well as progressing our pricing and risk-return evaluations. All of us who have struggled with these challenges will agree with this assertion. DFA models may have a new name, but the approach is not new, and insurance asset/liability models (ALM), or solvency models, can be traced back twenty years or more. So, the new generation of DFA models will only deliver the results that the authors suggest if they overcome the limitations of these earlier models. In my experience there are three main reasons why ALM or solvency models have failed to live up to their promises. The main reason is the poor economic scenario generators (ESG) that were implemented in these models. The second, and here I disagree with the authors, is the practical difficulty that one faces in actually building and calibrating these models. Quite often too much detail goes in and far too much comes out. This makes both the validation and the interpretation very difficult, if not impossible. Identifying the minimum level of input necessary to produce meaningful and useful results is a non-trivial task. The third reason is the one that the authors discuss here, which really revolves around robust measures for risk and return, and much less emphasis on crude proxy measures, such as those based on capital allocation.

So, I would go a stage further than the authors, and suggest that the key to unlocking these mysteries is to be found within the ESG of the DFA models. These ESGs should provide, not only the linkage between assets and liabilities, but also resolve the risk-return conundrum. In other words, any economic evaluation should be done inside the DFA model rather than outside it.

This demands a lot from the ESG, and none of the older economic models had the functionality necessary both to explain current market pricing or to calculate future values consistently. Such models are now appearing in the literature, and, for the time first, we have the potential for a quantum leap in this whole area of risk modelling and evaluation. In turn, these developments will, in time, have a considerable impact on the way in which managers of financial institutions review their pricing and performance, as well as on how they evaluate alternative strategies.

I believe that this paper will now encourage others to pick up these issues and progress them to practical implementation. There is much to look forward to.

Mr P. J. Nowell, F.I.A.: It is, perhaps, a shame that 'shareholder value' is not one of the keywords of this paper, as this may be the bottom line for many people who would want to use the techniques suggested by the paper.

The CAPM approach provides an interesting insight into the behaviour of businesses and equities. However, it does depend, as the authors clearly state, on assumptions such as perfect knowledge and the ability to diversify non-systematic risk. When these assumptions are relaxed, we are left, in practice, with perhaps three components of the required return on equity. Over and above the risk-free return, these are: systematic risk premium, non- systematic risk premium, and an imperfect knowledge adjustment.

In ¶1.1.1 the authors say that: "the premium should always lie . . . below the maximum loss." I agree that, if the maximum loss is known to the insurer as well as to the insured, this may be the case, but if only the insurer knows the maximum loss, then this upper bound does not apply. This may be an extreme example. In general, the point to be made is that pricing decisions should be based on what the market will bear, based on some sort of profit maximisation, with the theoretical 'premium basis' as the minimum which should be charged. In practice, of course, most risks are not fully understood and the distribution of outcomes can only be estimated, often on a very limited amount of knowledge. This applies just as much to savings products as to general insurance products, with, perhaps, sales volumes being the most difficult area in savings products.

In order to evaluate the theoretical pricing which should be charged, I would suggest that the paper's principles could be applied in two ways:

(1) All elements of non-systematic risk could be assessed on a reasonably prudent basis (say 90% probability of the outcome being better), and the resulting cash flows discounted at the risk-free rate. The solvency capital employed in the business would be the maximum of the amount required by the regulator, or credit agencies, or the amount required to withstand, say, a 1-in-10-year event, or whatever risk level was acceptable. If pricing is done on this basis as a minimum, there is a high probability that the actual outcome will be well in excess of the calculated return, and this may be sufficient to raise the achieved return to a level which justifies the shares in the company standing at a premium to asset value. The return on assets of the company can be further enhanced by investing in non-risk-free assets. In CAPM terms, I would suggest that the level of non-risk-free asset investment should be sufficient to raise the expected beta from such investment to be at least at, or just above, one, assuming that other risks are not correlated with the market risk. In this way I contend that, provided the company is successful, the share price will, over time, stand at a premium to asset value, to reflect the additional return being achieved by pricing the risk being taken at above the expected cost of the risk.

(2) An alternative approach would be to value all elements at the 'premium basis' on a 'realistic basis', that is at the expected outcome. Given the uncertainty of the estimate, as opposed to the inherent variability of the returns, and given the desire by management to retain their jobs, it would be reasonable to build in some conservatism in the discount rate to allow for the risk of assumption error. Using this model, management has a choice of approach to solvency-type capital. If it assumes that the capital is not at risk, then the risk-free rate can be used. Alternatively, the discount rate chosen could be pitched closer to the risk-free rate and applied to the whole of the cash flow, including the solvency capital. Once again, the investment policy could be determined to give a sensitivity to the market of one. As with the previous approach, if results are as expected by the management, investors will be willing to pay above asset value for the shares.

I think that either of these approaches explains two of the elements of stock market prices. First, prices reflect assets employed in the business which are expected to cause the company's shares to perform exactly in line with the equity market. The second element is a premium value to these assets, reflecting the value that investors place on the actual outcome of non-market-related risk taking being better than anticipated in product pricing.

There is a third element which is required to complete the picture, which is the fact that investors probably have a lesser understanding of the likely actual outcome of any company's business than the management has. They will, therefore, change their views of companies and sectors based on what they are told by advisers and management. It is this element which explains the very large share price swings, driven by optimism for companies which appear to deliver shareholders' expectations, and extreme adverse reactions to companies producing disappointing results.

I think that the main contribution made by the paper is to differentiate systematic from non-systematic risk. Whilst I agree with the authors in their approach to systematic risk, I believe that companies do get rewarded for taking non-systematic risk, and shareholders will gain or lose to the extent that they are able to identify when share prices under or over estimate these rewards.

Mr J. P. Ryan, F.I.A. (in a written contribution that was read to the meeting)**:** This paper needs to come with a very large health warning. The authors' conclusions in a number of places only make sense with a number of simplifying assumptions. Many of these are not found in practice in the general insurance industry. Consequently, some of their logic can sometimes be regarded as flawed. On the other hand, there are other occasions when these simplifying assumptions do apply, and the authors' comments make sense.

One important point to realise is that capital is required in a general insurance company (a pension fund and life company as well) for the benefit of policyholders and not for shareholders.

The authors point out, quite clearly, that shareholders can diversify. However, policyholders cannot. One cannot place one's motor policy with ten separate motor insurance companies.

This would not matter if both the policyholder and the shareholder had the same risk profile. Unfortunately they do not. The policyholder is very concerned if large amounts of his claim are unpaid. He is probably not unduly concerned if only a minimal deduction is made from the claim. However, in the latter case, the shareholder will have lost his entire investment and will not suffer any further should substantial shortfalls occur to the policyholder. The authors ignore this point. This would not matter either if all the risks were symmetrical, because the ranking of risks by order would not change for most likely risk measures for both policyholders and shareholders. This would be true of many investment and banking risks. However, it is not the case in the insurance industry, where many of the liability distributions are extremely skew. Consequently, there will be differences in the ordering of risks as well as in relative trade-offs.

The underlying assumptions, therefore, of the Modigliani & Miller model do not apply. Their paper was essentially designed for industrial companies, where the customers do not have the same stake in the ongoing company, and where, generally, distributions are not so skew. Indeed, in the example quoted in ¶¶3.7 and 3.8 there will be many cases where the authors' analysis is plainly wrong. If there is the significant gain in policyholder security that the authors imply by their suggestion that capital can be repaid, then the policyholders will pay more for a more secure company, which will more than compensate the shareholders for the risk concerned. We do not have enough information in this example to evaluate this correctly, but one can clearly demonstrate cases where there is a real gain. Indeed, the authors hint at this in ¶6.8.

In the paper the authors do mention the importance of risk measures. This is an important area, and one where much more attention will have to be paid by the actuarial profession in the future. The financial community is beginning to do a significant amount in this area, and its thinking is changing. Unfortunately, the authors do not even hint at this. The reason that this is important to the actuarial profession is, again, because of the skewness of the distributions with which we deal generally. The investment community is beginning to identify these problems; not only because of the ability to do the calculations, but also because of options and similar investment vehicles which have highly skewed distributions.

An example of this is value at risk, which is the standard risk measure in banking. It works because most risks in the banking arena are symmetrical. Certainly the risks where most research has been done are symmetrical. The exceptions are probably credit risk and operational risk, which the banking community is only beginning to get to grips with now. Again, it can be shown that value at risk ranks most risks in the same way as the expected policyholder deficit (EPD) measure if the risks are symmetrical, but often will not do so if they are not. If we fail to get this message across as an actuarial community, we will find that bankers are imposing inappropriate risk measures on the insurance industry.

I add my doubts to those touched on by the authors on the general applicability of CAPM, and the fact that, in most cases, insurance markets are far from perfect. This is the beginning of quite a long road, and anybody utilising these techniques needs to go into very much more detail than the authors have done.

Mr P. J. Twyman, F.I.A.: The paper is a little tentative about what the problem is that is being solved. In fact, it is rather long on solutions for problems that are relatively less pressing in the insurance industry. Most general insurers have much bigger problems, with much more urgent solutions required. Putting it in an actuarial way, the techniques are probably a necessary condition for success, but by no means sufficient.

U.K. general insurance companies have, in aggregate, probably destroyed value over the past 15 years. There have been some short periods when value has been created, generally interspersed with much longer periods when value has been destroyed. By 'value creation' I mean total shareholder return in excess of the All-Share return. The practical question that I ask the authors is: "Would the application of these techniques have led to a dramatically different result in the last 15 years?" If I ask the question in another way, and we had a look at the variability between

the good companies and the bad companies, how much of the variability can be explained by the application of techniques like this, and how much can be explained by other things?

Considering catastrophe bonds, in theory exposure to these could be valued by the market. In fact the opposite seems to be the case, and the market seems to be unduly concerned about catastrophes. For example, just consider a very simple case. A company announces that it is likely to lose £50 million from the latest hurricane. As a result, the share price tends to fall by £100 million to £200 million; clearly an over-reaction. The price should fall by no more than £50 million, and perhaps even less.

The comments on agency costs, in Section 6, were interesting. This is a rather good way of talking about backing self-interest. Managers do not normally justify geographic diversification using techniques like this. They actually justify it because they like the air miles or it makes their business much bigger.

The paper provides a very good framework for making some of the corporate decisions in general insurance, but there are other much more important things, like how does the company know that it is in the right business line? Does it have the right people? Has it institutionalised the right processes for pricing, for risk acceptance, for claims settling and reserving? It may well be that it is better to try to find the efficient frontier for these rather elementary activities than to spend large amounts of money researching further this very interesting intellectual activity, which, at the margins, does not create much value.

Mr S. J. Mehta. F.I.A.: I have one criticism of the paper relating to the title. Why should sensible decisions be restricted only to general insurers?

The paper should become required reading for life insurance, pensions and investment actuaries. There is not very much in the paper that is new (see Bride & Lomax, 1994; Mehta, 1992), but does this mean that the paper is not worthwhile? Not at all; quite the contrary. The profession is at a turning point, and the more help that actuaries can be given to understand modern financial theory, the better.

A number of speakers in this discussion have provided illustrations of why training in economics would be useful. Misconceptions about CAPM and how financial economists allow for systematic risk seem to abound, and they should read the paper again. The fact that shareholder owned companies have capital in excess of statutory requirements shows that, contrary to the assertions of some speakers, there are advantages to holding capital for shareholders — for example, in attracting new business. To suggest, as Mr Ryan did, that most risks in the banking sector are symmetrical is plainly absurd.

One of the issues facing the profession is that the robust techniques being suggested will often involve the use of sound financial economic stochastic asset models, not just different methodologies. At present, only the financial economists among us have access to such models. One of the many positive steps that the profession could make is to commission the construction of an ALM model that all actuaries could use to replace the Wilkie style models currently in vogue. Clearly, there would need to be an interest among actuaries to use this model for sensible purposes. It would, in my view, be a great shame to go to the trouble of producing a good tool if U.K. actuarial ALM and valuation methodologies were not updated at the same time. Bad advice is often worse than no advice.

Based on my experience of a few years ago, a paper such as this would have been extensively criticised, and, at least in the life and pensions areas, publication would have been difficult to achieve. I find it encouraging that times are changing, and that the merits of economics-based advice are gradually becoming accepted. The authors are to be congratulated on helping this trend.

Mr C. Miranthis, F.I.A.: As the authors indicate, actuaries need to keep abreast of financial economic theory to lay claim to a role in corporate decision making in general insurance. Perhaps too much detailed modelling has prevented us from seeing clearly the wood for the trees.

Having said that, I was disappointed that the expectations I had, after reading the title, were only partially met. The paper neither reviews current actual practices at boards of general insurers, nor does it push out the frontiers of 'normative' financial theory. Indeed, many of the insights offered by the paper rely on the theory that, to a large extent, has been around for 40 years or more (e.g. the distinction between systematic and non-systematic risk, and the Modigliani & Miller proposition). To be fair to the authors, throughout they recognise 'various imperfections', which would lead to departures from their theoretical prescriptions or explain sub-optimal behaviours (e.g. managerial self-interest). My own position is that the nature of these 'imperfections' and the absence of market mechanisms and institutions are so pervasive as to stand the theory on its head. Indeed, abandoning the distinction on systematic/non-systematic risk may be the rational course of action in many situations. DFA risk measures, which mix the two types of risk, may, indeed, lead to optimal behaviour and be in the interest of shareholders.

To expand on this, I now mention some general facts, from my personal experience and from other publicly available research, that go against the drift of the paper. Then I will refer briefly to some plausible theoretical reasons why these facts do not indicate irrational behaviour:

Fact 1. Most finance directors are interested in total risk management of earnings volatility, and do not distinguish between systematic and non-systematic elements.

Fact 2. The market (at least in the U.S.A.) appears to reward low earnings volatility. Again, the distinction between systematic and non-systematic risk adds very little insight.

Fact 3. Tests on the CAPM proposition of betas or systematic risk being the most important element in risk pricing are generally falsifying the proposition. Indeed, it seems that, once total capitalisation and book to market value ratios are allowed for, other factors may not be that significant (a good summary is in Fama & French, 1988) since the issue of size is debatable. Beta measuring does very little to explain risk premiums.

Fact 4. I have not come across any fund manager who feels comfortable in diversifying non-systematic insurance risk. They would rather have the insurance mangers do it.

How does one reconcile these behaviours against the expectations from the theory in the paper? One can use the managerial theories of concentration of managerial interest/wealth in the total risk of the firm. The authors clearly recognise this in ¶6.13.

Much more importantly, however, one can query the elegant underlying theory; a theory that is based in an equilibrium world, with symmetric information on the part of shareholders, managers and financiers. As any manager who has had to endure grillings from analysts or rating agencies knows, the world is vastly different. The moment that non-systematic risk performance becomes a proxy for how well the company is managed, the whole picture changes. It becomes rational to control signals that the company wants to represent to the market. It becomes rational to rely on retained earnings for financing innovative, but potentially high risk, projects. It is rational to worry about rating agency ratings, which, at least partially, depend on total capital, since these affect the 'real' profitability of the underlying business. It becomes rational to benchmark total return volatility against competitors and set target rates of return. Risk becomes just a fact of meeting, or not meeting, expectations laid out in a plan or communication to shareholders. Measuring the probabilities of not meeting target returns becomes a real measure of risk.

Of course, part of the target returns and expectations could be cast in terms of 'beating' the market (or, perhaps more importantly, beating the 'sector'), in which case we have a reintroduction of some level of 'systematic' risk in the overall performance criteria, but only through a roundabout and much more imprecise way. The point of all this is that, in a world full of information asymmetries, it is not possible to ignore the signalling effect which management of total earnings has. The paper fails to recognise that, and seems to place much more emphasis on the divergence of managerial and shareholder interests.

Recognising real life constraints may not yield an elegant theory. However, such models may be much more useful to managers than any abstract distinctions between systematic and non-

systematic risk. It is by meeting or exceeding analysts' expectations that firms can create shareholder value.

Reference

FAMA, E. F. & FRENCH, R. K. (1988). Dividend yields and expected stock returns. *Journal of Financial Economics,* **22**, 3-25.

Mr N. Shah, F.I.A.: This is a paper that demonstrates how we can effectively combine financial economics and actuarial methodologies and bring them to bear on some of the problems that occur.

The authors comment that building a model is generally the easy part, and understanding the output is the difficult part. In theory, I agree with them. However, in practice, when one is dealing with an organisation that is even moderately complex, the situation is not that clear-cut. I think that the builder of the model has to take into account issues, such as the availability of data, where decisions are actually made within the organisation, which makes the task non-trivial. In many instances I think that the model does have to be reviewed after the output has been analysed, and there the authors are quite correct in that the challenge is in the analysis.

Operational risk has been mentioned in some of the discussion. I think I would agree, to some extent, with Mr Twyman's remarks, that there are more pressing problems that actually need to be solved in insurance organisations which could contribute more towards creating shareholder value, and more immediate action on that would be more effective. In some ways, much of the risk that is being modelled is due to the operations in nature. So I think that more work needs to be done in terms of defining the risks more accurately.

There are several references to free lunches in the paper. Where there is a free exchange of information and a common view of the future is shared between the different people looking at the businesses, then free lunches are illusory. However, considerable differences between the information available for management, shareholders and analysts actually means that it is an important aspect in the creation of shareholder value, in aligning management actions with what shareholders are expecting in terms of returns and the risks with which they are faced.

Mr G. P. M. Maher, F.I.A.: I have much to agree with in the paper, and find that the general thinking fits with that which I have employed over the last several years in working with companies in, for example, their establishment of optimal risk retention, whether for corporate buyers in their determination of insurance requirements or for insurers in their reinsurance purchasing decisions.

Towards the end of ¶1.3 the authors state that: "the risk measure . . . can vary with what management thinks is most important in any given set of circumstances." This is critical. What management means by risk varies enormously, as much as it does with the individuals in this room, and many factors affect this. For example, ownership structures, whether the company is privately held, quoted, or a subsidiary, affect the ways in which management is implicitly thinking of risk in the decisions that it makes all the time in relative trade offs. The culture and history of the company also play a role. Management changes often alter the meaning of risk within the organisation.

As the authors rightly state, these different definitions of risk lead to different optimal solutions, and that is why the definition is important. If risk, as used in the analysis, is not the same as used implicitly by management as a whole, then, for example, the reinsurance strategy being suggested may be wholly inappropriate to the company. Bearing in mind the importance of reinsurance for financial strength and well being, there exists a significant danger of materially inappropriate advice being given. In evaluating the trade off between return and risk, risk must, therefore, be given the definition that underlines the company's thinking.

Equally important, it is no use presenting to senior management graphs which show the relative returns under different risk scenarios, when the risk definition does not match the

management way of thinking. Probability of ruin, for example, is not something that is thought about by most management, although some do, and there are many ways of thinking of risk — for example: earnings volatility, loss of Standard & Poor's rating, regulatory action, weakening of competitive position and so forth. Also, in practice, the risk metric is often a mixture of these. Management, often, has not explicitly formulated what is an underlying part of its everyday thinking, and facilitating the process of explicitly stating what risk means in each particular case often requires skills from the actuary which, in many cases, are not part of his or her stock in trade.

Equally important is the time frame, and figures such as those presented by the authors, prepared for the same risk metric, but over different time frames, can look very different, indicating that entirely different strategies are suggested if different time frames for decision making are used. In such cases figures similar to those set out in the paper lead management to take longer-term decisions than they otherwise would, accepting a higher — explicitly quantified — short-term risk. Key here is the decision-making process and getting agreement at the different levels within the company. When the higher accepted risk has been quantified and understood around the table, it becomes part of the plan. When higher short-term volatility emerges than under the previous strategy, this is accepted, and is not a reason to fault the change in approach. Successfully managing this part of the process is often, in practice, the area where most value is added.

Involving people at different levels is necessary. Again, to take reinsurance as an example, if the discussions involve only the reinsurance manager, different risk metrics may be used in the analysis than if the chief financial officer and the chief executive are involved. These discussions are also necessary for transparency of process and for ensuring that the project obtains the buy-in necessary for success. A by-product from these discussions can also be changes in the general understanding of risk in the organisation.

I agree broadly with the authors in ¶3.3, where they state that building the model is not the difficult part, understanding the output is. I would, however, like to add to that that getting the assumptions right is often as difficult. Generating a set which matches the underlying reality is not always easy, and it is possible, if too theoretical an approach is taken, to fall into the trap of understating volatilities, and I firmly believe that the actuarial profession has unique capabilities in this area.

Mr D. M. Hart, F.I.A.: I raise with the authors the matter of specific or non-systematic risk. In this context, I agree with Mr Ryan. As I understand it, the authors are saying that the shareholders may be prepared to accept more risk on an individual insurer than would be implied by the risk of insolvency of that insurer. This is because, insofar as the risk is not systematic, they can diversify it by a judicious investment strategy, leading to a portfolio of risks which, overall, provides a reduced risk profile. This suggests, at the extreme, that they are prepared to accept greater risk of the insolvency of an individual insurer for the greater return thus possible on the portfolio as a whole, whether the remainder of the portfolio is in the insurance or other industries. This seems perfectly acceptable from the shareholder's point of view.

However, I would like to consider the proposition from the policyholder's and/or regulator's perspective, and I believe that these viewpoints are, at least in this context, very similar. Neither of these parties has any interest in the shareholder's overall return on his investments, but both have very considerable interest in the continuing solvency of the individual insurer. Are they not equally important stakeholders in the insurer? In addition, the insurance industry, as a whole, has a significant interest in the solvency of its members, as insurer collapses have a seriously adverse public relations impact, even on the surviving companies. This is obviously a significant factor in the policy of the industry, through the ABI, of taking over and running off a number of failing companies. The situation is further complicated by the impact of the levies to the Policyholders' Protection Board in respect of the reimbursement of the liabilities to personal policyholders of failed insurers.

I do not believe that the financial models in the paper allow for these 'real world' interactions between companies, and wonder to what extent these interactions distort the theoretical position, and whether, as suggested by Mr Miranthis, they undermine the distinction between systematic and non-systematic risk.

Mr A. N. Hitchcox, F.I.A.: I am one of the co-authors of the paper. Mr Cumberworth, in his opening remarks, mentioned that the balance of decision-making may be shifting in the City. The point that I would like to make is that it is not just in the City that this is happening. My company has recently been acquired by a large reinsurance group whose ultimate shareholder is one of the largest industrial concerns in the world, manufacturing items from aero engines to light bulbs. It is absolutely obsessive about measuring risk and reward at corporate level. It employs large numbers of Harvard MBAs, all versed in financial theory and all keen to apply it to my business.

As it happens, the natural advantages that we outlined in ¶7.4, namely, the experience in dealing with unhedged risk, to which they are unused, and then the realisation that liabilities are not just negative assets, but actually represent our customers' expectations, enable me to make many telling points that they were not capable of making themselves. There is absolutely no doubt that, if I cannot speak their language, which is, like it or not, the language of financial economics, then I do not actually get into the debate at square one.

Mr J. J. Park (a visitor)**:** I not an actuary, nor am I British. The paper is important for actuaries to think more about shareholder outcomes, shareholder value outcomes.

My first comment, and I am echoing what has already been said, is that both the quantum and the nature of systemic and non-systemic risk are very much in the eye of the beholder. I thought that employers' liability and mortgage indemnity business were subject to the same set of economic variables, and I am clearly not among the majority in that regard. That is a perverse American view about unemployment and insurance claims. Also, there is the kind of systemic risk that we cannot foresee. In 1993 most of us made a bad call and thought that the motor insurance business was not very risky, because we underestimated the extent to which a fundamental change in the way people sell and buy insurance and a strong economy would combine to make this lowest of risk-based capital insurance businesses eat our capital. We should think about what actually is systemic risk as we go forward.

My other comments go to the cultural issues. In fact, the company described in the paper will make its decisions according to the culture of which one of the three businesses it winds up running. Two of the things that actuaries should spend more time doing are more qualitative studies on economic change and its impact on underwriting results, and, with regard to the cultural issue, some casework on the impact of acquisition and change on insurance groups is recommended. There have been several major acquisitions here that will provide you with good examples. The problem is that you have just too small a field to work with in the U.K.

I have a third comment, which has to do with the shareholder market and capital markets issues. I agree with the criticism about CAT bonds being theoretically low-beta assets. In fact, they are very high beta assets. The reason comes from the investment market, and has nothing to do with the assets. Fixed income investments that are hard to explain have higher betas than fixed income investments that are easy to explain. Derivatives and asset-backed securities simply have higher betas than 'pure' instruments, and these CAT funds have fallen into that group, regardless of risk.

I also think that securities markets are relatively good at rewarding or penalising excellence, or a lack thereof, in managing non-systemic risk within a sector of the insurance industry. Good execution gets rewarded. They are completely irrational in dealing with systemic risk, and the most outstanding example of this would be the high multiples and warm embrace given by the capital markets to the catastrophe specialist insurers, in the wake of Hurricane Andrew. If you have to deal with a market reality like that, then you cannot assume rational behaviour, and we must start with perceived investor values as much as actual ones.

Mr D. W. Dullaway, F.I.A.: This paper sets out some very important things, and dismisses a few myths which have been around too long. From this paper we should now understand that the value of an asset is simply the market value of that asset, at least to a first approximation, and that the value of a liability is, to a first approximation, dependent upon its risk characteristics, and not upon the assets held to back reserves.

We should understand that diversification happens at a very high level, not within an individual company, but at the level of the whole market. At that high level it does not really matter what the shape of a company's profit distribution is. The law of large numbers still works. If we understand these things, we understand, to a first approximation, what the value of a company should be. However, the first approximation is very important. We are also starting to understand that it does not always hold, and that once we have removed our belief in free lunches, the areas where this approximation does not hold are actually what drives behaviour, what drives value.

Two particular points from the paper, where we need to understand these modifications to our first approximation, are the role of financial impairment and the role of agency costs.

Total risk, which includes non-diversible risks, is important, but not because shareholders are rewarded for it in the market, or would like to be rewarded for it (diversification removes this source of reward), but because our customers penalise us for it. Our customers are incredibly credit sensitive. If it looks as if an insurance company is in the slightest financial difficulty, its customers will stop doing business with it, and, in the end, the value of our companies is driven by the value of new business. This is why it is so important to carry out risk management. The sort of risk management that we have to do is fairly easy and fairly low-cost. We can set underwriting limits; we can hold extra capital (which does not have much of a cost); we can use reinsurance, or hedging in the market. Risk management is cheap, it reduces financial impairment costs, and we should do it.

Even if it is cheap, I am not sure that I would want to do a lot of the risk allocation that I have heard being discussed. The question is: "What am I allocating?" If risk management reduces financial impairment costs to a minimum, there will be little cost left to allocate between products.

The other point is agency costs. I have some discomfort with the idea that managers may be taking their owners for a ride. I would point out that they do not need to be doing this on purpose. If there is a systematic optimism among managers in a firm, this actually gives exactly the same result, and, indeed, needs to be treated in exactly the same way. I think that insurance company managers are an optimistic bunch by and large, and if there is a lot of capital, they feel that they have to do something with it — to get some extra value out of it, even if decisions based on optimism are often wrong. Agency costs do not have to arise only from cynical self-interest.

There is a trade-off, a tension, between risk management and reducing financial impairment costs. A good way of reducing financial impairment costs is to hold on to capital. However, a good way of minimising agency costs is to have little free capital to play around with. The trade-off between these two costs will determine how much capital we hold; it will drive whether we do other things, like looking for contingent capital, other financing approaches, and other ways to do risk management that, at the same time, reduce agency costs. These second order effects have a major influence on behaviour, and that is an important point.

I have two requests for the future. One is that actuaries really need to stop getting quite so worried about the CAPM. Financial economists have been aware for 25 or 30 years that the CAPM model is not technically correct. There are plenty of other models, such as Merton's intertemporal CAPM, or arbitrage pricing theory, that address the problems of the CAPM. We should stop getting upset that the CAPM model is not perfect. What we really need to see now is hard numbers. I think that we understand the theory. We need some research to quantify the size of the missing parameters, such as the impact of agency costs.

Mr J. E. O'Neill, F.I.A. (closing the discussion)**:** Before I take stock of the discussion as a whole, I will add my own thoughts on this paper. First, what does the paper do for actuarial theory? We have heard, and I agree, that it does not advance it greatly. What it does do is to make many concepts accessible, and that is an important thing to have done. What does it do for actuarial practice? There are some very good arguments that actuarial practice is not covered in great detail here. For a practitioner, the paper will be very useful in setting out some of the shortcomings of the various approaches that are considered. The most important issue is the implication for actuarial training. Once again we have seen it demonstrated that financial economics and modern financial theory, or variations of those subjects, are extremely important, in a wider sense, in actuarial training, and not applied just to general insurance.

Turning to the discussion, Mr Cumberworth, on behalf of the authors, informed us that they saw themselves as pioneers, with the purpose of promoting models and modelling generally. They wanted to make sure that actuaries were not marginalised in this process; an extremely important development.

The opener set the scene for us. He spoke about the financial impact and the importance of that being measured on diversification or on merger or acquisition of general insurance companies. He raised a question which ran right through the discussion, which is what investors charge for risk; and what is the assessment for risk over and above the pure loss cost. Many of the issues raised in the paper were discussed, and a number of conclusions were stated. A general and wide conclusion was that we need to understand the fundamentals of the business and what drives the business, and not merely rely on a model or a set of black box results.

Several speakers have highlighted the importance of dynamic financial analysis modelling, one arguing that it is the only way to rationalise the issues in pricing, solvency and capital management; clearly a very important issue for us. Others considered the different perspectives of policyholders, shareholders and even regulators. Their risk profiles are different. Their approaches to systematic and non-systematic risks are different. The authors have shown us that the efficient frontier may not be appropriate in all these assessments. An interesting aspect of the discussion was that we are not all at one on exactly what systematic and non-systematic risks are. Indeed, what do actuaries or investors do, even when they have agreed on what constitutes systematic and non-systematic risk?

There were a number of areas in which, given time, we would have pressed the authors further. The next stage in the process that they outlined would be to look at different risk measures, and also to look at decision making, as exercised at different levels in an organisation. Yet again, we might have encouraged them to look at some of the impacts of an imperfect market. Shareholder value is important, but then so is the non-risk related component of this evaluation. This allows even more interesting speculation and further work.

We also identified a number of areas for further research. There was a call for the calculation of the beta values for non-life business, which, from a practitioner's point of view, is an extremely important development, and long overdue.

We also heard the suggestion that, perhaps, as a profession, we should develop an asset/liability model that we could adopt as a common standard. This is interesting as a research project, although it might not be of immediate practical value.

Mr A. D. Smith (replying)**:** First, I should like to answer fairly directly the question that Mr Twyman raised as to whether shareholders would be better off if, for the past 15 years, managers had been using some of these techniques. My experience is that the process of calibrating one of these models involves a deepening of the understanding of the business, which is of great value in pricing decisions. I suggest that many bad pricing decisions could have been avoided. Many other bad pricing decisions could have been avoided if the role of capital had been better understood 15 years ago. You can certainly think of managers who lost their jobs in takeovers who would still have their jobs had they managed risk better. In terms of what might be current priorities, you would not have expected asset/liability

modelling, perhaps, to have prevented pensions mis-selling, but the guaranteed annuity option is certainly a case where some more stochastic modelling would have picked up some of those issues earlier. So the answer, I think, is yes, that shareholders would have been better off.

In terms of measures of risk, a number of speakers have raised this, suggesting that standard deviations and ruin probabilities have their limitations. Some mentioned the earnings volatility, probability of missing targets, probability of credit downgrades, and so on, and a number mentioned the importance of skew distributions. All of these distinctions can be important. Our major point is that none of these methods really work, because they make the heroic assumptions that the contract is considered in isolation away from any other financial instruments or commitment. As Mr Christofides has noted, whatever your preferred method is for aggregate portfolio risk management, you cannot make sense of individual contracts without introducing some notion of systematic and non-systematic risk.

Many of the findings of Modigliani & Miller, in particular, are robust for the choice of risk measure. Mr Cumberworth referred to people who, perhaps, stopped with their understanding of this point in 1952, but Mr Ryan fell into that trap by espousing the fallacy that Modigliani & Miller relied on distributions being symmetric. It absolutely does not.

Mr Nowell raised an interesting point, that other speakers picked up, to do with imperfect knowledge adjustments and the value of asymmetric information. I agree with a number of speakers that the communication of these ideas is very important, and that there are signalling effects which need to be quantified. I would dispute the point that Mr Shah raised that this gives rise to free lunches. I suggest that, once you take into account the cost of acquiring the information, usually the free lunch goes away. Mr Miranthis also mentioned that our paper seemed to rely upon a lot of theory that had been around for 40 years. I would actually go further than that. It relies on concepts, like addition and multiplication, that have been around for 2000 years, at least, but, like Modigliani & Miller, they have matured remarkably well.

Mr Miranthis asked the specific question about the calculation of beta, whether we used historical data or from the model. My answer is that the beta we used is what you would technically call a cross-sectional estimate, so it goes across a number of simulations rather than a number of years. It is actually technically impossible to do that from historic data. The model that you need to complete the cross-sectional estimate is calibrated for historic data.

I agree with comments made by Mr Mehta and Mr Christofides, that a coherent asset model is important. The hardest part is to get the projections consistent with the way that you value the cash flows. For example, if you want to use CAPM, and use it to value the cash flows from £100 of index-linked bonds, you would like to find that the value of those cash flows is £100, and if not, you have an inconsistency with the model. In our simple example this was not a major issue, but advanced users will know that asset models and valuation models really come together in pairs. You have to choose them together.

A number of speakers questioned the soundness of some of the financial theories that we have used. I would join Mr Dullaway in not trying to defend the universal accuracy of simple models such as the CAPM, but I also do not want to fall into the trap which Mr Miranthis illustrated, of saying that, because theory requires difficult analysis, we have *carte blanche* to invent our own irrational theory instead.

The President (Mr P. N. Thornton, F.I.A.): I like this paper because it takes actuarial ideas — that is, stochastic modelling — from one area, asset planning, into another, and then tests the conclusions that can be drawn against current approaches. As you might have expected, this has flushed out a variety of responses. I also liked the holistic approach which it took to a whole business and its shareholders, and, when I first read it, I thought that this would neatly avoid the problems that at least one of the authors ran into when he was looking at pension funds — that there are trustees of pension funds who have different interests from the management or the shareholders. Of course we have the policyholders in insurance companies, so many of the

issues, in practice, are the same. As with pension funds, we need to look at the shareholders, the management, and the ultimate beneficiaries.

I also like the way that the paper puts emphasis on the efficient use of capital. This may be one of the ways in which we can broaden our involvement into other parts of the financial sector. It is important that we are able to talk in the same language as bankers, in particular, and I believe that an emphasis on the use of capital helps in all of that.

The conclusion of the paper calls for actuaries to learn the language of finance theory and embrace the finance culture. I have some sympathy with the general thrust of this, although I hope that actuaries will not accept these ideas uncritically. I do not think that there is too much danger of that, given this discussion.

Mr Mehta suggested that the profession might develop an agreed asset/liability model. We should have a look at that suggestion, and see whether it might be feasible. I think that it is an ambitious project, and it might not be easy to get agreement across the whole profession on a particular model. In fact, there is some value and strength in having alternative models, so that one can approach problems using different models, and see how the results compare. Nevertheless, I think that it would be worth revisiting the question of asset/liability models, and seeing whether there is more common ground now than there might have been when the subject has been discussed in the past.

There are two ways in which the call from the authors that actuaries should learn the language of finance theory can be addressed. One of them is a medium-term way, through adjusting the education syllabus. The syllabus which is now fully in force embraces stochastic modelling and financial economics, so we have at least made a start. Furthermore, we are already looking at the review of the syllabus for the next five years, looking at the whole structure of the education process, so the opportunity to continue to embrace ideas from finance theory in the educational part of the profession's activities is certainly there.

In the short term, the best way in which actuaries can learn to speak the language of finance theory and embrace the ideas in finance theory are through discussions on papers like this.

I am sure that you join me in expressing our thanks to the authors, the opener and the closer, and all those who participated in the discussion.

WRITTEN CONTRIBUTIONS

Mr B. R. P. Joseph, F.I.A.: It is not often that we are provided with a paper on general insurance that really should serve as a wake-up call to the profession regarding the interface of one of its core skills, DFA modelling, with modern financial economics, and the authors must be congratulated for that.

The paper advocates the use of efficient frontiers to interpret the results of DFA models. It uses the systematic and non-systematic risk elements to caution about the use of efficient frontiers, especially when attempting to consider the shareholders' perspective. I would extend this further. The use of DFA models by insurers requires a detailed understanding of the market cycle and the drivers impacting the business. The interpreting of the results of the model is about the measurement of management preferences. The technique of preference analysis is designed to rank the various scenarios produced by the DFA model in a systematic fashion. The ranking depends on the objectives or preferences of management. Management needs to have a clear idea of its preferences, and then to consider the output from the various scenarios produced by the models in the context of the preference analysis conducted. This technique produces a ranking of the DFA scenario outputs, and could be used to explain why the merger scenario described by the authors could be an optimal strategy. Management could, for example, have as an objective the minimising of the short-term volatility of results. This may suggest that the merger strategy may be the best strategy. An objective of maximising profit could result in different conclusions. The use of an efficient frontier to define future management actions, without regard to the framework within which management is operating, is unlikely to yield robust results.

In ¶4.9 the authors correctly identify that any assessment of risk to shareholders needs to be forward looking or prospective. This is true for all companies, and not just for insurers. Shareholders, by purchasing shares within a company, are purchasing a basket of risks. They reward, based on the information that they have available, management that creates shareholder value and better control or hedges the risks in the portfolio better than its competitors. A topical example is the use of traded weather instruments, by Koch in the U.S.A., to better manage its weather-related exposures. DFA modelling can be applied to measure the risks represented by any enterprise, and then to assist management in quantifying the outcomes of various elected business scenarios and in measuring the use of capital employed within its business from a risk-related viewpoint. In the case of Koch, the diversification of its operational risk into weather-related contracts from third parties can be measured and quantified using DFA. This choice of strategy can be supported, or otherwise, using a preference framework.

The authors have made a very good start at the unification of actuarial theories and techniques with those of financial economics. I concur that, as actuaries, we need to communicate in a language that is understood in the boardroom, and I hope that work in this area, beyond the frontier, continues.

Mr C. Keating and Mr C. Brooks (the former of whom spoke at the meeting, and subsequently both submitted this contribution as a replacement for what was said)**:** We admire the objectives of this paper. We also believe that stochastic modelling of financial decisions can generate meaningful insights into the management of the firm. Indeed, we feel that one of the uses of a model is precisely to sharpen the questions. The process of modelling, to us, is an investigation of how far we can take a set of principles, limited by assumptions and simplifications, to draw realistic and relevant conclusions. The paper does an admirable job of identifying and surveying the important aspects of portfolio theory and CAPM, risk and cost of capital, and of presenting the findings in a refreshingly non-technical and non-alienating fashion. However, we do, of course, have some issues with regard to the paper and, in particular, the treatment of risk.

First among these issues is that the word 'risk' appears to possess a variety of possible meanings, depending upon the context. Our understanding of risk can be understood in the following manner. Return is the realisation of a process of (temporal) uncertainty. Risk is simply a subset (possibly subjective) of the uncertainty set — subsequently realised as an unacceptable return.

In turn, two consequences stem from this description of risk: first, that the common usage in, for example, Markowitz is concerned with uncertainty rather than risk; and secondly, that we can approach the richer models of risk in the management science literature — the work of, for example, Jianmin Jia and James Dyer.

It is probably necessary to expand the Markowitz example for clarity. In this framework, risk is defined in terms of the deviations of actual returns from their expected values. To give an illustration of a potentially serious deficiency with this measure, consider a stock with expected return of 50%, with a standard deviation of 5%. Then some staggeringly high returns would, under this measure, be considered risky, although the probability of a loss, defined as a return of less than zero, would almost certainly be extremely small indeed. It is, of course, possible to advance these risk measures to lower partial moments and the concept of downside measures. The authors have paid lip service to these techniques, but they have not explicitly considered the expected return versus the conditional expected loss (defined by the lower partial moment). This is important, for it is, after all, the risk return trade-off that requires least management education. Incidentally, if we expand the Markowitz framework to include the possibility of asymmetric distributions of returns, then a more complex formulation becomes necessary. (See, for example, Rubinstein, 1973.)

The differentiation that we are emphasising is that most insurance contracts serve to define risk as loss, while risk, in the usual investment context, has an entirely different meaning. The paper's definition of risk as the *likelihood of adverse outcome* seems inappropriate to us; we prefer likelihood times consequence.

We have a little difficulty with the line: "Risk is not itself a cost"; to us, this is like: "An earthquake is not of itself a disaster". In theory the statement is correct, but, in practice, it is nonsensical. In our world risk is realised as an adverse return, according to the laws of probability. We do, however, accept that cost might be defined in terms of discretionary spending.

The distinction between systematic and non-systematic risk is also interesting. In fact, this leads to one of the prime *raisons d'être* of a financial intermediary. Non-systematic risk is diversifiable, and therefore goes unrewarded in the classical theory. Perhaps it is easiest to think of non-systematic, diversifiable risk as cross sectional in nature. Even here, if this is functionally convex, we should expect to profit from its acquisition, and this opens the door to some classical insurance pricing approaches. If the diversifiable risk is thought of as lying cross-sectionally (orthogonally) to time, then systematic risk may be thought of as occupying the time line — that is to say being time variant.

The inter-temporal transformation of systematic risk is the role of the financial intermediary to which we referred earlier — and this, we would contend, is the prime concern of most financial management. This is the stuff of booms, recessions, politics and many natural hazards.

The authors highlight some of the limitations of Modigliani & Miller. Let us be more explicit. Under general equilibrium, the basis of Arrow-Debreu and Modigliani & Miller, there are no frictions and symmetric information abounds. There is also an implicit Walrasian auctioneer. This framework has given us many useful insights into the management of investments. However, as it could not make profits, there is no justification for the existence of any financial intermediary, for, in this world, the problems which financial intermediaries exist to address do not arise.

To justify the existence of financial intermediaries, it is usual to rely upon market imperfections, to introduce games theoretic approaches and to descend into modern micro-economics. Also, it is worth noting that there are many possible sources of imperfection, including, for example, the existence of public goods, taxes, search costs, and so on. It is also usual to work in a partial equilibrium context. This will, in some, but by no means all, circumstances at the limit, produce the same results as general equilibrium. Let us assure the avid mathematicians that these models can be extremely complex — in fact, a good many of the moral hazard formulations remain unsolved.

In the context of this paper, it appears that there is a desire to add information asymmetry, games and frictions as an afterthought to the CAPM, but such a simple modification is not possible. These are fundamental changes to the axiomatic framework, and cannot be introduced without a complete revision of the derivations of Modigliani & Miller and of Sharpe. Think of the assumptions as ingredients in a cake mix: flour, margarine, eggs and sugar — if we were to remove flour and substitute cement — would we still get a cake?

The problem, as we see it, lies less in the holistic modelling of the firm, that is both assets and liabilities, than in modelling business asset valuations. Given that these are predicated upon revenues flowing from complex game strategies that are patently outside of the standard CAPM framework, this is no trivial exercise. Quite separately, we need to address the optimal valuation of the firm for an external shareholder, and this also may require us to move beyond the realm of the elementary financial economics of the efficient markets hypothesis.

Incidentally, we are unsure what the authors mean, at the end of ¶3.12, when they say that moving towards the market portfolio increases systemic risk.

The framework of ¶¶4.10 to 4.11 is intuitive, but may not work in practice. There are, to our knowledge, almost no near zero-beta stocks in existence. A corollary of this fact is that a beta measured using the correlation of the market return with the business return is sensible if one is valuing a project, but of less use for investors valuing the shares of a company. In practice, even if the correlations of the business returns with the market were zero for all of the firm's activities, it is likely that investor sentiment would lead the firm beta to be positive.

There is much discussion in the paper regarding the benefits, or otherwise, of within firm diversification for shareholders. The authors correctly note that the incentives for broad

diversification across industries (for example, a merger of a manufacturer of ice-cream and a manufacturer of battleships) may be primarily managerial in nature, since it is often more difficult for managers to diversify their interests than shareholders, but the paper does not bring out a few key issues.

For example, the fundamental question, in terms of the effects of diversification on shareholder value, is whether firms can diversify risk more efficiently than individuals. For large mutual fund investors, the answer to this question is almost certainly that shareholder diversification is preferable, but for individual investors with modest budgets, who, for one reason or another, wish to invest in a limited sense in a small number of companies, their costs of diversification may be prohibitive.

More fundamentally, mergers can create shareholder value if there are synergies between the products or services offered by the two firms, which result in economies of scale or scope. For example, two firms in different parts of the insurance business, or an insurance company and a bank, may make substantial gains from mergers, which will manifest themselves as cost savings or revenue enhancements, if a common sales and distribution network, or link-sales tactics can be used.

This paper, notwithstanding our comments above, represents a refreshing first step to informed decision making and better management. As the paper notes, modern financial theory and insurance practice seem to have developed almost independently of one another. The CAPM, in its most basic forms, has been around for over three decades, and yet the authors argue, in the first line of their abstract, that "the powerful and flexible tool of stochastic modelling can be applied to a range of business decisions . . .". This is not a criticism of their paper, but rather a disappointing reflection of the lack of dialogue between finance and actuarial academics. The authors have demonstrated how tools from financial economics may usefully be applied to problems in insurance; we believe that the reverse is also true. For example, much recent research interest in finance has centred upon optimal methods for calculating an institution's value at risk. An important aspect of accurately parameterising such models is in the modelling of tail probabilities, perhaps using extreme value theory. We thus end by conjecturing that there is much scope for a fruitful two-way cross-fertilisation of the disciplines.

References

Jia, Jianmin, & Dyer, J. There is a broad spectrum of papers considering risk and risk perception (many with direct applications to finance) available from the Institute for Operational Research and Management Science website: www.informs.org

Rubinstein, M. E. (1973). The fundamental theorem of parameter-preference security valuation. *Journal of Financial and Quantitative Analysis*, January, 61-69.