Institute of Actuaries of Australia

Resilience Reserve Taskforce (2005) Report

This report is the same as that presented to the Institute's Biennial Convention in May, but with the draft wording in section 9 of that report removed as it has been overtaken by subsequent developments.

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RESILIENCE RESERVE TASKFORCE (2005) REPORT

EXECUTIVE SUMMARY

1 Introduction

This summary of the Resilience Reserve Taskforce (2005)'s (the Taskforce) report is intended also as a stand alone document incorporating all its recommendations.

The Life Insurance Practice Committee of the Institute of Actuaries of Australia (LIPC) established the Resilience Reserve Taskforce (2005) to provide a tenth anniversary review of the Resilience Reserves used in the determination of statutory solvency and capital adequacy requirements of life insurance companies in Australia. Of particular concern to the LIPC were explicit reserves for credit risks, and clarity as to the number of adverse scenarios that required testing.

In beginning its deliberations, the Taskforce identified three main issues that have to be considered in evaluating resilience reserves.

- Investment returns are not normally distributed, and have thick tails.
- Correlations between the returns on different assets are required in order to determine how to classify assets and to allow for the benefits of diversification. Observed correlations are not however stable over time, and also appear to vary in the tails of the distribution of returns.
- The likely change in asset values is not independent of the level of the market and of interest rates.

Not having access to any publicly available investment models that adequately dealt with these issues, most of the Taskforce's work was based on the empirical returns experienced in Australia over the past 20 to 30 years. The Taskforce does not think it likely that any models will produce significantly better results, given that they have to be calibrated using the same data.

It was assumed that the resilience reserves should be sufficient to cover liabilities for at least a year: 95% of the time for the Solvency Standard and 99% for the Capital Adequacy Standard. Opportunities for management action to reduce risks during the year, and the protection provided by other reserves, are likely to reduce the overall probability of ruin well below 1%. It is recognised that such statistics are not exact, nor are any investment market distributions. The method used to determine resilience reserves should therefore at least be simple.

Following its review, the Taskforce recommends three main changes. These are:

- Incorporation of credit risks into the resilience reserve framework.

- Adjustments to the diversification factors used when calculating the resilience reserves.
- Incorporation of mean reversion factors into the determination of resilience reserves.

2 Credit Risks

As life insurers are now more exposed to credit risks, it appears desirable to establish explicit reserving requirements.

Credit risk includes potential:

- defaults,
- transition from one credit rating category to a lower category with higher spreads,
- adverse variations in market credit spread levels.

Table 4 of the report gives the recommended factors to apply for credit risks – based as much on US as local data, given the paucity of the latter. The value of fixed interest assets of the classes specified is recalculated at a yield that includes the yield movement; the value is then reduced by the relevant default factor.

Table 4: Credit factors

Rating (S&P)	Default Factor (Solvency)	Default Factor (Capital Adequacy)	Yield Movement (Solvency)	Yield Movement (Capital Adequacy)
AA *	0.25%	0.3%	0.3%	0.5%
A	0.5%	0.7%	0.4%	0.6%
BBB	1.5%	2.2%	0.5%	0.8%
BB	3.5%	5.0%	0.6%	0.9%
B	7%	10%	0.7%	1.0%
Below	10%	15%	0.8%	1.2%

* We suggest that only OECD central and state governments rated AAA should not be loaded for credit; all other borrowers treated as AA.

3 Diversification Factors

The current approach to diversification appears unsatisfactory for two main reasons:

- It does not appear to distinguish appropriately between changes to the yield and the value of fixed term investments – unlike the relationship between dividend yields and prices they are not interchangeable.

- It assumes zero correlations between asset classes – this is not supported by the empirical evidence examined by the Taskforce.

The Taskforce suggests an alternative approach more closely aligned to the theory, which would allow in the future for varying correlations between asset classes to take shocks in the correlation structure into account.

3.1 Theory

Consider investing in a portfolio that will have value P at the end of the year. Proportion k_i of the portfolio at the beginning of the year is invested in asset i which has a random value of X_i at the end. X_i has a mean of μ_i, and a variance of σ_i^2. The mean value and variance of the portfolio at the end of the year is:

$$\mu(P) = \sum_{i=1}^{n} k_i \mu_i \qquad (1)$$

$$\sigma^2(P) = \sum_{i=1}^{n} k_i^2 \sigma_i^2 + 2\sum_{j}^{n} \sum_{i}^{j-1} k_i k_j \operatorname{cov}(X_i X_j) \qquad (2)$$

The resilience reserve can be based on the variance of the surplus in the fund, which is the value of the portfolio less the value of the liabilities at the end of the year. If there is no surplus at the beginning of the year, one can use formula 2 to determined the value of the surplus by adding the liabilities as an asset for which k_i = -100%.

3.2 Classification of Assets

The current diversification factor assumes a zero correlation between the value of equities, fixed interest and property investments, and 100% correlation between different shares and different types of property.

There does however appear to be a positive correlation between the value of equities and long term fixed interest investments and a stronger correlation between equity and property investments particularly in the adverse tail of the distribution of returns. On the other hand, different market sectors and foreign markets are not perfectly correlated with each other. The current diversification factor does not recognise the benefit of diversification within the equity portfolio.

The Taskforce felt that it would be acceptable to work with a 20% correlation between equity and fixed interest asset values, which reflects the experience of the past 30 years.

It felt however that there was not sufficient justification to single out the property sector as sufficiently different from other growth investments. It was felt that most portfolios of growth assets would be adequately diversified so, rather than give credit for diversification, it recommends a 10% penalty on portfolios that are more than 25% invested in a single sector. The sectors for this purpose would be every foreign market and Australian Financial (ex Property), Property, Industrial and Resource shares.

It was felt that no distinction should be made between direct and listed property, considering that the illiquidity of the former and gearing in the latter added a similar volatility to realisable asset values.

4 Mean Reversion

Actuarial intuition, reflected in almost all actuarial models, is that dividend yields, real interest rates and inflation should show a tendency to revert to some longer term mean. If true, this means that the probability of a future adverse shock depends, at least in part, upon the current state of the market relative to its mean position. Formula 5 in the report, produced below, describes the models implied by the use of dividend yields to determine shocks.

$$DY_{t+1} - DY_t = \kappa(DY_{average} - DY_t) + \varepsilon_t$$
$$or \qquad (5)$$
$$DY_{t+1} = \kappa DY_{average} - (1-\kappa)DY_t + \varepsilon_t$$

K is the pace of reversion: the current shock test assumes K = 0, but K = 1 (i.e. that the expected value of the dividend yield at the end of the year is always 4%) performs slightly better statistically against our data. The best fit is about half way between the two.

The summary table below shows the results of the Taskforce’s tests on the empirical data and its proposals.

Summary Table	K	10 year mean	R^2	*Suggested mean*
Dividend yields	50%	4.0%	25%	*4.0%*
Property yields	80%	7.5%	40%	*7.6%*
Real interest rates	25%	3.0%	20%	*3.4%*
Anticipated inflation	55%	2.5%	40%	*3.0%*
Suggested rated of mean reversion for all parameters				*25%*

It is recognised that dividend yields depend on relatively arbitrary management decisions, which are influenced over time by tax considerations and fashions in investment and corporate governance theory. The Taskforce recommends that further research should be done on models incorporating earnings yields as being likely to provide a more stable basis for determining yield shocks. At this stage, dividend yields do appear to provide significant information as to expectations of future price movements – although it does appear more appropriate to use the dividend yield of the index as a whole rather than that of a particular portfolio in determining the effect of shocks. The parameters will require monitoring but the approach is likely to be more robust than the current method.

While mean reversion has a fundamental justification, there are also fundamental reasons for believing that the mean may drift – although not to the extent of the year to year movements in the value of the dividend yield. As shown in the table, the Taskforce recommends a reversion rate of 25% for all asset markets to take account of this uncertainty. In the case of international equities, it suggests that companies be permitted to develop mean reversion factors for those countries in which they have invested, but not to use mean reversion factors of more than 25%.

5 Proposals

5.1 The Shocks

Based on the target levels of adequacy and the empirical data, the following adverse shocks are recommended:

	Solvency	Capital Adequacy
• Real interest rates:	0.8%	1.2%
• Anticipated inflation:	0.2% + 20%CF	0.5% + 30%CF
(where CF is the current level of anticipated inflation.)		
• Dividend yields:	1.25%	2.0%
• Currency:	14%	20%

The shocks would be an increase in yield, except for currency.

5.2 The New Resilience Reserve Formula

The proposed new resilience reserve formula is – in outline:

$RR = L' * A/\{A'' - \sqrt{[E^2+F^2+K^2+2(.2(EF-EK)-FK)]}\} - L$

A = market value of admissible assets of the statutory fund.

A" = value of the assets after the prescribed change for mean reversion and allowance for credit risks.

L = the liability held for the statutory fund prior to the determination of the resilience reserve.

L' = value of those liabilities after the prescribed change for mean reversion.

The amount within the square-root bracket allows for the reduction in value of assets and liabilities - already adjusted for mean reversion – as a result of the prescribed shocks.

E is the reduction in value of equities and properties,

F is the reduction in value of fixed interest and indexed bonds, and

K is the reduction in the value of liabilities.

5.3 Other Factors

If there are assets or liabilities with option-like characteristics that respond asymmetrically to changes in the resilience factors, then they have to be separately valued and included in E, F or K appropriately. Allowance can be made for hedging, and so linked business can be excluded from the calculations. The bonuses on with-profit business can be reduced to a level that reflects the fall in asset values.

It is also recommended that unlisted investments be valued on a look through basis.

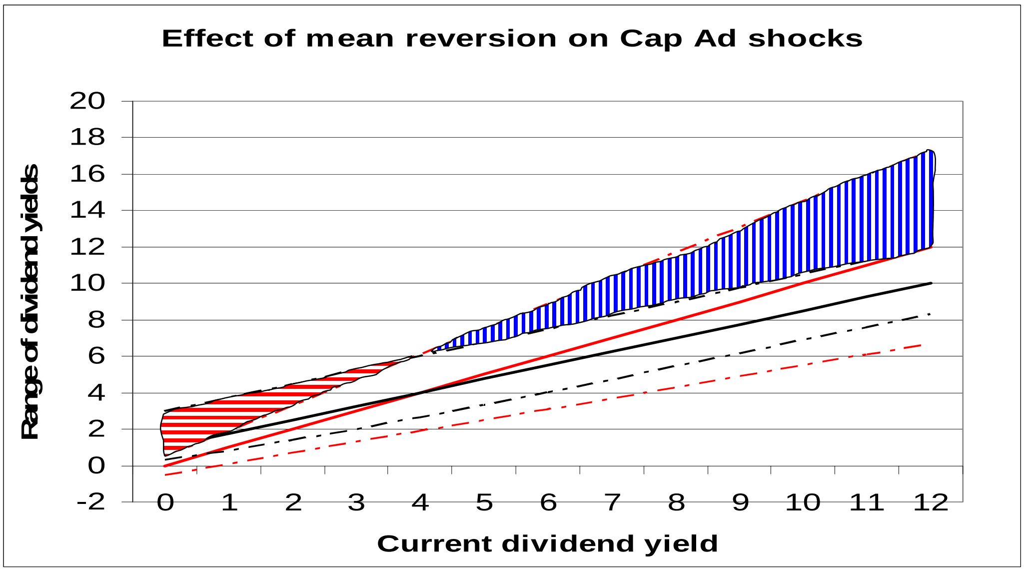
The Taskforce also looked at making separate provision for non-parallel shifts in the yield curve and reinvestment risks for very long term liabilities, but decided that the additional complications outweighed the benefits.

5.4 The Implications

The formula provides for one calculation for both increases and reductions in yields and anticipated inflation.

Using upward movements on yields is more generous than the current approach because the formula applies symmetrically to both increases and decreases. This may be seen as a problem as a fixed reduction in yields has a significantly greater impact on values than an identical increase. This is justified in the case of growth assets in most circumstances where companies are not exposed to losses when asset values rise. Those companies that are exposed to such losses will need to make additional provision for them.

The graph below illustrates the impact for the capital adequacy requirements. The proposals require significantly greater reserves against a fall in asset values when dividend yields are low (shaded horizontally) – and considerably less when they are high. This arises from both mean reversion and the use of a fixed shock rather than one that depends on the current level of dividend yield.



In the case of fixed interest assets and liabilities, the historical data shows that large increases in interest rates are much more likely. In fact, over the past 20 years, the only occasion when Capital Adequacy resilience reserves would have been inadequate was during 1994 when interest rates increased from 6.4% to 10.4%. The Capital Adequacy shock suggested would however only protect against an increase of 2.7% (1.7 + 30% of 3.3%) - as against 2.3% (1.0 + 20% of 6.4%) of the current shocks. If it is felt necessary to cope with a similar occasion in future, there is no benefit that can be gained from the mean reversion factors, and it would be necessary to increase the Capital Adequacy shock by over 1%.

6 Conclusion

The Taskforce is pleased to be able to offer the suggestions contained in this paper for public discussion and debate. While the Taskforce has some remaining reservations about the parameters of the new model, and has set out some areas in which it believes further research would be beneficial, it is hoped that the approach and methodology set out in this report will contribute to the development of a coherent set of resilience reserves for life insurance company regulatory capital assessment purposes.

RESILIENCE RESERVE TASKFORCE (2005) REPORT

Members: Anthony Asher (Convenor), Colin Grenfell, Anton Kapel, Martin Paino, Ken Ragell, James Wang and Prof Michael Sherris.

14 June 2005

The Resilience Reserve Taskforce was appointed in November 2004 by the Life Financial Reporting Tax & Legislation Sub-Committee of the Life Insurance Practice Committee of the Institute of Actuaries of Australia.

The Taskforce was given the brief of reviewing the resilience reserve parameters, determined originally in 1995, and to suggest other changes where appropriate, for consideration by the Life Insurance Actuarial Standards Board.

The major changes suggested in this report are the inclusion of mean reversion in the determination of the reserves, the use of an alternative diversification formula using explicit correlation factors, and the inclusion of explicit allowances for credit risk.

1 Introduction

Resilience reserves are required in actuarial standards developed by the Life Insurance Actuarial Standards Board (LIASB)[1] to cover a range of adverse investment shocks which life companies should be able to sustain.

This report sketches the background and reasoning behind the reserves and the process taken by the Taskforce in evaluating the current reserves.

The first two sections of this paper describe the background and the standards as they are currently set. In our initial work we discussed how the statistical distributions required for modelling investment markets were poorly behaved. None of the series is particularly stable, investment returns are more fat-tailed than normal, and the correlations determining the benefits of diversification are larger in the tails.

Section 4 raises the question of mean reversion, which was initially thought to be outside our terms of reference. The academic literature however has found persistent evidence of some mean reversion, and when the Australian data particularly was examined, it became clear that there was plenty of evidence of mean reversion in the shocks we were investigating. We have therefore recommended an incorporation of mean reversion factors into the

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[1] The LIASB is constituted in terms of sections 100 to 112 of the *Life Insurance Act 1995* (LIA). The actuarial standards can be found at http://www.apra.gov.au/Life/Actuarial-Standards.cfm

determination of the resilience reserves. These are likely to make little difference when markets are close to their long term mean, but will have an asymmetric effect when markets have moved away from the average. Companies will have to provide greater reserves for a move toward the long term average but less for moves in the opposite direction. This means that the resilience reserves are likely to provide a softer cushion when market conditions are extreme.

Credit risks have not been an explicitly determined part of the reserves thus far, but appear to be of increasing importance, so section 5 recommends a method of incorporating them.

The diversification factor is discussed in section 6, where we suggest a theoretically easier approach that will avoid the need for shocks in different directions.

A few minor issues are raised in section 7 and section 8 summarises our recommendations.

While there are two relatively significant changes recommended in addition to some recalibration of the parameters, we believe that the results will assist in understanding the nature of the resilience reserve and lead to better prudential outcomes.

1.1 Background

Actuarial Standards 2.03 (Solvency Standard), 3.03 (Capital Adequacy Standard) and 6.02 (Management Capital Standard) and their predecessors included resilience reserve parameters that were based on work carried out by Shuttleworth et al (1996) as a working group of the Institute of Actuaries of Australia. The working group's brief was to develop parameters that produced a resilience reserve that protected policyholders' entitlements in a statutory fund against adverse market movements with a specified probability of adequacy. The working group used an asset model that had been developed at AMP.

1.2 Terms of reference

The interim (and apparently final) report of the working group was based on asset/liability modelling of a single premium, five year, capital guaranteed product. The 2005 Taskforce was asked to look at a one year equivalent, and to give some consideration to whether anything different would be required for annuity products. Furthermore it was suggested that the resilience reserve parameters should focus primarily on movements in asset values. Offsetting movements in liabilities are taken care of elsewhere in the standards.

It was further suggested that the resilience reserve parameters should not need to take into account the fund's ability to meet resilience reserve requirements after an adverse market movement. Simple rules are required and the LIASB expressed a desire for the parameters not to go beyond the main asset classes, with the possible addition of international equities and credit premia.

In this initial draft version of our report, the Taskforce has arguably gone beyond these terms of reference by suggesting a restructuring of the approach to calculating resilience reserves, rather than simply updating the parameters required under the current approach.

1.3 Relevance

It is possible that the reserving requirements imposed by resilience reserves have led to a reduction in the volumes of certain types of contracts, specifically those with guarantees that give rise to significant reserves. The reduction in such unsustainable guarantees should be seen as a positive contribution to the financial stability of the life insurance industry.

While the prevalence of guarantees that create the need for large resilience reserves has reduced over time, the actuarial standards still require some means of determining the amounts of capital required to support investment type guarantees. A number of companies still have significant investment risks, and the ongoing demands of policyholders and shareholders may create temptations to offer some types of investment guarantee without adequate capital resources.

We were also cognisant of the impossibility of providing rules that could be seen as scientifically accurate. There is no absolute precision in the determination of the criteria we use, nor in the models to apply, nor the parameters that are estimated. There is no possibility for exactitude in the formulation of the ultimate resilience reserves. At best, we can only hope to be reasonable.

2 Statutory requirements

2.1 The standards

The Solvency Standard (the current version of which is AS2.03) is required by the *Life Insurance Act 1995* (LIA) to “ensure, as far as is practicable, that, at any time” each statutory fund of a life company is able to meet its liabilities as they become due. The LIASB has interpreted this to mean under adverse “but reasonably possible” scenarios.

The LIA requires the Capital Standard (currently AS3.03) to ensure that there is “adequate capital for the conduct of the business of the fund … in the interests of the owners of policies.” This is a different requirement, and while it might be expected to create a buffer above the solvency standard, AS3.03 acknowledges that it might not. Breaches of the capital standard will act as a “trigger for closer regulatory monitoring in respect of short term solvency.”

The Management Capital Standard (AS6.02) is required for the assets and liabilities outside the statutory funds and uses the same approach as used for the Solvency Standard. For purposes of this paper, it can be assumed to have the same objective.

The LIA entitles the Australian Prudential Regulation Authority (APRA) to give written directions to companies which it believes have inadequate capital for either solvency or capital purposes. If the solvency standard is breached, then APRA may apply to the courts for judicial management, or initiate investigations which may result in the company being wound up.

AS2.03 says: "To facilitate comparability across the industry, the standard adopts a primarily prescriptive approach". While the Capital Standard is generally less prescriptive, the resilience reserves take an almost identical approach, summarised below.

Table 1: Resilience Reserve Requirements - adverse yield shocks

Asset class	Solvency standard	Capital standard
Equities	1.25%	Max(1.25%, 0.5% + 40% of yield)
Property	1.25%	2.5%
Interest bearing	1.75% (max 20% of yield)	1% + 20% of yield
Indexed bonds	0.6%	1%
Currency	10% adverse reduction	15% adverse reduction

2.2 Diversification

In the current standards, there is an allowance for diversification that applies to the yield used in determining the resilience requirements. Diversification has two aspects.

Consider investing in a portfolio that will have value P at the end of the year. Proportion k_i of the portfolio at the beginning of the year is invested in asset i which has a random value of X_i at the end. X_i has a mean of μ_i, and a variance of σ_i^2. The mean value and variance of the portfolio at the end of the year is:

$$\mu(P) = \sum_{i=1}^{n} k_i \mu_i \qquad (1)$$

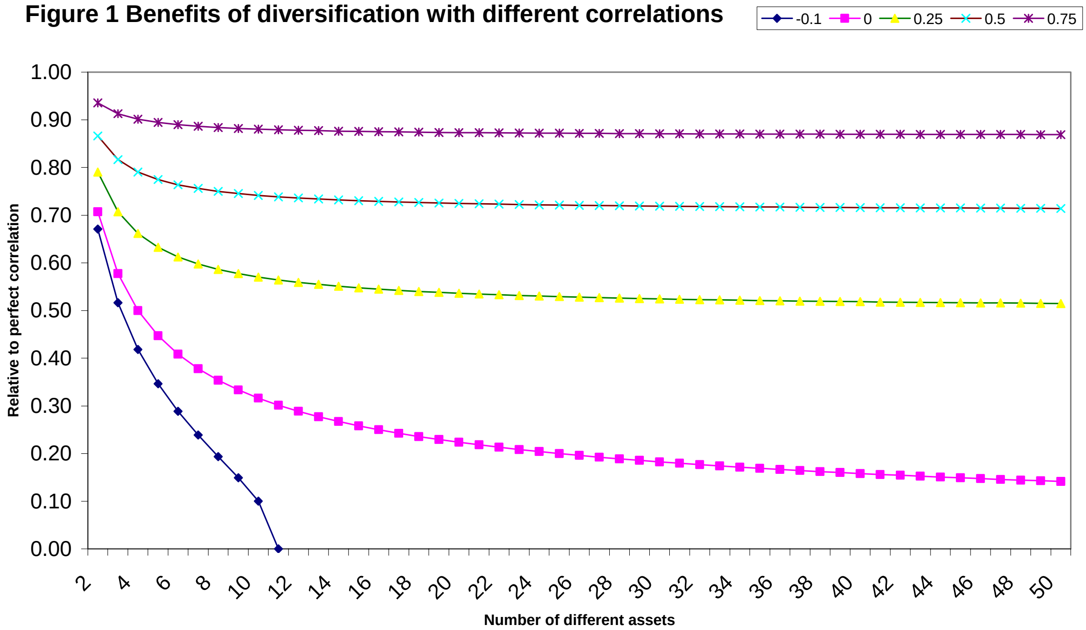
$$\sigma^2(P) = \sum_{i=1}^{n} k_i^2 \sigma_i^2 + 2\sum_{j}^{n} \sum_{i}^{j-1} k_i k_j \operatorname{cov}(X_i X_j) \qquad (2)$$

The first aspect of diversification means choosing assets whose covariances are as small (or as negative) as possible. This reduces the size of the second term of equation (2).

The second aspect of diversification means choosing a number of different assets. This reduces the size of the k_i's. Because they are squared, the size of the variance of the portfolio will reduce - unless there is perfect correlation between all the assets.

If a portfolio is equally divided between n assets with an identical variance and zero correlation in return, then the standard deviation of the return on the portfolio reduces with 1/√n, asymptotically to zero. When we introduce positive correlations, then the convergence is very much quicker to the square root of the correlation (times an average standard deviation of the return on each asset). If we can find enough assets with negative correlations, the variance can be eliminated entirely. These points are illustrated in Figure 1.

Figure 1 Benefits of diversification with different correlations



The diversification factor used in the current resilience reserve effectively assumes that there is no difference in diversification within each asset class, and a zero correlation between the yields in each asset class. Both assumptions require examination.

2.3 Hypothecation

The Capital Standard allows hypothecation of assets to subcategories within funds; the Solvency Standard does not.

It has been suggested that hypothecation should not be permitted as all the assets of each statutory fund are available for the benefit of all the policyholders within that fund, and suggestions to the contrary would be a source of confusion and perhaps legal controversy. The legal provenance of this last view is doubtful as the actuarial standards do not have the power to override the provisions of the LIA.

This may not be entirely relevant as the recommendations of the Taskforce do not require explicit hypothecation. If this element of our recommendations is not accepted, it is recommended that this issue be revisited.

2.4 Two or sixteen scenarios?

The Taskforce was asked to provide clarity as to whether reserves should be based on the maximum of two scenarios (interest rates up and down and adverse movements in the other asset classes), or sixteen (with all four asset classes both up and down).

2.5 The scenarios

The “reasonably adverse” scenarios have to include a time period and a level of adequacy. This issue is discussed in more detail in Appendix 1; this section sets out the basis of the Taskforce’s approach.

2.5.1 Time period

While the report of the 1995 working group focused on a five year guarantee, it appears, from the documentation available to the Taskforce that the existing resilience reserves were determined based on a probability of ruin over a one year time horizon - of 5% for the solvency standard and 1% for the capital standard.

The Taskforce felt that one year was an appropriate time-frame for the resilience reserve for pragmatic reasons, and also because we were considering a general market crash and it would be difficult for all companies to make use, simultaneously, of the de-risking strategies available in a shorter time period.

2.5.2 Level of adequacy

APRA’s Guidance Note GGN 110.2 (Internal Model Based Method for General Insurers) sets a probability of default for a company as 0.5% over a period of one year. The International Association of Actuaries (IAA) Insurer Solvency Assessment Working Party (2004) suggests 0.5% or 1%. This appears to be consistent with the Basel II framework, which appears to be prepared to permit banks with S&P BBB and equivalent ratings from other agencies.

The resilience reserves are, of course, only one element of the reserving framework. When combined with the other elements of the standards, resilience reserves that cover 95% of potential market movements are likely to produce probabilities of ruin significantly less than 5%.

The Taskforce decided that we would look at probabilities of adequacy of 95%, 99% and 99.9% at the end of a year. As we understand the requirements, this would imply that the 95% level would be acceptable as the Solvency requirement for a company with a range of other risks for which it had provided other reserves and that would find it relatively easy to de-risk itself. The 99.9% level might apply for Capital Adequacy or for a company with little reserves for other risks, and limited ability to respond quickly to investment losses. It was felt that the capital adequacy requirement could also be set at a level that produced a probability of 10% of infringing solvency. This might not be far from the 99% level. The approach used by the working group therefore appeared appropriate for our purposes.

It should be reiterated that while these percentages have some power to guide the overall level of reserves, they are educated guesses, and do not reflect an exact knowledge of the probabilities that apply to the future.

3 Modelling

The timescale given to the Taskforce did not permit any original modelling, nor was it likely that we would suddenly improve on the models that are already available elsewhere.

Like the earlier working group, we were looking for models that adequately addressed crisis points in investment markets rather than attempting to model normal behaviour. The main issues relate to:

- the tail distribution of each asset class,
- the behaviour of the correlations between asset classes in a crisis, and
- whether the distributions change with the level of asset prices, or any other exogenous factors.

The Taskforce was given access to a number of models, briefly described in the Appendix 2. The original working group's results were based largely in the ERCH (Exponential Regressive Conditional Heteroscedastic) model described in Harris (1994), but that model was not available to us, and has apparently not been developed further.

The Taskforce was cognisant of the danger of "model belief": that is, relying too heavily on model outputs that are not fully representative of reality. Models are interpretations of the behaviour of underlying markets, ultimately based on judgement and often calibrated by inadequate data. Mathematically complex models may not always be helpful in making these judgements and there is a view that they can be over promoted by those with particular interests. Smith (2004) makes the further point that more complicated models can be adopted for regulatory purposes because people are reluctant to oppose their introduction in case such opposition is misconstrued as incompetence in the area.

In the reported discussion of Shuttleworth *et al* (1996), it was mentioned that the original resilience reserve parameters had been set with reference to empirical data rather than theoretical models. This has its attractions. It requires less in the way of assumptions about the underlying structure of the market and it has an obvious practical application. The setters of capital standards have to be prepared to face the question: "Why did you not foresee this crisis: it has happened before?" The requirements also have therefore to be calibrated with the empirical distributions – or rather the extreme tails.

However the results are derived, they should also be tested against other information and theories we have about asset prices. Significant negative investment returns, for instance, are unlikely in a free market because investors can make use of other stores of value. Very high returns are unlikely over a sustained period because they represent a transfer from one group in society to another – and these become impossible to pay at some point.

3.1 Tail probabilities

Our first step was to compare various shocks at the adopted confidence levels that would be suggested by the models readily available to the Taskforce. The initial results are shown overleaf in Table 2, which also shows the extremes observed over the past twenty years (monthly observations of rolling twelve month periods). While some inadequacies were exposed when the model results were compared with each other, they appeared to give similar results for the initial tail probabilities that interested us. The empirical results appear to give a more or less full range of values and were therefore used in fitting and testing changes to the parameters and reserves.

The table suggests somewhat higher resilience reserves than those currently being used for the Solvency Standard, but that the Capital Standard appeared a little high for equities, and perhaps low for fixed interest and properties.

3.2 Correlations

Correlations are required for the classification of assets and the determination of the diversification factor.

3.2.1 Tail correlations

The problem is that correlations are not likely to be constant over time or over the range of the distribution of returns. In particular, there may be a "correlation meltdown", where asset classes more likely to move downwards together in times of crisis.

This finds some confirmation in the empirical data. Colin Grenfell's analysis (shown in Appendix 4) of the correlation between Australian Shares and Property Trusts was 0.56 when calculated normally. The rank correlation, which gives less weight to the tails was only 0.43, which suggests that the tail correlation is higher than 0.56.

Table 2 Some comparable results

		Global CAP:Link	AUSTMOD_S		Watson Wyatt		Empirical extremes
Australian shares return	Average	11%	10%		10.9%		13.7%
	95%	-18%	-15%		-18.6%		-31.9% (return)
	99%	-30%	-27%		-27.9%		+2.3% (yield)
	99.9%		-41%				
International shares (unhedged)	95%		-15%				
	99%		-26%				
	99.9%		-39%				-27.5%
10 year bond yield movement	95%	2.2%	1.4%		1.7%		
	99%	3.3%	2.0%		2.4%		-32.5% (return)
	99.9%	4.4%	3.2%				+3.8% (yield)
10 year bond yield less cash rate	95%	-1.8%			-1.4%		+1.8%
	99	-2.6%			-2.5%		-1.1%
	99.9%	-3.7%					
A and AA spreads (US)	95%				0.54% (AA)		+0.65%
	99%				0.49% (AA)		-1.1%
Other invest-ment grade spreads (US)	95%						+0.75%
	99%						-1.35%
Non-invest-ment grade spreads (US)	95%						+1.1%
	99%						-1.6%
Indexed bond yield movement	95%	1.2%			2.1%		0.8%
	99%	1.7%			1.9%		1.2%
	99.9%	2.3%					
AUD/USD	95%	-14%			-16.4%		-25%
	99	-19%			-22.3%		+34%
	99.9%	-24%					
Property			Direct	Trusts	Direct	LPTs	
	95%	-5%	-9%	-12%	8.0%	9.1%	
	99%	-10%	-26%	-25%	-7.5%	-12.8%	
	99.9%	-14%	-48%	-44%	-13.1%	-20.4%	

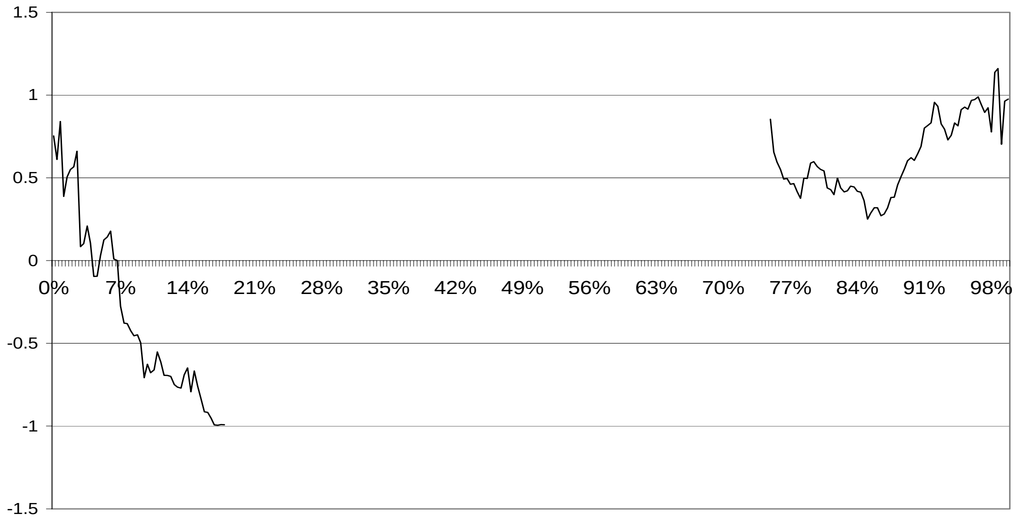
Note: The AUSTMODS 10 year bond shocks appeared too low. The Global CAP:Link property shocks apply to a direct properties class calibrated to a direct properties index. This may not be appropriate for setting resilience reserves, where a realisable market value is of more interest.

Campbell, Koedijk and Kofman (2002) describe how one can derive unbiased quantile correlation estimates in order to determine VaR type measurements. If the VaR quantile, Q, is a fixed multiple of the standard deviation, one can determine a quantile estimate of the correlation between assets x and y from formula 3.

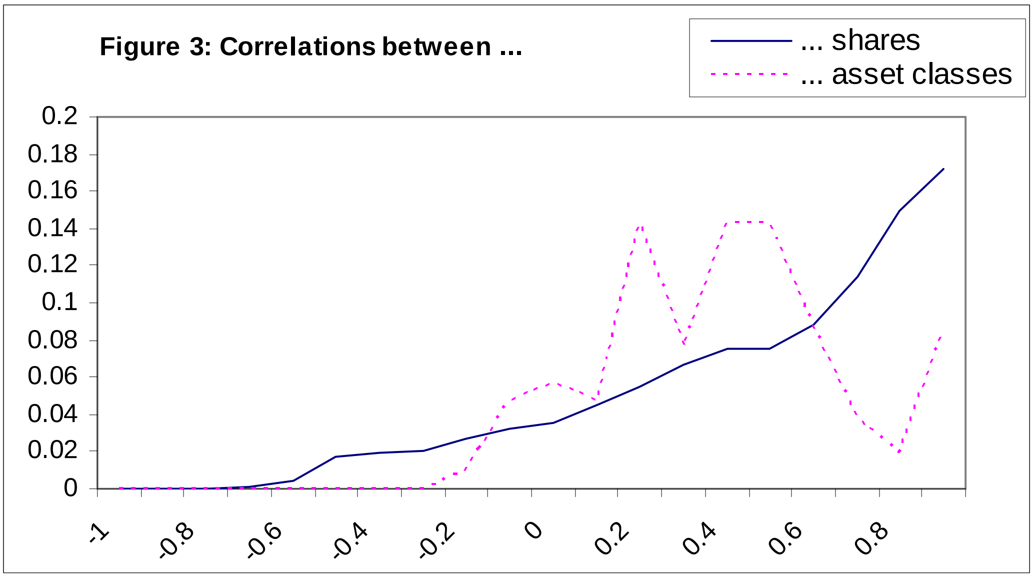
$$\rho_Q = \frac{q_{port,Q} - w_x^2 q_{x,Q}^2 - w_y^2 q_{y,Q}^2}{2 w_x w_y q_{x,Q} q_{y,Q}} \qquad (3)$$

The correlation between property and equity is the variable of perhaps greatest interest. We evaluated quantile correlations for the Australian S&P 200 and property trust index over the period since 1980. The results are shown in Figure 2. In the extremes, correlation has been high, but it drops off very rapidly and in most adverse scenarios has been negative in this data scenario. (The value in excess of one is not an error, but arises from the nature of the approximation.)

Figure 2: Quantile correlations for equity and property



There is, as illustrated in Appendix 3, an advanced mathematical approach to this problem using Copulas. The Taskforce did not feel that it had the time or resources to pursue this line of investigation although it may well have longer term merit.



3.2.2 Other observed correlations

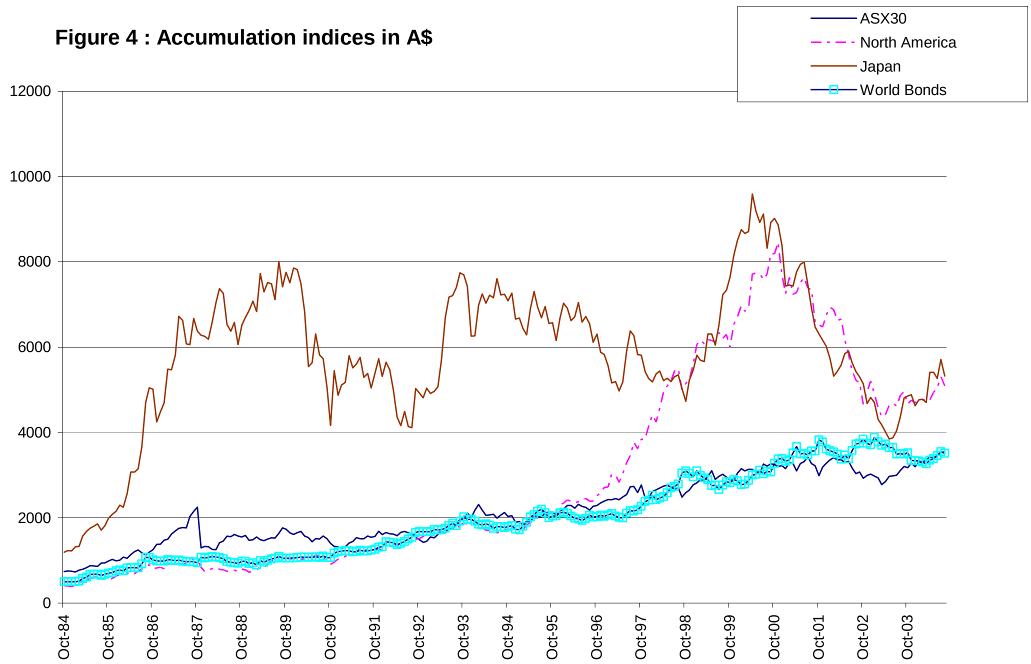
Figure 3 is a frequency plot of the correlations of those between the asset classes shown in the second matrix of Appendix 4, and between the largest 80 Australian shares - taken over a 10 month period in 2003. For the latter, it was found that the daily correlations were very similar to monthly although it is not clear whether they will last over longer periods.

While it is clear that diversification between asset classes is more likely to achieve a greater reduction in the volatility of a portfolio, it is apparent that it is also necessary to consider adequate diversification within classes.

3.2.3 Theoretical discussion

Current theory distinguishes between non-diversifiable market and diversifiable, or idiosyncratic risk, in an efficient market. The market risks arise from factors related to the supply and demand of investable funds and the underlying health of the economy. The idiosyncratic factors arise from the nature of the individual investment. There are also the intermediate factors that affect investment sectors, such as the supply and demand for office space, that falls somewhere between.

As investment markets become more global and investors become more skillful at eliminating diversifiable risk, one might expect universal factors such as the global supply and demand for funds and the health of the global economy to apply to all sectors and countries. Figure 4 below shows clearly how Japanese and North American shares have moved closely together in the past three years.



The question is whether the intermediate factors are of sufficient importance to justify distinguishing the different sectors from which they arise. Phylaktis and Xia (2004) review and extend the research on this subject and suggest that industry specific characteristics are not yet as important as country effects but are growing with increased international trade and capital flows.

Considerable research can and probably will be done on the mountain of data available in this area, but it would be surprising if it were not found that different crises displayed different correlations between asset classes. In some adverse scenarios, all asset classes would be similarly affected, in others the effects would differ between classes – as with the recent bursting of the IT bubble. Unless it can be shown that the first type dominates the second, some allowance should be made for more diversified portfolios to require lower resilience reserves.

3.3 Classification of assets

3.3.1 Equities

The arguments of the preceding section suggest that allowance should be made for diversification within an equity portfolio. Such allowance should however assume a fairly high correlation between the equity classes.

It is apparent, from Figure 1, that the benefits of diversification are soon reached when there is a high correlation between investments, and that the overall benefit is not that large. If mutual correlations are 75%, the diversification benefit after adding the fourth class would be 10%, increasing to a maximum of 13%. A pragmatic approach to setting the reserves would be to set factors assuming full diversification, and then increase the reserves by 10% (effectively eliminating all diversification benefits) if the amount invested in any one sector or country exceeds 25% of the equity portfolio. The sectors for this purpose would be Financial (ex Property), Property, Industrial and Resources.[2] This may be seen to provide an incentive for foreign investment.

3.3.2 Currency

Over the past 20 years, Australian shares have experienced a lower correlation with the hedged S&P 500 North American shares than with unhedged. An unhedged investment would have shown a greater maximum fall over a 12 month period although it reflects a lower standard deviation.

Hedging might thus appear to justify some diversification benefit. In principle however, one of the more plausible adverse scenarios one must consider with the large and persistent Australian current account deficit is a significant withdrawal of international investment funds from the Australian market. This would lead to a simultaneous drop in share prices and the value of the Australian dollar. Under such circumstances, hedging would eliminate the diversification benefit. Therefore, it seems that we should not require an additional reserve for currency exposure to overseas equities because the diversification benefit seems to offset country risk.

Short term fixed interest investments are however in a different category, and the currency allowance should apply. It is clear that the currency volatility is much higher than that implied by the current resilience reserve parameters. The standard deviation of annual changes over the last 20 years is 11%, which suggests twice the current parameter levels would be appropriate.[3]

Something less might be appropriate for long term fixed interest bonds, but the Taskforce did not feel that unhedged international bond portfolios justified another category of assets.

3.3.3 Property

It appears that the original working group considered direct property in deciding to create a separate asset class. They were encouraged to do so by the negative correlation between the property portfolio of a large office and Australian shares as reported in Shuttleworth (1996).

A large property trust sector has since developed which would question this relationship. The correlations reported in Appendix 4 between the property trust indices and other equities are relatively high.

Direct property would appear to differ from the listed trusts in that it is priced less often, less likely to be geared and is less liquid. Gearing increases volatility, but would be expected to increase the correlation of the property trusts to other equities only if the value of the borrowing was

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[2] See note 4 of the draft wording in **Error! Reference source not found.** below.

[3] See **Error! Reference source not found.**.

positively correlated with equity prices. While this has been true over some historical periods, it cannot be relied upon. If so it seems unlikely to have much of an impact on correlations. The infrequency in pricing direct property will however clearly reduce the correlation of its prices with the market, and it is suggested that the low and negative correlations observed may be largely a result of this artefact. Booth and Marcato (2004) discuss the issue and show how direct property indices can be de-smoothed to agree more closely with de-geared listed property indices particularly.

The resilience reserve is required to protect policyholders in adverse scenarios when asset prices are low and it would be more difficult than usual to liquidate direct property. It would be something of an anomaly to allow for a reduction in the resilience reserve because a statutory fund had more direct property rather than property trusts. It is thus difficult to justify them as a class separate to property trusts.

It would appear that property trusts do have a lower volatility than other shares, but the application of a fixed yield shock to their higher dividend yield makes allowance for this.

3.3.4 Inflation linked

Although index linked stocks were a small class, it was felt that treating them as fixed interest (or even equities) would greatly overstate their volatility, and wrongly discourage their use. It was felt therefore that they should be retained as a separate class.

3.3.5 Fixed interest

Retaining this as a separate class required no justification.

4 Mean reversion

The expectation of future returns could be governed by other variables. Most importantly, extreme events may not persist: bubbles burst and undervalued markets are likely to recover.

While the consideration of what occurs after an adverse shock was not within the Taskforce’s terms of reference, the possibility of an adverse shock would seem to depend, at least in part, on the current state of the market. Failure to consider likely moves from an extreme state makes it more difficult for the standards setter or regulator, in extreme circumstances, to decide that the standards were no longer appropriate. On the one hand, resilience reserves that do not adapt can be described as a “concrete cushion”, offering an inadequate capacity to absorb shocks. On the other, price bubbles offer a particular threat to the financial health of those who might be stampeded into investment at the peak.

This is a variant of the “procyclicality” question being discussed by the BIS where Basle rules may require credit reserves and provisions to be increased after poor experience and reduced after good. This aggravates the business cycle, and is criticised for this by Danielsson et al (2001). Provisions should be determined prospectively, increasing in times of fast expanding easy credit and reducing once poor experience has been properly accounted for.

4.1 Technical variables

There is some evidence of mean reversion and autocorrelation in asset price series, where the return for the next period R_t is based on a long term average return plus a mean reverting term that depends on the deviation of the current price from the long term average price: $P_{Average}$, a weighted average of earlier prices (autocorrelation) and an error term.

$$R_t = R_{Average} + \alpha(P_{t-1} - P_{Average}) + \Sigma\beta_k R_{t-k} + e_t \quad (4)$$

Colin Grenfell's AUSTMOD_S model shows positive and negative autocorrelation over periods of up to 20 years (refer October 2003 and December 2003 *Actuary Australia*). The autocorrelation for the share indices shows a negative correlation between one and two years – dropping as low as negative 23%. This is consistent with other research, reported for instance in Cutler, Poterba and Summers (1991), which shows that many markets overshoot in the short run and correct in the second year. This would however appear to be a function of the dominance of momentum investors in some markets that cannot be relied upon to persist.

Mean reversion is partly addressed by the current resilience reserves, which are based on yields rather than prices or returns: a yield shock has less of an impact if yields are higher.

4.2 Fundamental variables

Variables other than the price series that can be expected to have an impact on asset yields and prices. Apart from the supply of and demand for investable funds raised earlier, there are a number of factors relating to the underlying security or profitability of the assets that should affect price levels. GNP growth and inflation were specifically considered by the ERCH model used by the previous working group – the latter however being rejected as an indicator.

Tobin's q, which is the ratio of market price to book value, is one possibility that appears to have promise as an indicator. It is particularly attractive as there are fundamental reasons why share prices should not move too far out of line from the replacement costs of the assets. If q is too high, companies should attract competitors who can raise capital cheaply; if q is below one, companies should not re-invest but rather return depreciation flows to shareholders. The overall supply and demand for capital changes the yield on investments, but ultimately does not change the amount of the investment.

There is clear evidence of mean reversion in price earnings ratios and Tobin's q as described for instance in Harney and Tower (2003)[4]. They used a value for Tobin's q that adjusted for inflation, and produced values of less than 1 for most of the previous century. Feeney and Rogers (1999) appear to report a similar spread of the ratio for Australian shares. Current q ratios are however considerably higher as can be seen by looking at net tangible asset reported in the daily press. We did not however have access to an accurate series of q ratios to investigate further, and the reversion to fundamental values is clearly slow.

Malkiel (2004) looks at the success of technical and fundamental models to predict returns. He uses dividend yields, price earnings ratios and a model based on interest rates and Tobin's q, and finds evidence of out-performance based on the models. The UK resilience reserve test looks at the relationship between the equity earnings yield and fixed interest rates and assumes some convergence, although this allowance may be somewhat simplistic. Mean reversion of dividend yields, interest rates and inflation is frequently used in actuarial models. It is integral to the Wilkie model, widely used in its original and adapted versions, and now part of the standard actuarial syllabus.

4.3 Dividend reversion

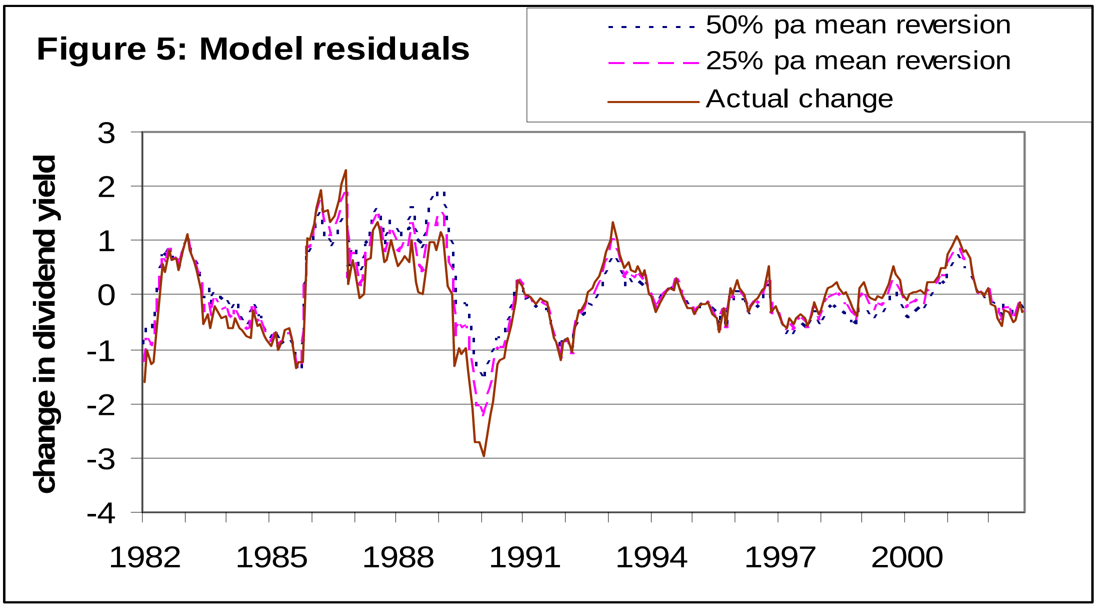
More work has been done on mean reversion to other estimates of fundamental value. Cutler, Poterba and Summers (1991) find significant reversions to the dividend yield in Australia, Canada, the UK and some US periods, but not in the other countries they model. The Australian rate of reversion to the mean is some 30% annually in the period from 1960 to 1988. Using their model in the twenty years for which we have data, the rate increases to over 40%. A better fit was found for a model closer to the current shock test – as shown in equation 5.

$$\begin{aligned} &DY_{t+1} - DY_t = \kappa(DY_{average} - DY_t) + \varepsilon_t \\ &or \\ &DY_{t+1} = \kappa DY_{average} - (1-\kappa)DY_t + \varepsilon_t \end{aligned} \qquad (5)$$

The value found for κ, the implied pace of convergence of the dividend yield, was 50% annually to its average of 4%. It can be noted that the current shock test assumes Κ = 0, but that Κ = 1 (i.e. that the expected value of the dividend yield at the end of the year is always 4%) performs slightly better statistically against our data. The best fit is about half way between the two.

The residuals are shown in Figure 5.

[4] Data on Tobin's q can be found on http://www.valuingwallstreet.com/qdata.xls



As the R^2 is only 25%, there is not an enormous improvement in the fit, but the model is significant statistically, with t values of 9 for both parameters. The result must be interpreted with some caution. All data series must have a mean, and because the dividend yields are based on market prices which are serially correlated, they would – even if the returns followed a pure random walk - display an element of mean reversion. Experimentation with random walk results produced statistically significant relationships, but with an R^2 of 4% and t values of 2. Our conclusion is that dividend yields have historically reverted faster than if they were pure random walks.

If the error is assumed to be bound by a 2% change in the dividend yield (some 2.5 standard deviations), this would provide a maximum limit for the dividend yield of 8%, which does not appear entirely unreasonable.

Given, however, that the rate of convergence is high relative to other countries and other times, it may be more acceptable to consider a lower rate of convergence. A lower rate of mean reversion also reduces the influence of the long term average – as can be seen from Formula 5. The Taskforce suggests a rate of 25%[5].

It is recognised however that dividend yields depend on relatively arbitrary management decisions, which are influenced over time by tax considerations and fashions in investment and corporate governance theory. It would be desirable to look at models that included some fundamental variables. Malkiel points out that the fundamental relationships should be based, at least partly, on real rather than nominal interest rates. The Taskforce recommends that further research should be done on models of this sort as being likely to provide a more stable basis for determining yield shocks.

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[5] See **Error! Reference source not found.**, note 1 below.

4.4 Property

Can property be treated similarly?

The Taskforce had some difficulty obtaining historical yields on any property series, but was able to obtain a ten year series of prospective property price earnings ratios. The regression based on Formula 5 produced an R^2 of 40% and an annual reversion of 80% to a mean of 7.5%. This is surprisingly close to the UK results of Booth and Marcato (2004), whose simple model found an annual mean reversion of 85%, and a long term mean of 6.1%

This is clearly sufficiently different to justify a separate mean reversion formula for property. Because mean reversion has been found to be lower in other markets, and a lower rate gives less weight to a relatively unreliable long term mean, it seems appropriate to use a lower rate of mean reversion and the Taskforce settled on the rate of 25% for all assets markets.[6]

4.5 International equities

Cutler, Poterba and Summers (1991) do find that mean reversion characteristics differ between different markets, but the Taskforce did not feel able to investigate every potential foreign market, nor that is was appropriate to attempt to do so. A number of possibilities present themselves, in increasing order of desirability:

- Use the Australian mean reversion factors to apply to other markets. This would be consistent with the view that share markets now tend to move together, and all are likely to be over or underprices together. Against this is the likelihood that special factors may apply to some markets that may be important to particular statutory funds.
- Not apply mean reversion factors to foreign markets in that they have not been adequately tested.
- Allow companies to develop mean reversion factors for the international markets in which they have invested. Such investigations should form part of due diligence procedures before investing in foreign markets. Against this would be the need to monitor the reasonability of the factors used.[7]

4.6 Interest rates

Interest rates might not appear to be amenable to this modelling because of the higher and variable rates of inflation experienced in the relatively recent past, and the government controls that have changed over the same

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[6] See **Error! Reference source not found.**, note 2.

[7] See **Error! Reference source not found.**, note 3

period. Nevertheless the data also has the same mean reversion pattern if real rather than nominal rates are used.

Inflation too reverts in a similar way, the parameters for the past 30 years being a 20% pa reversion to 6%, and over the past 10 for an 80% reversion to 2.5%. Anticipated inflation, as measured by the difference between the long bond yield and real yields also reverts to 2.5%. Over the last ten years, this has been at a rate of 55% annually and the R^2 of the model is over 40%. The fit for inflation may be particularly strong as a reflection of the manner in which it has formed a major part of government and RBA policy in the recent past. In the ten years before 1994, the R^2 is less than 10% and the rate of reversion less than 20%.

Real interest rates have reverted to an average of 4.0% (3.0% over the last ten years) at some 25% annually. The R^2 value is just under 20% and even worse over the longer period. This weak evidence is consistent with other research: Evans, Keef and Okunev (1994) and Lai (2004) find evidence of mean reversion but there is no unanimity. As the nul hypothesis is that real interest rates should be within a relatively small range, the Taskforce felt that an element of mean reversion was justified and that we would use a model of interest rate movements that separates the real interest rate from the effects of inflation.

4.7 Improved fits

Table 3 overleaf shows the improvement of fit using the mean reversion models suggested.

In each case, we are looking for a smaller and more symmetrical distribution of the error in Formula 5.

Panel A shows greater symmetry at low yields especially and a reduction in standard deviation for dividend yields, and a reduction in the maximum shock (error) experienced from 2.98 to 2.48.

None of the changes in panel B are significant.

Panel C and D show a small element of greater symmetry and reductions in standard deviation. The maximum shock is however reduced by 0.39% and 0.29% respectively.

These results are supportive of the nul hypothesis that there is mean reversion in each of the variables, and thus justify their use in the resilience reserve formula.

Table 3 Improved fit?				
	Against start of the year (%)		Against mean reverted value (%)	
	When greater than average	When less than average	When greater than average	When less than average
Panel A: Change in dividend yield over the year (Australian equities)				
Max	1.35	2.29	1.35	1.71
Min	-2.98	-1.25	-2.48	-1.52
Mean	-0.32	0.19	-0.32	0.13
Standard deviation	0.90	0.64	0.85	0.59
Panel B: Change in real interest rates over the year				
Max	2.26	2.25	2.21	2.26
Min	-1.40	-0.13	-1.06	-0.58
Mean	-0.17	0.38	0.12	0.24
Standard deviation	0.68	0.53	0.65	0.62
Panel C: Change in anticipated inflation over the year (last 20 years)				
Max	2.15	2.06	3.24	1.92
Min	-3.63	-1.09	-2.34	-1.06
Mean	-0.58	0.12	0.21	-0.01
Standard deviation	1.15	0.68	1.17	0.62
Panel D: Change in anticipated inflation over the year (last 10 years)				
Max	0.90	2.06	1.03	1.77
Min	-1.54	-1.09	-1.31	-1.06
Mean	-0.70	0.10	-0.45	-0.03
Standard deviation	0.55	0.65	0.55	0.58

4.8 Expressing the subsequent shocks

The question arose as to whether the subsequent shocks should be expressed as a fixed or as a percentage change in the variables we considered.

In order to answer this question, table 3 was divided into two columns – showing when the variables were above or below their long term averages.

In panel A, the standard deviation of changes to dividend yields is higher when yields are higher, but this is mainly explained by larger falls in dividend yield when yields are higher. As these are likely to be favourable, it would seem preferable to fix the shocks as a fixed change in dividend yields rather than as a percentage.

In panel B, there is less of a difference in standard deviation, and the maximum shocks (increases in real interest rates) are effectively identical. A fixed increase therefore also appears appropriate.

Panels C and D tell different stories. Over the longer period, with higher anticipated inflation, the movements are clearly more volatile. In the lower inflationary environment of the past ten years, a fixed shock is more appropriate. This suggests that the shock should be expressed as a combination that provides for both types of environment. The level of the shocks recommended is largely based on the current levels[8].

5 Credit risks

The resilience reserve has been focussed on relatively crude mismatch risks. However, other secondary mismatch risks, such as convexity mismatch and credit risk mismatch, have not been addressed substantially in the current standards.

Life insurers have, in general, been reducing their exposure to crude mismatch risk. However, in the search for ways to maintain their overall investment returns, this has often been accompanied by a move away from the use of sovereign and very high grade ("AAA" rated) fixed interest securities to higher yielding lower grade securities.

Concurrent with this, there has been a general:

- relative reduction in liabilities related to products such as discretionary credit (or asset return linked) investment account business; and
- an increase in competitively priced fixed rate, fixed term annuities, with often modest profit margins.

The result is that for many current portfolios, the current resilience reserve requirements and blunt inadmissible asset reserve requirements (focusing only on large, single counterparty exposures) may not generate sufficient capital reserves relative to the asset risks involved. In addition, given the convergence of banking and insurance products, there is some concern about regulatory arbitrage between the industries.

As a consequence, specific allowance for credit risk in the resilience reserve requirement is now considered appropriate.

5.1 Elements of credit risk

Credit risk includes:

- The impact of potential actual defaults.
- The impact of potential transition of assets held from one credit rating category to another (lower) credit rating category with a different (higher) market credit spread applying.
- The impact of potential adverse variation in overall market credit spread levels (relative to the liability discount rate basis).

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[8] The actual values of the proposed shocks are shown in section 8.1

5.2 Historical credit spreads

In developing a credit risk reserving basis a review of the current credit reserving approaches used by different banking and insurance regulators was undertaken. The Taskforce also looked at historic credit spreads and movements in the USA and Australia as the local market is relatively illiquid and immature and did not provide enough data for any confident analysis.

As credit spread movements are not perfectly correlated across ratings categories, and credit spread movements are not perfectly correlated with movements in government bond yields, a relatively low level of adequacy may be appropriate. Given time constraints further analysis of these factors was not undertaken.

5.3 Reserving for credit risks

Both Basel II and the Canadian regulator reserve for credit risk using a factor based approach. An alternative approach is to adjust the interest rate shock used in the resilience reserve calculation to allow for credit risk. It was decided to adopt the second approach, as it was felt that:

- Adopting this approach would be easy to implement for insurers, given the current solvency requirements, and
- It was an effective and elegant way of allowing for the impact of duration on the level of reserves.

The final question was whether it was worth differentiating between different ratings and durations, and making specific allowance for diversification. At this stage, it was not felt that there was sufficient data to make too many distinctions and that the interest rate shocks should be increased for credit risks by a small fixed addition. Further research should however be done in this area, particularly for any positive correlation with equity markets[9] and to ensure that regulatory arbitrage does not become a problem.

The Taskforce recommends that the default factors set out in table 4 be applied to all credit risks, and that applicable yield movements be added to the other yield shocks in determining the loading for non-cash fixed interest investments.

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[9] Suggested by Bill Pauling in a presentation found at http://www.casact.org/coneduc/rcm/2003/ERMHandouts/14

Table 4: Credit factors				
Rating (S&P)	Default Factor (Solvency)	Default Factor (Capital Adequacy)	Yield Movement (Solvency)	Yield Movement (Capital Adequacy)
AA *	0.25%	0.3%	0.3%	0.5%
A	0.5%	0.7%	0.4%	0.6%
BBB	1.5%	2.2%	0.5%	0.8%
BB	3.5%	5.0%	0.6%	0.9%
B	7%	10%	0.7%	1.0%
Below	10%	15%	0.8%	1.2%

* We suggest that only OECD central and state governments rated AAA should not be loaded for credit; all other borrowers treated as AA.

6 Diversification factor

6.1 Inconsistencies in the current factor

The existing diversification factor seems unsatisfactory.

- It does not appear to distinguish appropriately between changes to the yield and the value of fixed term investments – fixed interest or indexed linked. Unlike the relationship between dividend yields and prices, they are not interchangeable.
- It uses zero correlations between asset classes. The correlation between equities with direct property is discussed above. There is also an evident positive correlation between the returns on fixed interest and other investments.

The problems are illustrated in Table 5 in the simple case of just two classes of assets. If the term of the fixed interest assets is relatively long (7 years in the third and fourth column), adding equities increases the diversification factor. If the term of the fixed interest liabilities is short, then even a 1% investment in equities appears to create significant diversification.

Table 5: Apparent inconsistencies in the existing diversification factor

		Term of fixed interest: 7		Term of fixed interest: 1	
	Yield	Proportion invested	Diversification factor	Proportion invested	Diversification factor
Equities	0.04	99%	1.00	99%	1.00
Fixed interest	0.05	1%		1%	
Equities	0.04	50%	0.77	50%	0.95
Fixed interest	0.05	50%		50%	
Equities	0.04	1%	0.98	1%	0.86
Fixed interest	0.05	99%		99%	

6.2 A theoretical approach

Equation (2) can be used to determine the variance of the surplus – the difference between assets and liabilities. Equation (6) determines the variance of the surplus of a simplified portfolio invested in equities and fixed interest assets only. If we assume that there is initially no surplus, then the proportion invested in the liabilities is -1, and we can write.

$$\begin{aligned}\sigma^2(S) &= k_e^2\sigma_e^2 + k_{i(A)}^2\sigma_{i(A)}^2 + (-1)^2\sigma_L^2 \\ &+ 2[k_e k_{i(A)}\rho_{ei(A)}\sigma_e\sigma_{i(A)} + k_e(-1)\rho_{eL}\sigma_e\sigma_L + k_{i(A)}(-1)\rho_{Li(A)}\sigma_L\sigma_{i(A)}]\end{aligned} \quad (6)$$

Subscript e refers to equities, i(A) to fixed interest assets and L to liabilities. If the yield curve shifts in a parallel fashion, and we ignore convexity effects, the standard deviation of fixed interest portfolios will depend on the mean duration, so:

$$\sigma_{i(A)} = dn_A\sigma_1 \text{ and } \sigma_L = dn_L\sigma_1 \quad (7)$$

The correlation between the fixed interest portfolios, $\rho_{Li(A)} = 1$. If the entire portfolio is invested in fixed interest stock, and the mean duration of assets and liabilities are equal, the surplus will have zero variance. If the mean durations are not equal, the second, third and final terms produce a standard deviation of the surplus proportional to the difference in mean duration.

It can be seen that the current diversification factor ignores the last three terms. It appears that the original working party did this because the results were compatible with their modelling of a five year contract. Their assumptions were based on a correlation of 30% between equities and fixed interest. Our data in Appendix 4 suggests a similar correlation of 20%.

The formula does make the assumption that changes to the value of assets are symmetrical, which is clearly not true. A fixed increase in dividend yields produces a significantly smaller effect on asset values than an identical fall in yields. As we are invariably concerned about an increase in dividend yields, this does not appear to be a major issue.

The same effects apply to fixed interest investments, although the difference reduces with the mean term of the instruments. It is however clear from panel B of table 3 that falls in real interest rates are significantly smaller than increases. The same is true when anticipated inflation is low. It is not true when anticipated inflation is higher, but under these circumstances, mean terms are lower (because of higher nominal interest rates) and the asymmetry is reduced in any event. It would appear that these factors largely compensate for the asymmetrical effects of the formula.

It is therefore suggested that the formula for the resilience reserve could be reformulated using equation (6), which would eliminate the need to model alternative scenarios.

6.3 The implications

The first panel of Table 6 repeats Table 5 and shows the buildup of the resilience reserve under scenarios of increased yields and interest rates. The required reserves are of the same order, but it does appear that the current approach is inadequate for equity mismatches.

Table 6: Effects of proposal for new approach to diversification

Panel 1: CURRENT		**Long term fixed interest assets**			**Short term fixed interest assets**		
	Yield	Proportion invested	Diversific-ation factor	Resilience reserve	Proportion invested	Diversific-ation factor	Resilience reserve
Scenario 1							
Equities	0.04	99%	1.00		99%	1.00	
Fixed interest	0.05	1%			1%		
	Long fixed interest liabilities			47%			47%
	Short fixed interest liabilities			33%			33%
Scenario 2							
Equities	0.04	30%	0.71		30%	0.89	
Fixed interest	0.05	70%			70%		
	Long fixed interest liabilities			11.5%			18.7%
	Short fixed interest liabilities			11.0%			7.6%
Scenario 3							
Equities	0.04	1%	0.98		1%	0.86	
Fixed interest	0.05	99%			99%		
	Long fixed interest liabilities			0.6%			10.8%
	Short fixed interest liabilities			11.2%			0.5%

Panel 2: PROPOSED		Long term fixed interest assets			Short term fixed interest assets		
	Yield	Proportion invested	Factors	Required resilience reserve	Proportion invested	Factors	Required resilience reserve
Scenario 1							
Equities	0.04	99%	30.94%		99%	23.57%	
Fixed interest	0.05	1%	0.12%		1%	0.02%	
	Long fixed interest liabilities			30.9%			30.9%
	Short fixed interest liabilities			30.6%			30.6%
Scenario 2							
Equities	0.04	30%	11.90%		30%	7.14%	
Fixed interest	0.05	70%	6.13%		70%	1.23%	
	Long fixed interest liabilities			9.4%			13.0%
	Short fixed interest liabilities			12.6%			9.3%
Scenario 3							
Equities	0.04	1%	0.24%		1%	0.24%	
Fixed interest	0.05	99%	12.13%		99%	1.73%	
	Long fixed interest liabilities			0.3%			10.5%
	Short fixed interest liabilities			10.4%			0.3%
LIABILITIES	0.05	100%	12.25%		100%	1.75%	

The differences in pattern are relatively minor. The theoretical formula gives lower reserves for high equity impacts because of the correlation between equities and the liabilities. If a correlation of -1 is used, the theoretical results are much higher for the high equity scenarios but give credit for the negative correlation in the mixed scenarios.

The volatility of correlations is such that there might reason to use alternative values of the correlations in Formula 6 in order to make the resilience reserves more robust. This is a question that would benefit from further research.

7 Other issues

7.1 Application to individual portfolios

The current formula for the investment shocks is applied to the share index and not to the statutory fund's particular portfolio.

The question arises as to whether individual portfolios revert to the mean or retain their individual characteristics over long periods, and whether shares with higher dividend yields are less volatile than those with lower yields?

Stotz (2004) does find evidence of mean reversion in 50 large European shares, but uses a combination of profits and book values rather than dividend yields. The Taskforce unfortunately has no other data that might throw light on the mean reversion of individual shares to a long term mean, nor time to investigate the question.

As to whether volatility and dividend yields are related, it was relatively easy to compare the implied volatility of options on the shares of the major Australian listed companies in the daily newspaper. It showed a minimal impact. Based on this, it was felt that the use of the indices was more appropriate for determining mean reversion and the yield shocks, and thus no change was recommended to the current approach.

7.2 Reinvestment

If the asset terms are shorter than the liabilities, then there is a reinvestment issue and the resilience reserve requirement represents the present value of the shortfall that would arise if all reinvestment rates were to be equal to prescribed interest rates after the shock.

Under current circumstances, life annuities are likely to have a longer term than the longest available assets. They may therefore present a reinvestment problem. There are various markets in long term fixed interest investments, but the markets may be relatively thin, expensive and represent significant credit risks. The Taskforce wanted to tag this as an issue for a company that issued large volumes of annuities that would be difficult to match cost effectively, but did not feel the resilience reserve should be affected.

7.3 Yield curve slope and shape

In addition to yield shifts, yield curves are however also subject to changes in slope and shape which may have different impacts on different portfolios. Ang and Sherris (1997), among others, have used principal component analysis to model changes to the yield curve. Most analyses find three elements to be of practical significance. The first can be described as a parallel shift, although it often appears downward sloping (greater impact at the shorter end). The second is a change in slope – also with the greatest impact at the shorter end, while the third represents a change in curvature normally at relatively short terms. The curvature appears normally to be of little relative and practical importance, but it was felt that some consideration should be given to a change in slope, which can account for 15% of the movement.

The Taskforce looked at a liability with cash flows equal to a long (10-year) bond and a mid (5-year) asset. The result of this analysis suggested that the bulk of the total risk is captured by a parallel shift in the yield curve, and that pure tilt effects were less significant than parallel shifts. As a result, the Taskforce felt that stand-alone tilt risk is probably not worth testing.

7.4 Gearing, derivatives and hybrids

The existing resilience test has been criticised for not taking gearing, derivatives and hybrid assets explicitly into account.

The Taskforce felt that the resilience reserves had to apply to the effective exposure to the various asset classes. This means that companies should be adopting a type of “look-through” approach to geared exposures, hybrid assets and hedge funds to determine gross exposures to the “pure” asset classes. This requirement would not seem to be necessary, or indeed practical, for listed instruments. It would however be expected that unlisted investments would be much more closely monitored and that companies should have the necessary detail to “look through”.

Where assets or liabilities include options and more exotic derivatives, a more complicated approach is likely to be necessary. The value of the derivative instruments or liability options has to be re-determined as if the adverse experience had occurred. There may well be need for more guidance as to how this should be done, particularly given the effects of changes to volatility. More guidance may also be required in relation to indirect exposures to gearing (for example through listed property trusts) where the company may not be able to easily ascertain the level of gearing, and in relation to methods of treating various types of hybrid assets.

7.5 Inadmissable assets

Insufficient diversification is a factor in insurer insolvencies, and companies should be required to provide additional capital if they are not adequately diversified.

It would appear from Figure 1 that – for most realistic correlations between risks – that most of the benefits of diversification are achieved once the company is exposed to more than 20 distinct assets.

It is however not entirely clear whether the inadmissible cap would apply to shares and debt instruments in the same company or group. It is suggested that this would be desirable.

8 Proposed resilience reserves

The Taskforce suggests replacing the current resilience reserve formula by a method that looks at changes to the value of liabilities in the diversification factor and allows for some reversion to the mean.

We reiterate that we claim no scientific accuracy for the parameters below, but suggest that they ought to respond appropriately under reasonably foreseeable market fluctuations.

8.1 Calculation steps

This section outlines the suggested changes.

1 All assets and liabilities would first be revalued at rates that reflected the expected reversion to the mean.

2 As suggested in section 4.8, the following yield upward movement in yield shocks would then be applied:

	Solvency	Capital Adequacy
• Real interest rates:	0.8	1.2
• Anticipated inflation:	0.2 + 20%CF	0.5 + 30%CF
• Dividend yields:	1.25	2.0
• Currency:	14%	20%

(where CF is the current level of anticipated inflation.)

Using upward movements only means that there is no likelihood of dividend and interest rates less than zero, for the reasons of asymmetry discussed in section 6.2.

3 The resilience reserve formula would then be:

$RR = L' * \{A/A'' + \sqrt{[E^2+F^2+K^2+2(.2(EF-EK)-FK)]}\} - L$

where E, F and K represent the reduction in the value of equities, property and liabilities as a result of the yield shocks. It is assumed that the free assets are divided between equity and fixed interest type investments in the proportion they are of total assets. A'' takes credit risks into account - as outlines in section 5.3.

This approach takes the diversification factor suggested in section 6.2, and adds it to the adjustment for mean reversion.

8.2 Comparisons with existing reserve

The results have been compared with those required for the existing reserves to see whether they do indeed have an impact.

For fixed interest rates, the comparisons are taken back to 1985 from when we were able to obtain real interest rate data. It can be seen that the residual error on the proposed model (which is the change in nominal interest rates less the expected after mean reversion) has smaller extremes than the actuals. There is disappointingly no reduction in variance. What makes the changes worth proposing however is the significant savings in the extremes, shown in the final two columns of Table 7 The savings are calculated as the difference between the existing and proposed standards – based on an upward movement if interests rates are above the expected value (with mean reversion), or based on a downward movement if they are below. Based on the experience, the average saving would be of the order of over 0.5% for both the Solvency and Capital Adequacy standards.

For equities, the comparison has been with the actual return earned in the 12 months following the determination with the allowance for an equity shock. The results show that there is almost no change. Again however, this is regarded as satisfactory as the proposed approach is clearly less onerous when markets are low and more onerous when markets are high.

Table 7: Comparison with existing shocks (ignoring diversification)				
	Max	Min	Standard deviation	Mean
Actual change in interest rates (last 20 years)	4.04	-3.53	1.35	-0.43
Residual error on proposed model	3.80	-2.10	1.38	0.05
Solvency: Proposed saving in extremes	1.15	0.03	0.25	0.64
Capital Adequacy: Proposed saving in extremes	1.65	-0.36	0.50	0.53
Excess assets after actual returns				
Solvency – existing	106%	-4%	18%	34%
Solvency – proposed	107%	-10%	18%	34%
Capital Adequacy – existing	117%	5%	18%	45%
Capital Adequacy – proposed	117%	-0%	18%	44%

A comparison with the proposed reserves and actual experience over the previous 20 years (for a company invested 50% in equities and 50% in fixed interest liabilities) produces only 9 occasions when solvency would have been breached, and no occasions when capital adequacy was breached. This might suggest a slight reduction in the solvency shocks, but the Taskforce did not think that this was merited at this time given much of the success of the reserves is related to rapidly growing dividends over almost the entire period.

There would have been 8 occasions (out of 217 months) when the capital adequacy limits on fixed interest movements would have been breached. This is somewhat higher than the level of adequacy would require, which might suggest that the shocks should be increased. All 8 were in the 1994 year when real interest rates rose from 3.4% to 5.7% and anticipated inflation from 3.1 to 4.8%. If it is felt necessary to cope with a similar occasion in future, there is no benefit that can be gained from the mean reversion factors, and it would be necessary to increase the shock by almost 1%. This appears unreasonable if debatable. It might be argued that an independent Reserve Bank might see the need to raise interest rates significantly, or a significant foreign exchange shock might precipitate such a surge again. On the other hand, such rates represent a market failure against which companies cannot be expected to provide.

9 Conclusion

The Taskforce is pleased to be able to offer its suggestions for public discussion and debate.

The use of mean reversion comes closer to actuarial intuition about the forces underlying investment markets and is justified by the pattern of the returns on the market over the twenty years of data that we examined. The parameters will require monitoring, but the approach is likely to be more robust that the current methods used for mean reversion.

The suggested formula for diversification is more closely aligned to the theory, and would allow in the future for varying correlations between asset classes to allow for shocks to the correlation structure.

There are areas in which we still have reservations. One arises from the reliance, we have perpetuated, on dividend yields - particularly in foreign markets – for the shock to equities. This appears too subject to changing tax rules and corporate governance fashions to be entirely reliable. The use of earnings yields should be investigated.

We are also conscious that there is considerable homogeneity in the nature of the assets and liabilities of Australian life companies and that the crude structure of a simple resilience test is unlikely to be universally appropriate.

An area that should be debated is whether the capital adequacy reserves for fixed interest shocks should be increased by enough to deal with interest rate shocks of the size that occurred in 1994. This would involve an increase of some third in the required reserves.

We would hope however that our approach and the methodology used in our report would help in the development of a coherent set of reserves.

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Appendix 1 Underlying logic

1 Combining different risks

It can be noted that the Basel II framework is intended to align capital more closely to actual risks, but to keep the overall levels of capital more or less where they were under Basel I. It is not yet complete or entirely consistent. Internal modelling is permitted where the capital is calculated at a 99.9% adequacy level for each of operational, credit and market risk. It is however applies, effectively, over three months for market risk; and with a, probably inappropriate, normal distribution for the probability of default for credit risk. The capital requirements thus determined are then added without any allowance for “diversification”. One would not expect to need the full reserves for market, credit and operational risk simultaneously, but no specific allowances have been made for “strategic” and some other business risks.

The LIASB actuarial standards also make no allowance for the likelihood that the different types of risk are not correlated: all the reserves being merely added. It can however be noted that life companies have different business mixes, and their solvency and capital adequacy reserves may be composed almost entirely of one type of risk: for expense, for insurance risks or for the resilience reserve. The reserves for each risk category could perhaps be increased somewhat and some allowance made for diversification of risk types.

2 Management action

The percentages presumably take no account of management action during the year that would reduce the actual proportion of defaults. The period to use is a function of the time taken for a company to “de-risk” itself. This depends on:

- The timeliness of the company’s information systems and the speed of its decision making processes,
- the liquidity of the market for the assets concerned under the adverse circumstances involved or the availability of appropriate matching assets, or
- the time it would take to raise capital or find reinsurance under the adverse circumstances.

At one time, for some companies at least, actuaries would have understood solvency as requiring the assets and future cash flows of the statutory funds to cover the liabilities under existing policies as they fell due – without allowing for the possibility of raising new capital. Mutual offices constituted by legislation were in this position, and maintained their solvency by the issue of long term with profit contracts with significant discretion in bonus payments. This requirement might well be implicit in the wording of the LIA and in the consideration of the five year bond in 1995.

Long term policies are much less popular, and today's life companies rely on shareholders' capital and reinsurance to cover the risks of future losses. As long as the market value of its in-force business is positive, it would normally be possible for a company to restore its solvency by raising additional capital from the market, or reducing risk by changing its asset mix, reinsurance or sale of the business. Depending crucially on the liquidity of the assets, investment policy can often be changed within a month. Reinsurance is also relatively easily available, and listed companies may be able to access additional capital within three or four months.

Reserves to meet the solvency standard therefore have to be set at a level where the regulator has time to intervene and ensure action is taken before the value of in-force business becomes negative.

3 Reasonable expectations

The wording of the LIA suggests that the capital standard is correct in raising the "reasonable expectations" of policyholders as an issue. This is a concept of legal equity rather than contract and has meaning only in the context of with-profit policies. The implication would seem to be that the company should be reasonably confident that it will not have to change its investment policy in order to reduce its solvency risk – unless policyholders had been explicitly informed of the possibility. The shareholders in a company without with-profit business would be in a similar position: they would not want either to change their investment policy or to risk breaching solvency margins as it would put the franchise value of the company at risk.

If this is true, the capital standard should be determined, initially, by referring to the probability of breaching the solvency standard - before the company has time to raise extra capital or otherwise reduce risks. Three months is probably also a reasonable period, although the probability of breach could be higher, perhaps 10%.

4 Value at Risk (VaR)

It may be helpful to insert a few caveats about this approach. For those with some statistical training, it is a natural step to define insolvency in terms of an arbitrarily small probability of ruin or failure. It should be recognised that a defined probability of ruin can be 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. Even if it were accurate, the VaR capital is added to balance sheets determined by somewhat arbitrary accounting standards.

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. As with many with more than the average statistical training, they also dislike the VaR approach because it fails to satisfy the test of sub-additivity[10]; does not take the distribution of losses beyond the VaR into account, and makes no use of more sophisticated techniques[11] 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 that the results should be recognised as being fuzzy and therefore expressed diffidently. Capital over and above that required by VaR approaches may well be necessary.

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10 Meaning that one cannot necessarily add the VaR of two separate portfolios of risks and get the VaR of the combined portfolio.

11 Such as consideration of non-elliptical joint distributions and extreme value theory.

Appendix 2 Models used

1 " AUSTMOD-S " 14/2/05

Stochastic and *Historical* Investment Simulation Model

The model is an Excel workbook that displays 30 to 40 year historical (past) and simulated (future) investment performance for 15 "sectors":

B	Bill rate (90 day bank) in middle of year
C	Cash sector
D	10 year bonD rate in middle of year
F	Fixed interest sector
G	Government semis 0-3 years (SBC/UBS Warburg index SSG03)
I	International shares sector (MSCIAI prior 30/6/88)
J	International bonds sector
L	Loans sector
M	Mortgage trust (valued on a hold to maturity basis)
N	Inflation linked bonds (all maturities) UBS index
P	Direct property (one third NM/AXA, two-thirds AMP)
Q	Property trust accumulation index (from 31/1/01 S&P/ASX 300, from 30/6/02 GICS)
S	Shares sector (All Ordinaries accumulation index prior 31/3/65)
W	AWOTE by quarter (= av 1.5 mths lag) , not seasonally adjusted. Full-time adults (post 9/81), Males original (pre 9/81), AWE Males (pre 1/75)
X	CPI indeX by quarter

The model results are displayed in both table and chart forms. The simulated results depend on inputed assumptions for means, standard deviations, cross-correlations, auto-correlations, skewness, kurtosis, taxation and investment fees.

Appendix A, October/November 1997 Institute of Actuaries of Australia paper, "*Uses of S.I.S. (Superannuation Investment Simulations)*" by Colin Grenfell is a reasonable specification of the then Version O of Austmod. The latest model (Version S), retains all the features of Austmod 0 and includes many improvements, for example:

1. Three auto-correlation options
2. Three skewness options
3. Two kurtosis options
4. Inflation-linked bonds
5. An exempt tax option (with or without imputation credits)
6. Historical results at quarterly intervals back to 30/6/60
7. With or without investment fees
8. With or without cross correlations
9. Plus or minus an additional rate if required
10. Compound and arithmetic means
11. Four net cash flow input alternatives
12. Twelve superannuation and investment simulation output alternatives
13. Choose 8, 40, 200 or 1,000 simulations
14. A user-friendly input page
15. Updated assumptions and proportions

2 Global CAP:Link

The Towers Perrin Capital Market Scenario Generator, Global CAP:Link, is designed to help institutional investors in "decision-making under uncertainty". The underlying philosophy is that financial markets are subject to variability, much of which is unforecastable, but which still exhibits elements of pattern and shape. Global CAP:Link can model this "structural uncertainty" by simulating an internally consistent set of economic variables and the resulting asset class returns.

The most prominent feature of Global CAP:Link is its system of linkages among the various model components. For example, there are direct linkages between simulated bond yields and resulting bond returns and partial linkages between interest rates and inflation. GDP, credit spreads, and stock market returns are similarly linked. Given (user-specified) assumptions for a few economic variables, Global CAP:Link will provide a distribution for the evolution of key variables through time.

Global CAP:Link is based on a cascading set of stochastic differential equations. The form of these equations is identical in each country, although the assumptions and calibration parameters reflect unique characteristics of each particular economy.

In general, there are four drivers of Global CAP:Link's simulation results:

• Initial Conditions (determined by the market)

• Normative Conditions (user specified)

• Calibration Parameters (based on history and judgement)

• Random Terms (diffusion process; also based on history and judgement).

The Taskforce chose to adopt normative conditions equal to initial market conditions for the purpose of developing the results displayed in this paper.

3 Watson Wyatt

Watson Wyatt's stochastic asset model is intended to be used for long-term asset projections of the kind used for asset allocation studies and asset liability modelling. These projections typically extend over a period of some 5 to 25 years. The model has been developed over a number of years and has involved the use of experience, judgement and analytical investigation to arrive at the final model structure and parameter values. In broad terms, the model has an inflation-driven cascade structure, with inflation influencing bond yields, which in turn influence cash returns, which in turn influence equity returns.

In terms of the actual distribution of returns, equity returns are modelled as a form of random walk, and are assumed to follow a lognormal distribution. Cash rates and long bond yields are modelled separately, enabling a projected yield curve to be derived and then returns to be calculated. Cash rates and bond yields are both assumed to be autoregressive, with the starting values based on current market yields."

Appendix 3 Non-normal correlations

The use of a correlation matrix in case distributions are not Normal Tail Correlation, Henk van Broekhoven, 12 August 2004

With the use of correlation factors several risk distributions are combined into one distribution. This method works correctly in the case the distributions are all from the Normal-family. The standard deviation of the combined distribution of two normal distributions (1 and 2) with a correlation of ρ_{12} follows:

$$\sigma_{12} = \sqrt{\sigma_1^2 + \sigma_2^2 + 2\rho_{12}\sigma_1\sigma_2}$$

The new combined distribution (12) will also be Normal.

Two problems using this method are:

1) the distributions should be from a normal-family and for most of the risks used in insurance this is not the case
2) the correlation between the stand alone risks should be constant over the whole range of the distributions. Also this is not the case: in a lot of situations the correlation under extreme circumstances will be higher than under average circumstances.

The use of a method out of the Copulas-family instead of the correlation matrix would solve this problem. Using a Copulas function two distributions are combined into one combined distribution.

Problem with that theory is that the Copulas function is rather complex to estimate, particularly when more than two risks are involved.

With the use of a simulation model, both problems mentioned above are analysed.

With the simulation model two separate distributions and also the combined distribution are formed under several circumstances. Each simulation contains 100,000 runs. With the two separate “stand alone” distributions and with the combined distribution the Value at Risk (Var) is calculated at several confidence levels (combined exact). The relation between the stand alone Var’s and the combined Var is analysed and compared with the use of the correlation matrix (using cor. factor). Instead calculating a standard deviation for the combined distribution we use the Var’s to find a combined Var.

Simulation 1: Two independent normal distributions:

Correlation factor : 0			
	Conf. 90%	Conf. 99%	Conf. 99.95%
Risk 1	1.3	2.4	3.2
Risk 2	1.3	2.3	3.2
Combined exact	1.8	3.2	4.5
Using Cor. Factor.	1.8	3.3	4.5

As expected works the use of the correlation matrix in this case correct.

Simulation 2: risk 1: log-normal ; risk 2: Poisson (10) - independent

Both type of distributions are usually part of the solvency calculation.

Correlation factor : 0			
	Conf. 90%	Conf. 99%	Conf. 99.95%
Risk 1	1.8	8.8	24.1
Risk 2	4.0	8.0	12.0
Combined exact	4.7	11.9	24.4
Using Cor. Factor.	4.4	10.8	27.0

The method using the correlation matrix is less accurate, although the "mistake" is not extreme. But we should be careful using the correlation matrix method, particularly when highly skewed distributions involved, even in case of independent risks.

Simulation 3: both normal distributions, but with a high dependency. The dependency is formed by: the result of distribution 1 gives the expected value of distribution 2.

Correlation factor : 0.70			
	Conf. 90%	Conf. 99%	Conf. 99.95%
Risk 1	1.2	2.2	3.3
Risk 2	1.8	3.3	4.7
Combined exact	2.8	5.1	7.4
Using Cor. Factor.	2.8	5.1	7.4

The method with correlation factors works correctly, as expected.

Simulation 4a: like 3 but dependency only in tail of distributions (above 2 sigma's)

Correlation factor : 0.12			
	Conf. 90%	Conf. 99%	Conf. 99.95%
Risk 1	1.2	2.3	3.3
Risk 2	1.3	2.7	4.4
Combined exact	1.8	4.8	7.3
Using Cor. Factor.	1.9	3.8	5.9

The method with correlation factors works wrongly, particularly in the far tail. The Var's are underestimated.

Simulation 4b: like 4a but with adjusted correlation factors

Correlation factor : 0.12, adjusted for tail correlation : 0.70			
	Conf. 90%	Conf. 99%	Conf. 99.95%
Risk 1	1.2	2.3	3.3
Risk 2	1.3	2.7	4.4
Combined exact	1.8	4.8	7.3
Using Cor.	2.3	4.7	7.2

The adjusted tail correlation is based on the fact that the same kind of correlation is used as in simulation 3.

This method works fine, at least in the far tail. The method doesn't work close to the average.

Of course it will be hard or better in most cases impossible to estimate tail correlation factors at a high confidence level. For the time being the use of expert judgement must be used.

Appendix 4 Empirical based correlations (Source: AUSTMODS – November 2004, Colin Grenfell)

Recommended 2yr RANK cross correlation matrix

	S	I	PT	P	L	Mortgage	F/G	Semi-govt	IB	C	N	Bill myf	Bond myf	AWOTE	CPI
S	1	.62	.43	.05	.18	.22	.08	.19	.05	.17	.08	.17	.15	-.03	.08
I	.62	1	.29	.11	.18	.29	.25	.28	.22	.19	.31	.22	.28	-.03	.07
PT	.43	.29	1	.05	.21	.14	.42	.32	.42	.11	.43	.07	.10	.04	-.02
P	.05	.11	.05	1	.36	.41	.00	.32	.11	.49	.05	.49	.46	.62	.65
L	.18	.18	.21	.36	1	.94	.52	.89	.55	.87	.54	.84	.87	.45	.51
Mortgage	.22	.29	.14	.41	.94	1	.44	.88	.46	.93	.47	.93	.92	.50	.59
F/G	.08	.25	.42	.00	.52	.44	1	.75	.96	.38	.90	.37	.38	-.08	-.06
Semi-govt	.19	.28	.32	.32	.89	.88	.75	1	.77	.86	.73	.83	.80	.39	.43
IB	.05	.22	.42	.11	.55	.46	.96	.77	1	.43	.87	.41	.42	.01	.03
C	.17	.19	.11	.49	.87	.93	.38	.86	.43	1	.41	.97	.88	.63	.71
N	.08	.31	.43	.05	.54	.47	.90	.73	.87	.41	1	.40	.40	.10	.14
Bill myf	.17	.22	.07	.49	.84	.93	.37	.83	.41	.97	.40	1	.88	.62	.70
Bond myf	.15	.28	.10	.46	.87	.92	.38	.80	.42	.88	.40	.88	1	.52	.58
AWOTE	-.03	-.03	.04	.62	.45	.50	-.08	.39	.01	.63	.10	.62	.52	1	.88
CPI	.08	.07	-.02	.65	.51	.59	-.06	.43	.03	.71	.14	.70	.58	.88	1
	Average	.456444	12/2003	.456444											

Recommended 2yr cross correlation matrix

	S	I	PT	P	L	Mortgage	F/G	Semi-govt	IB	C	N	Bill myf	Bond myf	AWOTE	CPI
S	1	.60	.56	.03	.13	.14	.18	.19	.16	.13	.16	.12	.13	-.17	.05
I	.60	1	.36	.08	.29	.33	.32	.35	.29	.30	.36	.27	.31	-.08	.08
PT	.56	.36	1	.00	.28	.22	.53	.41	.52	.17	.49	.12	.18	-.14	-.06
P	.03	.08	.00	1	.30	.41	-.15	.18	-.06	.46	-.05	.44	.38	.37	.52
L	.13	.29	.28	.30	1	.94	.62	.92	.67	.89	.61	.83	.87	.27	.40
Mortgage	.14	.33	.22	.41	.94	1	.47	.89	.54	.98	.50	.94	.93	.40	.55
F/G	.18	.32	.53	-.15	.62	.47	1	.81	.98	.39	.91	.34	.42	-.20	-.13
Semi-govt	.19	.35	.41	.18	.92	.89	.81	1	.85	.84	.78	.80	.82	.18	.31
IB	.16	.29	.52	-.06	.67	.54	.98	.85	1	.47	.91	.42	.47	-.13	-.05
C	.13	.30	.17	.46	.89	.98	.39	.84	.47	1	.44	.97	.92	.47	.62
N	.16	.36	.49	-.05	.61	.50	.91	.78	.91	.44	1	.38	.42	.02	.13
Bill myf	.12	.27	.12	.44	.83	.94	.34	.80	.42	.97	.38	1	.91	.45	.60
Bond myf	.13	.31	.18	.38	.87	.93	.42	.82	.47	.92	.42	.91	1	.39	.52
AWOTE	-.17	-.08	-.14	.37	.27	.40	-.20	.18	-.13	.47	.02	.45	.39	1	.83
CPI	.05	.08	-.06	.52	.40	.55	-.13	.31	-.05	.62	.13	.60	.52	.83	1
	Average	.445956	12/2003	.445956											

The tables cover the 11 investment sectors and 4 financial indicators coded B to X in "AustmodS15" set out in Appendix 2. They have been derived by examination of long term (32 year) trends in historical forces of return for each of these 15 "sectors" up to 31/3/03, 30/6/03, 30/9/03, 31/12/03 and extrapolating forward the results by a couple of years. The first set is based on data ranks; the second set is based on actual data. These factors have now been superseded by Grenfell (2005)