Institute of Actuaries of Australia

Inflation Risk in General Insurance

Prepared by John De Ravin and Mike Fowlds

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The Institute of Actuaries of Australia
Level 7 Challis House 4 Martin Place
Sydney NSW Australia 2000
Telephone: +61 2 9233 3466 Facsimile: +61 2 9233 3446
Email: actuaries@actuaries.asn.au Website: www.actuaries.asn.au

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Abstract

Actuaries, insurance executives and insurance regulators have long been aware of the risks posed by inflation to general insurance companies. The inflation risk has implications for many aspects of an insurer's operations including:

- design of policy terms and conditions
- pricing
- reserving
- asset/liability matching
- risk management
- capital management

In considering the above issues a number of questions arise to which no widely accepted and agreed solutions are available, including:

- Is inflation an insurable risk in long term contracts without indexation of deductibles and limits?
- How should we price for the risk that future inflation departs from 'best estimates'?
- How should we reserve, and set aside capital, for the risk that future inflation departs from 'best estimates'?
- What investment policy should be adopted to best 'match' inflation-impacted liabilities?
- If the insurer wishes to minimise regulatory capital requirements, what investment policy would best achieve that objective?
- How should inflation risk be measured and incorporated into an insurer's approach to risk management?
- How should inflation risk be incorporated into regulatory risk charges?

The paper discusses the implications of inflation risk in each of these areas.

Keywords: inflation; superimposed inflation; regulatory capital; APRA capital standards; reserving; pricing; risk management; investment policy; ALM.

1 Introduction

1.1 Background

Over the past 25 years, few papers concerning the impact of inflation on general insurers have been presented to actuarial forums. Perhaps that is because of the relatively benign inflationary environment in recent decades, which has been referred to by many economists as the 'Great Moderation', but currently some high profile economics commentators are concerned that the inflationary dragon is not dead, but sleeping. For example Phillipa Malmgren was quoted as asserting at a recent Australian conference that "the world faces pressures pushing economies towards inevitable defaults on their borrowings and high, damaging inflation."[1]

In the aftermath of the Global Financial Crisis (GFC), prospects for future inflation have attracted a high degree of attention internationally, and with good cause. Some economists argue that many already financially extended governments resorted to massive spending measures to tide their peoples through the GFC, with mixed success, but at a cost to their international indebtedness. Particular attention has been focussed on the debt burden of the so-called 'PIIGS', Portugal, Italy, Ireland, Greece and Spain, as well as some of the largest developed economies. Projected debt levels are now so large that many economists are concerned whether those countries will be able to meet their debt burden without either doing major damage to their economies or relaxing monetary discipline. The inflation risk has a significant political component. One possible consequence of widespread relaxation of monetary discipline by governments or their central banks is a bout of global inflation to match the oil-price induced inflation of the 1970s or the inflationary spike of 1934. (It should be added that, somewhat paradoxically, investors also fear *deflation*, as government and household austerity to reduce debt levels gives rise to reduced demand).

Of course, not every economist believes that we are necessarily headed for renewed high inflation. A balanced assessment is provided by Conning Research and Consulting:

"Surveys of economists and forecasters suggest that prospects for inflation remain fairly benign, though the dispersion around those projections is widening. While the expected rate of inflation may be modest, the probabilities of increased inflation and the potential severity of that inflation may be increasing."[2]

So the potential for a global inflation breakout is one reason to reconsider the inflation risk. Another, more local, reason for a renewed focus on inflation is that APRA has proposed changes to the regulatory capital requirements for the life and general insurance industries.[3] APRA has proposed that the capital requirements for general insurers will depend not on a simple table of percentages to be applied to asset values (varying only according to counterparty financial strength), but on the results of a more complex set of stress tests that require simultaneous stressing of the assets and the liabilities under a number of scenarios, combined with a 'correlation matrix' approach to allow for diversification of risks and thereby to produce the overall required Asset Risk Capital Charge.

APRA has (rightly, in the opinion of the authors) taken the view that inflation is one of the key risks faced by insurers, and that the current regulatory capital regime is not *appropriately* sensitive to that risk (although insurers may argue that there should already have been an implicit allowance for inflation in the current insurance risk charges). Inflation is therefore explicitly included as one of the parameters that insurers will be required to stress in order to calculate the new asset risk charge. The new risk charge structure may cause insurers to give renewed consideration to their investment policies, and many are likely to review their investment policy in the light of asset-liability matching considerations and the amended statutory capital charges.

[1] Dunstan (2010).
[2] Conning Research and Consulting (2010).
[3] APRA (2010a); APRA (2010b).

The inflation risk is more relevant to long tail classes of business than short tail classes. The further into the future a settlement is expected to be made, the more time there is for the 'expanding funnel of doubt' to apply to the ultimate settlement amount.

1.2 Definitions and nomenclature

It will be useful to adopt some notation for the discussion.

Let us adopt the following definitions:

$\{P_{ij}\}$ = payments in development year j (j=0, 1, 2, 3 ….) arising from accident year i
N_0 = the current year.

Generally historical payments $\{P_{ij}: i+j \leq N_0\}$ are known but future payments must be projected and are subject to inflationary risk.

In general terms, to an insurer, the 'inflation rate' is the percentage by which a claim settled in one year may be expected to be higher than a similar claim settled in the previous year due to changes in the settlement environment including not only changes in prices and wages but also changes in the legislative, social, economic and judicial environment. This claims inflation is therefore unlikely to equal other measures of inflation such as consumer price inflation.

In some insurance models (for example, in the 'Separation' reserving method[4]), the payments are assumed to be a simple function of:

- exposure and other accident-year phenomena – say F_i
- the development year – say K_j; and
- a payment-year inflation indicator, λ_{i+j}.

In the separation method, the $\{P_{ij}\}$ are modelled as follows:

$$P_{ij} = F_i * K_j * \lambda_{i+j}$$

Taylor's separation method allows simple direct estimates of the payment-year inflation variable $\{\lambda_{i+j}\}$ to be derived. In practice, however, these estimates may be impacted by factors such as the randomness of the claims experience (e.g. more large claims in one year than another) or fluctuations in settlement patterns.

Note that the inflation as measured by the $\{\lambda_{i+j}\}$ includes both 'index inflation' (inflation as measured by an index that the insurer considers suitable for projecting future claims payments to allow for variations in the purchasing power of money) and 'superimposed inflation', that is, inflation over and above the value of the selected 'index'.

In general insurers are exposed to both 'index' and 'superimposed' inflation. Pearson and Beynon found that "[t]he causes of superimposed inflation are varied and involve complex behavioural, social, legal and legislative forces." [5]

Some of those forces include:

- changing social values being reflected in settlement amounts awarded by the Courts;
- as societies becomes wealthier, they have more resources to allocate to the seriously bodily injured;
- inclusion of new 'heads of damage' into liability awards;
- advances in medical technology which create new (but expensive) treatment options;

[4] Taylor (1977).
[5] Pearson and Beynon (2007).

- changing costs of medical treatment, legal advice and rehabilitation; and
- increasing lifespan, so that seriously injured claimants live longer than previously.

Measuring superimposed inflation (SII) depends on the definition of normal inflation as well as whether, for example, changes in benefit utilization are modelled separately.[6] Attempts to measure SII have given the range 3% – 6% per annum for Australian CTP for the 10 years to 2002.[7] A Swiss Re study of European Motor markets in 2003 gave a wide range of SII, between 0.4% and 9% per annum, depending on market. Apart from CTP business in Queensland, the SII environment has been benign in Australia in the past 5 years however, with some SII studies giving a result of very modest or even negative SII.

Insurers are of course well aware of the phenomenon of superimposed inflation, and the need to price, reserve and invest appropriately for it. Pearson and Beynon[8] noted that most insurers do not model the cycle of strong and benign SII in a sophisticated way, but rather they assume a constant level of SII in pricing and reserving. From a management perspective, simply knowing the historical level of SII is not sufficient to guide an appropriate management response. Only by knowing the underlying drivers of the SII, does management have a chance of taking concrete action.

Although in this paper, there is probably more focus on general ('index') inflation than superimposed inflation (partly as a result of the proposed new APRA capital standards), in the opinion of the authors, the risks posed by superimposed inflation to the financial health of an insurer writing long term business are at least as great as those posed by index inflation.

1.3 Contents of this paper

This paper is divided into seven sections. The next five sections relate to the interaction between the inflation risk and each of the following key insurance activities:

- policy design (Section 2);
- pricing (Section 3);
- reserving (Section 4);
- investment (Section 5); and
- risk management (Section 6).

Section 7 summarises the paper’s conclusions and suggests some areas for further research.

[6] Pearson and Beynon (2007).
[7] Robinson and Harrex (2002).
[8] Pearson and Beynon (2007).

2 Inflation Risk, Modelling and Policy Design

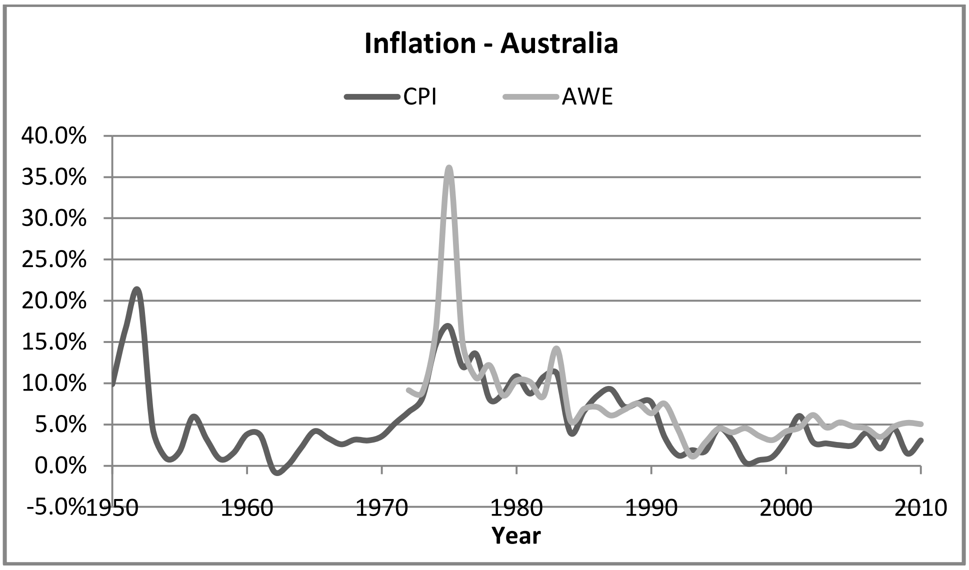
2.1 History of inflation in Australia

It will be useful to start by reviewing the history of inflation in Australia.

There are two chief indices of inflation in Australia, the Consumer Price Index (CPI), which is a measure of price movements as experienced by the typical household consumer, and the Average Weekly Earnings (AWE), which measures movements in average wages. Both indices are maintained by the Australian Bureau of Statistics (ABS). Both are in reality a collection of time series; for example, the published CPI statistics include sub-indices by State and for subsets of the standard consumer basket of goods.

The CPI values for Australia since 1948 are tabulated in Appendix 1 and AWE values (Public and Private Sectors, original series, full time adults Ordinary Time Earnings) are tabulated in Appendix 2. Graph 1 below summarises the movements in the CPI (June quarter to June quarter) and AWE (March quarter to March quarter) in successive years.

Graph 1 – CPI and AWE Inflation, Australia, 1948-2010



From Appendix 1 and the above chart, we can see that for the majority of the last 60 years, price inflation has been in the range 0% to 5% per annum, but that there are periods when price inflation was much higher. For example, in the late 1940s and early 1950s (until 1953) inflation was above 10% per annum, even exceeding 25% between December quarter 1950 and the December quarter 1951. Again for much of the period following 1973, inflation was above 10% (this time reaching a maximum of 17.6% in the March quarter 1975) and was not brought back below 5% until 1991.

The breakouts can be sudden and very steep, and when they do happen, they are certainly sufficient to cause major consequences for insurers writing casualty lines of business, where a material proportion of the claims expense may be outstanding even 10 years after the date of loss. They also appear unpredictable, given that people's inflationary expectations are typically anchored to the current inflation rate. Who could have known, in the March quarter 1950, when inflation was running at 7.7%, that inflation would be running at 25.6% by December 1951? Or who could have predicted, in the March quarter 1973 when inflation was 5.7%, that by the March quarter 1975, inflation would be running at 17.6%?

When we turn to wage inflation, similar conclusions hold. If anything the historical spikes appear even more marked than the spikes in price inflation. In the 12 months to the March quarter 1975, AWE rose by a staggering 36.2%.

The Australian experience of steep and unpredictable breakouts is not unique, but has been noted also in international inflation experience.[9]

The overall claims cost of a general insurance liability portfolio can be broken down into a number of components, each with its own source of inflationary pressure. Heads of damage relating to loss of earnings will be subject to wage inflation. Medical care will be subject to medical inflation. Claims handling expenses (particularly legal costs) will have their own inflationary index, and so on.

CPI inflation reflects the annual increase in cost of purchasing goods and services, weighted by the consumers' typical basket of goods, which is unlikely to reflect the cost weightings of a typical claim. Inflation in certain sectors, such as construction and healthcare, is likely to warrant a higher weighting for insurers. The Producer Price Index (PPI) is likely to be more relevant for commercial insurance, while CPI is appropriate for personal lines insurance. For example, analysis of the losses incurred in one reinsurer's domestic property portfolio suggests that the inflation rate that appears to apply to domestic property losses is higher than the overall CPI, but lower than the construction cost index.

The preceding paragraph raises the question of the correlation (or basis risk) between CPI inflation and wage inflation or sector inflation. Studies[10] suggest the following:

- The main index and the sub-index are more closely correlated at longer time horizons (e.g. 5 years) than shorter time horizons.
- Larger inflationary shocks have a higher correlation than smaller shocks (since the former tend to be macro-economic in nature and impact all sectors).
- Upward inflation shocks tend to be more correlated than deflationary shocks.

2.2 Inflation models

Over the years, a number of economists and actuaries have attempted to construct econometric models that present reasonable stochastic representations of inflation rates and other macroeconomic variables such as GDP, interest rates, equity share dividends and prices, property rentals and prices and in some cases, other variables. Such models are of great interest to insurers in the context of:

- analysing the asset and liability risks inherent in their portfolios;
- determining their economic capital; and
- designing and constructing Dynamic Financial Analysis (DFA) models.

Constructing a realistic model is a challenging exercise, not least because the future level of inflation is partially within the control of the world's central bankers, and modelling human behaviour is always difficult. For example, a realistic model would have to capture the scenario that the RBA increases its inflation target from the current 2-3% to, say, 4-6%, and to model its degree of commitment to meet its targets.

In this Section we briefly describe two such models, the Wilkie and Thomson models, and briefly mention a number of others, and note the criticisms that have been made of some of those models.

2.2.1 Wilkie Model

A model that will probably be familiar to many actuaries and which has been widely used for actuarial purposes is the Wilkie Model.[11,12]

[9] Conning Research and Consulting (2010).
[10] Goldman Sachs (2010).
[11] Wilkie (1986).

The structure and parameters of the original Wilkie model are summarised succinctly as follows.[13] The model consists of four time series, generated by four sequences of independent unit normal random variables QZ(t), YZ(t), DZ(t) and CZ(t).

(1) Retail Prices Index (Q(t))

$\log[Q(t)/Q(t-1)] = 0.05 + 0.6\{\log[Q(t-l)/Q(t-2) - 0.05\} + 0.05\, QZ(t)$

(2) An index of gross equity dividends (D(t))

$\log[D(t)/D(t-1)] = 0.8\, DM(t) + 0.2 \log[Q(t)/Q(t-1)] - 0.0525\, YZ(t-1) + 0.1\, DZ(t)$

where $DM(t) = 0.2 \log[Q(t)/Q(t-1)] + 0.8\, DM(t-1)$

(3) The gross dividend yield (Y(t))

$\log[Y(t)] = 1.35 \log[Q(t)/Q(t-1)] + YN(t)$

where $YN(t) = \log 0.04 + 0.6\{YN(t-1) - \log 0.04\} + 0.175\, YZ(t)$

(4) The gross yield on UK Consols (Government bonds) (C(t))

$C(t) = CM(t) + CN(t)$

where $CM(t) = 0.05 \log[Q(t)/Q(t-1)] + 0.95\, CM(t-1)$

and $\log[CN(t)] = \log 0.035 + 0.91 \log[CN(t-l)/0.035] + 0.165\, CZ(t)$

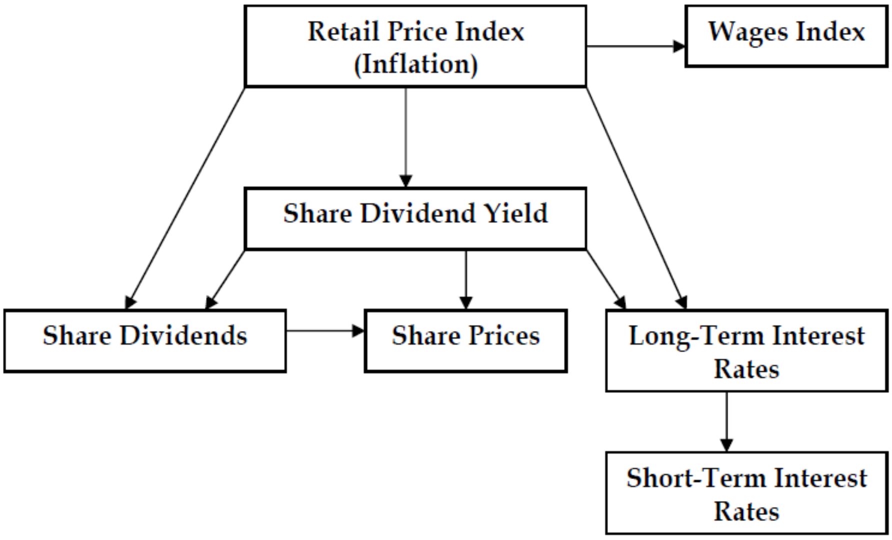
Using these four time series, three others are constructed: an equity price index, an equity accumulation index (net of tax on dividends) and an accumulation index for Consols (net of tax on interest payments).

The later Wilkie paper[14] extended the original model to include a wage index, short term interest rates, property rentals and yields, and yields on index-linked stock.

The structure of the Wilkie Model is summarised in the following diagram.[15]

[12] Wilkie (1995).
[13] Macdonald (1991).
[14] Wilkie (1995).
[15] Sahin et al (2008).

Diagram 1 - Structure of the Wilkie Model



The Wilkie model has been heavily criticised over time however, and has been found not to be suitable for Australian conditions[16] nor for South Africa.[17,18] A review of the updated Wilkie model was still critical of the model.[19] A key aspect of the critique is that the underlying assumption of the model that parameters are stationary over time is not supported by the experience. A recent review[20] found that:

- The residuals of the inflation model are not normal and the mean and standard deviation are not stationary over time;
- Wilkie's attempt in his 1995 paper to generalise the model to an Autoregressive Conditional Heteroscedastic (ARCH) model to avoid non-normality of the residuals had succeeded for data up to 1994 but the 'fit' had deteriorated with the inclusion of subsequent data, with the result that the residuals were no longer normal and the parameters were non-stationary;
- The share dividend yield model is stable and its parameters are stable over time;
- The parameters of the share dividend model however are highly unstable and the model is clearly not stationary;
- It was necessary to modify the long term interest rate model to avoid the anomaly of negative real interest rates but even after the modifications, the residuals were not normal and the parameters were not stationary;
- However the short term interest rate model satisfied diagnostic tests and its parameters were stationary over time.

Clearly the observed weaknesses of the Wilkie model are such that its use in practice would need to be heavily qualified. In particular, if it were to be used as an inflation model, the user would need to be aware that the 'tail' of the residuals is in reality much 'fatter' than suggested by the normal random variables used in the model's error terms.

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[16] Carter (1991).
[17] Claasen (1993).
[18] Claasen and Huber (1992).
[19] Huber (1995).
[20] Sahin et al (2008).

2.2.2 Thomson Model

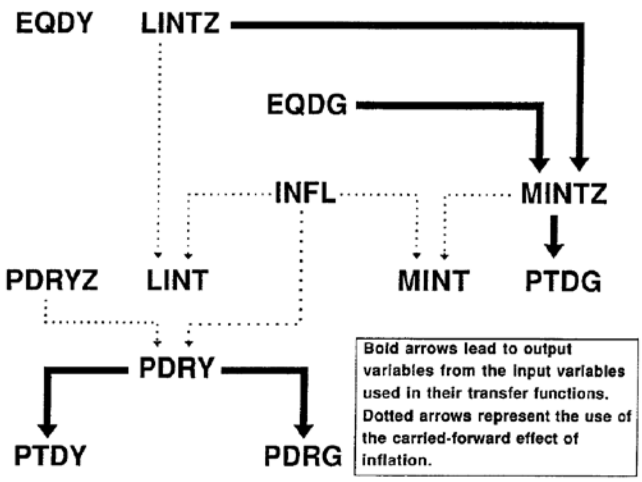
Thomson[21] attempts to set out a general method of establishing a General Linear Model modelling inflation as well as returns on the money market, bonds, equities and property. He acknowledges that in the South African context, given that (at the time of his paper) there were only some 34 years of inflation data to work with, his model was not intended for use for projection periods exceeding 10 years.

The Thomson Model uses the following notations:

$INFL_t$	The average force of inflation during year t
$EQDG_t$	The average force of dividend growth during year t
$EQDY_t$	The logarithm of the dividend at time t
$PDRG_t$	The average force of rental growth on direct property during year t
$PDRY_t$	The logarithm of the rental yield on direct property at time t
$PTDG_t$	The average force of dividend growth on property unit trusts during year t
$PTDY_t$	The logarithm of the dividend yield on property unit trusts during year t
$LINT_t$	The force of interest corresponding to the yield to redemption on long term interest bearing securities at time t
$MINT_t$	The average force of interest on money-market instruments during year t
$z_{X,t}$	The carried-forward effect of inflation at time t in respect of variable X
XZ_t	The 'real' value of variable X relative to the carried-forward effect of inflation.

The structure is as outlined in Diagram 2 below.

Diagram 2 - Structure of the Thomson Model



The final formulation of the Thomson Model for South Africa is as follows. In each case the $\{\eta_t\}$ are independent and identically distributed normal random variables with mean 0 and variance 1. Annual measurement intervals are used so that the time difference between time t and time t-1 is one year. Other symbols refer to constants to be fitted statistically to the available date.

$$
\begin{aligned}
EQDG_t &= \mu + \sigma(\eta_t - \theta_1 . \eta_{t-1}) \\
&= .093 + .116\eta_t + .076\eta_{t-1}.
\end{aligned}
$$

[21] Thomson (1996).

$$\begin{aligned}INFL_t &= \mu + \phi_1(INFL_{t-1} - \mu) + \omega_{EQDG,0}(EQDG_t - \mu_{EQDG}) \\ &\quad -\phi_1.\omega_{EQDG,0}(EQDG_{t-1} - \mu_{EQDG}) + \omega_{EQDG,2}(EQDG_{t-2} - \mu_{EQDG}) \\ &\quad +\phi_1.\omega_{EQDG,2}(EQDG_{t-3} - \mu_{EQDG}) + \sigma.\eta_t \\ &\approx .008 + .899INFL_{t-1} + .088EQDG_t - .079EQDG_{t-1} + .077EQDG_{t-2} \\ &\quad -.069EQDG_{t-3} + .020\eta_t.\end{aligned}$$

$$\begin{aligned}z_{LINT,t} &= (1 - k_{LINT})(\beta_{LINT} + \alpha_{LINT}.INFL_t) + k_{LINT}.z_{LINT,t-1} \\ &= .006 + .126INFL_t + .85z_{LINT,t-1}.\end{aligned}$$

$$\begin{aligned}LINTZ_t &= \sigma(\eta_t - \theta_{1.\eta_{t-1}}) \\ &= .010\eta_t + .006\eta_{t-1}. \\ LINT_t &= z_{LINT,t} + LINTZ_t.\end{aligned}$$

$$\begin{aligned}z_{MINT,t} &= (1 - k_{MINT})(\beta_{MINT} + \alpha_{MINT}.INFL_t) + k_{MINT}.z_{MINT,t-1} \\ &= .004 + .141INFL_t + .85z_{MINT,t-1}.\end{aligned}$$

$$\begin{aligned}MINTZ_t &= \omega_{EQDG,0}(EQDG_t - \mu_{EQDG}) + \omega_{LINTZ,0}.LINTZ_t + \sigma(\eta_t - \theta_1.\eta_{t-1}) \\ &= .008 - .091EQDG_t + .885LINTZ_t + .019\eta_t + .010\eta_{t-1}.\end{aligned}$$

$$MINT_t = z_{MINT,t} + MINTZ_t.$$

$$\begin{aligned}EQDY_t &= \mu + \phi_1(EQDY_{t-1} - \mu) + \sigma.\eta_t \\ &= .310 + .810EQDY_{t-1} + .198\eta_t.\end{aligned}$$

$$\begin{aligned}z_{PDRY,t} &= (1 - k_{PDRY})(\beta_{PDRY} + \alpha_{PDRY}.INFL_t) + k_{PDRY}.z_{PDRY,t-1} \\ &= .486 + .559INFL_t + .740z_{PDRY,t-1}.\end{aligned}$$

$$\begin{aligned}PDRYZ_t &= \phi_{1.PDRYZ_{t-1}} + \sigma.\eta_t \\ &= .680PDRYZ_{t-1} + .061\eta_t.\end{aligned}$$

$$PDRY_t = z_{PDRY,t} + PDRYZ_t.$$

$$\begin{aligned}PDRG_t &= \mu + \omega_{PDRY,0}(PDRY_t - PDRY_{t-1}) + \sigma(\eta_t - \theta_1\eta_{t-1}) \\ &= .096 + .545(PDRY_t - PDRY_{t-1}) + .068\eta_t + .041\eta_{t-1}.\end{aligned}$$

$$\begin{aligned}PDTY_t &= \mu + \omega_{PDRY,0}(PDRY_t - \mu_{PDRY}) - \omega_{PDRY,4}(PDRY_{t-4} - \mu_{PDRY}) + \sigma\ .\ \eta_t \\ &= 2.547 + .598PDRY_t - .738PDRY_{t-4} + .104\eta_t.\end{aligned}$$

$$\begin{aligned}PTDG_t &= \mu + \omega_{MINTZ,0}\ .\ MINTZ_t - \omega_{MINTZ,1}\ .\ MINTZ_{t-1} + \sigma\ .\ \eta_t \\ &= .077 + 1.721MINTZ_t - .967MINTZ_{t-1} + .053\eta_t.\end{aligned}$$

It is interesting to note that there are structural differences between the Wilkie and the Thomson models. For example, in the Wilkie Model, equity dividends are driven by inflation, both directly and via the impact of inflation on share dividend yields, whereas in the Thomson Model, equity dividends are not influenced by any other macroeconomic variables.

On the question of stationarity of model parameters, Thomson considers whether varying parameters, particularly heteroscedasticity, should be considered, but quotes with approval the findings of an earlier review of the Wilkie Model[22] which suggested that in the long run, ignoring heteroscedasticity has little impact on the results, but in the medium term, the main effect is on extreme values. This suggests that if the main purpose of a model is to facilitate a set of projections that will be a reasonable representation of the range of most likely outcomes, then it is not a disadvantage to use the Wilkie or Thomson models, but if the purpose is to determine capital at risk of loss in (say) a 1 in 100 year loss scenario, then the models may understate the true risk capital required.

2.2.3 Other models

There are numerous other econometric models that attempt to model most or all of the following macroeconomic variables:

- inflation (perhaps both price and salary inflation)
- equity returns (perhaps decomposed into dividends and increase in value)
- bond yields (short and long term separately)
- currency exchange rates
- property returns

Among them are the:

- TY Model[23]
- Carter Model for Australia[24]
- Tanaka Model for Japan[25]
- Ranne Model for Finnland[26]
- Harris regime switching VAR Model[27]
- Efficient Market based models[28,29]
- Falcon Model[30]

The scope for model building is limited only by the available data and the imagination of the researcher. However, when standard statistical tests are applied, not infrequently the relatively simple models fail tests such as tests for the normality of residuals. Modelling past inflation is particularly problematic because of its tendency to spike erratically and apparently unpredictably. In addition, there is the philosophical issue that the world is constantly changing, and in ways that might reasonably be expected to have an impact on future global macroeconomics, so that it is questionable whether, even if a 'perfect' model could be found that fitted past time series, the future will necessarily 'look' like the past. This point is also made by Thomson, with particular force given the changing social and economic conditions in South Africa at the time he wrote.[31]

[22] Geoghegan et al (1992).
[23] Yakoubov et al (1999).
[24] Carter (1991).
[25] Tanka and Inui (1995).
[26] Ranne (1998).
[27] Harris (1997).
[28] Smith (1996).
[29] Dyson and Exley (1995).
[30] Dempster and Thorlacius (1998).
[31] Thomson (1996).

Unfortunately neither the statistical challenges nor the philosophical issues absolve insurance risk management professionals from having to do their job.

2.3 Statutory classes

In Australia some classes of insurance, particularly Compulsory Third Party Motor, Workers Compensation and Home Owner's Warranty, are subject to policy terms and conditions which are prescribed or severely constrained by regulation. Therefore, insurers writing these classes do not always have the flexibility to introduce terms and conditions (such as sum insured limits) which they would normally use to mitigate the risk of writing those classes of insurance.

In these classes of business, insurers may be able to pass some or all of a relevant risk to a reinsurer. Otherwise, insurers have little choice – they must elect either to be 'in' the market, in which case they must accept the statutory constraints on policy terms, or they choose not to participate in that class of business at all.

On the other hand, the statutory benefit structure - heads of damage and benefit levels – are under the control of the statutory controlling body. While this may also develop in unpredictable ways from the perspective of the insurer, the observed superimposed inflation is likely to be less extreme than for common law claims in the non–statutory classes.

2.4 Other classes

In other classes, the insurer has the right to insert policy conditions of their choice. A key policy condition that an insurer would use in a non-statutory class is to limit the sum insured to a fixed dollar amount. In that way, even the most serious type of claims augmented by a sustained bout of hyper-inflation cannot produce a claim against the insurer for more than the specified policy limit.

It provides much greater protection for the insurer if the policy limit is *inclusive* of legal expenses. Superimposed inflation is often as much due to defence costs as to the claim award itself.

Another policy condition that provides protection to the insurer against unexpected inflation is a profit sharing formula for corporate business, since the profitability of the policy or treaty will likely be lower in an inflationary scenario. Policies can also be issued on a claims made rather than claims occurrence basis; the policyholder retains the inflation risk between the date of claim occurrence and date of reporting, while the insurer remains exposed to inflation between the date of reporting and the date of settlement. Finally, long term general insurance policies are not common in Australia (where there are regulatory restrictions) but in some jurisdictions such as Japan and Korea there exist long term fire policies, with durations of 30 years or more, that are sold in conjunction with residential mortgages. Insurers have traditionally assumed the (quite considerable) claims inflation risk on these types of policies. Reinsurance of these contracts typically includes an explicit inflation cap, where inflation takes into account the construction index as well as the general inflation index.

Even if the maximum loss has been capped at the policy limit, the insurer is still exposed to unexpected superimposed inflation of claims within the limit. History has shown that high common law claims inflation can persist for long periods of time, but it is interesting to consider whether superimposed inflation has its own in-built stabilisers. After 5 or 6 years of record breaking court awards for bodily injury claims there is often a public and judicial 'backlash', with the resulting tort reform reducing claim levels. This doesn't save the insurer from higher loss ratios on past accident years however.

2.5 Reinsurance

Reinsurance may be used to pass part of the inflation-associated risk to a reinsurer. Excess of loss reinsurance in the liability classes usually passes a more than proportionate share of the superimposed inflation risk to the reinsurer, because of the 'gearing effect' of the attachment point. For example, suppose that claim sizes across the board increase by an unanticipated 10%. Then a $2m claim becomes $2.2m but a reinsurer writing excess of $1m finds that the excess claim increases from $1m to $1.2m, a 20% increase, and some claims which previously would not have penetrated the reinsurer’s layer (say a claim for $950K before the unanticipated increase) will now cause a reinsurance claim.

In liability reinsurance, an important factor which mitigates the inflation risk from the reinsurer’s perspective is the 'stability clause' under which both the limit and the attachment point of the layer are adjusted in line with the movement in an agreed inflation index such as the Consumer Price Index (CPI) or Average Weekly Earnings (AWE). Effectively the result of such a clause is to remove the index inflation component of the inflation risk, but the superimposed component remains.

An exception to the general rule that long term classes of business in Australia are subject to stability clauses arises in medical malpractice. Historically when this class of business has been reinsured, the limits and attachment points have been specified in nominal dollars. Some reinsurers have decided not to participate in this market for this reason. For the time being, however, it appears that the IT systems of Medical Defence Organisations (MDOs) are geared up to nominal attachment points and limits, and there is sufficient available reinsurance capacity for those insurers to be able to 'fill' their reinsurance programmes on these favourable terms. Reinsurers that continue to participate are likely to regret their decision if there is a sudden outbreak of inflation again on the scale of the 1970s. Such an outbreak would probably force a re-evaluation by reinsurers of the inflation risk and capacity would probably disappear from the market, forcing the MDOs to accept stability clauses.

3 Inflation Risk and Pricing

3.1 Introduction

The typical approach to pricing a (re)insurance treaty, contract or policy is to calculate the required premium to cover the expected cost of claims, commissions, internal expenses, the cost of capital, tax, and an allowance for profit. Each of these components should be discounted to allow for the time value of money.

Generally speaking, expected future inflation can be factored into the best estimate claims and expense costs. It is the *unexpected* future inflation, or the volatility around the expected level, that potentially requires some additional premium. This allowance can be implicit, by taking a conservative view of the expected claims cost, or explicit, by allowing for inflation risk directly in the computation of the insurer's economic capital and hence in the shareholder's required profit margin.

If it were possible to hedge completely against unexpected future inflation, or to diversify this risk away, then there would be no need to charge a higher premium for the inflation risk (and a competitive market would not allow it). However, as other sections of this paper have discussed, it is difficult to hedge general (i.e. consumer price) inflation satisfactorily, and even more difficult to manage the 'basis risk' between general inflation and insurance claims inflation. Furthermore, inflation tends to be systemic across lines of business and geographical boundaries, and hence difficult to diversify away. Therefore, some allowance needs to be made for inflation risk in pricing.

Insurance companies receive a fixed premium at early durations but pay an uncertain, inflation impacted, claim payments at later durations. This inflation risk is a challenge for insurance companies to manage. One redeeming feature, however, is that its systemic nature means that an unexpected surge in claims inflation will also hurt competitors. This will tend to lead to a hardening of premium rates, allowing the insurance industry as a whole to recoup its losses.

This tendency is of course not something to rely on, and in the case of statutory lines of business with regulated price ceilings it may not be possible. Even in non statutory lines of business, it may be difficult from a marketing perspective to impose premium increases at levels higher than general inflation. So, in addition to the direct pricing risk due to inflation, there is also an indirect impact of inflation due to regulatory and/or marketing constraints on *future* price increases, that we might perhaps term *repricing* risk, for an insurer committed to remaining in the relevant class of business.[32]

3.2 Expected claims cost

If we consider a burning cost approach to estimating the claims cost component of the premium, the underwriter will make use the observed historical claims experience for a representative portfolio for the business to be priced. For example, the underwriter may have claims triangles (of paid and incurred claims) for the 2005 to 2009 accident years, plus a business volume measure, from which he or she wishes to estimate the expected claims cost for the 2010 accident year (AY), per unit exposure.

The historical experience will need to be 'on-levelled' to 2010, to allow for trends in claims frequency and severity. The question arises whether to on-level from observed accident year to priced accident year, or from observed calendar year of claim payment to priced calendar year of claim payment. Both the calendar year trending methodology and the accident year trending methodology are seen in practice, but in the opinion of the authors, except in cases where there are major accident-year related changes to benefits, the default loss trending methodology should be calendar year trending for loss severity and accident year trending for frequency.

[32] Goldman Sachs (2010)

The reason for this is that claim severity is most impacted by the inflation index prevailing at the date of claim payment, while the number of claims is generally more impacted by the prevailing social and economic environment that exists at the time of claims occurrence e.g. the occurrence of an injury is often a function of safety standards at the time of accident.

While the two methods of on-levelling involve inflating claims for the same number of years, the calendar year methodology involves fewer years of past (already observed) claims inflation and a greater number of years of future (to be assumed) claims inflation. The past inflation rate should be the actual observed general inflation rate, plus an allowance for superimposed inflation (SII). It is common practice to make a constant SII assumption, whereas it is generally accepted that SII comes in cycles.[33] This may appear curious, when the past SII is theoretically observable from the data. However, as mentioned in Section 1.2, estimating year-by-year SII from past data is notoriously difficult (or even estimating the average SII over a few years), due to the 'noise' of random fluctuation in claims experience.

Similarly, a constant assumption is generally also adopted for future general inflation and future SII, whereas the actual SII from the year of pricing (2010, say) to the claims payment year will vary greatly, depending on one's position in the SII cycle. Unfortunately, it is quite difficult to know where one 'is' in the SII cycle. It would pay to be wary if there have been recent tort changes, particularly changes which facilitate the claims process even if there is no explicit change to benefit levels. Even if the legal changes are designed to reduce claims costs, there may be a honeymoon period of lower SII, only to be followed by a renewed bout of claims inflation later when claimants and plaintiff lawyers work out how to circumvent the new regulations.

In addition to the cost of settling the claim, the insurance company will incur direct claims handling expenses. These will inflate in future due to factors such as the wage growth of loss adjusters, and wages tend to increase with gross domestic product (GDP) growth (assuming a constant apportionment of GDP is between labour and capital). GDP, in turn, grows at faster than inflation due to productivity improvements. Legal defence costs are another important component of claims handling expenses, which grow with lawyers' wages. The insurance company will also incur indirect claims handling expenses, in particular the cost of operating a claims department to process claims, the costs of which will increase with the wage inflation of claims personnel. Hence, the underwriter needs to allow for inflation in allowing for claims handling expenses.

Finally, it should be noted that inflation is a macro-economic phenomenon, and the results for some lines of business are correlated with the general state of the economy. In particular, unanticipated inflation may directly and adversely impact the various classes of credit insurance by increasing claim frequency in addition to increased claim severity.

3.3 Commissions

Broker and other fixed commissions are generally allowed for as a fixed percentage of premium, so do not pose any challenges from a claims inflation perspective. Profit share commission terms, on the other hand, will tend to offset the negative impact of unanticipated claims inflation.

3.4 Internal expenses

Internal, or management, expenses can be a large component of the premium. One of the permanent challenges in insurance pricing is the distinction between the *marginal* internal expenses of writing a new treaty or policy (relatively low) and the *average* internal expense of writing that treaty or policy (much higher), and how to allocate expenses in a non arbitrary way.

The biggest expense for an insurance company is staff wages which, as discussed above, will increase faster than general price inflation in the longer term. On the other hand the company may be able to offset

[33] Pearson and Beynon (2007)

increasing staff costs by greater use of technology (i.e., productivity improvement) or by shifting work to cheaper locations. Fortunately for the insurance industry, insurance penetration tends to increase with real GDP growth (i.e. as a society gets wealthier, it spends a greater proportion of its resources on protecting its assets, providing compensation for its injured, and so on). This suggests that total internal expenses should reduce as a percentage of total premiums in the longer term, although the benefit of this should accrue to policyholders rather than shareholders in a competitive market.

In terms of pricing, the underwriter needs to allow for both general inflation, and SII, in allowing for run-off internal expenses.

3.5 Cost of capital

Suppose that the claims cost component of the premium allows for anticipated inflation only, and that unanticipated inflation is to be allowed for in the cost of capital. There are many ways of calculating the cost of capital, but the approach most familiar to the authors is to impose an annual charge of x% of capital required, where the capital required is a function of regulatory capital, rating agency (or respectability) capital, and economic (internal model) capital.

Regulatory and rating agency capital may or may not incorporate inflation risk, depending on the jurisdiction. APRA's proposed capital regime (intended to commence in 2012) is significantly more sensitive to inflation risk than the current requirements. The economic basis capital requirement may be calculated on a 'peak risk' scenario, for example the 99^{th} percentile of the statistical distribution of claims incurred, or the 1-in-100 year shortfall (i.e. the average deficit given the 99^{th} percentile, or worse, claims experience).

The peak risks for a reinsurer will likely include large potential natural catastrophe events, and claims inflation will generally also be recognised as a peak risk. The question then arises how best to model the inflation peak risk. The answer is, as with most questions on this subject, 'with some difficulty'!

When modelling the claims inflation peak risk to determine economic capital for cost of capital calibration, a key assumption is whether central banks worldwide will 'hold the line' to maintain their long term inflation targets. Alternatively, as in the case of the US Federal Reserve and Australia's Reserve Bank, the central bank may not have an explicit inflation target but instead will express a 'desired target range', and the insurer needs to form a view as to the central bank's commitment to rein in any unanticipated spike in inflation.

Generally central banks around the world have been very successful in recent years in keeping inflation at low levels, although they have been aided in this by the rapid growth of cheap imports from developing economies such as China and India. Ultimately, this source of moderation of inflationary increases may weaken as real wage levels in those developing economies improve. For the time being, investors' belief that inflation will remain low in the future is reflected in low bond yields for US, UK, German, etc, 10 year treasuries. Earlier this year, however, the International Monetary Fund's top economist, Olivier Blanchard, caused a stir among investors by suggesting that central bankers would give themselves more flexibility if they targeted a higher level of inflation, say 4% instead of the current 1% to 3% levels.[34] It doesn't appear that any of the main central bankers intend at present to take up this suggestion, but it does underscore that inflation targeting is ultimately merely a statement of good intent.

If stable low long term inflation can be assumed, the appropriate inflation model for the cost of capital calculation is an auto-regressive time-series. In other words, one would assume a short term spike in inflation lasting one or two years, rather than higher inflation that persists indefinitely. The level of inflation then reverts to the long term mean over the following few years.

The error-term random variable, that determines the deviation around the mean for the inflation time-series, has often in the past been assumed to be normally distributed, but with the computational facilities

[34] Blanchard et al (2010)..

currently available there is no reason why it would not be possible to develop models with fatter tailed residuals that might result in a better 'fit'.

Interest rates and credit spreads may also be components of the economic capital requirement calculation, and the question arises whether there should be a model link between interest rates and inflation. It is reasonable to assume that there is a correlation between interest rates and inflation, but there are divergent views on the appropriate linking model, so the insurer might choose to ignore this aspect for simplicity.

3.6 Tax

This component of the premium would not normally require any special consideration when allowing for claims inflation in the pricing model. The tax code may include some deductions and reliefs that are set in nominal terms (such as a carried-forward tax loss), but this wouldn't generally be modelled for pricing purposes. It should be noted, however, that tax does provide some relief against inflation: if an insurer loses money due to high inflation, there is a tax offset for 30% of its losses. Relief in the form of carried-forward tax losses is only available to the extent that losses can be offset against future profits, and the regulatory treatment of such tax assets is understandably restrictive.

3.7 Allowance for profit

The risk of unanticipated claims (and expense) inflation is something that shareholders require compensation for, which would be reflected in a higher profit margin requirement. However, if the cost of capital already allows for this risk, then the profit margin after cost of capital does not need adjustment.

3.8 Discounting

A standard approach to allow for the time value of money is to construct an assumed nominal payment pattern for all items of income and outgo, particularly for claims payments. These future payments are then discounted to present values based on a zero coupon yield curve. The yield curve will be 'risk-free', based on Government nominal bond yields or a swap market, with perhaps an additional spread for illiquidity. Implicit in the bond yield is the investors' expectation of future inflation plus a real return.

An alternative approach would be to construct an assumed *real* payment pattern (i.e. in 2010 dollars) for all items of income and outgo, and to discount using the real yield implied by Australian Government inflation linked bonds (ILBs). While this is theoretically appealing, it is only likely to be a sensible approach if the insurer actually intends to invest a material portion of its assets in ILBs.

3.9 Conclusion

This section has considered each component of the premium calculation - claims, commissions, expenses, cost of capital, tax, and profit – and discussed how the possibility of unanticipated claims inflation should be considered for each. The two main areas are in the calculation of claims cost and the cost of capital.

The claims cost should allow for claims inflation at the expected, anticipated level, though care needs to be taken to make sufficient superimposed inflation allowance when on-levelling the observed claims experience to the current accident year and when projecting it into the future to the expected year of payment. The cost of capital calculation can make allowance for the unexpected, unanticipated level of claims inflation, modelling a peak risk scenario of an inflation spike that occurs over a year or two before reverting to the long term inflation mean.

4 Inflation Risk and Reserving

4.1 Introduction

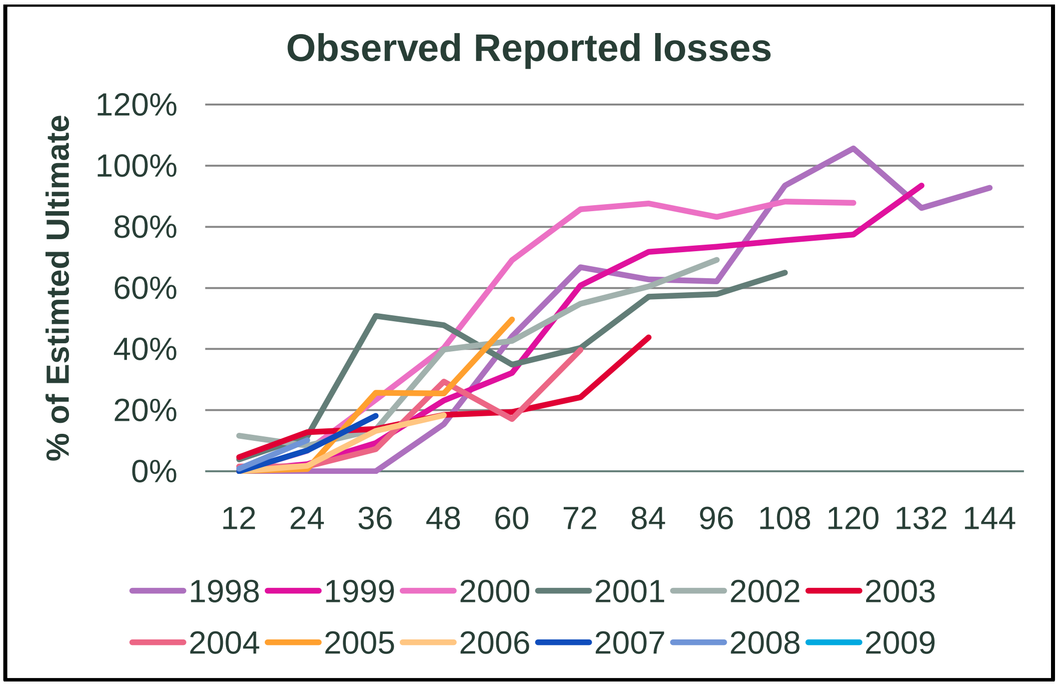
This section considers how some of the standard methods used by insurers to reserve for their non-life business 'perform' when there is unexpected claims inflation. The methods considered are the chain ladder, Bornhuetter-Ferguson (B-F), and Benktander methods, on paid and incurred claims. These methods are also, for reasons relating to the availability of data, of particular interest to reinsurers. For illustrative purposes, we consider a reinsurance portfolio of non proportional general liability business.

The limitations of the reserving methods listed in the previous paragraph have long been recognised. In particular, they assume that inflation levels implicit in the historical data will continue into the future. These methods also ignore claim count, and hence trends in claim frequency are not distinguishable from increases in claim severity. The B-F and Benktander methods give some credibility to the priced loss ratio, and if unexpected claims inflation causes the priced loss ratio to be understated, the estimated ultimate loss ratio will be understated too. In general, these methods suppress a lot of information about the claims process. One would therefore expect the methods to perform less well than methods that include explicit assumptions for future inflation, or those incorporating stochastic reserving techniques.

Nevertheless they are useful for reinsurance work, since the portfolios considered tend to exhibit sparse and volatile historical experience, where more sophisticated methods would arguably be spurious. In addition, claims count may not be available, or may not be very meaningful given the variety of attachment points and layer limits comprising the portfolio under consideration. When selecting the reserving basis, the reserving actuary needs to overlay the selection suggested by the experience with his or her knowledge of the portfolio and should allow for known changes in the mix of business, with information gained from other sources regarding market and economic conditions. The relevant market and economic information would include information about general price inflation and a view on superimposed inflation. A strength of the methods is that they have the flexibility to enable the actuary to include this overlay.

Graph 2 below, illustrates the volatility of historical reported losses for the selected liability portfolio, expressed as a percentage of estimated ultimate loss. There is considerable variation in the observed experience, while the graph of paid losses (not shown) appears even more 'messy'.

Graph 2 – Observed reported losses



Sections 4.2 presents a base reserving scenario and sections 4.3 to 4.6 consider different scenarios of unexpected inflation, in particular considering the two extreme scenarios:

- just one year of unexpected inflation; and
- an increase in claims inflation that persists indefinitely.

It is also relevant whether the Claims department immediately recognises and reviews all open case reserves to reflect the inflated ultimate settlement, since this impacts the reported claims inflation that the actuary bases his or her work on.

In the scenarios below we consider the impact of claims inflation on the determination of the best estimate of unpaid losses, though it should be noted that the risk margin should arguably also increase after a year of unexpected inflation, to reflect uncertainty on how long the additional inflation will persist for. Making appropriate adjustments to the risk margin for this uncertainty is beyond the scope of this paper.

4.2 The base scenario

The base scenario projects the unpaid losses for a reinsurance portfolio of non proportional general liability business, based on the paid and incurred claims triangle to 31 December 2009, in respect of underwriting years 1983 to 2009. It is generally accepted that claims inflation in the recent years to 2009 has been benign, and no special allowance is made in the lag factor selections for this in the base scenario.

The results based on the B-F method on reported losses, are as follows:

Table 1: Base scenario reserves

	As at 31 December 2009	**As at 31 December 2010**
Paid losses	$52.1m	$62.9m
Case reserves	$34.0m	$36.9m
IBNR	$73.1m	$59.4m
Ultimate loss	$159.2m	$159.2m

The basis for the B-F method on paid losses has been calibrated to also give an ultimate loss estimate of $159.2m, and the results shown as at 31 December 2010 assume that the assumptions made a year earlier are borne out.

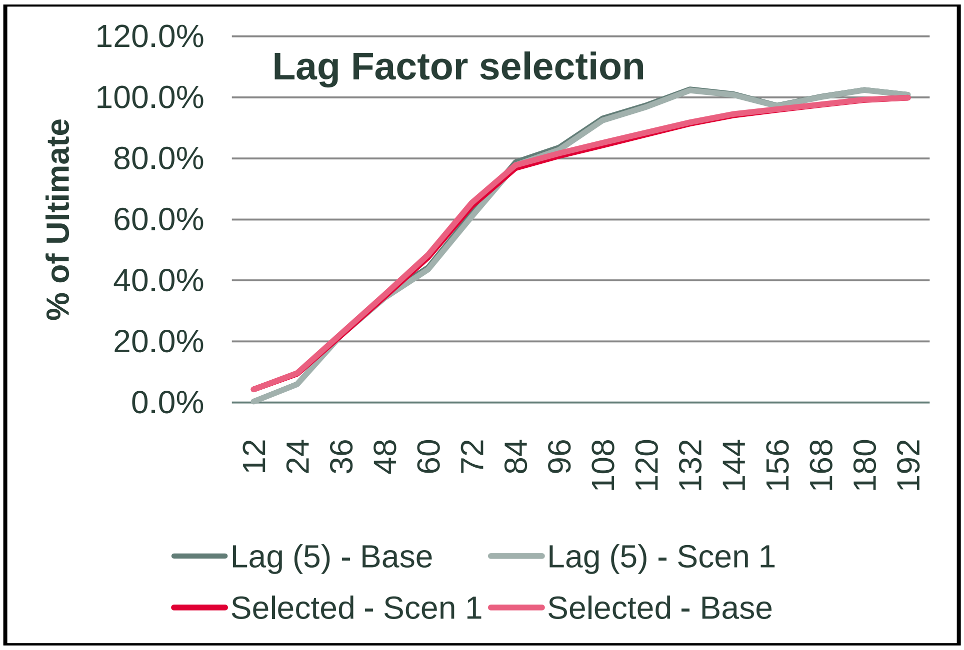
This base scenario is taken to be the future 'reality' (before unanticipated claims inflation), as the benchmark to compare the revised ultimate loss estimate a year later, 31 December 2010, if the portfolio experiences unanticipated inflation in calendar year 2010 as per the scenarios below.

4.3 Scenario 1

Scenario 1 posits 5% unexpected inflation, relative to the base scenario, in the 1st projection year only (i.e. 2010). This inflation is not anticipated by the Claims department, which continues to hold the same case reserves as in the base scenario. Paid losses in calendar year 2010, $10.8m in the base scenario, are 5% higher, or $11.4m in scenario 1, and all later payments are also 5% higher. If we take the Base scenario to be 'reality' before unexpected inflation, then we can conclude that unpaid losses will be 5% higher than the base scenario, and ultimate losses will therefore be (from table 1) 52.1 + 1.05 (34.0 + 73.1) = $164.5m.

As at 31 December 2010 the actuary re-selects lag factors, and these will tend to be heavier than in the base scenario due to the higher paid losses (and hence reported losses) in the latest diagonal. The selection will not be as heavy as it needs to be, however, since the actuary will take an average development ratio over the past few years, for example the weighted average over the previous five years.

Graph 3 – Lag factor selection: Scenario 1



The impact on the observed 5-year average lag factor due to one year of claims inflation at the 5% level is almost imperceptible, and the new estimated ultimate loss will therefore be understated:

Table 2: Scenario 1 reserves

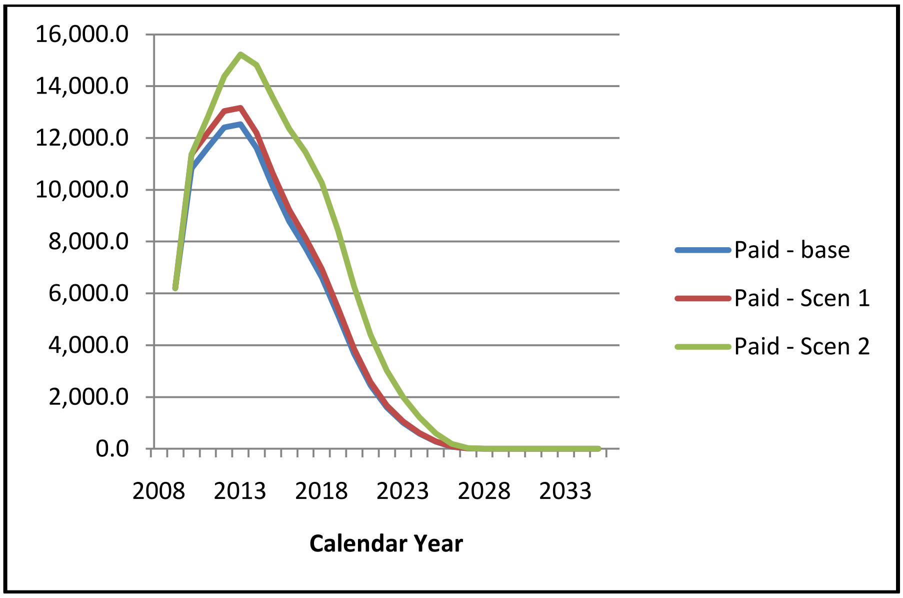
	As at 31 December 2010 'Reality'	**As at 31 December 2010 B-F on reported**
Paid losses	$63.4m	$63.4m
Case reserves	$36.9m	$36.9m
IBNR	$64.2m	$60.5m
Ultimate loss	$164.5m	$160.8m

Of course, if the actuary uses a shorter averaging period, three years say, or recognises that the 5% unanticipated inflation is not random fluctuation and allows for this in the selection, then the B-F method will perform better. The chain ladder and Benktander methods will also understate the ultimate loss, but to a lesser extent since the inflationary increase is subject to a multiplier in these methods.

4.4 Scenario 2

Scenario 2 assumes 5% unexpected inflation (relative to the base scenario) in all future projection years. Like scenario 1 this is not anticipated by the Claims department. Payments in 2010 are 5% higher than in the base scenario, 10.25% higher in 2011 (5% compounded for 2 years), and so on. This is a much more extreme scenario than Scenario 1.

Graph 4 – Claims paid by Calendar Year



Since there is no change to the paid and reported claims in financial year 2010, there is no change to the reserve estimates for any of the chain ladder, B-F or Benktander methods, and the ultimate loss will be *severely* understated (unless the actuary makes appropriate subjective adjustments).

Table 3: Scenario 2 reserves

	As at 31 December 2010 'Reality'	**As at 31 December 2010 B-F on reported**
Paid losses	$63.4m	$63.4m
Case reserves	$36.9m	$36.9m
IBNR	$94.1m	$60.5m
Ultimate loss	$194.5m	$160.8m

4.5 Scenario 3

Scenario 3 assumes 5% unexpected inflation in the 1st projection year, as per scenario 1. However, the inflation is anticipated by the Claims department, which increases case reserves by 5%.

In comparison with scenario 1, the B-F method on reported losses will now tend to 'over-shoot' the correct ultimate loss, since the one-off review of case reserves in 2010 is partially assumed by the method to continue into the future. The chain ladder and Benktander methods will overstate the correct ultimate loss to an even greater extent.

Table 4: Scenario 3 reserves

	As at 31 December 2010 'Reality'	**As at 31 December 2010 B-F on reported**
Paid losses	$63.4m	$63.4m
Case reserves	$38.7m	$38.7m
IBNR	$62.4m	$66.1m
Ultimate loss	$164.5m	$168.2m

4.6 Scenario 4

Scenario 4 assumes 5% additional inflation in all future projection years, as in scenario 2. However, in this scenario the Claims department increases all case reserves to make provision for the additional inflation. Thus, for case reserves at the end of development year 3 (DY 3), there is an estimated further 6.1 years to settlement. The case reserves in respect of DY 3 and contract year 2009 (CY 2009) are therefore inflated by a factor of $1.05^{(6.1+2)}$, while case reserves for CY 2008, DY 3 are inflated for one year less, by a factor of $1.05^{(6.1 + 1)}$, since the inflation applies from the end of calendar year 2009.

Once again, we compared the results of applying the B–F method on reported losses with the known result. The method understated the required result, as in scenario 2, but much less severely.

Table 5: Scenario 4 reserves

	As at 31 December 2010 'Reality'	**As at 31 December 2010 B-F on reported**
Paid losses	$63.4m	$63.4m
Case reserves	$46.2m	$46.2m
IBNR	$84.8m	$74.0m
Ultimate loss	$194.5m	$183.6m

4.7 Summary

This section considered a reinsurance non proportional general liability portfolio, with claims triangles to 31 December 2009. We applied traditional reinsurance methods to derive a base scenario of projected claims paid and reported, to ultimate. We then considered various scenarios of additional inflation from calendar year 2010, and Claims department response, assuming that claims experience would follow the base scenario assumptions exactly (except for the additional claims inflation). We then compared this 'reality' with the results of re-applying the standard reinsurance reserving techniques as at 31 December 2010.

In some of the scenarios our main reference method, the Bornhuetter Ferguson method on reported losses, understated the required ultimate loss, though in scenario 3 it overstated the required ultimate loss. Generally speaking then, the methods do not perform well, at least when applied mechanically, in allowing for claims inflation.

It is important therefore that the actuary uses independent sources from the observed claims triangle to determine if the portfolio is experiencing inflation, that he or she forms a view whether the additional inflation is short-lived or will persist, and finally to check with the Claims department as to whether case reserves have been reviewed in light of the additional inflation. This will allow the actuary to apply a subjective overlay when selecting appropriate lag factors.

5 Inflation Risk and Asset-Liability Management

5.1 The 'standard' approach to Asset-Liability Management (ALM)

Probably the majority of Australian general insurers traditionally have adopted the following general approach to ALM, at least in respect of matching technical liabilities:

- Determine the best estimate of nominal future cash flows.
- Select a portfolio of nominal fixed interest assets (Australian government, semi-government and corporate bonds) so that the cash flows associated with the asset-proceeds (coupon payments and redemption proceeds) equate, as far as possible, to the cash flows associated with the liability-outgo.

In the Australian general insurance regulatory environment, where assets are measured at market value and liabilities valued using risk-free rates derived from sovereign securities, it is substantially possible to 'immunise' the portfolio against the risk of interest rate movements in either direction. The only exception to this rule relates to very long-dated liabilities, where there may not be assets of sufficiently long maturity dates to 'match' the liabilities.

The problem with this approach is that, although it is entirely effective at hedging interest rate market risk, it is entirely ineffective at hedging against inflation and in this sense it ignores the true structure of the insurer's liabilities, specifically the susceptibility of the liabilities to vary as a function of future inflation. The 'standard' approach leaves the insurer fully exposed to both index and superimposed inflation.

5.2 Structure of the liabilities

To identify the true 'structure of the liabilities' it is necessary to consider an analysis of the liabilities at a detailed level. Specifically, liabilities could be analysed by:

- line of business;
- type of loss;
- head of damage; and
- geographical location of risk.

This four-way analysis of exposure to inflation risk is likely to produce a liability structure of which part is not inflation-exposed (especially total losses, which are frequently limited to a fixed nominal sum insured), but the remainder is likely to be inflation exposed with a wide variety of indices being needed to characterise the cells at the most detailed line of business / type of loss / head of damage / geographical location level. This 'inflation footprint' would vary from one insurer to the next and no two insurers would have precisely the same 'inflation sensitivity', though of course there would be a very strong correlation between any given standard measure of inflation (such as CPI) and the inflationary component of the structure of an individual insurer’s liabilities.

As noted in Section 1.1 above, APRA, when designing the proposed new Asset Risk Capital Charge, has taken advantage of the opportunity not only to make the new Risk Charge sensitive to duration mismatches, but also to require insurers to consider the sensitivity of the net assets to inflation.[35] However, in the interests of reasonable simplicity, APRA has effectively made the implicit assumption that all general insurance liabilities can be considered as being linked to a single, generic, index. Whilst this introduces an element of basis risk by comparison to the true inflation-affected structure of the liabilities, this simplifying assumption does not seem unreasonable and was probably necessary to make the proposed new Asset Risk Charge, which has already been criticised by the industry on grounds of complexity, both more workable and more comparable from insurer to insurer.

[35] APRA (2010b).

5.3 Approaches to 'hedging for inflation'

In principle, there are a variety of assets in which an insurer can consider investing to 'match' the inflationary component of its liabilities:

- equities;
- property;
- commodities, especially gold;
- other exotic investments such as jewellery, works of art, collectibles, etc.;
- cash;
- inflation-linked securities; and
- inflation derivatives and bespoke inflation hedges.

5.3.1 Equities

It is natural to suppose that equities would provide an attractive hedge against inflation, because the dividend streams that they return to shareholders are derived from the corporate profits which are based on the operation of real assets. One might assume that corporate entities would normally be able to pass on inflationary price increases to their customers. However two researchers from the International Monetary Fund (IMF) recently found that although equities are a good hedge in the very long term, they are a poor hedge in the short or even the medium term. A powerful medium-term illustration of this is that during the 1970s inflationary outbreak, the major equity indices performed very poorly. In detail, the researchers found that:

"Equities experience even larger negative effects [than bonds], with [a] 1 percentage point increase in inflation leading to a fall in returns of 2.67 percentage points and 3.50 percentage points for the large capitalization U.S. equity and SDR-weighted equity benchmarks respectively."[36]

Equities provide long-term real asset returns, but it is sufficiently clear that the correlation between inflation and equity returns in the short run is negative that one academic economist suggested that,“this negative correlation leads to the surprising and somewhat disturbing conclusion that to use common stocks as a hedge against inflation, one must sell them short”![37]

It is not clear whether this conclusion would remain true if a deliberate policy of selecting equities which were regarded as 'inflation-proof' (for example, by taking overweight positions in food, oil and gas, utilities and pharmaceuticals) were adopted.

5.3.2 Property

Property, particularly residential property, is often touted as a hedge against inflation. Proponents of this view point to long periods of rising house prices that appear to exceed the rate of inflation. In Australia, the post-World War II period, at least until about 2003, produced significant real gains in residential property prices.

But whilst it may be true that historical prices have increased at rates above inflation, there are many who believe that as a result, current property prices in Australia are in a 'bubble'. They point to high ratios of the median cost of servicing debt to median household income, and low net rental returns.

[36] Roach and Attie (2009).
[37] Bodie (1976).

"The rise [in mortgage debt] against GDP is far more dramatic than against household disposable income because other government policies – the stimulus package itself and the RBA's 4 per cent cut in interest rates – boosted disposable income dramatically last year (but even so, mortgage debt is now a higher proportion of household disposable income than before the GFC). The Boost-inspired house price bubble was financed by households adding another 6 per cent of GDP to their already unprecedented debt burden, when prior to The Boost they were on track to reduce mortgage debt by about 3 per cent of GDP in 2009."[38]

Even if house prices, long term, do increase faster than inflation, the experience of the USA during the recent GFC should make it clear that in the short term, there can be serious risk of dramatic reductions in house prices. In the short to medium term, residential property is only a weak hedge against inflation.

Commercial property is more volatile than residential property, and in Australia we have recently seen a significant slump in commercial property values. So the conclusion that there is no strong short term link between property values and inflation applies to commercial as well as residential property. Even in the longer term, researchers have found that there is a delay in the linkage between inflation and property price increases, suggesting an imperfect hedge.[39] There is little reason to suppose that the conclusion would be different if attention were focussed specifically on particular categories of property such as industrial property, retail property, agricultural land or hotels and motels.

5.3.3 Gold and other commodities

It has been nearly 40 years since the United States unilaterally terminated convertibility of the dollar to gold. Yet gold bugs still see gold has been the ultimate 'currency' and store of real value.

Gold should probably be seen more as a 'crisis hedge' than an 'inflation hedge'. The historical time-series of gold prices is extremely volatile. Gold performed very poorly between 1981 and 2001, in nominal terms and even more so in real terms. Returns have been strong this past decade and gold currently offers a sound hedge against all governments trying to achieve the impossible of weakening their currencies simultaneously to achieve an export boost.

Other commodities (e.g. agricultural commodities and oil) can also be considered. Studies have shown that these tend to have a positive inflation correlation or sensitivity. Commenting on six such studies, Roach and Attie summarised their findings as follows.

"Overall, the research provides quite strong evidence that commodities provide effective short-run protection against inflation." [40]

The downside of commodities is that their return is influenced by many other factors such as geopolitical events and the weather, and returns are volatile.

5.3.4 Exotic investments

Leaving aside questions as to the effectiveness of exotic investments (such as vintage cars, works of art, coins, stamps and other collectibles) as an inflation hedge, they suffer from the following deficiencies:

- They require significant expertise (and expense) to assess and valuations are often partially subjective and therefore debatable;
- They are generally unique and not easily scaleable;
- Transaction costs are relatively high;
- Typically they offer no running yield, only a hoped-for increase in value; and

[38] Keen (2010).
[39] Hoesli et al (1997).
[40] Roach and Attie (2009).

- These assets are typically somewhat illiquid.

For these reasons, institutional investors would not generally tend to make much use of exotic investments.

5.3.5 Cash

Perhaps surprisingly, investing 'dead short' in cash is not such a bad hedge against inflation because short term interest rates tend to move substantially in line with inflation due to the 'Fisher effect' whereby investors want to be compensated for the perceived devaluation in the purchasing power of their (cash) investment. Apart from the economic rationale due to the Fisher effect, there is clearly a direct causal relationship between higher inflation and higher rates of return on cash, because central banks (including the RBA) use variations in the cash rate as their primary weapon when they wish to fight inflation. But investing in cash, though a tolerable inflation hedge, is a poor interest rate hedge.

Australian general insurers are subject to local accounting conventions so if they invest heavily in cash they will suffer a significant fall in net assets when interest rates fall (due to the increase in the actuarial value of the liabilities). In addition to this - what might be called - reporting risk, the yield curve tends to be upward sloping. There is therefore a penalty in investing in cash in the form of lower returns. Due to central bank actions in many parts of the developed world at present, returns on short paper are currently practically zero.

5.3.6 Inflation Linked Securities

Inflation linked securities, or 'linkers', indisputably do a good job of hedging simultaneously against index inflation and (if matched by duration of liabilities) interest rate risk. Australian Government Index Linked Bonds are capital indexed bonds and were first issued by Treasury in July 1985.[41] Australia was one of the first issuers of indexed securities, but issuance has been subject to swings in the budget deficit and twice (from 1988 to 1993 and again from 2003 to 2009) issuance has been suspended. On both occasions, the reopening of the market involved syndicated auctions. Since the issue of the ACGB 2025, the AOFM has undertaken monthly indexed bond tenders.

Indexation is to the Consumer Price Index – Weighted Average, Eight Capital Cities, All Groups. However most ILB issues do not decrease coupon or maturity payments if inflation is negative; in that sense they are a hedge against deflation.

As of 2008, government issued inflation linked bonds (ILBs) accounted for $1.5 trillion of global debt.[42]

However, in Australia, an insurer wanting to use such securities as its sole response to the inflation risk would face problems, as described in the following sections.

5.3.6.1 Limited choice of maturity dates

There is a relatively low volume of such securities on issue and there are few and widely spread maturity dates, making it impossible to get a perfect 'match' to liabilities. There are three series of Capital Indexed Bonds on issue by the Reserve Bank of Australia at the date of writing, and a fourth (August 2010) recently matured. The three current issues have maturities in 2015, 2020 and 2025, and the Australian Office of Financial Management intends to issue a new security with a maturity date in 2030 in the 2010-11 financial year.[43]

[41] UBS (2010).
[42] Barclays Capital Research (2008).
[43] Australian Office of Financial Management (2010a).

Apart from series issued by the RBA, some State Treasuries have issued index linked bonds. The NSW Treasury Corporation announced on 6 August 2010 that it intended to issue its third capital indexed bond series, with a coupon rate of 3.75% and a maturity date of 20/11/2020, with an expected issuance amount of between $0.5 billion and $1.5 billion. This is in addition to the previous issues of $1.05bn with a 2.75% coupon, maturing on 20/11/2025, and $0.61bn with a 2.50% coupon, maturing on 20/11/2035. The Queensland Treasury Corporation also has issued capital indexed bonds.

Obviously it would be helpful to insurers attempting to construct minimum risk replicating portfolios if there were a wider range of issue dates available. A suitable first step would be for the Australian Office of Financial Management to issue additional inflation linked securities with maturity dates midway between the present quinquennial maturity dates.

5.3.6.2 Illiquidity

The amount of stock of Inflation Linked Securities in the Australian market is small compared to nominal Australian Government Bond issues. As at 17 September 2010, the total Australian Government debt on issue was as follows:[44]

Treasury Bonds	$130.2 billion
Treasury Notes	$ 17.5 billion
Treasury Indexed Bonds	$ 12.3 billion
Total:	$160.1 billion

Thus only 7.7% of Australian Government debt is inflation linked. Because the market is so 'thin' indexed bonds are not well traded and are relatively illiquid. This would be a disadvantage if an insurer envisages the need to dispose of a large quantity other than at a redemption date. Note, too, that there may be practical elements of the indexing of the ILB coupons and maturity payment that might lead to imperfect protection e.g. payment of coupons and maturity values with reference to a lagged value of the change in the inflation index rather than the current value.

5.3.6.3 Taxation

The taxation of the securities is such that the coupon net of tax may actually be negative if inflation is high. This is because it is not only the coupon payment which is taxable, but also the notional write-up in the nominal value of the bond. This tax treatment is also somewhat disadvantageous, since the tax which might otherwise have been paid on a capital gain at maturity is instead payable as income tax in the current year.

5.3.6.4 Value

Because the market is relatively small, it is possible that distortions in the market may result in the securities being poor value to purchase. Certainly breakeven inflation rates dropped dramatically during 2009, from about 375 basis points in May to about 100 basis points in December, although it must be admitted that inflation also fell from 5% p.a. to little over 1% p.a. in 12 months.[45] From general considerations of supply and demand, one might also expect a lower nominal return (on average) from these instruments, in return for greater inflation protection.

5.3.7 Inflation derivatives and bespoke inflation hedges

Other than the direct purchase of assets which are presumed to have a correlation with inflation, there are a variety of derivatives which are available to insurers to assist in protecting them against inflation risk.

[44] Australian Office of Financial Management (2010b).
[45] UBS (2010).

Among these derivatives are inflation swaps, inflation options, inflation swaptions and bespoke hedges.

5.3.7.1 Inflation swaps

A zero coupon inflation swap is a plain vanilla inflation protection derivative. These will typically be arranged by a merchant bank. Under the terms of an inflation swap, the client agrees to pay, t years in the future

$X(1+f)^t$ in return for receiving X(CPI(t))/(CPI(0))

where: $X is the agreed face value of the swap
f is the agreed breakeven inflation rate
CPI(t) is the value of the CPI index at the time when the payments are swapped.

If in fact, CPI(t) = $(1+f)^t$ * CPI(0) then the net swap payment will be zero.

Inflation swaps are an unfunded investment so can be made without impacting the funds available for investment in other asset classes. Also they can, in principle, be tailored to meet the needs of the insurer; this is one advantage relative to inflation linked securities, because the range of available maturity dates is not restricted by the very small number of inflation linked issues that have been made in Australia.

However, there are several disadvantages to inflation swaps. Apart from the implicit or explicit costs that will be charged by the bank arranging the transaction, there is clearly also a counterparty risk and APRA will require that the insurer making use of derivative arrangements allows for this in the Volatility module of the proposed new Asset Risk Capital Charge.

5.3.7.2 Inflation options

Under the terms of an inflation option, a client purchases the right to a future payment, after t years, of an amount:

$X\{(CPI(t))/(CPI(0))-(1+f)^t\}$ if $(CPI(t))/(CPI(0)) > (1+f)^t$

Otherwise no payment is received.

An advantage of this form of protection is that it is one-sided in the sense that a payment is only received by the insurer if inflation deteriorates, and no payment is received if inflation reduces. In that sense it appears more suited to the ALM issues faced by an insurer.

Again, the cost and counterparty issues apply as well as the APRA regulatory capital issues in respect of Volatility.

5.3.7.3 Inflation swaptions

A third instrument which would offer an insurer inflation protection is an inflation swaption. Under the terms of a swaption, the insurer would purchase at time t=0, the right but not the obligation to enter into a swap at a future date and at a breakeven inflation rate agreed at time t=0.

For example, an insurer might purchase a swaption at time t=0 giving it the right to enter, in two years' time into a retrospective swap with a five year duration and an agreed breakeven inflation rate of (say) 2.5% per annum. If at time t=2 years, it exercised its right to enter the swap, then at time t=5 years it would pay $X(1.025)^5$ and receive X((CPI(5)/CPI(0)).

An inflation swaption might be an inexpensive insurance policy for an insurer that expected inflation to remain benign, but is concerned that there is a risk of a breakout, and believes that it will be clearer in two years' time whether the breakout is a serious threat or not.

Apart from the usual issues of cost, counterparty risk and regulatory capital requirements for derivatives, it would also need to be resolved how to treat the purchase of an inflation swaption during the initial period, before the insurer was required to decide whether to exercise its right to enter into the swap.

5.3.7.4 Bespoke hedging

Finally, an insurer may construct a bespoke inflation index that it wishes to hedge, and attempt to find a counterparty in the over-the-counter market to take on the opposite side of the transaction. It is doubtful whether such a transaction would be easy to arrange in the Australian market. Even in deeper markets, such as the US, it is likely that the desired hedge has to be combined with a second, more common hedge, to render it marketable.

5.4 APRA Risk Capital Charge

For two reasons, it is worth considering the structure of APRA's proposed new Asset Risk Capital Charge.[46] Firstly, many smaller insurers may not have developed their own DFA or other economic capital model, and use APRA's Prescribed Capital Amount (or a multiple thereof) as a proxy for their economic capital. These insurers will naturally wish to minimise the economic capital consumed in writing their business. Secondly, even those insurers which base business decisions on their own internal capital models will find that they have greater capital flexibility by minimising their regulatory capital, and may therefore maximise their embedded and appraisal values by investing in a manner that takes into account APRA's capital constraints.

APRA requires insurers to stress test their net assets under various scenarios involving changes in:

- risk-free real interest rates;
- future inflation rates;
- equity dividend yields;
- property rental yields;
- currency exchange rates;
- volatility;
- credit spreads; and
- default risk.

All insurers are subject to real interest rate risk, inflation risk and default risk, and many choose to have at least some exposure to credit spreads. However,

- Many insurers have limited exposure to equities or property;
- Most insurers should be able to minimise currency risk simply by investing approximately the amount of each foreign currency liability exposure in assets denominated in those currencies; and
- Many insurers do not invest in derivatives and have no volatility exposures.

But for all insurers, real interest rates and inflation are likely to be two key stressors on net assets. Table 6 summarises the impact of these two stressors according to the underlying investments.

[46] APRA (2010b).

Table 6 – Impact of APRA stress tests on various classes of investment

Asset Class		Real interest rates UP	Real interest rates DOWN	Inflation UP	Inflation DOWN
Inflation linked securities	Asset impact	↓	↑	=	=
	Liability impact	↓	↑	=	=
	Net asset impact*	=	=	=	=
Fixed interest	Asset impact	↓	↑	↓	↑
	Liability impact	↓	↑	=	=
	Net asset impact*	=	=	↓	↑
Cash	Asset impact	=	=	=	=
	Liability impact	↓	↑	=	=
	Net asset impact	↑	↓	=	=

*If matched by duration.

In summary, under the APRA capital charges:

- Duration-matched inflation linked securities are treated as the perfect 'hedge' against both inflation and real interest rate movements
- Cash and structured assets effectively hedge against inflation but are exposed to real interest rate decreases
- Duration-matched fixed interest securities effectively hedge against real interest rate movements but are exposed to increases in the inflation rate.

However, as noted above, there are various drawbacks to investing solely in inflation linked securities. Most insurers currently invest heavily in fixed interest securities (but only a small proportion currently would be inflation-linked). In order to consider the consequences of APRA’s new capital charge for a variety of fixed interest investment policies, consider an insurer which operates in the following way:

- it holds no equities or property;
- it has no exposure to derivatives (and therefore to volatility);
- it is matched by currency; and
- it invests only in risk-free securities.

The effect of these simplifying assumptions is that the determining factors that govern the level of the Asset Risk Capital Charge are the way in which net assets respond to the first two scenarios, namely changing real interest rates and changing future inflation rates.

The stressors to be applied to real interest rates in APRA's Technical Paper[47] are as shown in Table 7:

Table 7 – APRA real interest rate stress multiples

Maturity (t years)					
	t<1	1<t<3	3<t<5	5<t<7	t>7
+	0.80	0.70	0.65	0.60	0.55
-	0.70	0.60	0.55	0.50	0.45

By comparison, the stressors to be applied to inflation rates are shown in Table 8.

[47] APRA (2010b).

Table 8 – APRA inflation rate stress multiples

Maturity (t years)					
	t<1	1<t<3	3<t<5	5<t<7	t>7
+	0.95	0.75	0.65	0.60	0.55
-	0.85	0.65	0.55	0.50	0.45

Let us note firstly that the stressors are of broadly similar magnitude (in fact, they are the same for durations greater than three years, though slightly higher for inflation rates for durations shorter than three years.

Currently real interest rates and expected inflation rates are of a similar order of magnitude, with nominal interest rates being about 4.8% for a 5 year duration maturity and real interest rates being about 2.4% and inflationary expectations making up the difference. So currently, very roughly speaking, the undiversified Asset Risk Capital Charge that an insurer would attract would be slightly higher if it invests wholly in matched fixed interest stocks than if it invests wholly in cash.

It would therefore seem likely that, taking into account the diversification effect, the ideal investment approach (ignoring inflation indexed securities) would be a weighted mixture of cash and duration-matched fixed interest investments, with the optimal weighting to cash currently exceeding 50%. This means that the optimal investment mix to minimise APRA’s new Asset Risk Capital Charge will be *significantly shorter* than would have been arrived at by the traditional ALM approach with its entire emphasis on immunising against interest-rate movements.

By general reasoning, we can also make an observation relating to the way in which the investment mix that would minimise APRA’s Asset Risk Capital Charge would respond to changing relativities between inflation and real interest rates. In times of high inflation, the inflation stress test would dominate and insurers wanting to minimise their regulatory capital would need to invest more in cash (or floating rate assets) and less in bonds of fixed coupon and maturity. Conversely, if we were ever in a very low inflation environment (for example, if the deflation that some economists fear in the absence of further post-GFC stimuli materialises) then insurers could minimise their capital requirements by switching the mix of their investments away from cash and into fixed interest investments.

5.4 Model Insurer

Traditionally, many insurers have invested in fixed interest stocks that are broadly 'matched' to the duration of the liabilities, to reduce the potential for interest rate movements to impact adversely on net assets. An investment policy that focuses primarily on minimising interest rate risk has been very common through the industry. However, such a policy does not minimise overall risk, nor will it minimise APRA's proposed capital charges. In this section, we calculate the impact of APRA's proposed new Asset Risk Capital Charges on the required level of regulatory capital of a 'model insurer', as a function of the investment policy.

5.4.1 Details of model insurer

To perform these investigations, we consider an insurer with the following skeletal details.

The insurer has assets of $1.50 billion and undiscounted liabilities (including claims handling and policy administration expenses) of $1.00 billion before addition of a risk margin. Throughout this section it will be assumed that the risk margin is 12% of the central estimate of the liabilities. Its expected payment pattern is as shown in Table 9 below.

Table 9 – Model insurer undiscounted payment pattern

Term to maturity	Undiscounted payment pattern
0.5	42.0%
1.5	22.5%
2.5	11.9%
3.5	7.1%
4.5	4.8%
5.5	3.4%
6.5	2.4%
7.5	1.8%
8.5	1.3%
9.5	1.0%
10.5	0.7%
11.5	0.5%
12.5	0.3%
13.5	0.2%
14.5	0.1%
15.5	0.1%

The average settlement delay is 2.21 years. Any resemblance between the above hypothetical payment pattern and the actual payment pattern of a well known European-based global reinsurer is purely imaginary.

Next we will assume that the insurer invests solely in risk-free fixed interest assets and in fact that, apart from cash, it holds only four securities, namely those shown in Table 10.

Table 10 – Model insurer investment assets

Issuer	Coupon Rate %	Maturity Date	Term to Maturity (yrs)
Australian Government	5.75	15 Jun 2011	1.0
Australian Government	6.25	15 Apr 2015	4.8
Australian Government	5.25	15 Mar 2019	8.7
NSW Treasury Corp	5.50	1 Nov 2028	18.4

Whatever assets are not invested in one of the above four securities are held in cash.

5.4.2 Economic assumptions

From the Australian Government yield curve as at 30 June 2010, zero coupon discount rates may be derived for each duration and the following table sets out the zero coupon discount rates, and the equivalent fixed yield curve, for the model insurer. Table 11 shows the summarised calculations for the model insurer.

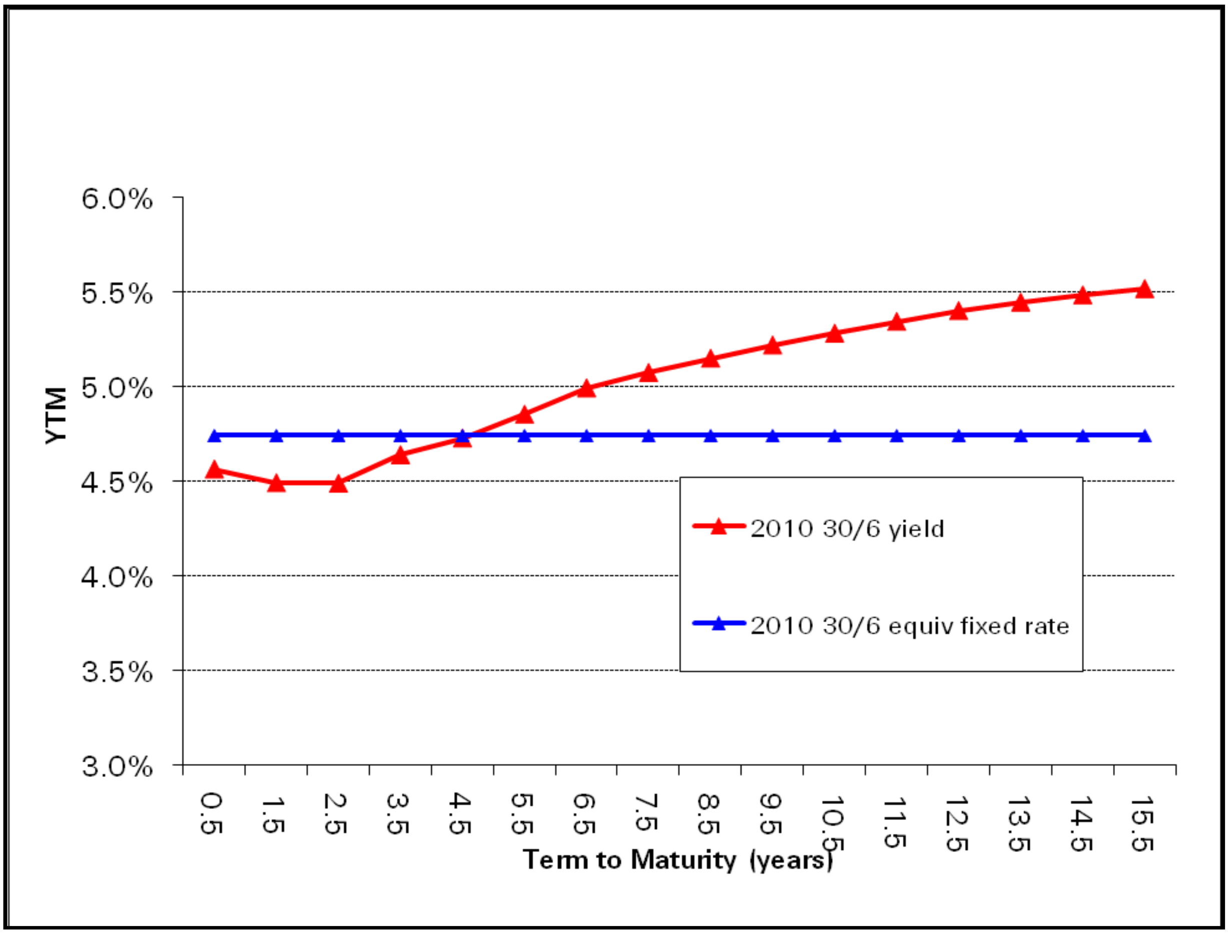
Table 11 – Nominal discount factors as at 30 June 2010

Term to maturity t years	Zero Coupon Discount Rates 30.6.2010	v^t	Fixed rate	$(1+\text{Fixed rate})^{-t}$	Undiscounted payment pattern
0.5	4.56%	97.8%	4.74%	97.71%	42.0%
1.5	4.49%	93.6%	4.74%	93.28%	22.5%
2.5	4.49%	89.6%	4.74%	89.06%	11.9%
3.5	4.64%	85.3%	4.74%	85.03%	7.1%
4.5	4.73%	81.2%	4.74%	81.18%	4.8%
5.5	4.85%	77.1%	4.74%	77.50%	3.4%
6.5	4.99%	72.9%	4.74%	73.99%	2.4%
7.5	5.07%	69.0%	4.74%	70.64%	1.8%
8.5	5.15%	65.3%	4.74%	67.44%	1.3%
9.5	5.22%	61.7%	4.74%	64.39%	1.0%
10.5	5.28%	58.3%	4.74%	61.47%	0.7%
11.5	5.34%	55.0%	4.74%	58.69%	0.5%
12.5	5.40%	51.8%	4.74%	56.03%	0.3%
13.5	5.44%	48.9%	4.74%	53.49%	0.2%
14.5	5.48%	46.1%	4.74%	51.07%	0.1%
15.5	5.52%	43.5%	4.74%	48.76%	0.1%

The discounted mean term may be calculated from the above as 1.79 years.

The zero coupon discount rate curve is shown graphically below.

Graph 5 – Zero Coupon Yield Curve as at 30 June 2010



There is no single standard methodology for decomposing a zero coupon nominal yield curve into real interest rates and inflationary expectations. It is possible either to construct a real interest rate curve from the yields on the available inflation linked securities, or to construct inflationary expectations from expert forecasts. In this situation it is interesting to note that the selected decomposition may have a material impact on an insurer's required regulatory capital. Either way, strictly one should take into account the tax position of the average investor, because the incidence of tax varies according to the nature of the security (nominal or inflation linked) and from investor to investor. So for a given set of inflationary expectations, the preferences of investors in different taxation positions for particular securities may vary.

For illustrative purposes, in this paper the decomposition of the nominal discount rates into expected inflation and real interest rates as at 30 June 2010 was assumed to be as shown in Table 12.

Table 12 – Decomposition of nominal discount factors into real interest rate and expected inflation

Term	Nominal Zero Coupon Discount Rate	Expected Inflation Rate	Real interest rate
0.50	4.56%	2.20%	2.31%
1.50	4.49%	2.30%	2.14%
2.50	4.49%	2.40%	2.04%
3.50	4.64%	2.50%	2.09%
4.50	4.73%	2.50%	2.17%
5.50	4.85%	2.55%	2.25%
6.50	4.99%	2.60%	2.33%
7.50	5.07%	2.63%	2.38%
8.50	5.15%	2.67%	2.41%
9.50	5.22%	2.70%	2.45%
10.50	5.28%	2.70%	2.51%
11.50	5.34%	2.70%	2.57%
12.50	5.40%	2.70%	2.63%
13.50	5.44%	2.70%	2.67%
14.50	5.48%	2.70%	2.71%
15.50	5.52%	2.70%	2.74%

With the above analysis of nominal discount rates into expected inflation and real interest rates we are now in a position to analyse the impact of APRA's proposed new capital requirements on the insurer.

5.4.3 Real interest rate risk

The real interest rate risk charge is the difference between the impact of the real interest rate change on the assets and the impact on the liabilities.

5.4.3.1 Liabilities

The impact of a change in real interest rates on liabilities is calculated by applying the APRA real interest rate stress test parameters to the real interest rates and recomposing the nominal rates using the modified real rates.

For our model insurer, the calculations are performed in Appendix 3. The impact of the calculations is shown in Table 13.

Table 13 – Impact of real interest rate stresses on liabilities of the model insurer

	Discount Rates Assumed		
	30.6.2010 Rates	Rates Stressed Up	Rates Stressed Down
BEL (Undisc.) ($m)	1,000	1,000	1,000
Discount Factor	90.76%	88.33%	92.96%
BEL (Disc.) ($m)	907.6	883.3	929.6
Risk Margin ($m)	108.92	106.00	111.55
APRA Liability ($m)	1,016.6	989.3	1,041.2
Liability Impact ($m)		- 27.26	24.62

Thus if real interest rates rise, the value of our model insurer's liabilities will fall by $27.26m. If real interest rates fall, the value of our model insurer's liabilities will rise by $24.62m.

5.4.3.2 Assets

The impact on the assets of course depends on the chosen mix of cash and the four investment assets. To investigate the impact of a range of asset portfolios on both asset risk and inflation risk, a series of twenty-one distinct asset portfolios were constructed. The portfolios were selected so that the discounted mean term of the asset proceeds varied in multiples of 0.1 year from 0 years (i.e. 100% cash) to 2.0 years.

The details of the portfolios are as shown in Table 14.

Table 14 – Alternative investment portfolios of the model insurer

Issuer	AUST GOVT	AUST GOVT	AUST GOVT	NSW TREAS. CORP	Discounted Mean Term
Coupon	5.75	6.25	5.25	5.50	
Maturity	15/06/2011	15/04/2015	15/03/2019	1/11/2028	
1	-	-	-	-	0.0
2	290.0	-	-	-	0.1
3	580.0	-	-	-	0.2
4	870.0	-	-	-	0.3
5	870.0	34.7	-	-	0.4
6	870.0	69.4	-	-	0.5
7	870.0	104.0	-	-	0.6
8	870.0	138.7	-	-	0.7
9	870.0	173.4	-	-	0.8
10	870.0	208.0	-	-	0.9
11	870.0	242.6	-	-	1.0
12	870.0	242.6	21.0	-	1.1
13	870.0	242.6	42.0	-	1.2
14	870.0	242.6	63.0	-	1.3
15	870.0	242.6	84.0	-	1.4
16	870.0	242.6	105.0	-	1.5
17	870.0	242.6	105.0	12.6	1.6
18	870.0	242.6	105.0	25.3	1.7
19	870.0	242.6	105.0	38.0	1.8
20	870.0	242.6	105.0	50.7	1.9
21	870.0	242.6	105.0	63.4	2.0

Essentially the portfolio was constructed starting with 100% cash, then:

1. Adding $290m (face value) of the Australian Government bond with the 2011 maturity to each previous portfolio (and reducing cash by the corresponding market value) until the mean duration was 0.3 years;
2. Adding $34.7m (face value) of the Australian Government bond with the 2015 maturity to each previous portfolio (and reducing cash by the corresponding market value) until the mean duration was 1.0 years;
3. Adding $21m (face value) of the Australian Government bond with the 2019 maturity to each previous portfolio (and reducing cash by the corresponding market value) until the mean duration was 1.5 years;
4. Adding $12.6m (face value) of the NSW Treasury bond with the 2011 maturity to each previous portfolio (and reducing cash by the corresponding market value) until the mean duration was 2.0 years.

The impact of the real interest rate increases on the above portfolios increased monotonically with the mean asset duration. The results are summarised in Appendix 4.

5.4.4 Inflation risk

The inflation risk component of the Asset Based Risk Charge is a function solely of the impact of inflation on the insurer's assets. It is assumed in the APRA approach to the Asset Risk Charge that the impact of altered expected inflation rates on the value of the liabilities will be twofold:

1. the actual nominal amounts of the future payments will be increased to the extent of the altered future expected inflation; however,
2. the assumed future nominal risk free investment earnings rates will be changed by an equivalent amount (i.e. keeping the real return constant) so that the discounted value of future liability outgo will be the same as prior to the change of inflationary expectations.

The net impact of the inflation stress scenario is therefore simply the impact of the future inflation stress on the value of the insurer's assets. Clearly there will be no risk charge arising as a result of a decrease in inflation (as such a change will simply increase asset values and hence net assets). So the inflation risk module will always require a projected increase in the value of future inflation rates.

In the same way as the Real Interest Rate stress scenario impacts differently on an insurer according to differences in its investment portfolios, so too will the Inflation module impact differently on insurers with different investment policies. Appendix 4 shows the impact of the Inflation module on our Model Insurer as a function of which of the 21 investment portfolios outlined above it has selected.

5.4.5 Default risk

The default risk component of the Asset Risk Charge for most insurers will be a function of unpaid premiums and reinsurance recoveries. For the purposes of the model insurer, it will be assumed that the default risk component (before intra-asset risk charge diversification) is a constant $25 million. The default risk component of APRA's proposed Asset Risk Charge is not subject to the intra-Asset Risk Charge diversification benefit.

5.4.6 Deriving the final Asset Risk Capital Charge

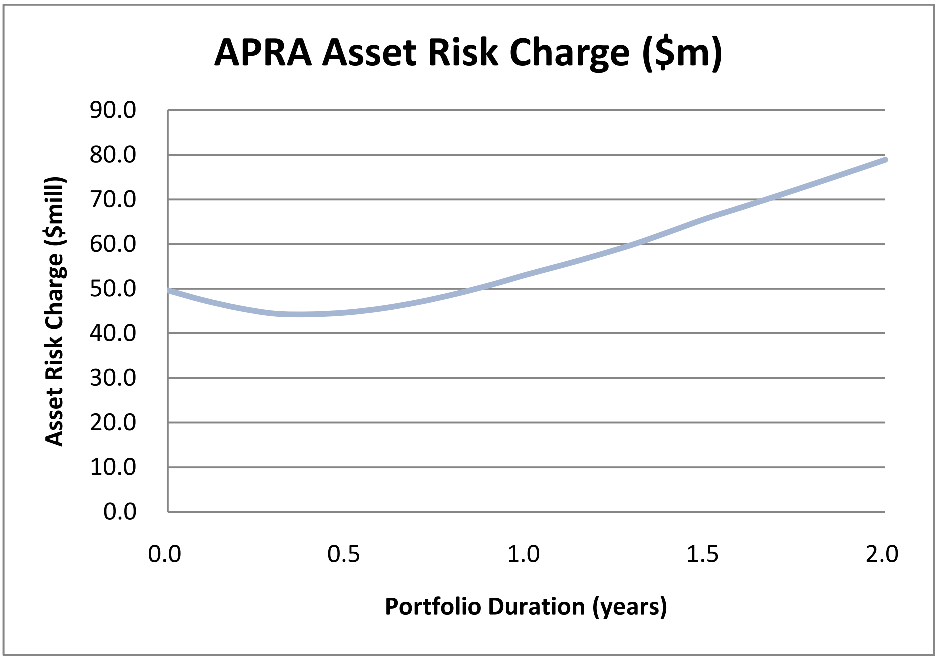
The final Asset Based Risk Charge is determined by applying a correlation matrix to the undiversified risk charges from the eight modules. In the case of our model insurer, only three of the eight modules produce a positive Risk Charge component: the Real Interest Rate Risk, the Inflation Risk and the Default Risk. The Default Risk module is not subject to the diversification benefit. Because it is always the 'inflation up' scenario that produces the requirement for a risk charge, there are effectively two options for the correlation matrix. If assets are more interest sensitive to changes in the real interest rate than liabilities (i.e. assets are invested 'long'), then the net impact of an increase in the real interest rate will be to decrease the net assets of the insurer.

Because APRA regards inflation and real interest rates as positively correlated, but is unwilling to give credit for negative correlation, effectively the correlation between the interest rate risk and the inflation risk is assumed to be:

- +0.2 if an increase in real interest rates increases the capital requirement (i.e. if assets are invested 'longer' than liabilities), but
- 0 if an increase in real interest rates reduces the net assets (i.e. if assets are invested 'shorter' than liabilities).

Graph 6 shows the Asset Risk Charge as a function of the Portfolio Duration (discounted mean term).

Graph 6 – Calculated APRA Asset Risk Charge as for model insurer



It is interesting to note some of the features of the above graph.

Firstly, it is notable that the portfolio duration which minimises the APRA Asset Risk Charge (0.4 years) is quite short relative to the mean term of the liabilities – the mean term of the assets is about one-fifth of the mean term of the liabilities. Partly this can be understood because there are simply more assets than there are liabilities, so even on the old 'interest rate matching' paradigm we should have expected the optimal portfolio duration to be something like two thirds of the liability duration (given that the assets are about 150% of the liabilities). But with a mean liability duration of 1.8 years, that suggests that under the old 'interest rate matching' concept, the chosen portfolio duration would have been approximately 1.2 years.

With the current decomposition of nominal interest rates into real interest rates and inflationary expectations, and the current APRA stress testing parameters for Real Interest Rates and Inflation, if we ignore the excess assets (or assume that they are invested in cash), it appears that the mean duration of invested assets that will minimise the regulatory capital charge is less than half the mean term of the liabilities, perhaps about one-third.

The implication for those insurers that currently adopt an 'interest rate matching' policy is that if they wish to minimise their regulatory capital requirements from 2012 (assuming that the proposed APRA amendments are implemented) without investing materially in index linked securities, they will need to significantly shorten the duration of their fixed interest portfolios to accommodate APRA's explicit recognition of inflation risk as well as real interest rate risk in the regulatory capital regime.

In summary, under the proposed APRA capital standards, an insurer can avoid any charge for inflation risk by investing wholly in cash, but in that case there will be a significant real interest rate risk charge. Alternatively, the insurer can avoid real interest rate risk by investing in nominal bonds of an amount and duration equivalent to the liabilities, but in that case the insurer will attract a significant inflation risk charge. But it seems that the optimal investment policy for an insurer that wishes to minimise its Asset Risk Charge without investing in inflation linked securities, is to invest in a mix of cash and fixed interest securities such that the mean term of the 'matched' assets is approximately one third of the mean term of the liabilities.

6 Inflation Risk and Risk Management

6.1 Quantification of inflation risk

With the massive increase in interest in recent years in Enterprise Risk Management, particularly for entities in the financial services sector, all insurers are likely to have adopted some form of holistic approach to the measurement, monitoring and control of the risks that they wish to accept. In particular, it is clear that one of those risks is inflation, including both index and superimposed inflation.

This leads us to a consideration of how inflation risk is to be measured for organisational risk management purposes. A key point in this context is that it is not total inflation that is the risk, but only unanticipated inflation. Specifically, the risk is unanticipated inflation that is higher than expected. Insurers are likely to operate on an economic capital model that measures 'risk' as the amount of capital which would be lost due to risk X in the event of a 1 in N year adverse occurrence involving risk X (the 'Value at Risk' or 'VaR' criterion) or the mean of all possible losses arising from risk X given that a loss event at least as serious as a 1 in N year event occurs (the 'TailVaR' criterion). So insurers must evaluate the probability distribution of future adverse inflation events and their correlation with other modelled variables.

This is an extremely challenging task. Some of the issues that arise are the following:

- Assuming that the inflation will be modelled using historical data, how to identify 'anticipated' inflation at each historical moment in time;
- Whether to model index inflation only or all inflation;
- If the decision is taken to model all inflation, how will superimposed inflation be modelled;
- Even if index inflation only is modelled, how will the model treat changes in central bank philosophy and approach in dealing with inflation;
- Even if a model can be constructed that reasonably represents unanticipated inflationary movements in 'normal' times, can this model be relied upon to provide appropriate probabilities of the extreme events that are of the greatest interest, when quantifying risk;
- How will the model respond to current global circumstances, where both deflation and renewed inflation are seen as more likely developments than pre-GFC;
- Modelling the impact of inflation on assets as well as liabilities; and finally
- Modelling the correlations between inflation risk and other risk elements such as natural catastrophes or counterparty credit risk.

These issues are so challenging that it is likely that close scrutiny of even sophisticated attempts to model extreme inflation events is likely to reveal one or more weaknesses. The authors believe that there can be no "perfect" inflation risk model, but that nevertheless, the impossibility of achieving 'perfection' is not an excuse for failure to construct a model, using a mixture of historical data and professional judgment, as part of the organisation’s efforts to manage risk in all its forms.

7 Conclusion

7.1 Summary of findings

The findings of this paper are set out in Table 15.

Table 15 – Summary of findings

No.	Section	Finding
1	1.1	At present there is more uncertainty about the prognosis for future general inflation rates than there has been in the last quarter century.
2	1.2	Superimposed inflation tends to occur in bouts and for complex causes.
3	2.1	Inflation in Australia has been well controlled in Australia in the last two decades while the 'Great Moderation' has been in progress, but historically there have been unpredictable bursts of very high inflation.
4	2.2	Numerous macroeconomic models have been proposed to describe the movement in macroeconomic variables such as price and wage inflation, short and long term bond yields, equity and property prices and yields. However, it is difficult to find a simple model which satisfies standard statistical tests.
5	3.2	Although frequency trending (as part of the pricing process) would be performed by accident year, typically loss severity trending should be performed as a function of payment year.
6	3.2	Pricing is normally performed using a best estimate of future index and superimposed inflation. The pricing process requires significant judgment of hard-to-estimate quantities particularly future rates of superimposed inflation.
7	3.4	The risk of unanticipated inflation should be included explicitly via the cost of capital, as a component of the insurer's economic capital.
8	4.6	Traditional reserving methods, particularly those frequently used for reinsurance business, do not perform well in allowing for unanticipated inflation that emerges in the latest claims diagonal. It is important that the reserving actuary monitor sources independent of the claims data, as well as the Claims department response, to be able to make appropriate subjective adjustments to the reserving basis.
9	5.2	The liabilities of general insurers are generally inflation-exposed. APRA's proposed new Asset Risk Capital Charge explicitly charges for the inflation risk that is implicit in the liabilities.
10	5.3	A variety of asset classes have been proposed as hedges against inflation but some (such as equities and property) that may be tolerable long run hedges are not suitable in the short term. Other than derivatives, only sovereign inflation-linked securities offer a risk-free hedge that can substantially eliminate the inflation component of the APRA Risk Capital Charge.
11	5.3.6	However inflation linked securities also suffer from some disadvantages, and cannot represent a 'perfect hedge'. It would be helpful if the present range of Australian government issues were broadened so that maturity dates were less sparsely spaced and to include some longer maturity dates.
12	5.4	An insurer investing an amount equal to its insurance liabilities in nominal bonds and wishing to minimise the proposed new APRA Risk Capital Charge should invest much shorter than the duration of its liabilities. Currently the mean term of its assets should be about one third of the mean term of its liabilities.
13	6	Quantification of the inflation risk in order to determine an insurer's economic capital is an extremely challenging task. As noted above there are no 'perfect' models for index inflation, and superimposed inflation is likely to be even more difficult to model. An element of subjective professional judgment is likely to be required to produce a reasonable, useable model.

Perhaps the two key conclusions of this paper may be summarised as follows.

Firstly, the benign general inflation conditions of the past two decades, and the modest superimposed inflation levels of the past five years, may have lulled Australian insurers and their actuaries into a false sense of security. Claims inflation remains a key risk for the insurance business, and the current fiscal positions of many nations magnify this uncertainty. Finding an adequate response in terms of pricing, reserving, and investment, is a difficult and in some respects intractable challenge.

A second clear conclusion is that the traditional investment approach that 'matches' the liabilities using nominal bonds of similar duration to the liabilities leaves the insurer exposed to inflation risk. The approach which minimises the proposed new regulatory capital requirements (and presumably, overall risk) is to invest in inflation linked bonds. Alternatively if an insurer chooses to remain invested in nominal bonds, then the duration of those bonds should be significantly shorter than the duration of the liabilities.

However, whilst there has been an emphasis in this paper on investment policy that minimises regulatory capital requirements, minimising regulatory capital will not necessarily be the overriding objective for many insurers. Many insurers will instead adopt the investment policy that meets some alternative criterion, perhaps expressed in terms of return on economic capital and perhaps including constraints relating to risk appetite or perhaps expressed in terms of their embedded or appraisal values. But even these insurers may wish to reconsider, prior to the implementation of the new APRA standards, whether the traditional interest rate matching paradigm is still appropriate.

7.2 Further work

It will be clear to the reader of this paper that there are many avenues for further research that would be helpful to Australian actuarial practitioners. Some of those avenues are mentioned below.

7.2.1 Published macroeconomic model

It would be very useful to a wide range of users including insurers if a researcher would publish a simple, current, parameterised Australian model of price and wage inflation, short and long term bond yields and equity and property yields and prices. Whilst the authors acknowledge that there is probably no such thing as a 'perfect' model, certainly not a 'perfect' simple model, there is a need for workable models even if it would be necessary to make potential users aware of the limitations of such a model.

7.2.2 Inflation risk as a component of economic capital

The authors are unaware of detailed published work on techniques for modelling inflation (and especially superimposed inflation) risks in order to determine an insurer's economic capital. However it is likely that a number of insurers have approached APRA with documented (but proprietary) DFA models that include general and superimposed inflation models.

7.2.3 Inflation linked securities

Given that APRA's proposed new capital requirements will give a clear incentive to insurers to invest in inflation linked securities, there is scope for research into:

- How to match insurance liabilities using inflation linked securities, given that at present the latter are only available with maturity dates at 5-yearly intervals.
- The liquidity of such securities and constraints that any lack of liquidity might impose on the optimal investment policy.

- Under what circumstances may inflation linked securities be considered to offer 'value' relative to nominal securities.

7.2.4 Optimal investment policy

The work in this paper noted the conclusion that the 'model insurer' investing only in nominal fixed interest securities should invest with a mean duration of about one third of the mean duration of the liabilities in order to minimise the proposed new APRA Risk Capital Charge.

However, the example considered in this paper was very simple and restricted. There is a great deal of scope to consider:

- Optimal fixed interest duration in conjunction with some holdings of inflation indexed securities;
- Whether the conclusions of the paper continue to apply when the insurer also holds equities or property;
- The impact of investment policy on insurers' embedded and appraisal values as a function of their investment policy (allowing for differential earnings to be expected from different classes of asset).

7.3 Acknowledgements

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Appendix 1 – Historical CPI Inflation - Australia

Table 16 - Historical CPI Values, Australia, 1948-2010[48]

Year	Mar	Jun	Sep	Dec	Annual
1948			6.7	6.8	6.8
1949	7.0	7.1	7.3	7.4	7.2
1950	7.5	7.8	7.9	8.2	7.9
1951	8.6	9.1	9.6	10.3	9.4
1952	10.6	11.0	11.2	11.3	11.0
1953	11.4	11.5	11.6	11.5	11.5
1954	11.6	11.6	11.6	11.6	11.6
1955	11.7	11.8	11.9	12.0	11.9
1956	12.1	12.5	12.8	12.8	12.6
1957	12.8	12.9	12.9	12.9	12.9
1958	13.0	13.0	13.0	13.1	13.0
1959	13.2	13.2	13.3	13.4	13.3
1960	13.5	13.7	13.9	14.0	13.8
1961	14.1	14.2	14.1	14.1	14.1
1962	14.1	14.1	14.1	14.1	14.1
1963	14.1	14.1	14.2	14.2	14.2
1964	14.3	14.4	14.6	14.7	14.5
1965	14.8	15.0	15.1	15.3	15.1
1966	15.4	15.5	15.5	15.7	15.5
1967	15.8	15.9	16.2	16.2	16.0
1968	16.3	16.4	16.5	16.6	16.5
1969	16.8	16.9	17.0	17.1	17.0
1970	17.3	17.5	17.6	17.9	17.6
1971	18.1	18.4	18.8	19.2	18.6
1972	19.4	19.6	19.9	20.1	19.8
1973	20.5	21.2	21.9	22.7	21.6
1974	23.3	24.3	25.5	26.4	24.9
1975	27.4	28.4	28.6	30.2	28.7
1976	31.0	31.8	32.6	34.5	32.5
1977	35.3	36.1	36.8	37.7	36.5
1978	38.2	39.0	39.7	40.6	39.4
1979	41.3	42.4	43.4	44.7	43.0
1980	45.7	47.0	47.8	48.8	47.3
1981	50.0	51.1	52.1	54.3	51.9
1982	55.3	56.6	58.6	60.3	57.7
1983	61.6	62.9	64.0	65.5	63.5
1984	65.2	65.4	66.2	67.2	66.0
1985	68.1	69.7	71.3	72.7	70.5
1986	74.4	75.6	77.6	79.8	76.9
1987	81.4	82.6	84.0	85.5	83.4
1988	87.0	88.5	90.2	92.0	89.4
1989	92.9	95.2	97.4	99.2	96.2
1990	100.9	102.5	103.3	106.0	103.2
1991	105.8	106.0	106.6	107.6	106.5
1992	107.6	107.3	107.4	107.9	107.6
1993	108.9	109.3	109.8	110.0	109.5
1994	110.4	111.2	111.9	112.8	111.6

[48] Australian Bureau of Statistics (2010a).

1995	114.7	116.2	117.6	118.5	116.8
1996	119.0	119.8	120.1	120.3	119.8
1997	120.5	120.2	119.7	120.0	120.1
1998	120.3	121.0	121.3	121.9	121.1
1999	121.8	122.3	123.4	124.1	122.9
2000	125.2	126.2	130.9	131.3	128.4
2001	132.7	133.8	134.2	135.4	134.0
2002	136.6	137.6	138.5	139.5	138.1
2003	141.3	141.3	142.1	142.8	141.9
2004	144.1	144.8	145.4	146.5	145.2
2005	147.5	148.4	149.8	150.6	149.1
2006	151.9	154.3	155.7	155.5	154.4
2007	155.6	157.5	158.6	160.1	158.0
2008	162.2	164.6	166.5	166.0	164.8
2009	166.2	167.0	168.6	169.5	167.8
2010	171.0	172.1			

Appendix 2 – Historical AWE Inflation - Australia

Table 17 - Historical AWE Values, Australia, 1971-2010[49]

Average Weekly Ordinary Times Earnings				
Year	March Qtr	June Qtr	September Qtr	December Qtr
1971	76.4	83.7	84.3	89.9
1972	83.4	90.6	90.5	97.3
1973	90.8	100.8	103.1	112.2
1974	105.6	119.9	129	143.9
1975	143.8	156.4	157.1	172.4
1976	165.3	180.7	184.7	195.5
1977	182.9	198.7	203.9	213.6
1978	205.2	215.5	218.9	229.1
1979	222.7	232.8	238.3	248
1980	245.7	256.7	268.1	289.1
1981	270.7	295.1	304	285.2
1982	293.5	306	317.7	331.5
1983	335.2	336.5	339.8	351.7
1984	353.6	364.9	369.4	375.2
1985	378	383.1	388.8	397.1
1986	404.9	408.3	419.8	428.4
1987	429.6	435.6	446	450
1988	458.8	465.6	470.1	484.5
1989	493.4	501.4	509.7	516.8
1990	524.8	534.5	541.7	554.4
1991	564.3	560.2	567.5	580.1
1992	588.8	587.3	585.7	586.9
1993	595.5	598	600.8	603.5
1994	612.3	616.9	620	629.9
1995	639.9	647.2	653.1	661
1996	665.8	671.2	674.6	685.5
1997	696.1	697.6	704.3	710.9
1998	721.3	725.2	735.4	742.7
1999	743.8	747.3	753	764.2
2000	774.8	784.2	796.1	800.4
2001	810.6	824.1	838.5	848.7
2002	860.5	866.8	879.4	889.6
2003	900.4	921	929.6	938.4
2004	947.8	949.5	962.9	976.4
2005	992.9	1006.7	1023.2	1025.7
2006	1037.5	1041.6	1053	1058.6
2007	1073.8	1090	1105.1	1108.5
2008	1124.8	1131.1	1151.4	1165.3
2009	1183.4	1195.6	1204.2	1226.8
2010	1243.1			

[49] Australian Bureau of Statistics (2010b).

Appendix 3 – Model Insurer – Payment Pattern and real interest rate stress calculation

Table 18 – Calculation of model insurer real interest rate stresses

Term to maturity t years	Undiscounted payment pattern	Zero Coupon Discount Rates 30.6.2010	v^t	Discount Rates Stressed Up	v^t	Discount Rates Stressed Down	v^t
0.5	42.0%	4.56%	97.8%	6.46%	96.9%	2.91%	98.6%
1.5	22.5%	4.49%	93.6%	6.03%	91.6%	3.18%	95.4%
2.5	11.9%	4.49%	89.6%	5.95%	86.5%	3.24%	92.3%
3.5	7.1%	4.64%	85.3%	6.03%	81.5%	3.46%	88.8%
4.5	4.8%	4.73%	81.2%	6.18%	76.4%	3.50%	85.6%
5.5	3.4%	4.85%	77.1%	6.24%	71.7%	3.70%	81.9%
6.5	2.4%	4.99%	72.9%	6.43%	66.7%	3.80%	78.5%
7.5	1.8%	5.07%	69.0%	6.42%	62.7%	3.97%	74.7%
8.5	1.3%	5.15%	65.3%	6.51%	58.5%	4.03%	71.5%
9.5	1.0%	5.22%	61.7%	6.60%	54.5%	4.09%	68.4%
10.5	0.7%	5.28%	58.3%	6.70%	50.6%	4.12%	65.4%
11.5	0.5%	5.34%	55.0%	6.80%	46.9%	4.15%	62.6%
12.5	0.3%	5.40%	51.8%	6.89%	43.5%	4.19%	59.9%
13.5	0.2%	5.44%	48.9%	6.95%	40.3%	4.21%	57.3%
14.5	0.1%	5.48%	46.1%	7.01%	37.4%	4.23%	54.8%
15.5	0.1%	5.52%	43.5%	7.07%	34.7%	4.25%	52.5%
Total	100%		90.76%		88.33%		92.96%

Appendix 4 – Model Insurer – Asset Risk Capital Charge as a function of Investment Portfolio

Table 19 – Calculation of APRA Risk Capital Charge as a function of Investment Portfolio

Portfolio	Portfolio Mean Duration	Real Interest Rate Up Net Impact	Real Interest Rate Down Net Impact	Inflation Impact	Default Impact	Total Undivers. Impact	Capital Requirement (Up)	Capital Requirement (Down)	Final Capital Requirement
1	0.0	27.3	-24.6	0.0	-25.0	-49.6	25.0	49.6	49.6
2	0.1	24.6	-22.2	-2.9	-25.0	-50.1	27.9	47.4	47.4
3	0.2	21.9	-19.8	-5.7	-25.0	-50.5	30.7	45.6	45.6
4	0.3	19.2	-17.4	-8.6	-25.0	-51.0	33.6	44.4	44.4
5	0.4	17.2	-15.6	-11.3	-25.0	-51.9	36.3	44.3	44.3
6	0.5	15.2	-13.8	-14.1	-25.0	-52.8	39.1	44.7	44.7
7	0.6	13.2	-12.0	-16.8	-25.0	-53.7	41.8	45.6	45.6
8	0.7	11.2	-10.1	-19.5	-25.0	-54.7	44.5	47.0	47.0
9	0.8	9.2	-8.3	-22.3	-25.0	-55.6	47.3	48.8	48.8
10	0.9	7.2	-6.5	-25.0	-25.0	-56.5	50.0	50.8	50.8
11	1.0	5.2	-4.7	-27.7	-25.0	-57.4	52.7	53.1	53.1
12	1.1	3.3	-3.0	-30.1	-25.0	-58.1	55.1	55.3	55.3
13	1.2	1.5	-1.3	-32.5	-25.0	-58.8	57.5	57.5	57.5
14	1.3	-0.4	0.4	-34.9	-25.0	-60.3	60.0	59.9	60.0
15	1.4	-2.2	2.1	-37.3	-25.0	-64.5	62.8	62.3	62.8
16	1.5	-4.1	3.8	-39.7	-25.0	-68.7	65.7	64.7	65.7
17	1.6	-6.0	5.7	-41.6	-25.0	-72.6	68.2	66.6	68.2
18	1.7	-8.0	7.7	-43.5	-25.0	-76.5	70.8	68.5	70.8
19	1.8	-9.9	9.7	-45.5	-25.0	-80.4	73.5	70.5	73.5
20	1.9	-11.9	11.7	-47.4	-25.0	-84.3	76.1	72.4	76.1
21	2.0	-13.8	13.7	-49.4	-25.0	-88.2	78.9	74.4	78.9