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Determining Capital: Messy Targets and Smoother Dividends

by

Anthony Asher

Visiting Fellow
Department of Actuarial Studies

Anthony.Asher@apra.gov.au

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Division of Economic and Financial Studies
Macquarie University
Sydney NSW 2109 Australia

DETERMINING CAPITAL: MESSY TARGETS AND SMOOTHER DIVIDENDS

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Abstract

How much capital do financial institutions require? Regulators have used simple rules of thumb for many years, but are now moving towards the use of set probabilities of insolvency. One strand of economic theory would target capital at a level that minimises frictional costs. An actuarial approach is to attempt to maximise the value of dividends. Management practice is also influenced by investor demand especially for smooth profits and dividends. The reality is complex and messy, but simple models can be useful and suggest that standard deviations as well as tail probabilities should be used in determining the level of capital. This paper uses a simple spreadsheet model to explore some of the relationships and the rules that can be used for determining capital. Significant buffers over regulatory minima seem to be desirable from every perspective.

1 INTRODUCTION

How should management decide a firm's level of capital? Changes to accounting and prudential standards have given this question increased prominence. This paper attempts to give an overview of the issues, and some guidelines in developing appropriate policies for managing capital.

Two levels of capital can be identified. The first is the minimum solvency or statutory capital required to avoid insolvency, below which regulators will take action. The second is the fuzzier concept of target capital to provide a buffer to absorb one or more relatively minor random losses and avoid falling below statutory solvency. This level may also allow for a smooth flow of dividends to shareholders.

Actuaries have not, traditionally, considered the question of balance sheet capital. Insurers' balance sheets were based on historic cost and thus of little value in evaluating solvency, which must always be prospectively determined. Actuarial capital was in their assumptions' margins. The need to calculate balance sheet capital is arising as balance sheets become more market related, and regulatory practices converge with that of the banking industry. Changes to international accounting standards and regulatory convergence are likely to accelerate the process.

A number of different approaches can be taken to model, or otherwise determine, the amount of capital required. This paper attempts an eclectic approach to the modelling of target capital, and incidentally produces some rules for established companies to pay smoother dividends. The intention has been to try and incorporate the major factors into a simple set of rules that can be used to set targets and manage capital towards it.

The next section outlines some different approaches from the actuarial, economic and management literature to the determination of regulatory and economic capital. The third section raises some issues related to the modelling of capital: the measuring of profit, the impact of time delays, capital allocation to different projects and the required return on capital. Two simple, but hopefully helpful, perspectives on the problem are described in the fourth section.

A spreadsheet based model that attempts to reconcile the different theoretical and practical approaches, and produces dividend smoothing rules, is described in section five. Section six concludes.

A theme that recurs in many sections is that reality is messy. Reference can be made to Herbert Simon's theory of bounded rationality[1]. We want to look for ideas that can give some structure for thinking, and provide useful heuristics (rules of thumb) for action.

2 ALTERNATIVE APPROACHES

This section discusses the regulatory capital required to avoid insolvency; the economic capital that minimises frictional costs, and the optimal capital and dividend rules that maximise the value of future dividends.

The capital with which we are concerned is that provided by ordinary shareholders. Capital is also provided by subordinated debt, other "innovative capital" with a higher risk of default and by participating policyholders. In order to simplify the discussion in this paper, they are ignored except to the extent that they affect the risks borne by ordinary shareholders.

2.1 Regulatory capital

To the extent that policyholders or depositors have been guaranteed benefits of one kind or another, financial institutions need capital to be able to absorb random losses and meet their promises.

Capital is an issue to the extent that insolvency is a problem. Insolvency may not be important if it merely involves a renegotiation of contracts not critical to the financial well being of the parties. The costs of renegotiation can be priced into the contracts at inception. For purposes of this paper, however, it is assumed that the insolvency of financial institutions places intolerable burdens on their clients (depositors, policyholders or beneficiaries), and that neither the managers of these institutions nor their regulators will accept significant rates of default.

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1 Theoretical models are useful in examining the impact of important variables, but the real world is often too difficult to model accurately. Simon (1983) provides a framework for the reality that human rationality is not only bounded by our inability to understand everything, but we are also "satisficers" rather than maximizers in our motivation. His theory provides an explanation and a rationale for regulators and company directors to use relatively simple heuristics to determine capital requirements. Such heuristics make life easier and are often adequate for their purpose.

Should such an assumption need further justification, it can be argued that it derives from the demand for trustworthy investments, where the investor is not required to evaluate the risks. The difference between the return on equities and lower risk investments forms the equity premium puzzle. Vissing-Jorgensen (2000) provides a recent survey of the literature on this puzzle, and derives an estimate of the information costs that would explain US levels of stock market participation. This in turn suggests that the cost of obtaining appropriate information explains a large part of the puzzle. Some investors are prepared to accept significantly lower returns from investments which do not require detailed investigation. We can presume that they use their time more profitably, and that such investments provide a useful social function.

Insignificant risks, in this context, would mean that the clients of financial institutions should not have to consider the possibility of default. This suggests that these institutions should structure themselves so that the probability of a purely random insolvency is effectively zero.

2.1.1 Value at Risk (VaR)

For those with any mathematical training, it is a natural step to define insolvency in terms of an arbitrarily small probability of ruin or failure. This is the approach being taken by the Bank for International Settlements with its Basel II framework – at least for those banks using internal models. In life insurance, the International Association of Actuaries (IAA) Insurer Solvency Assessment Working Party (2004) also uses it. The working party suggests that capital reserves should be sufficient to meet obligations, for each type of risk, with a high level of probability over one year. The probabilities they suggest are 99% or 99.5% over one year, compared with the 99.9% now required by Basel II. This is the VaR approach.

From one perspective a defined probability of ruin is spurious, misleading in its appearance of science and of accuracy. The future probabilities are not so much estimated as projected from past experience. The distributions of loss, particularly in the tails, are neither stable nor likely to reflect the non-random risks to which financial institutions are exposed. These latter risks, arising mainly from management action, have to be managed by a variety of regulatory tools other than capital requirements, such as audits on appropriate governance and risk management processes.

Even if it were accurate, the VaR capital is added to balance sheets determined by somewhat arbitrary accounting standards which exclude many intangible assets and liabilities. These intangible items are related to future cash flows that significantly alter the probabilities of insolvency, so reducing the meaningfulness of the calculated probabilities.

Danielsson *et al* (2001) criticise the VaR approach for a number of other reasons. Most importantly they warn that it fails to acknowledge that “risk is endogenous” to the financial system. By this they mean that the behaviour of some participants creates risks for others: their models suggest that the widespread use of VaR to determine capital will exacerbate the likelihood of a systemic crisis. They also dislike the VaR approach because it fails to satisfy the test of sub-additivity[2]; does not take the distribution of losses beyond the VaR into account, and makes no use of more sophisticated techniques[3] to take into account the interactions of different risks. Of these criticisms, the first may be unfair because capital may not be intrinsically additive – not least because of the interactions between the different risks.

The conclusion from this is not that we should abandon VaR models, but rather that a range of differing perspectives should be considered, and that the results should be recognised as being fuzzy and therefore expressed diffidently. Capital over and above that required by the VaR approaches may well be necessary.

2.1.2 Political factors

Regulatory rules evolve with the political economy. Two significant sources of change can currently be recognised. One comes from regulated entities, as they find that the current regulations inhibit their commercial interests in a changed economic environment. Another is the public demand for change that arises from failures, whether this is justified or not.

It is useful to appreciate how the demand for such changes is dominated by major players with a strong interest in the matter. Olson (1965) explores the collective action of the small groups that will often dictate the nature of regulatory debates. Large companies and professional partnerships are likely to be disproportionately represented in all debates and lobbying, and achieve outcomes that advantage them at the expense of smaller less well organised groups.

Berger *et al* (1995) see the role of the regulators as being to require capital to protect the public against the externalities of insolvency, and to reduce the cost of state funded deposit guarantee insurance. It is possible to consider the behaviour of regulators as a game where they attempt to minimise political intervention in their functioning and to increase their own funding.

One might hope to derive simple heuristics to set capital requirements. The reality seems to be rather the introduction of a large number of heuristics that can hardly be described as simple, and prove something of a burden to compute. The new Basle II rules provide an example of growing complexity. One might ask whether much of the complexity arises from the political nature of the process, rather than the real underlying intricacies of the risk process - complex as they are.

2.2 Economic capital

The mainstream economists' approach to determining capital can be found in Berger *et al* (1995). Applications to insurance are given in Hancock et al (2001) and Ng and Varnell (2003). The approach derives from the objective of the managers of firms,

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2 Meaning that one cannot necessarily add the VaR of two separate portfolios of risks and get the VaR of the combined portfolio.
3 Such as consideration of non-elliptical joint distributions and extreme value theory.

which is to maximise the wealth of shareholders - or in some extended versions of the theory, their own wealth.

Optimal capital for a firm is that which minimises frictional costs. These can be classified into two: the costs of financial distress and of agency. There may also be tax costs or benefits. With suitable assumptions, it is possible to model the trade off between these costs, and so indicate the optimal level of capital.

2.2.1 Agency costs

Agency costs arise from the divergence in interest between a firm's principals, its shareholders, and their agents, its managers[4]. It has been suggested that these costs can be contained by reducing the company's free cash flow so the managers have less capital to "waste". Berger and di Patti (2002) provide a convincing case where they link the profitability and efficiency of over 700 banks with the level of overlap between managers and shareholders (that is the presence of agency risk), and their relative gearing (that is the absence of free cash flow).

There may however be alternative explanations for the profitability: some might be explained as a return on that part of the human capital of the owners invested in the business. Alternatively owner managed firms may appear more profitable on the metrics used (higher return on capital), because of their owners' reluctance to raise capital and risk losing control.

Agency costs are not limited to firms with excess capital. Companies that are no longer profitable create their own class of risks. As Lemieux (1999) puts it:

> Recapitalizing a troubled institution that has major problems with such things as loan underwriting, insider lending, internal controls, or risk management only gives bank management and owners more money to lose.

Even if agency costs are sometimes exaggerated, there must be a point when additional capital serves no purpose and can only tempt management into incurring unnecessary expenses.

2.2.2 Costs of financial distress

The costs of financial distress arise when firms have already made losses. They arise from the expenses involved in raising additional capital, loss of reputation (leading to loss of customers and increased costs in compensating staff and suppliers, including debt holders, for risk) and the costs of down-scaling operations or of reducing their business risk, which in turn may lead to losses of economies of scale. The costs are

[4] Some of the literature also use agency risk to describe the possibility that managers will exploit their freedom to expose debt holders to increased risk. This risk is however more in the nature of a moral hazard that the managers will not fulfil their contract. The principal/agent problem is perhaps better used to describe the fiduciary or employment relationships.

likely to vary inversely with the size of the remaining capital, increasing as the firm approaches insolvency and liquidation.

The costs of financial distress are obviously greater in firms with lower levels of capital.

2.2.3 Tax costs

Tax costs or benefits will arise if the tax on the earnings of a firm differs from the tax that would be paid by shareholders if they held the assets of the firm directly. Many tax jurisdictions give significant tax advantages to debt over equity financing.

2.2.4 Other factors

Bounded rationality would suggest that managers and shareholders are likely to be inefficient wealth maximisers, satisfied by a quieter life.

Managers who choose a quiet or ethical life may tend to avoid significant risks. When they do take risks, they will tend to do so under pressures that apply to their entire industry, and so tend to "herd" with other firms. If losses eventuate, they will then be able to raise prices – for as long as barriers to entry prevent new competitors entering the market too easily.

Myers (1984) describes one simple rule which he calls the "old fashioned pecking order framework, in which firms prefer internal to external financing and debt to equity". He suggests that this arises because raising equity is relatively more expensive in the presence of information asymmetries between the managers and potential shareholders. He suggests that the optimum level of capital covers a fairly wide range and is often not worth calculating, and that managers 'stock up' on equity issues when they see yields as low. In a recent statistical evaluation of these two alternative approaches using corporate data, Philippon (2004) finds support for a trade off between different frictional costs, and for the pecking order theory as well as finding that CEO tenure is correlated with lower gearing. He explains this in terms of the CEOs' desire for a quiet life; it might also be explained by lower information asymmetry as the CEOs have proved their ability.

Graham and Harvey (2001) investigate the question by surveying 392 chief financial officers (CFOs) in the US. When issuing debt, the surveyed CFOs were particularly concerned with maintaining financial flexibility, their credit ratings – absolutely and relative to competitors - and with reported earnings. When issuing equity, managers appear to have been particularly concerned with not giving away profit unnecessarily. The theoretical considerations of taxation and financial distress were ranked much lower. Agency costs were not mentioned. The authors say:

> We find some support for the pecking-order and trade-off capital structure hypotheses but little evidence that executives are concerned about asset substitution, asymmetric information, transactions costs, free cash flows, or personal taxes.

They conclude that "executives rely heavily on practical, informal rules when choosing capital structure" and suggest that it may be time to critically re-evaluate the mainline theories. Such re-evaluation will need to recognise the success of heuristics in producing satisfactory approximations to the theory. They, for instance, refer to McDonald (1998), who shows how rules of thumb can implicitly, but effectively, allow for real options[5] in capital budgeting decisions.

2.3 Dividend discounting

Capital structure and dividend policy are closely linked. An actuarial approach to determining optimal capital and rules for capital management is to model the dividends paid and attempt to maximise their expected value. If their discounted value is being determined this involves balancing the dividends payable in the short term future against the increase in the probability of ruin. Gerber and Shiu (2004) provide a recent example of this literature.

Modern financial theory tends to approach the question from Miller Modigliani's dividend irrelevance proposition[6]. Within this strand of thinking, it sometimes appears the onus is on the firm to justify why it pays dividends. This can be explained by now abolished US tax rules that penalised dividends. It seems however to be inappropriate in neutral jurisdictions, as dividends must be the natural way for shareholders to enjoy their firms' profits. While there may well be good reasons not to distribute profits, or to use other methods of distribution, the onus must surely be on companies who do not want to pay dividends to justify their non-payment. Frankfurter *et al* (2002) make these points, and survey some 400 German CFOs, confirming that the managers surveyed believe that shareholders want dividends. They also report that the CFOs believe investors do not like changes to dividend policy, and appear to want smoother dividends to reflect the long term profitability of the firm. Dong *et al* (2003) in a survey of individual Dutch investors found that while investors preferred dividends, only older investors had a preference for smoother dividends.

From the perspective of the financial lifecycle, or of a defined benefit pension fund, a more obvious reason for preferring smoothed dividends is the information they provide for funding a smooth lifetime consumption path. This is because they provide an indication of the real level of return on investment. A policy of smoothing dividends would also justify the actuarial approach that smooths retirement fund contributions by reference to smoothed asset values based on discounted dividends. It would also be consistent with the findings of Dong *et al.*

Smoothed dividends will also reduce the number of stocks that an investor wanting a smoothed income stream needs to hold. It would therefore save on the costs of acquiring information to evaluate the investment merits of more companies. A company paying smoother dividends might then have a lower cost of capital.

3 MODELLING CAPITAL

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5 Real options arise from the ability to delay investment decisions until more information is available. Their value depends on the potential savings of avoiding non-viable projects compared with the loss of procrastination.

6 Described, for instance, in Whelan et al (2002)

This section sketches some of the other issues involved in producing useful models for capital determination.

3.1 The statistical distribution of profit

The statistical distribution of profits (by which is meant the probability density function of the stochastic variable “profit”) depends on the business environment and the various methods adopted by management to exploit opportunities and mitigate risks.

3.1.1 Accounting distortions

The profits reported in annual accounts differ, and may well be less volatile, than underlying profitability.

- Accounting rules by requiring prudence create the deferral of profit. This in turn will create smoothing if the profits are brought to account over a number of years.
- Accounting standards exclude many internally generated intangible assets such as those created by research and advertising. Apart from the effect on the balance sheet, this means that investment in intangibles is shown as an expense and depreciation of intangibles is not shown as an expense. This approach could be expected to increase the volatility of reported earnings, but it allows managers to adjust intangible investments in order to smooth their reported profits. Firms’ market values normally exceed the book value – often being twice as large, or more, which suggests that the value of the intangible assets not included in the accounts is significant, and may be more important than the net tangible assets. Murphy and Zimmerman (1993), looking at US experience, confirm that there are significant changes to intangible investment over periods of stress.
- In financial institutions particularly, profit is a function of the manner of determination of liabilities and reserves. These will be based on best estimates of underlying assumptions. It is however in the nature of such estimates that they utilise data from both the recent and more distant past. This again has the effect of smoothing changes, and thus profits.
- The use of accounting discretions (if not subterfuge) may also camouflage losses. Holland and Ramsay (2003) show a tendency to hide small losses in a survey of Australian data. Small hidden losses may be accumulated. They may later be recovered during years of good profits, or added to larger disclosed losses when they may be less noticed. Murphy and Zimmerman find such discoveries often coincide with, and may be aggravated by, a change in management.

3.1.2 Empirical volatility

The statistical distribution of profit changes over time, and could differ significantly between companies. Holland and Ramsay’s (2003) data was from listed non financial Australian companies from 1990 to 1997. It was not a good period for the smaller 50% of companies, which reported losses, on average, over the period. Their results cannot therefore be taken as typical. For the larger 50% of companies, they calculate a standard deviation of profits of two and a half times the mean return, with 19% reporting losses over the period. They do not report on insolvencies. Their profits are expressed as a percentage of sales rather than of equity. If the return on equity was between five and ten percent, this implies the annual standard deviation is some 20 per cent of the capital employed.

The author took a smaller sample of the profitability of financial companies from the database of the Australian Prudential Regulation Authority (APRA). For 196 authorised deposit-taking institutions (ADIs) in the eight quarters to June 2003, 8% of the quarterly returns showed losses and 10% of the annual. In contrast, of 129 general insurance companies over the 4 quarters available to September 2003, 24% of the quarters showed losses, and 20% of the annual results. The average standard deviation of the estimated return on capital employed was just over 2% per quarter for the banks, and 4 times greater for the general insurers. There were no insolvencies in the data examined.

It can also be noted that the distributions of reported profit were skewed: tax effects and management actions are different when a firm makes losses. Each side, when taken separately was consistent (although not formally fitted) with a t-distribution with 4 or 5 degrees of freedom.

Gizycki and Goldsworthy (1999) show that the volatility of the shares of Australian banks in the nineties show annualised estimates of the standard deviation of between 15 and 25 per cent. This is somewhat greater than the volatility of reported profit of the sample of ADIs described in the previous paragraph. This difference in size is a common result used, for instance, by Shiller (1981) to try and prove that the investment market was inefficient. Apart from the effects of changing real interest rates, the difference may also be a function of the smoothing of accounting profit.

3.1.3 Empirical insolvency

Default rates on marketable debt can be significant - as shown in table 1.

TABLE 1: SOME DEFAULT RATE STATISTICS			
Credit rating	10 year default rates	Annual equivalent	Approximate spread over risk free rate
	%	%	%
AAA	0.61	0.06	0.75
AA	1.06	0.11	1.00
A	2.10	0.21	1.50
BBB	7.60	0.79	2.25
BB	26.61	3.05	5.00
B	44.59	5.73	7.50
CCC	62.92	9.44	17.50

Adapted from Standard and Poor (2003)

Default rates even worse than these are reported in Pennacchi (2002), who calculates risk premiums for 42 US banks in the ten years to 1996. The results show probabilities of default of some 2% annually. It would however seem common cause that such risks in financial institutions are unacceptable. Other factors to consider are the depositor protection offered in the US and the moral hazard it creates, the size of the loss given default, and the flexibility of US bankruptcy laws that can allow for the preservation of much of a company's franchise value during the process of rehabilitation. Under such circumstances, the amount of capital required can be settled by negotiation with the deposit insurer.

On the other hand, Laeven (2002), in an international study, finds that the value of deposit insurance can be expressed as a fraction of a basis point in some countries with a strong regulatory environment. Defaults for AAA rated debt, as reported by Standard and Poor, do not occur until the third year, after the debt has been downgraded. Financial institution debt – as reported in the Standard & Poor study – appears to have similar default rates to AAA debt.

The six basis points, reported as the annual risk of AAA debt, can perhaps be classified as immaterial – at least within the context of the approximate models to which we can aspire. The errors in our modelling are likely to be considerably greater than a probability of six in ten thousand.

3.1.4 The insolvency put

Where there is a material probability of insolvency, then calculating shareholders would incorporate it in models that determined the optimum level of capital. The value of the risk is in the nature of a put option (of their interest in the firm at a zero price to the institution's holders of debt), and will tend to reduce the optimum level of capital. If the debt has been negotiated between equal parties, this is a fair arrangement. In the case of financial institutions where the holders of the debt are clients who have been led to believe in the trustworthiness of the institution, this is neither fair nor consistent with legally imposed statutory duties.

Put plainly, it is immoral and illegal. To add the value of the put option to the value of associated shares is equivalent to adding the present value of the chances of robbing your neighbours to that of a property in a wealthy neighbourhood. This author will not include any further consideration of this option on the grounds of his moral disquiet at valuing infidelity.

3.1.5 Sculpted distributions

Although this paper assumes that the distribution of profit is reasonably smooth, it may not be. The firm's relative tax status, junior debt, various types of options and guarantees to clients, and different hedging and reinsurance contracts can change the distribution of anticipated profit. The changes to the distribution may be intended or the contracts may be aimed at making profits. Underlying profits can thus be "sculpted" in an almost infinite number of ways.

The optimal capital mix will depend on prevailing prices and tax rates. Graham and Harvey find that significant management attention is focussed on ensuring that capital is raised on favourable terms. This implies that managers are not necessarily confident about the efficiency of the market for capital. This is not inconsistent with other findings about the efficiency of capital markets: indeed it explains how they remain efficient. Managers need to spend effort to ensure that the market has enough information to enable their company to raise money on reasonable terms.

If markets are inefficient at times, managers can find opportunities to raise capital cheaply. This would also help explain the wide variety of innovative capital instruments, which otherwise have to be explained by regulatory arbitrage.

For financial institutions the process of issuing debt, or the equivalent derivatives and guarantees, is likely to be an intrinsic part of their business. In such cases, questions of relative demand may be of overriding importance and the overall distribution of profit may differ significantly from that of well behaved distributions.

Brown *et al* (2004) warn about sculpting strategies that effectively "short volatility", leading to an increase in returns and a reduction in volatility in normal times, but much larger losses when markets become more volatile. The sale of options invariably has this impact. Such sculpting can also reduce VaR, but significantly increases losses in the distant tails of the distributions.

3.2 Timing

It is necessary to measure a firm's experience over a reasonable time period before it can be given real credibility. There is often a delay from the end of this period until the results are reported to management, and another delay before they respond.

The author has been told of an insurance company that uses its monthly experience to update the following month's premiums, but this is clearly an exception – albeit exemplary and profitable. More frequent perhaps is the opposite extreme of an annual analysis of experience that leads to appropriate action by mid year, with another year's delay before the effects of changes to annual premiums are fully effective.

The time taken to respond to news is therefore of considerable importance when determining capital requirements.

3.3 Allocating capital

One important question that arises is how to determine the capital for different projects. Projects in this context are taken to include lines of business and any new developments in marketing or production.

If managers wish to maximise shareholder value, their firm should participate in all projects that yield a positive net present value based on an appropriate cost of the appropriate capital. The basic economics is that, for each project, viability is determined by its marginal contribution to profit. The marginal capital requirements of a project are unlikely to add up to the total capital required by the firm. This problem has been widely discussed, as for example by Cummins (2000). As with all project overheads, the firm must cover capital overheads to stay in business, but overheads are not relevant to individual project decisions. This means that the allocation of total capital to different projects may be unhelpful because it will make some profitable projects appear unprofitable.

It is also not necessary when determining a “fair” regulated price. If some lines of business are regulated and others not, the regulator can force lower premiums by insisting on marginal pricing. If all lines of business are regulated, a range of economic “cross subsidisation” will be possible, as long as each line makes some contribution to overheads.

This theoretical position sits uncomfortably with many managers and actuaries: a common response is that revenue must be sufficient to cover overheads, and so overhead costs must be allocated. This approach however arises from a cost plus pricing framework: a useful heuristic but one that does not maximise profit. This issue is discussed at some length in Chalke (1991).

It also means that larger and more diversified firms are likely to require less capital proportionally: there can be economies of scale and scope[7]. In a market with perfect competition, firms will not cover their cost of capital unless they can extract the greatest possible benefits of size and diversification. The theory does however allow for diseconomies of scale, so the optimum can accommodate smaller companies. In the real world, smaller companies also find market niches and operating efficiencies that allow them to compete.

3.4 The required return on capital

In a complete and frictionless market each project has a unique present value: the implied discount rate is the required return or the cost of capital. This theoretically will be the return on the market portfolio adjusted for the beta. Managers, in practice, seem to use discount rates with a significant margin over the theoretical cost of capital. Various other explanations have been given for these margins.

The costs of raising capital need to be included in the cost of capital. Jarrow and Purnanandam (2004) suggest that these and other costs of financial distress should be seen as a firm overhead, and allocated to projects by an increase in their capital charge. This is probably adequate as a rule of thumb, but the theoretical optimum would be achieved by measuring the project’s marginal contribution to the costs of financial distress and raising capital in future.

Smith *et al* (2003) explain the margin in terms of charges for the firm’s franchise value. The franchise value could include intangible assets developed by the firm or monopoly type rents. As far as intangible assets are concerned, an additional margin is not necessary if the intangibles are properly accounted for. Rents, on the other hand, drive up the average return on capital, but projects yielding monopoly rents should also be priced on a marginal basis if firms wish to maximise profits.

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[7] The economies arise because the coefficient of variation of the experience decreases as the number of risk events increases – if the correlation between them is less than one. Economies of scale occur if the correlation is zero or positive, economies of scope effectively arise from negative correlations.

In Chew (1998)[8], cost plus pricing and excessive hurdle rates are explained as a failure in understanding. More charitably they can be explained as working heuristics that attempt to shortcut an otherwise impossible task.

In less than perfect markets, there may be correlations between the risks of one project and others and with elements of the capital structure. Higher yielding projects with higher risks and higher covariance with other projects will for instance require a less geared capital structure in order not to risk insolvency. This means that the amount and cost of capital allocated to each project may have to be determined simultaneously - on a marginal basis. The cost of capital would be a weighted average over time, and over the types of capital that will be most optimal to fund the particular riskiness of the business with and without the new project. This is impossibly complicated in practice. Sweeping simplifications are necessary, and arbitrary margins may well have to be introduced to make up for our ignorance.

In this context, the economic theory that allows for a separation of the investment decision from the question of capital structure[9] also depends on a perfectly competitive and frictionless market, and shareholders must be able to borrow at the same rate as the firm. It is however a useful heuristic.

This author suspects that one likely explanation for apparently excessive *ex ante* profit loadings, especially when compared with the *ex post* returns, is that the margins are required to counterbalance excessive management optimism – especially the tendency to underestimate the cost and likelihood of disasters. Another common reason mentioned for increasing the hurdle rate is a rationing tool necessitated by the reluctance of managers to risk a change of control by raising additional capital.

Given that it does not appear to be widely recognised, it may be worth mentioning in this context that excessive margins will mean that prices will be set somewhat higher than optimally. The consequence will be that profitable projects will be abandoned and so total profits will be reduced in spite of the fact that the returns on capital employed will be higher.

3.5 Deriving the distribution

The derivation of appropriate profit distributions is beyond this paper. There is the usual trade off between sufficient data and relevant subdivision.

Each of the major risk classifications (investment, insurance and business) can be further classified and given separate consideration. If so, further work has to be done on

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8 See the panel discussion on pages 165-188

[9] The Miller Modigliani capital irrelevance proposition, described, for instance, in Whelan *et al* (2002), is that shareholders can adjust their own exposure to the market risk, so firms cannot add value for shareholders by their decisions on capital structure. This goes back to Irving Fisher's separation theorem in the early part of last century.

the interaction between them, especially in the tails. For practical purposes, it may be enough to assume a smooth distribution, and use a variety of stress tests to ensure sufficient capital is held to cope with specific disaster scenarios.

4 SIMPLE ALTERNATIVE PERSPECTIVES

This section describes two simple approaches that can be used to derive simple rules of thumb.

4.1 The probabilities of loss and insolvency

The first compares the probability of a loss with that of going insolvent. Both probabilities depend on the statistical distribution of a firm's underlying profit. Assuming that the distribution function were to be symmetrical and continuous, it could be largely determined if one knew the mean and the probabilities of insolvency and loss. It may therefore be instructive to consider possible distributions in terms of these three numbers.

It seems that the probability of making a random loss that would be acceptable to investors is normally associated with very small probabilities of insolvency. This would certainly be so for a normal distribution and even some with fatter tails. Panel A of table 2 illustrates, using a typical fat tailed distribution. If shareholders would want the probability of a loss to be no greater than 20% in any one year, the probability of insolvency in that year would seem to be significantly less than 0.5%.

TABLE 2: IMPACT OF PURELY RANDOM LOSSES

		Standard deviation of profit as percentage of capital					
		10%	15.0%	20.0%	30.0%	40%	50%
A. Using a T distribution with 5 degrees of freedom[10]							
Expected 10% pa return							
Probability:	of insolvency	0.002%	0.011%	0.043%	0.260%	0.822%	1.817%
	of a loss	13%	21%	27%	34%	38%	40%
Expected 20% pa return							
Probability:	of insolvency	0.001%	0.007%	0.029%	0.179%	0.588%	1.349%
	of a loss	2%	7%	13%	21%	27%	31%
B. Using a sample[11] **from a T Distribution with 1 degree of freedom**							
Expected 5% pa return							
Probability:	of insolvency	0.884%	1.325%	1.766%	2.645%	3.521%	4.391%
	of a loss	17%	23%	27%	33%	37%	39%
Expected 10% pa return							
Probability:	of insolvency	0.843%	1.265%	1.686%	2.526%	3.362%	4.194%
	of a loss	9%	13%	17%	23%	27%	31%

10 The T distribution with few degrees of freedom produces a heavy tail distribution. For 5 degrees of freedom, 2.6 standard deviations provides only 98.5% adequacy.

11 A T distribution with one degree of freedom is so fat tailed that it has no defined variance. Any finite sample must however have a standard deviation.

Expected 20% pa return							
Probability:	of insolvency	0.773%	1.160%	1.545%	2.316%	3.084%	3.848%
	of a loss	5%	7%	9%	13%	17%	20%

This does however depend on the distribution. Panel B shows that an even fatter tailed distribution can allow higher probabilities of insolvency to be associated with lower probabilities of loss. T distributions, with fewer than 5 degrees of freedom, have undefined or infinite variances. As infinite profits and losses are not possible, one might therefore tentatively suggest that, for the fattest tailed feasible distributions, most companies would be expected to aim for a relatively low probability of a loss in any year - as well as a low probability of insolvency. As a rule of thumb, for a reasonably profitable firm, a risk of loss of 20% would be associated with a risk of insolvency of one basis point.

This suggestion would depend on the extent that profits are not excessively sculpted and can be described by a single distribution. It also ignores the difference between reported and underlying profits, and possibilities of manipulation. The distributions used here appear to be consistent with the shape of reported profits discussed in section 3.1 above.

The table also illustrates the importance of profitability on the probabilities of loss and solvency. A higher expected return does reduce the likelihood of insolvency. To the extent that higher returns arise from intangible assets, they perhaps deserve some recognition. The impact of profitability on the probability of making a loss is however generally greater than on the insolvency probability. Highly profitable firms will therefore need to accept a stricter rule of thumb than that suggested above.

4.2 Allowing for timing

The analysis can be extended by considering the effect of a delayed response time. Table 3 illustrates the impact of a sequence of smaller losses if the company is slow to respond to the need to reduce its risk profile or raise additional capital. The probabilities of insolvency are not merely compounded. A 99.5% level of adequacy over one year reduces to below 97% if the company takes 2 years to respond to its losses.

It is assumed in the table that there is no correlation between successive losses, and that the company takes immediate action to reduce some of its risks. This may in fact be conservative; in both sets of the APRA data described above, there was a significant autocorrelation in the data. Reported losses do appear often to come in runs.

TABLE 3: IMPACT OF SEQUENCE OF LOSSES[12]				
	Standard deviation of profit as % of capital in year 1			
Out of 10,000 starts	25%	30%	35%	40%

12 The model used here allows risk to be partly related to investments, partly to the insurance portfolio. The investment strategy yields an expected 10% with a 12.5% standard deviation if the company makes a profit, but 5% with no risk if it makes a loss. The balance of the risk comes from an insurance portfolio with a T distribution with 5 degrees of freedom.

Insolvencies in year one	14	27	51	71
Insolvencies in year two	39	57	162	263
Insolvencies in year three	93	153	328	536

The table is consistent with a simple rule that the risk of insolvency trebles as the time to respond doubles.

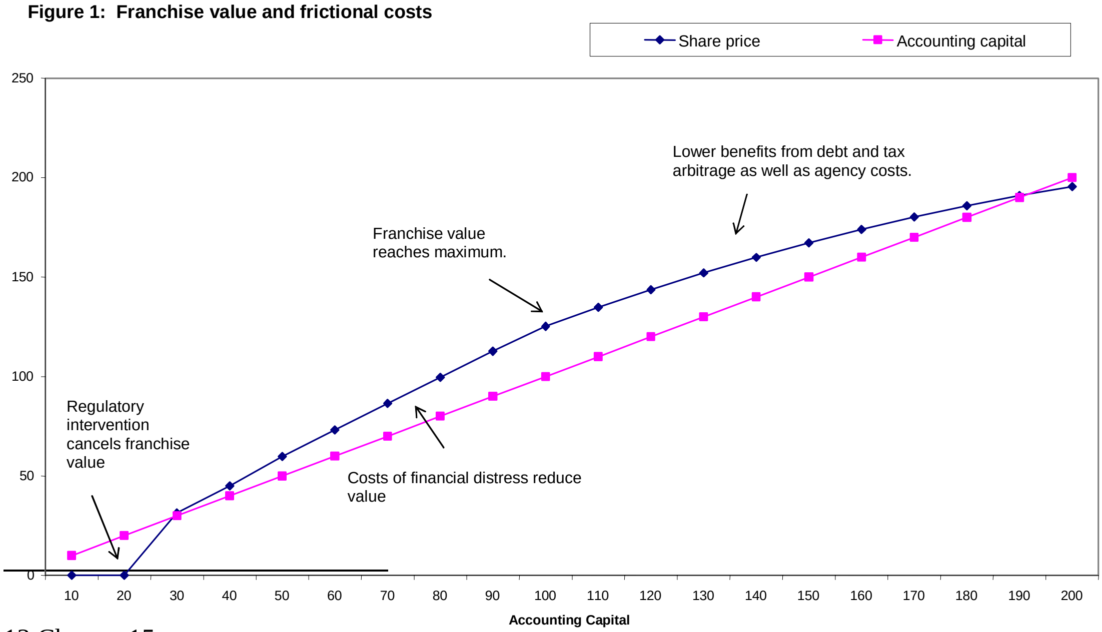
4.3 The Kelly criterion

The Kelly criterion, described for instance in Luenberger (1997)[13], provides another multi-period perspective on the problem. The Kelly criterion emerged from the St Petersburg paradox.[14]

The paradox is resolved by introducing a utility function that explains why the certainty of loss outweighs the expectation of profit. The Kelly criterion, or log optimal strategy, uses a logarithmic utility function. Given a particular set of odds, it produces the proportion of capital that will be gambled each time. The strategy avoids ruin (because the “bets” are always less than the capital available), and has the useful property that it maximises expected utility both over a single period, and in the long run. It does not of course maximise the expected return, which is achieved by gambling everything on the bet with the highest expected return.

Companies do not have utility functions themselves. The existence of frictional costs does however produce a non-linear relationship between a company’s capital, as reported in its accounts, and its likely share price. We might get the relationship shown in figure 1.

Figure 1: Franchise value and frictional costs



13 Chapter 15.
14The paradox is that, in a fair game, it is easy to develop a gambling strategy that guarantees a win for anyone with infinite capital. The expected value is positive, but ruin is certain because no one has infinite capital and few people attempt such a strategy. The gambling analogy is similar to the dividend discount model of Gerber and Shiu (2004).

The share price has a similar shape to a utility function. Utility rises with increasing capital, but at a declining rate. The decline is explained by the reduction in franchise value and increasing agency costs. Maximising the difference between share prices and accounting capital will therefore be mathematically analogous to maximising utility. The value of the firm would then be maximised by an optimum mix between risk and capital, which can be achieved for any given level of business risk. This can be achieved by reducing risks through limiting guarantees or reinsurance, or by adding capital earning a risk free rate.

Luenberger shows that the log optimal position is reached when the reward for risk is equal to the variance of the capital at year end. The Kelly criterion therefore provides another simple rule of thumb. For example, a risk premium of 4% should go with a standard deviation of 20% of capital.

5 SPREADSHEET

This section develops a simple spreadsheet based model that allows for a more detailed consideration of the factors that give rise to optimum levels of capital.

No attempt is made at the mathematical sophistication that has been brought to bear on this problem in some of the literature, such as Leland (1998), Purnanandam (2004) and Jarrow and Purnanandam (2004), to which it is otherwise in debt. Firstly, it is clear that models, and more particularly parameter estimates, are at best illustrative. The future cannot be predicted from the past. If the models are illustrative, then they perhaps should be more readily accessible to a wider audience. It is this author's experience that stochastic calculus is not easy to read even by those with the requisite background. Simple spreadsheet models may well be capable of wider understanding and application.

The second reason is that the preservation of the models' mathematical elegance and the desire for closed form solutions may lead to the omission of significant variables. The models' usefulness is thus further circumscribed. Realistic models require a multitude of variables, most of which are discrete or measured only at discrete intervals. There is furthermore no reason to believe that realistic models will be tractable or that the solutions will yield universal optima. A spreadsheet model allows for easy experimentation with alternative approaches. If a more complex model is to be preferred, the onus would appear to rest with its proponents to demonstrate its superiority.

Details of the two spreadsheets in the workbook are given in the appendix.

5.1 Profits

Profits are generated by a random process in which part of the profit arises from investment returns, obviously proportional to capital employed. This is modelled using a log normal distribution, but the projections are at discrete intervals. They could be taken to represent a year, or at least the period between full investigations of profitability.

The rest of the profit is taken to arise from the firm's insurance business, which is not seen as proportional to capital. This is modelled using an approximate t distribution because it provides realistically fattish tails. The pure insurance business is more often modelled in the actuarial literature by a compound distribution that takes into account the random nature of both the number and amount of claims. This is likely to be skewed, but the skew is likely to be ameliorated by reinsurance. Volatility of the expense result (the difference between expense loadings and costs) can in any event swamp the pure insurance results, and so, in this paper, both are combined in a symmetrical t distribution.

The variables are therefore the degrees of freedom, and the mean and standard deviation of these two variables relative to the target capital. The model is run over 10,000 periods – each represented by a row. Run time is almost instantaneous on the author's PC. While some of the results are not particularly stable, it proved easier to use a simple macro to average a few runs rather than extend the number of rows. More rows led to a slowing in speed and difficulties in saving the workbook.

5.2 Setting dividends and raising capital

It is assumed that the company is not growing. The model can be seen as a system, which needs to be kept in equilibrium, and optimised by minimising frictional costs. Equilibrium is maintained by managing capital: paying dividends, returning capital when it becomes excessive or raising it when it becomes inadequate. Each of these is regarded as "dividends" – which are therefore shown as positive or negative. The average capital over the 10,000 periods needs to be kept close to the target for the model to give meaningful results on average.

It is not immediately clear what metric will give the best measure of profitability. The net present value of dividends is an obvious candidate. Alternatively, one might look for the highest average net dividend. A third alternative would be to minimise frictional costs. It would seem that each would give the same answer - if no account were taken of the volatility of dividends. All are shown in the summary sheet.

The following parameters were allowed to vary. The names in brackets are those used in the calculation worksheet, shown on the second page of the appendix.

- Frictional costs are introduced as a fixed proportion (agency_cost) of any capital repaid, and as a portion of the capital raised. The former primarily represents agency costs, the latter the costs of financial distress. Because the costs of financial distress are likely to increase non-linearly as capital falls, the proportion of capital raised is arbitrarily increased to the power of 1.5 and multiplied by a factor (financial_distress).
- Normal dividends are paid when the capital of the firm is in a range close to the target. They are set at a percentage of the current capital (normal_rate).

- The dividends may be reduced to a proportion of the normal dividend (reduction_factor) if the capital falls below a proportion of its target level (DivF).
- They may no longer be paid once the capital falls below another point (PayDiv).
- If capital falls below another point (Capr2), the firm will be recapitalized. This point marks the minimum buffer over the regulatory capital required. The amount raised would be a proportion (percent_raised) of the capital needed in order to fully restore the target. The average capital over the previous two years (Capr1) must also be below a particular level - to illustrate the effects of delays.
- If capital reaches another fixed point above the target range (RCap2), having been on average above another point (RCap1), excess capital, or a special dividend, is returned to shareholders. This again restores a proportion (percent_returned) of shortfall from the target capital ratio. An alternative would be to enter new fields, or make an acquisition, but both are presumed to have similar effects.
- Dividends can be lagged so that a fixed proportion (Lag_Div) derives from the prior year's dividend.

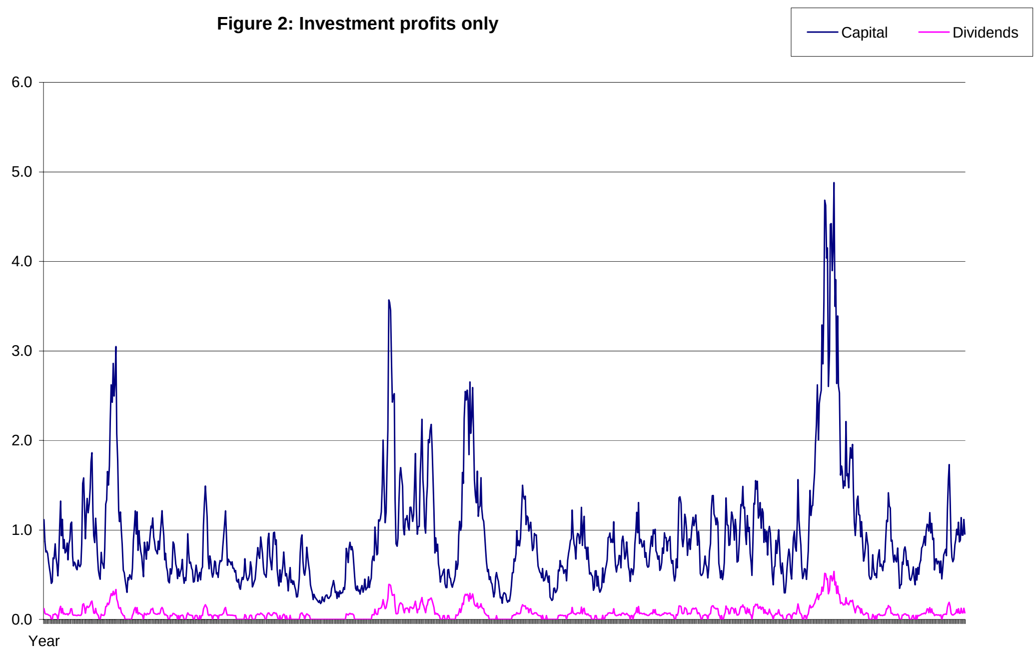
5.3 Results

This section discusses the results of some experimentation.

5.3.1 Investment risk only

The first scenario modelled assumes all risks are related to investments: there is no insurance risk. The returns are lognormal with a mean of 8% and a standard deviation of 20%[15]. A few experiments found that a dividend of 11% of capital, reducing to 70% when capital was below the target, produced an appropriate average capital (i.e. close to 1). Stability is however difficult to achieve and the results can diverge very quickly. The results are shown in the first column of table 3. Ruin is counted when capital reduces to below 0.1 to allow for costs of financial distress and some delay in responding to losses. Figure 2 shows the first 1,000 years of a typical run. Many years of good returns can be randomly followed by years of very limited pickings. It illustrates the very messy results of randomness, and how spurious trends frequently arise.

[15] This should produce an arithmetical average return of some 10% p.a.; the actual returns were some 0.25% higher on average due to discontinuities in the lookup table. It seemed unnecessary to make any adjustment.



5.3.2 Adding insurance business

Insurance or business risk is then added to the model. It is assumed to have a t-distribution with 5 degrees of freedom, a mean of 0.25% of the target capital, and a standard deviation parameter of 10%[16]. The increased volatility means that the firm frequently faces ruin - at which time further capital is raised - as shown in the second column of table 3. Profits from the insurance business must be sufficient to compensate for these costs.

TABLE 3: Scenario Summary				
	Investment only	Insurance added	Raising capital	Less gearing
Investment mean	8.0%	8.0%	8.0%	7.0%
Standard deviation	20.0%	20.0%	20.0%	15.0%
Business mean	0.00%	0.25%	0.50%	2.00%
Standard deviation	0.0%	10.0%	10.0%	10.0%
Normal dividend as % of capital	11.0%	12.0%	12.5%	12.5%
Factor - if below ideal capital	70.0%	70.0%	70.0%	70.0%
Dividend if > than:	50.0%	60.0%	70.0%	70.0%
Capital raised if >	0.0%	0.0%	50.0%	50.0%
Average profit	9.3%	9.3%	9.8%	9.4%
Standard deviation	28.8%	28.8%	25.7%	20.2%
Frequency of losses	35.0%	37.2%	36.3%	32.2%

16 The t-distribution of many degrees of freedom approximates the normal. The method used effectively “spreads” the distribution as the degrees of freedom are reduced. At 5 degrees of freedom, the sample distributions had standard deviations of between 12.5% and 13%.

Average dividend	9.2%	9.2%	9.2%	9.2%
Standard deviation	20.9%	11.7%	13.9%	9.3%
Reduced dividend	49.3%	32.5%	32.8%	37.8%
Average present value	1.15	1.17	1.15	1.14
Ruin	0.01%	1.83%	0.08%	0.08%
Return of capital	0.04%	0.00%	2.53%	1.04%
Capital raised	0.01%	1.83%	5.62%	3.82%

5.3.3 Adding buffer capital

These higher probabilities of ruin are unacceptable, so it is necessary to raise capital before ruin eventuates.

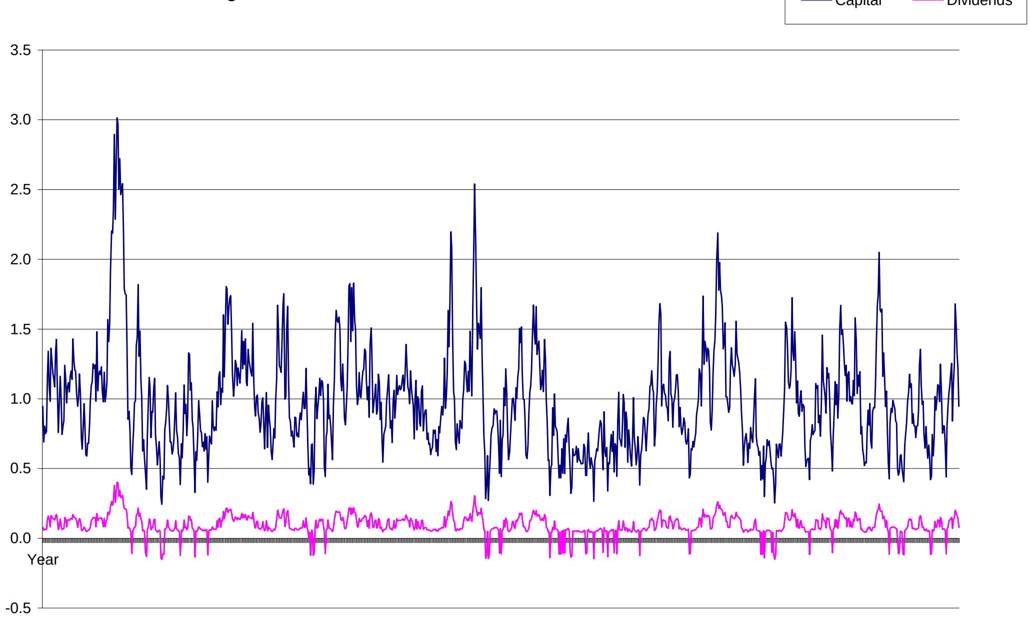
Some experiments were attempted to reduce the volatility of the "dividends" (including the capital payments). The variables manipulated were the bounds beyond which capital was raised or returned, and the percentage of the deviation from target restored. It seemed desirable not only to look for an acceptably low probability of ruin and low frictional costs, but also the frequency of raising capital. The target was arbitrarily taken to be less than once in twelve years. The lowest possible standard deviation seemed to be achieved by the parameters shown in the third column of table 3. This allows for 70% of the "normal" dividend to be paid when capital is low, and produces dividends 90% of the time, raising capital less than one year in 13. The first 1,000 years of such a strategy is shown in figure 3. Because it requires a further increase in frictional costs, it requires another increase in the profitability of the business – to 0.5% in this example.

This model seems to produce trivial probabilities of ruin and requires capital to be raised when it falls to 50% of target. This suggests that regulatory capital will be set at approximately this level. An additional buffer may be required if there are significant costs in falling short of the regulatory minimum. The costs of financial distress at the level of 50% of target work out, with the parameters in this model, at some 18% of the capital raised. If this is reasonable, it implies that the target capital is some twice the regulatory minimum.

5.3.4 Reducing gearing

An alternative means of reducing risk would be to adopt less gearing. The fourth column of table 3 shows the impact. Such a strategy requires even greater expected profitability from the insurance business. It might well be adopted when greater profit margins were available.

Figure 3: Smoothest "dividends"



5.4 Dividend smoothing

These results provide the context for discussing the smoothing of dividends.

No smoothing occurs if the firm pays all its excess capital out as dividends and raises capital if there is a shortfall. If it does not raise capital some smoothing results, but ruin will be certain as in the Gerber and Shiu literature.

Paying a fixed proportion of profit as dividends is a common rule of thumb, as apparently first described by Lintner (1956). It requires a slight modification of the current spreadsheet but is not shown. The strategy causes capital to accumulate more rapidly – and thus requires frequent lump sum returns of capital, and so makes the dividend more volatile. Lintner found that managers in his survey smoothed dividends, and modelled this by incorporating a one period lag. This does produce a further reduction in standard deviation, but it does not however provide nearly as much smoothing as the dividend based on a percentage of capital.

This result is not surprising: as an estimate of the true profit, last year's profit has a standard deviation equal to that of the distribution of profit. An algorithm based on the true expected profit would necessarily be smoother – if we knew what it was. The real question is which is the better estimator of next year's profit?

- Last year's profit.
- The expected rate of return times current capital.

The latter is likely to be preferable. The expected return should be of the same order as the return earned by other companies, and will almost certainly be in a relatively narrow positive range. A firm's true capital – including intangibles – is difficult to measure, but again the percentage measurement error may be considerably less than that created by the volatility of profits.

Figure 3 shows long periods of growth and decline (with significant variations around the trend); mean reversion is slow. There is effectively a choice between keeping capital close to the target and smoothed dividends. As the target is a messy idea, while the dividends have tangible benefits to shareholders, it is not surprising that management rules of thumb focus on the latter. The adjustment to dividends should however increase as the deviation from target increases, as this will coincide with greater confidence that a deviation has in fact occurred.

5.5 Other results

The other parameters produced relatively uninteresting results.

- Switching to lower risk investments when capital was low seemed rather to increase the risk of ruin as there was even less chance of making an investment profit, while the lower investment risk is small relative to the business risks.
- Switching to lower risk insurance business when capital is low merely had the impact of reducing profitability and the dividend payable.
- Requiring evidence of losses over a longer period before raising capital increases ruin probability fairly significantly.
- The business risk has to be kept at a level such that there was an insignificant probability of losing the target capital in one year.
- The costs of raising new capital, and of repaying capital, are not that great if the probability of doing so is kept small,

The results seem to confirm the discussion that random profits must be less variable than suggested by one year VaR analysis if companies are to operate with conventional dividend policies and some degree of stability. Put another way, they need considerably more capital relative to their random risk profile.

5.6 Calibration

The advantage of this economic capital approach over a VaR type model is that the calibration of the model depends on the whole distribution and not just the tails. There are more observations, and the precise placing of the tail is not critical. The past however remains, at best, a rough guide to the future, and decisions as to dividends and risk management must be dependent on valid estimates of the distribution of profitability.

If the distribution is smooth, the most important variable would appear to be the standard deviation of profits. The distribution will probably be distorted during times when the company is making losses, so it should probably be estimated from the positive half of the distribution.

5.7 Growing companies

This model had less of an application to rapidly growing companies.

It does not appear necessary to adapt this model to allow for smooth rates of growth. It can presumably be treated as one would treat inflation: each item in the balance sheet represents a fixed percentage more units in each succeeding period. A fixed proportion of profits must be retained to finance the growth, so profitability will reduce in "real" terms. Similarly, sporadic growth "inflates" each balance sheet item, and will have the same impact as a sporadic loss.

If companies are growing faster than their rate of profitability, they will suffer from an ongoing capital shortage. Using the inflation analogy of the previous paragraph, they face a "real" expected loss each year. They therefore require regular injections of capital, and inevitably provide more difficult regulatory problems.

5.8 Summary

After adjusting for growth, and making appropriate provisions to adjust the reported accounts to reflect underlying reality, we thus have the bone of a capital management strategy. It may be little more than a first approximation, but it is at least a start.

Such a strategy will pay more than the expected level of profit when capital appears excessive, and less when it appears inadequate. Dividends may cease as capital falls further from the target, and extra capital will need to be raised (or other risk reduction strategies adopted) at a point that seems to be around 50% of the target capital – providing this exceeds regulatory capital by an adequate margin. This is consistent with a heuristic that target capital should be about twice the size of regulatory capital or six times the standard deviation of the profit (measured over the time to react to experience). When capital exceeds perhaps 150% of the target, then a refund of capital (or increase in risk) is perhaps indicated.

6 CONCLUSION

While the economic and actuarial literature appears to identify all main issues surrounding this topic, there is no simple solution to the problem of how much capital to hold. The problem is made particularly complicated and messy by the differences between reported and underlying profits as the distribution of the underlying profit is the most important variable.

Managers and regulators need relatively simple rules of thumb. They need to target a level of capital, which balances the needs for solvency, allows for smoothed dividends and takes into account the costs of financial distress. The spreadsheet model developed here attempts to do all these. For acceptable levels of business risk and plausible distributions of profit it is possible to derive a dividend strategy that halves the standard deviation – relative to underlying profit.

The views expressed in the paper are the author's, and should not be taken as representing those of anyone else. Thanks are due to my colleagues Alun Pope, Neil Esho and Andrew Kirk for especially helpful suggestions.

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8 APPENDIX

SPREADSHEET 1: Assumptions and Results

ASSUMPTIONS							
Distribution statistics	Standard deviation	Mean	Degrees of freedom				
Lognormal distribution for investments	20.00%	8.00%					
Risk free rate		4.00%					
Student t for claims and expenses	10.00%	0.50%	5				
Check	Max	Min	Average	Theoretical average	Standard Deviation		
Lognormal distribution for in	95%	-49.50%	10.17%	10.00%	22.36%		
Student t for claims and exp	96%	-82.45%	0.28%	0.50%	12.81%		
Random numbers	0.9999	0.0001	0.4975	0.5000	28.85%		
Capital and dividends		**Limits relative to ideal capital**					
		Average>…	Average<…	Current>…	Current < .	Risk reduction factor	
Risk reduction							
For investment			0.00				
For insurance			0.00			0.50	
Dividend rules							
Return of capital	0.30	1.50		2.00			
Capital raised	0.40		1.00		0.50		
Dividend if > than:				0.70			
Dividend as % of capital	12.50%						
Factor below ideal capital	70.00%				1.00		
Loss on return of capital		0.15					
Cost of raising capital		0.50					
RESULTS				**Other dividend statistics**			
	Total profit	**Dividend**	**Capital**			**Count**	
Max	1.5495	1.2334	3.6079	Zero		1720	17.20%
Min	-0.9915	-0.4578	-0.1444	Return of capital		253	2.53%
Average	0.0980	0.0921	1.0224	Capital raised		562	5.62%
Standard Deviation	0.2565	0.1393	0.4249	Normal		4437	44.37%
Frequency of losses	36.33%	0.08%	ruined	Reduced		3280	32.80%
Frictional losses	-0.59%			Net present value		$1.15	

SPREADSHEET 2 Calculations

1 Columns, and first 4 rows

A	B	C	D	E	F	G
						Average
Random numbers		Profit			Capital	capital
Investment	Business	Investment	Business	Total	1.0000	
					1.0000	1.0000
0.96504274	0.896065	0.4050	0.1640	56.90%	1.5690	1.0000

H	I	J	K	L	M	N	O
Return of capital	Raise capital	Pay dividend	Pay reduced dividend	Dividend & capital payments	Frictional costs	Total dividend & costs	Net present value
FALSE	FALSE	TRUE	FALSE	0.196	0.000	0.196	$1.08

2 Formulae

A =RAND()

B =RAND()

C =IF(G4>inv_risk_reduction,VLOOKUP(A5,lognormal_table,2),risk_free)

D =IF(G4>bus_risk_reduction,1,bus_reduction_factor)*

(VLOOKUP(B5,t_table,2)*t_sd+t_mean)

E =C5*(F4-L4)+D5

F =F4+E5-L4

G =AVERAGE(F3:F4)

H = AND(G5>RCap1,F5>RCap2)

I =OR(AND(G5<Capr1,F5<Capr2),F5<0.1)

J =F5>PayDiv

K =AND(J5,(F5<DivF))

L =IF(H5,percent_returned*(F5-1),0)+IF(I5,percent_raised*(F5-1),0)

+IF(J5,F5*normal_rate*IF(K5,reduction_factor,1),0)

M =-IF(H5,agency_cost*L5,0)-IF(I5,financial_distress*-L5^1.5,0)

N =(L5+M5)

O =NPV(8%,N5:N100)

3 Statistical lookup tables

P	Q
Lognormal_table	
Cumulative	Returns
0	-90%

First column: =LOGNORMDIST(1+Q4,
lognormal_mean,lognormal_sd)
Second column: =0.005+Q4 (from row 5 onward)

P	Q
T_table	
Cumulative	SD’s
0	-10.50

First column: =TDIST(ABS(Q379),DoF,1) until zero,
and then =1-TDIST(Q1079,DoF,1)
Second column: =Q379+0.015 (from row 380 onward)