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Manufacturing Inflation Risk Protection

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1 EXECUTIVE SUMMARY

Inflation plays a central role in the management of personal wealth to meet future consumption wants and needs. It is particularly important in the management of long-term savings to meet retirement-related needs, which can span durations well in excess of 30 years. Over such periods of time, even low to moderate levels of inflation can have extremely large impacts on the ability of accumulated wealth to maintain purchasing power. A central part of any long-term retirement investment plan should be a strategy of how wealth is invested and protected in order to maintain its purchasing power, and thus to secure and sustain adequate standards of living throughout retirement.

This paper examines various wealth management solutions, both existing and new, that provide inflation-protected benefits designed to meet consumers' wealth accumulation and post-retirement income needs.

This paper examines various wealth management solutions, both existing and new, that provide inflation-protected benefits designed to meet consumers' wealth accumulation and post-retirement income needs. Section 2 discusses inflation risk in the context of these needs, across a number of developed markets. For these markets, consumer price inflation has tended to range predominantly in the 0% to 5% levels over the last two decades, although there have been extended periods of both lower and higher inflation over long historical time frames.

The importance of providing inflation-protected retirement solutions is clearly evidenced through the provision of social security provided by the state, as well as through the dependence on defined benefit (DB) occupational pension schemes provided by employers, both of which provide elements of inflation indexation of retirement income. However, with the broad movement away from these vehicles over recent years towards private provision of retirement solutions, there has been little corresponding use of investment or insurance solutions which provide equivalent benefits. The use of retail products such as inflation-indexed fixed annuities, inflation-indexed variable annuities, and inflation-guaranteed bonds has been extremely limited. Section 3 discusses these solutions in further detail.

Traditional investment solutions have focused primarily around the use of traditional asset classes such as equities, fixed income and property to provide nominal returns that are correlated to inflation. However, the analysis outlined and discussed in section 3.6 shows that the performance of these assets can vary significantly from inflation, generating at best relatively weak correlations for equities, nominal bonds and property. Cash and inflation-indexed bonds do provide moderate levels of positive correlation to inflation; however, they are not the most attractive asset classes from an expected risk premium perspective to base a long-term investment strategy around.

To date, the predominant forms of retail market risk protection have focused on nominal capital and income protection. In many cases these are provided within insurance wrapped products such as fixed and variable annuities. Section 4 of this paper outlines how such products can be designed and priced to provide capital and income benefits that are protected against inflation. The conclusion from this analysis is that retail products can be designed in such a way to provide inflation protection that meets capital and income protection retirement needs, for an attractive price for most markets.

These products are particularly sensitive to both break-even inflation rates which drive moneyness levels, and real interest rates which reflect the pure impact of discounting. As a consequence, the raw form of these products will tend to be expensive in markets such as the UK, where both break-even inflation rates are high and real interest rates are particularly low at the current time of writing. However, there are many features in the product design toolkit that enable product benefits to be tailored to meet customer needs and that can be offered at attractive prices. The notable ones are the use of floors, caps and participation rates which are explicitly linked to inflation-protection benefits, although there are numerous others that apply more generally that are outlined in section 4.5.

Inflation-protection benefits can also be designed within either an investment or insurance vehicle (or wrapper), to meet the needs of any particular market segment depending upon whether insurance risk transfer is also important. This is discussed further in section 4.4.

The provision of inflation-protection benefits requires the adoption of a dynamic replication strategy. Such strategies rely upon the availability of liquid derivative instruments that can be used to construct and dynamically rebalance a hedge portfolio over time in line with evolving market conditions. Inflation swaps fulfil this role, and there is a sufficiently deep and liquid market in these products to facilitate such dynamic replication strategies. Inflation volatility-based derivatives can be used by guarantee providers to manage inflation volatility risk, although their liquidity is somewhat more limited relative to other interest rate swaps in most markets. Section 5 discusses the risk management implications of these products in further detail.

In order to develop and manage inflation-based products, the key operational activities that need to be undertaken include product design and pricing, hedge design, operating a hedging program on a real-time basis, production of management information and administration of collateralisal structures or processes. As many of these activities are highly specialised, a key decision will be whether to undertake them on an internal, outsourced or partnership basis with third parties. This will be highly dependent upon existing levels and costs of internal expertise, experience and resource capacity the organisation has. Section 6 discusses this as well as other product delivery options and economic capital considerations for guarantee providers. Analysis of the economic capital requirements of an inflation-linked guaranteed insurance product shows that they have comparable capital levels to their nominal product cousins.

For those readers interested primarily in the discussion on the opportunity for product innovation and development, we invite you to skip over the background and context discussion in sections 2 and 3, and jump straight to sections 4, 5, and 6.

In summary, retail investment and insurance products can be readily designed and manufactured to provide inflation risk protection benefits that meet the core needs of the wealth accumulation and post-retirement income generation market segments.

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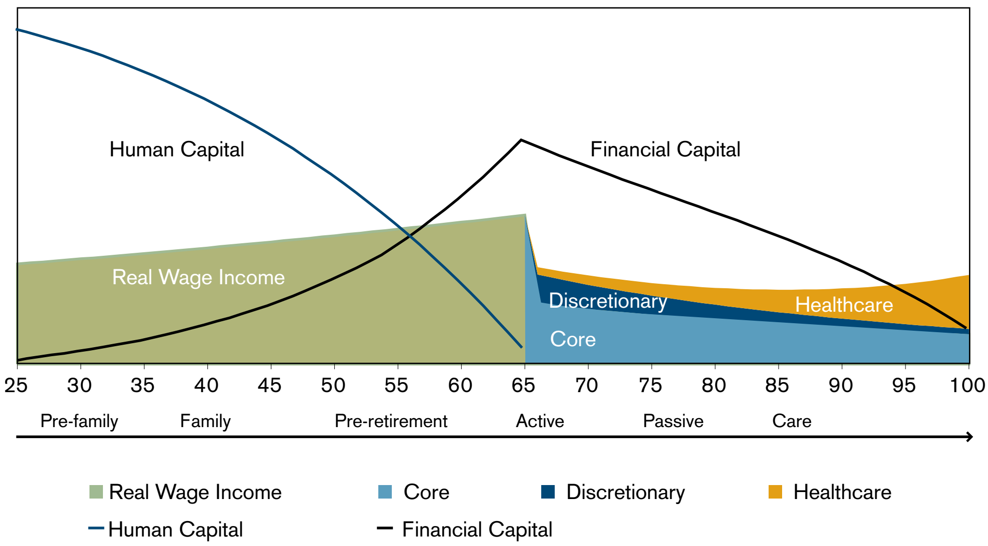
2 THE NEED FOR INFLATION RISK PROTECTION

2.1 Lifecycle Consumption

The need for inflation protection derives from the financial lifecycle of a person. A person's financial lifecycle refers to the dynamic relationship between his or her human capital (the value of future income) and financial capital (the value of savings and investment returns), which are used to meet current and future consumption requirements. Almost all aspects of a person's life are influenced by his or her financial lifecycle, and management of the decisions governing it are of central importance to not only the individual in question, but also to professionals working in financial services, such as financial advisors and product manufacturers.

The central feature of a person's lifecycle financial development is the transition of human capital into income for immediate consumption and financial capital used to meet future consumption. This is illustrated in the following diagram.

FIGURE 1: HOLISTIC FINANCIAL LIFECYCLE OF A PERSON (SOURCE: CORRIGAN (2009))



Inflation risk arises when financial wealth is invested to meet future consumption needs. The dominant form of this arises with respect to the provision of retirement income, although there may be other shorter-term needs.

Inflation risk arises when financial wealth is invested to meet future consumption needs. The dominant form of this arises with respect to the provision of retirement income, although there may be other shorter-term needs which arise during the family stage, such as saving for asset or consumer durable purchases (house, car, electronic equipment, etc.) and children's education.

People at the start of their careers may actually have long inflation exposure, as the value of their future income (human capital) may increase more due to future inflation relative to their consumption. This is particularly the case where there is a heavy debt burden as the result of education, which becomes deflated in the event of future inflation. In some sense, these people are natural net providers of inflation risk, relative to other groups who are natural buyers of inflation risk.

In the case of saving for asset purchases, this typically occurs over periods of around three to five years, whilst saving to meet children's education may occur over a longer period of five to fifteen years. In these cases the *liability* that is being provisioned for is a specific asset and, as such, the risk is that investment returns upon expected savings are not sufficient to keep pace with the price inflation of that specific asset. In the case of some consumer durables such as personal computers, price inflation may be zero or negative, or very high in the recent case of precious jewellery, which is influenced by commodity prices. General inflation measures such as the Consumer Price Index (CPI) are a proxy for the price inflation of these items.

By contrast in the former case, saving for retirement starts during a person's 20s, and can end beyond age 100 – a time period of 80 years! Viewed in terms of materiality of wealth and risk exposure, retirement provision typically has time horizons from the mid-40s through to the mid-80s, which is still 40 years. The savings invested over the course of a working career must generate returns in excess of inflation over this time horizon in order for living standards not to be adversely affected in the future.

Post-retirement expenditure can be broadly classed into three main categories:

- **Core expenditure**: Required to maintain a basic standard of living covering a broad range of consumer goods and services needed for subsistence.
- **Discretionary expenditure**: Consumption to cover our *wants and desires* on items such as holidays, expensive cars, boats, bequests, etc.
- **Healthcare expenditure**: Consumption on items to maintain personal health, such as medical expenses, aged care, etc.

These three different types of consumption give rise to three different needs for inflation protection.

1. Protecting against **general increases** in the price level as captured by indices such as the CPI is important in order to meet core expenditure and thereby maintaining basic living standards. The consequences of not mitigating this risk in advance can be severe, as little can be done once in a situation of high inflation and static nominal income at elderly ages.

2. Price inflation for **discretionary expenditure** purchases will be highly specific to the nature of the consumption. For example, travel costs can be highly leveraged to exchange rates and consumer durables can be driven by large movements in commodity prices. However, despite this, the need for protection against inflation on these items is relatively low because of the fact that they are discretionary. In the worst-case scenario, they can simply not be purchased, and in most cases less expensive substitute products are readily available, such as domestic car holidays in lieu of overseas holidays or a mass-market consumer durable brand in lieu of a prestigious brand.

3. **Healthcare expenditure** shares characteristics of both of the above classes. All people wish to be both alive and to maintain a minimum health standard of living during retirement. However, the cost of doing so is highly correlated to medical inflation, which can be significantly different to broad measures of consumer inflation (noting, however, that it is a subcomponent of broad measures of inflation). Thus, this type of inflation risk is both significant and highly specific, and is particularly relevant for older age people, as it makes up a growing proportion of the overall basket of consumption. As a consequence, private health insurance and long-term care products are specifically designed to mitigate these risks.

The need for inflation protection relates predominantly to post-retirement core income needs.

In summary, the need for inflation protection relates predominantly to post-retirement core income needs. Single-premium at-retirement products that provide inflation-protected income streams for life are likely to be attractive to those who have already built up a retirement pot. These will likely be sold to people aged 60-65, and have durations of around 15-20 years. There is also a potential need for products to be sold to 20- to 60-year-olds that provide inflation-protected wealth accumulation to retirement (to cater for tax-free cash opportunities) and lifetime income streams during retirement. These could be in the form of either single-premium, recurrent single-premium or regular-premium products. Such products may have regular-premium accumulation durations of up to 40 years, although evidence based upon current product designs and sales also suggests an important role for short-term, five- to 10-year duration products to meet the needs of people in the pre-retirement stage.

2.2 Inflation

The standard measure of inflation in most countries is the CPI. This index represents the price of a standardised basket of goods and services representative of the average consumer. It thus reflects the general price level for the economy, and serves as the most appropriate measure for assessing and comparing purchasing power over time.

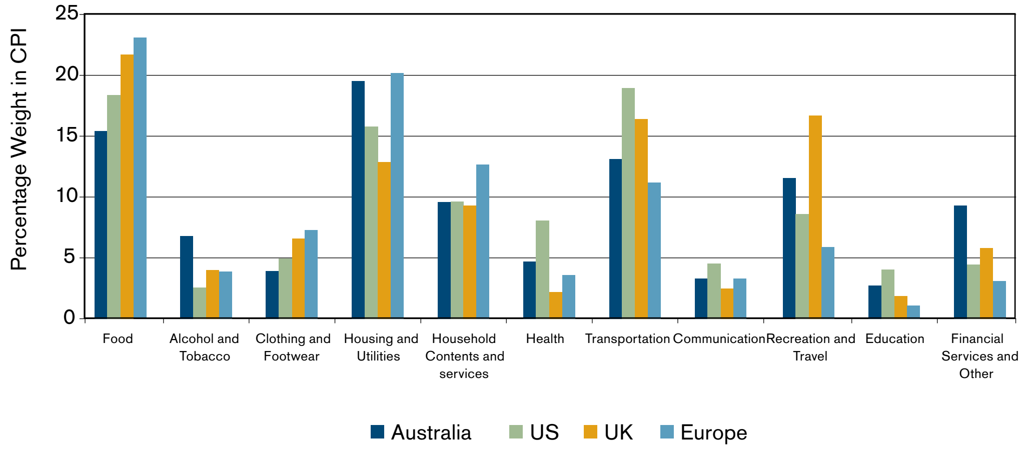
Throughout this report, four major economic regions / countries are discussed and analysed:

- Australia
- UK
- US
- Euro-zone

As the Euro-zone constitutes a large number of countries, the relevant price index used is the Harmonised Index of Consumer Prices (HICP).

Changes in the CPI will reflect changes in both the price levels for each good or service in the index, and changes in the weights used to define what constitutes the standard basket of goods and services in each region/country. Figure 2 below illustrates the absolute and relative weights of these categories across each region/country.

FIGURE 2: COMPONENT WEIGHTS OF CPI IN EACH REGION[1]



As can be seen, there is broad comparability of the component weightings across the various regions/countries. There are some differences in the food, housing and utilities, transport, and recreation and travel components, which largely reflect cultural differences. These components are also the largest components of the CPI and will thus influence inflation more than the others. The choice of the relative component weightings give rise to alternative measures of inflation such as

1 Source: Milliman research based upon data sourced from the Australian Bureau of Statistics (CPI 15h Series), the European Central Bank (HICP 2010), Office of National Statistics (CPI Updated Weights for 2010), US Department of Labor Bureau of Labor Statistics (CPI Dec-2009). Re-categorisation of some components of each index were made in order to achieve comparability; with the removal of owner equivalent rents in the US CPI due to their exclusion in the other measures of CPI.

the retail price index (RPI) and producer price index (PPI). Although these measures are used in some countries for some purposes, the CPI is the most relevant index to capture broad consumption patterns and trends. It is thus the most relevant index to reference for general consumption needs against which protection and guaranteed solutions can be structured around.

2.3 Inflation Risk

Inflation risk comes in many different forms, including hyperinflation, deflation, moderately high inflation, and inflation spikes. We briefly discuss each of these in turn.

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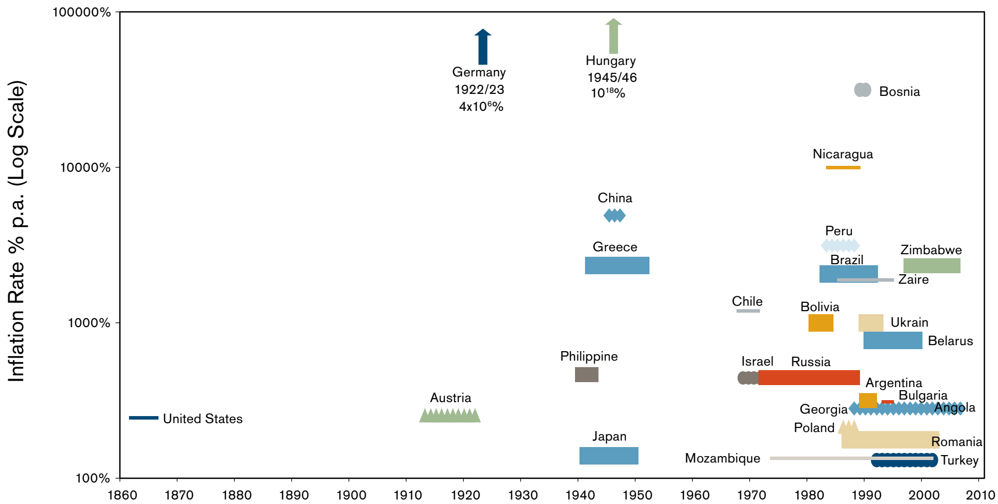
2.3.1 Hyperinflation

The most damaging of all inflation risks is hyperinflation. Hyperinflation occurs when inflation is at extreme levels, typically in excess of 50% per month,[2] with there being no tendency for it to revert back to normal levels. It is brought on by the government printing money that is not supported by a corresponding growth in the output of goods and services. This results in a loss of confidence in the currency, which leads to a severe loss in currency value and subsequent consumer purchasing power.

Hyperinflation has occurred many times across many economies. Figure 3 below shows examples of hyperinflation that have occurred over the last century or so. In the recent past, hyperinflation has been mainly restricted to the emerging economies of Eastern Europe and South America.

FIGURE 3: EXAMPLES OF HYPERINFLATION OVER THE LAST 150 YEARS



2 As defined by International Accounting Standard 1.

One notable recent example of hyperinflation occurred in Zimbabwe over the last decade. Shortly before the government abandoned the currency in 2009, it printed the 100 trillion dollar bill, as shown in Figure 4 below.

FIGURE 4: $100 TRILLION ZIMBABWE DOLLAR NOTE ISSUED IN 2009

Whilst hyperinflation is always a possibility, the prevalence of independent central banks throughout the developed world means that this risk could be considered to be lower relative to past history.

2.3.2 Deflation

Deflation occurs when the level of prices decreases, resulting in a negative inflation rate.

The impact of deflation is different for different people. Deflation benefits those who have significant liquid financial wealth (the *savers* and *lenders*), as their financial wealth increases their real purchasing power. These people tend to be those nearing or at retirement. Conversely, deflation harms those who have low financial wealth or significant borrowings (the young and *borrowers*), as their human capital is reduced through lower wages and future loan repayments increase in real monetary terms. These people tend to be in the 20-45 age categories, older people who haven't provisioned enough for retirement, or those with significant personal leverage through borrowings.

A deflationary environment can still lead to problems for pre-retirement savers and retirees, since it tends to be associated with periods of low or negative economic growth.

A deflationary environment can still lead to problems for pre-retirement savers and retirees, since it tends to be associated with periods of low or negative economic growth. This can lead to increased risk of loss of human capital via job loss or reduced income, and may cause increasing bankruptcies in financial and institutions and corporate companies that may also impact investment returns, counterparty risks and liquidity risks that impact the financial position of consumers.

Table 1 below outlines some notable examples of deflationary periods that have occurred over the last 100 years.

TABLE 1: EXAMPLES OF DEFLATIONARY PERIODS

COUNTRY	YEARS	DEFLATION TOTAL IMPACT	DEFLATIONN % PER ANNUM	EVENT / CAUSE
UNITED STATES	1921 TO 1932	-32%[3]	-3.2%	GREAT DEPRESSION
UNITED KINGDOM	1920 TO 1933	-37%[4]	-3.6%	GREAT DEPRESSION
AUSTRALIA	1929 TO 1933	-22%[5]	-6.1%	GREAT DEPRESSION
WEST GERMANY	1949 TO 1950	-7%[6]	-3.7%	END OF WORLD WAR II
JAPAN	1999 TO 2009	-4%[7]	-0.4%	CAPITAL MARKET BUST
HONG KONG	1999 TO 2004	-15%[8]	-2.6%	ASIAN FINANCIAL CRISIS
IRELAND	2009	-5%[9]	-5.0%	CREDIT CRISIS, BANKING DEBTS

As at the time of writing, there was considerable debate as to whether developed economies would experience a bout of deflation as a result of the credit, banking and subsequent government debt crisis of 2008–2009.

2.3.3 Normal Inflation

Between the two extremes of hyperinflation and deflation, lies a *normal* inflation environment. *Normal* in this sense means that inflation is generally considered to be under control, facilitating a productive economic environment for all participants. This may vary somewhat from country to country as central banks target different inflation tolerance or target ranges, and also between developed and developing countries. For most developed countries, a *normal* inflation environment might mean inflation between 0% and 10% in any given year, with longer-term averages being between 0% and 5%.

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3 US Department of Labor, Bureau of Labor Statistics, ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt.
4 UK Office of National Statistics, www.statistics.gov.uk/statbase/TSDdownload1.asp.
5 Reserve Bank of Australia, www.rba.gov.au/inflation/measures-cpi.html#year_ended.
6 Federal Statistical Office of West Germany, www.bundesbank.de/statistik/statistik_zeitreihen.en.php?lang=en&open=&func=list&tr=www_s311_lr_vpi.
7 Japanese Statistics Bureau, www.stat.go.jp/english/data/cpi/index.htm.
8 Census and Statistics Department, The Government of the Hong Kong Special Administration, www.censtatd.gov.hk/hong_kong_statistics/statistics_by_subject/index.jsp?charsetID=1&subjectID=12.
9 Central Statistics Office Ireland, Consumer Price Index www.cso.ie/releasespublications/documents/prices/current/cpi.pdf.

The following graphs and tables outline the official long-term inflation experience of the four main economies under consideration in this paper.

FIGURE 5: ANNUAL AND ROLLING FIVE-YEAR CHANGES IN THE US CONSUMER PRICE INDEX[10]

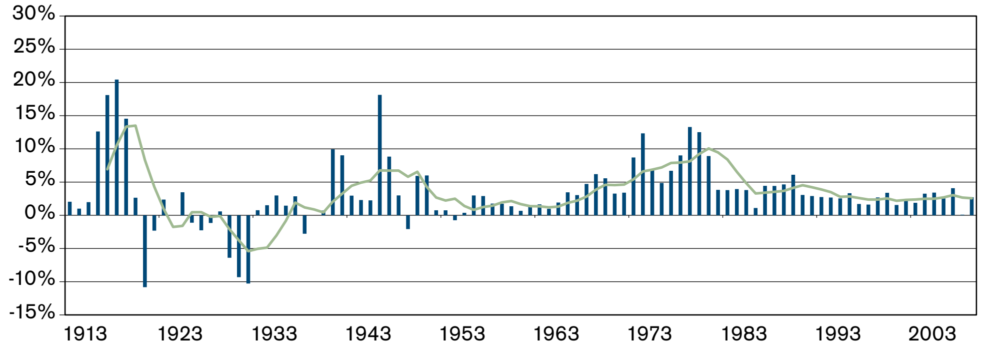


FIGURE 6: ANNUAL AND ROLLING FIVE-YEAR CHANGES IN THE UK CONSUMER PRICE INDEX[11]

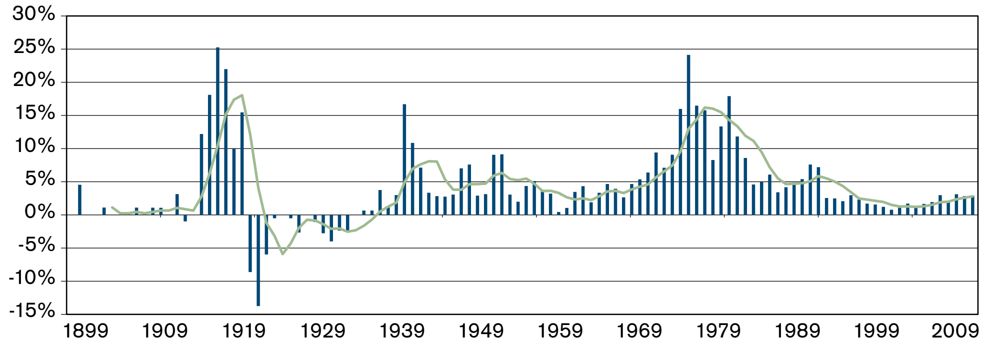
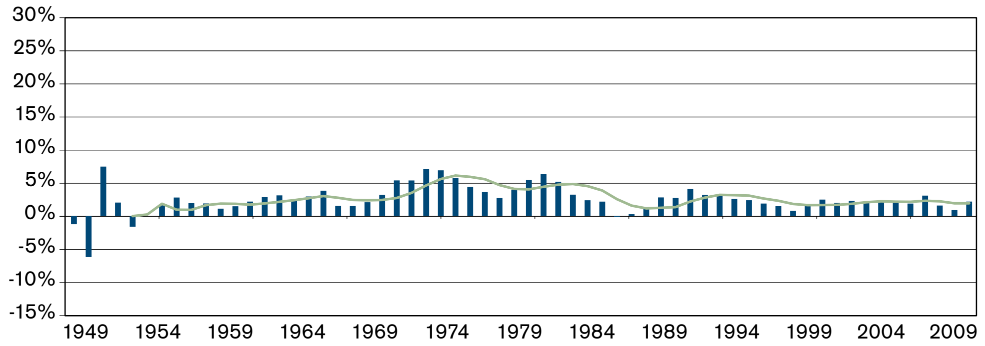


FIGURE 7: ANNUAL AND ROLLING FIVE-YEAR CHANGES IN EUROPEAN INFLATION (WEST GERMANY CPI FROM 1949 TO 1990, EURO HICP FROM 1991 TO 2009)[12]



10 Sourced from US Department of Labor, Bureau of Labor Statistics.

11 Sourced from UK Office of National Statistics, Composite Price Index from 1900 to 1987, Consumer Price Index from 1988.

12 Sourced from Federal Statistical Office of West Germany and European Central Bank.

FIGURE 8: ANNUAL AND ROLLING FIVE-YEAR CHANGES IN THE AUSTRALIAN CONSUMER PRICE INDEX[13]

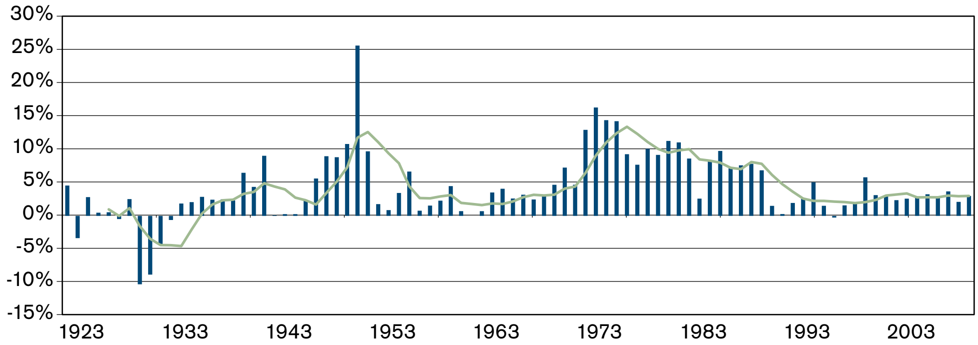


TABLE 2: INFLATION RATE ANALYSIS TO 2010

	START	MEAN	ST. DEV.	1YEAR AUTO-CORRELATION	DISTRIBUTION OF ANNUAL INFLATION RATES <0%	>0% AND <5%	>5% AND <10%	>10%
US	1990	2.7%	1.2%	-0.12	0%	95%	5%	0%
AUSTRALIA	1990	2.7%	1.7%	0.06	5%	81%	14%	0%
UK	1990	2.5%	1.8%	0.75	0%	90%	10%	0%
EUROZONE	1990	2.2%	0.8%	0.50	0%	100%	0%	0%
US	1950	3.7%	2.9%	0.74	2%	82%	16%	5%
AUSTRALIA	1950	5.3%	4.8%	0.66	2%	74%	25%	15%
UK	1950	5.3%	4.8%	0.81	0%	77%	23%	11%
EUROZONE	1950	2.6%	2.1%	0.37	5%	80%	15%	0%
US	1913	3.2%	5.0%	0.65	11%	76%	13%	8%
AUSTRALIA	1923	4.1%	5.0%	0.68	8%	69%	23%	10%
UK	1900	4.1%	6.1%	0.75	11%	74%	15%	14%
EUROZONE	1948	2.5%	2.2%	0.42	6%	79%	15%	0%

From the above analysis it can be seen that:

- The last 20 years has seen a very benign inflationary environment for all economies, with inflation averaging in the 2% to 3% range, and inflation volatility in the 1% to 2% range (as measured by the standard deviation of annual inflation rates).
- Inflation is significantly higher and more volatile over longer time periods, particularly for the UK, Australian and US economies, experiencing bouts of both deflationary and high inflationary periods.
- Inflation tends to exhibit characteristics such as regime switching, moving from periods of persistent high to persistent low inflation, with strong positive autocorrelation. Positive autocorrelation measured on a one-year time lag is very high at around +0.6 to +0.8, which means that a increase in annual inflation is more likely to be followed by another increase, and vice versa. Interestingly, over the last 20 years, the US and Australian markets do not exhibit this characteristic, in contrast to the UK and Eurozone markets, which do.

13 Sourced from Reserve Bank of Australia.

There is a significant risk in looking solely at recent inflationary history for a single market as an indication for what the future may hold.

The analysis presented in this section provides a broad indication of the various types of inflationary environments that have existed over time and across a number of markets. The key point of conclusion is that there is a significant risk in looking solely at recent inflationary history for a single market as an indication for what the future may hold. Inflationary environments tend to persist for time spans on the scale of decades, but can undergo significant yet gradual shift to new environments over time spans beyond this that are of central importance to the needs of retirement provision for consumers.

2.3.4 Currency-related Inflation

Inflation risk can also arise due to the importation of goods and services. As economies become increasingly interdependent, the consumption basket contains a larger proportion of goods and services that are imported from other countries. Domestic inflation risk can then arise due to two additional sources:

1. Foreign inflation that is imported directly
2. Home currency devaluation that causes the local price of foreign goods and services to increase

In this way consumers can be significantly impacted due to both the economic policies of foreign nations and domestic exchange rate policy of the government or central bank.

2.3.5 Impact of Inflation

Inflation leads to a loss of purchasing power. The extent of this loss is dependent upon the average level of inflation over the investment horizon. The above analysis has shown that inflation has averaged around 2.5% over the last two decades for the four economic regions, but has been significantly higher over longer time periods such as since the 1950s. The following table shows the loss in real purchasing power if inflation averages 2.5% and 5% over investment horizons of 5, 10, 15, 20, 30 and 40 years.

TABLE 3: IMPACT OF INFLATION ON REAL PURCHASING POWER

INFLATION	INVESTMENT HORIZON (YEARS)					
RATE P.A.	5	10	15	20	30	40
2.5%	88%	78%	69%	61%	48%	37%
5%	78%	61%	48%	38%	23%	14%

Clearly the impact of inflation plays a critical role when investing current wealth to meet future consumption needs over medium to long time frames.

Even in relatively benign and typical inflationary environments where inflation averages 2.5% p.a., purchasing power is reduced by 22% over only 10 years, and over 50% after 30 years. However, this effect is significantly amplified if inflation is higher, at say 5%, where almost 40% of purchasing power is lost after only 10 years, and over 60% after 20 years. Clearly the impact of inflation plays a critical role when investing current wealth to meet future consumption needs over medium to long time frames.

3 EXISTING INFLATION-LINKED INVESTMENTS AND STRUCTURES

The need for inflation protection identified in section 2 has existed for a long time. Not surprisingly, various retail, occupational and public savings, investment and pension vehicles exist that are designed to meet these needs. These include:

- Defined benefit pensions
- Inflation-indexed annuities
- Inflation-guaranteed bonds
- Variable annuities or investment/unit-linked with guarantees
- Social security

In addition to these products, all of which provide benefits that are explicitly linked to an inflation-index, investments in asset classes such as equities, fixed income, and property can be used to potentially generate returns that may be correlated to, and ideally in excess of, inflation.

The following sub-sections outline the inflation-linked characteristics of each of these vehicles.

3.1 Defined Benefit Pensions

The most significant solution to the provision of post-retirement inflation protection in the world today is the occupational defined benefit pension plan.

The most significant solution to the provision of post-retirement inflation protection in the world today is the occupational defined benefit pension plan. These plans are provided by employers to employees, which promise to pay a proportion of (typically) final salary in the form of an inflation-indexed lifetime annuity. Employers effectively underwrite all the risks in the plan, as they are liable for meeting the pension obligations. Whilst modern accounting standards reflect this by placing this liability on the sponsor's balance sheet,[14] this historically has not always been the case. The consequence of this is that these benefits were not *priced* or charged for on a fair market basis at the time they were made, giving an incentive to their creators to provide generous benefits that subsequently proved to be very costly to employers. The consequence of this is that DB pension plans are in significant decline, with the vast majority now closed to new members and thus effectively in run-off.[15]

Despite their lack of use for relatively young and new employees, there is a large number of people who have part of their retirement related assets in these plans. This is particularly true for the Baby Boomer generation that started reaching retirement around 2010. Thus, many people will be relying on the inflation-protection characteristics of these retirement plans to meet their post-retirement needs.

DB pensions exist in most economies in the world, with the largest being the developed markets of the UK, US and Japan. Given its size and importance, we use the UK to illustrate how these benefits are structured with respect to inflation risk. DB pension plans in the UK provide alternative forms of inflation protection depending upon the three types of member status: actives, deferreds and pensioners.

3.1.1 Pensioners

Pensioners are members who were previously employees who have reached retirement age.

For pensions in payment to pensioners, annual payments are indexed to inflation (typically the RPI). A typical scheme would then subject this annually to a maximum increase of 5% and a minimum increase of 0% (i.e., they cannot fall in nominal terms). This is known as Limited Price Indexation

14 For example, refer to International Accounting Standard IAS19.
15 Notwithstanding that existing active employees/members are still accruing additional benefits for the remainder of their current employment term.

(LPI). However, differences between schemes exist such that the floors may be higher than 0% and the caps may be lower than 5% (2.5% is also somewhat common).

3.1.2 Deferreds

Deferred members are those who were previously employees, but are no longer actively employed by the employer and who have not yet reached retirement age.

For these members, UK legislation requires minimum increases in deferment of inflation with a cumulative cap at 5% p.a. and floor at 0%.[16] Note that this is different to the increases applied to pensions in payment, where inflation caps and floors are applied on an annual basis. As a consequence, deferred pensioner benefits depend on when the members became a deferred member (left employment) and when they expect to retire. For example, if inflation has been low for some time (such as in the last 10 years) and it increases above 5%, then increases in deferred pension amounts will not be capped each year at 5%, but rather increase in line with inflation until the 5% cumulative cap is hit.

3.1.3 Actives

Active members are those who are actively employed by the employer. For these members, accrued pension benefits are linked to individual salary inflation, which can be considered to constitute inflation plus real salary growth.

Given all the above inflation-linked benefit components, it is clear that the inflation protection provided to the member is highly specific to the characteristics of that member: their dates of employment entry, employment termination, retirement, as well as their personal salary profile (i.e., real salary inflation). The end result is a post-retirement income stream that is indexed to inflation, capped at around 5% p.a. and floored at 0%. This pension income stream is ideally suited to meeting the core expenditure needs of retirees.

3.2 Inflation-indexed Annuities

Inflation-indexed annuities are the simplest retail product designed to provide post-retirement income with all inflation and longevity risk transferred to the insurer.

Inflation-indexed annuities are the simplest retail product designed to provide post-retirement income with all inflation and longevity risk transferred to the insurer.[17] Annuity payments are simply indexed to a broad measure of consumer inflation such as the CPI. The initial annuity payment levels are lower compared to a fixed-level annuity, although they will increase over time in line with realised inflation. Effectively, the policyholder is receiving a lifetime income that stays constant in real terms, thus protecting their standard of living. By contrast, although the initial annuity level may be higher for a fixed-level annuity, it will decline in real terms over time as inflation erodes its purchasing power, hence leading to a decline in living standards.

The UK annuity market is one of the most established and mature annuity markets in the world, with a range of annuity products on offer. The most popular annuity product is the fixed-level annuity, although providers also sell inflation-indexed annuities that increase in line with inflation either in full or capped at a specified level such as 3% or 5% p.a. They thus provide an ideal income stream to meet the core expenditure needs of retirees. They can also be purchased with deferral periods which are ideal for those who have reached retirement age but do not require income immediately.

Inflation-indexed annuities constitute around 10% of total annuity sales in the UK market (around £1 billion p.a.). Given the inflation-risk-mitigating properties of inflation-indexed annuities, it is perhaps surprising to see a relatively low penetration rate of inflation-indexed sales. The behavioural factors leading to this result are:

16 Although at the time of print, legislative proposals were tabled to reduce the cap to 2.5%.

17 In some markets, alternative annuity structures also exist on a pooled basis where the insurer doesn't underwrite risks such as longevity, but rather the members share in the collective experience of the pool.

- Heavy focus on the headline annuity rate and the starting income level differences between a fixed nominal and inflation-linked annuity. Starting income levels for inflation-linked annuities will always be lower relative to a fixed annuity and thus be perceived to offer a less attractive benefit. This comparison dominates the comparison of future income relativities which will vary depending upon realised inflation.

- Lack of awareness/understanding of inflation risk exposure and how this is mitigated under an inflation-indexed annuity but not a fixed-level annuity.

- Hyperbolic discounting, in which people tend to over-value near-term benefits and undervalue long-term benefits (equivalent to using progressively higher future discount rates when making value assessments and comparisons).

The US market also provides inflation-indexed single-premium immediate annuity (SPIA) contracts. These typically have no cap on inflation increases, but provide either a 0% floor on either a cumulative or annualised basis.

Escalating annuities are also sometimes put forward as a product that provides inflation protection. However, in the pure sense, they don't provide any inflation protection as the benefit increases at a pre-specified rate, rather than one which is linked to an inflation-index. Consequently, they can only provide an income stream that increases in nominal terms over time, which will reduce the impact of whatever future inflation scenario is realised.

Similarly, there are many other examples of products that are marketed as providing *inflation protection* through the use of fixed, pre-specified increases to guaranteed benefit levels. These include various types of fixed annuity, with-profits and variable annuity products. Similar to escalating annuities, in reality these do not provide any inflation protection and their payment profiles can be readily approximated via an investment portfolio with an escalating allowable withdrawal rate.

There are many other examples of products that are marketed as providing *inflation protection* through the use of fixed, pre-specified increases to guaranteed benefit levels. These include various types of fixed annuity, with-profits and variable annuity products.

3.3 Inflation-guaranteed Bonds

Although not now currently available, historically some UK insurance companies sold guaranteed inflation bonds to retail customers. Such bonds were structured as with-profits bonds[18] that provided guarantees linked to inflation over a period of five years or more. These were available to onshore UK investors linked to the RPI, as well as to offshore investors linked to their relevant inflation-index such as the CPI in the US. Historically, insurance companies did not explicitly charge for these guarantees, resulting in product closures due to spiralling guarantee costs in the wake of the 2008–2009 credit crisis.

Another example of a similar product was the Italian Post Office equity-linked note product sold in the early 2000s. This product had either a 5- or 10-year maturity, which paid 50% of any appreciation in the specified equity index, with the real value of the initial principal payment guaranteed via it being indexed to the HICP. This product was primarily used for general savings and pre-retirement purposes.

3.4 Variable Annuities or Investment/Unit-linked With Guarantees

Variable annuity or investment/unit-linked with guarantee products provide guarantees upon managed funds. The guarantees can be structured in a number of different ways, such as to provide capital protection upon survivorship (GMAB) or death (GMDB), minimum income levels (GMIB) and minimum withdrawal benefits (GMWB). These terms are defined in the table below.

18 This is a retail investment product whereby the insurer manages the pool of assets collectively across all policyholders and credits smoothed investment returns to policies based upon actual returns experienced over longer time periods.

TABLE 4: DEFINITIONS OF ALTERNATIVE VARIABLE ANNUITY PRODUCT DESIGNS

ACRONYM	PRODUCT	DEFINITION
GMAB	GUARANTEED MINIMUM ACCUMULATION BENEFIT	PROVIDES A MINIMUM FUND VALUE UPON SURVIVORSHIP TO SPECIFIED TERM
GMDB	GUARANTEED MINIMUM DEATH BENEFIT	PROVIDES A MINIMUM FUND VALUE UPON DEATH
GMIB	GUARANTEED MINIMUM INCOME BENEFIT	PROVIDES A MINIMUM ANNUITY INCOME LEVEL UPON ANNUITISATION AT A SPECIFIED AGE OR TERM
GMWB	GUARANTEED MINIMUM WITHDRAWAL BENEFIT	PROVIDES A MINIMUM WITHDRAWAL AMOUNT FOR A FIXED TERM
GLWB	GUARANTEED LIFETIME WITHDRAWAL BENEFIT	PROVIDES A MINIMUM WITHDRAWAL AMOUNT FOR LIFE

The underlying funds can be a range of active and passively managed funds invested in a range of asset classes, with a key requirement being that they must be hedgeable to within an acceptable degree of error.

Guaranteed products designed to synthesise an income stream such as GMIB, GMWB and GLWB products have traditionally been designed to provide nominal benefit structures. However, there have been a limited number of launches of inflation-indexed GLWB products in the latter half of the past decade in the US Variable Annuity market.[19] These products provide guaranteed withdrawal amounts for life that can increase to meet either inflationary increases, or increases in the underlying account value (i.e., a market-based ratchet). This type of product enables the policyholder to remain invested in and benefit from the attractive market exposure, whilst still being guaranteed an inflation-adjusted income for life, regardless of subsequent market performance.

Section 4 of this report investigates alternative product structures that may also be provided to synthesise equivalent inflation-indexed benefits to meet customer needs.

3.5 Social Security Retirement Benefits

The aged pension provided by the state provides a base level of income during retirement. This income is subject to ongoing review by the government, and is typically increased in line with broad measures of inflation. However, there is no guarantee that the government will increase it at the level of inflation, nor reduce it during times of deflation. Thus, whilst it does provide reasonable inflation protection, it is not guaranteed and is a declining part of overall retirement wealth and income for many, particularly those in the mass affluent and high-net-worth market segments.

This form of social security is common throughout developed markets such as the US, UK, Australia and most European countries.

Various asset classes may be considered to have some inflation-protection properties. Investments in such assets may provide the ability to either hedge or diversify away the risks of inflation-linked liabilities.

3.6 Inflation-protection Characteristics of Various Asset Classes

Unlike the previous vehicles which provide explicit inflation-linked benefits, various asset classes may be considered to have some inflation-protection properties. Investments in such assets may provide the ability to either hedge or diversify away the risks of inflation-linked liabilities. In this sub-section we briefly discuss the evidence for various asset classes to perform this role.

3.6.1 Equities

Traditional arguments for equities being an inflation hedge reflect the notion that expected inflation will be reflected in expected corporate revenue growth, earnings and dividend levels. Current equity

19 For example, the Penn Mutual Purchasing Power Protector product at: https://www.pennmutual.com/pmlwebsite/pages/PML_Public/misc/home/ppp/page_12710.html.

valuations and returns should theoretically be relatively insensitive to the level of expected inflation, as higher nominal cash flows (revenue, earnings, dividends, etc.) are offset by higher nominal discount rates. Expected equity returns will thus reflect the higher level of expected inflation, maintaining real equity returns in light of persistent inflation.

The empirical evidence on this hypothesis is mixed. Many studies[20] focusing on the correlation between short-term (i.e., annual) equity returns and inflation find that changes in inflation are close to zero or even negative. There are a variety of factors that may cause this, including time lags and the differences in pricing power between firms. In 1981, Fama attempted to explain this empirical negative correlation with a *proxy theory* that stated that this is a proxy for positive correlation between equity returns and real variables of economic activity that are negatively correlated to inflation.

Figure 9 shows the return history of the US equity market against US inflation over the last 20 years.

FIGURE 9: US EQUITY RETURNS VERSUS US INFLATION (SOURCE: BLOOMBERG)

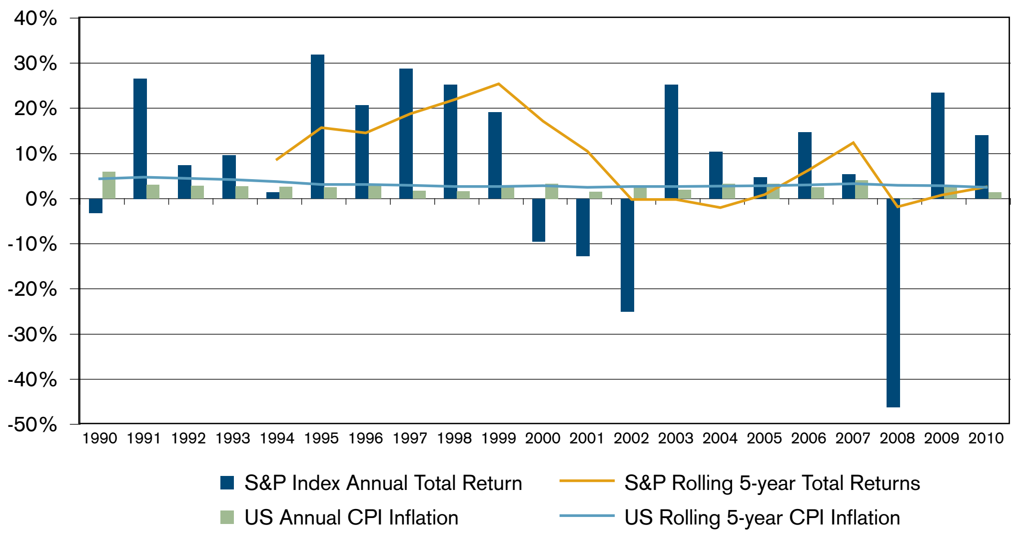


Table 5 outlines the return characteristics of this market, as well as the UK and Australian equity markets over the last 20 years to 2010.

TABLE 5: EQUITY MARKET RETURN STATISTICS FROM 1990 TO 2010 FOR THE S&P500 TOTAL RETURN INDEX, ASX ALL ORDINARIES ACCUMULATION INDEX, AND FTSE100 TOTAL RETURN INDEX (SOURCE: BLOOMBERG DATA)

ECONOMY	START YEAR	NOMINAL MEAN RETURN	REAL MEAN RETURN	STANDARD DEVIATION (NOMINAL)	PROBABILITY <0% (NOMINAL)	1-YEAR AUTO-CORRELATION	CORRELATION TO INFLATION
US	1990	8.2%	5.6%	19.4%	24%	0.05	0.16
AUSTRALIA	1990	9.2%	6.4%	19.9%	24%	-0.47	-0.34
UK	1990	7.9%	5.4%	17.0%	29%	0.06	0.02

20 Refer to Bodie (1976), Fama (1981), Geske et at (1983), Kaul (1987), Martin (2010), Sharpe (2002).

Whilst equities are poor hedges of inflation over short to medium time horizons, they are increasingly likely to be positively correlated to inflation over longer horizons and produce attractive real returns.

As can be seen, based upon one-year investment holding periods, correlations are low to negative, despite all markets producing positive mean real returns. Over this period, equity markets were a poor hedge for inflation. Figure 9 also shows that in 5 of the last 10 years, cumulative equity returns have been below inflation measured over a five-year investment holding period (note, however, that these are not independent events).

These findings are in contrast to other empirical studies[21] that show increasingly positive correlations for longer investment holding periods. These studies show that the purchasing power of equities tends to be preserved over long (10+) investment holding periods.

The overall conclusion from the literature and simple analysis conducted in this report is that whilst equities are poor hedges of inflation over short to medium time horizons, they are increasingly likely to be positively correlated to inflation over longer horizons and produce attractive real returns. This suggests that from an investment strategy and product design perspective, equity exposure is very useful for long-term investment periods, but should not be relied upon to hedge inflation over short to medium terms.

3.6.2 Inflation-linked Bonds

Inflation-linked bonds are designed to provide investors with real returns via either principal or interest payments being explicitly linked to realised inflation.

There are a large number of retail investment funds that invest in securities such as TIPS issued by the US Treasury, inflation-indexed gilts issued by the UK Treasury, and inflation-linked bonds issued by governments in Australia, Canada, France, Greece, Italy and Germany. A number of state-based government and private companies have also issued such securities, as they can typically obtain cheaper financing relative to the nominal market and their income sources are highly correlated to inflation which reduces their P&L risk.

Whilst these types of securities provide returns that are linked to measures of inflation, their market value can still fall below the level of inflation over short time periods (e.g., rising real interest rates on long-dated TIPS). As a consequence, these funds generally do not provide explicit inflation guarantees over short investment horizons, although they can be constructed in such a way as to provide this by investing in shorter-dated securities.

[21] Refer to Boudoukh et al (1993), Wei et al (1992), Ely et al (1997), Du (2006), Pilotte (2003).

Figure 10 below shows the return history of the US TIPS market relative to inflation over the last decade.

FIGURE 10: 10-YEAR CONSTANT DURATION ZERO COUPON BOND TOTAL RETURNS DERIVED FROM YIELDS ON US TIPS VERSUS US CPI (SOURCE: US TRAEASURY)

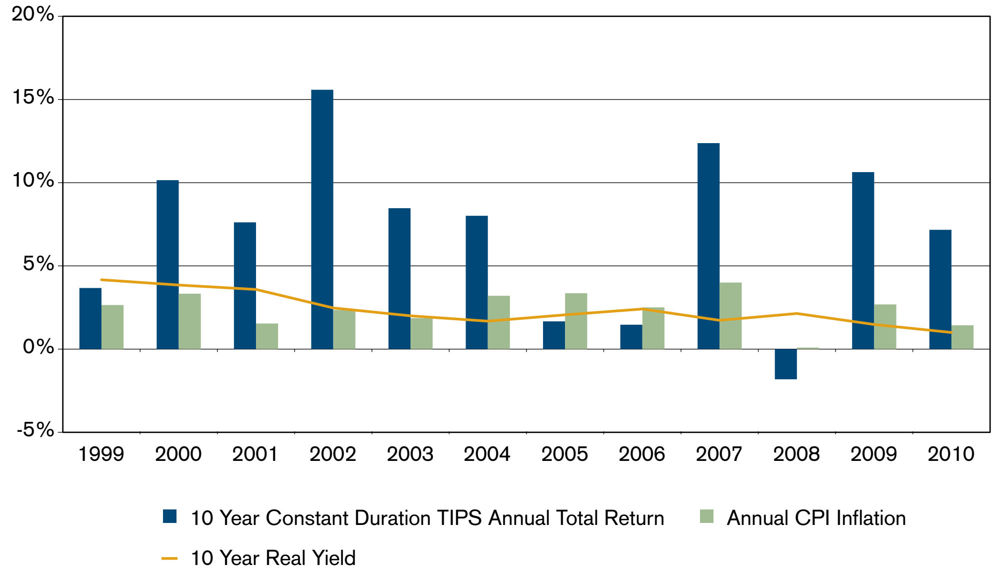
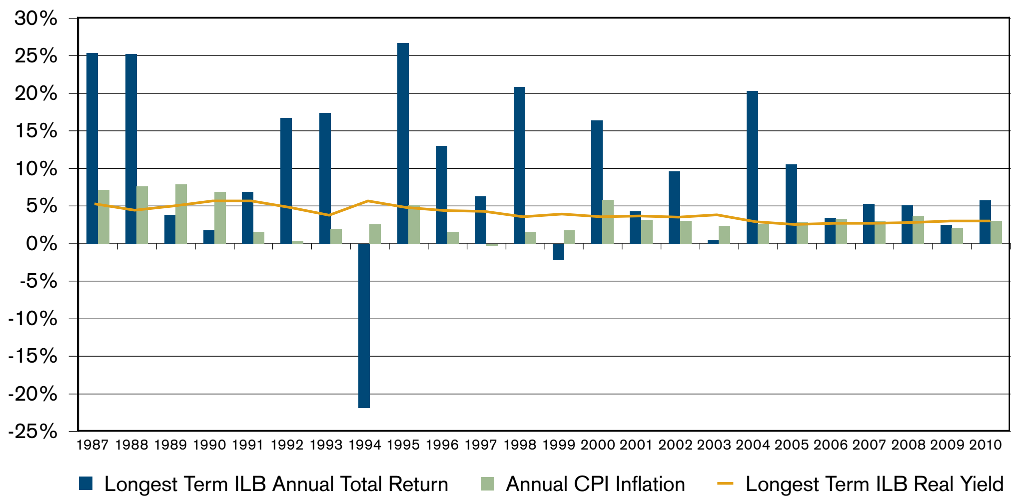


Figure 11 below shows the return history of the Australian inflation-linked bond market[22] relative to inflation over the last 24 years.

FIGURE 11: AUSTRALIAN INFLATION-LINKED BOND TOTAL RETURNS VERSUS AUSTRALIAN CPI (SOURCE: MILLIMAN ANALYSIS BASED ON RBA DATA FOR LONGEST MATURITY BOND)



[22] Based upon the Reserve Bank of Australia (RBA) data for the longest-dated outstanding bond.

The following table outlines the return characteristics of the inflation-linked bond markets in the US, Australia and the UK to 2010.

TABLE 6: 10-YEAR CONSTANT-DURATION ZERO-COUPON BOND TOTAL RETURNS DERIVED FROM YIELDS ON US TIPS (SOURCE: US TREASURY) AND UK INFLATION-INDEXED GILTS (SOURCE: BANK OF ENGLAND), LONGEST-DURATION AUSTRALIAN INFLATION-LINKED BOND RETURNS (SOURCE: RBA)

ECONOMY	START YEAR	NOMINAL MEAN RETURN	REAL MEAN RETURN	STANDARD DEVIATION (NOMINAL)	PROBABILITY <0% (NOMINAL)	1-YEAR AUTO-CORRELATION	CORRELATION TO INFLATION
US	1999	7.1%	4.3%	5.0%	8%	-0.27	0.43
AUSTRALIA	1988	9.3%	6.0%	10.8%	8%	-0.30	0.24
UK	1986	6.8%	4.0%	4.7%	4%	-0.06	0.24

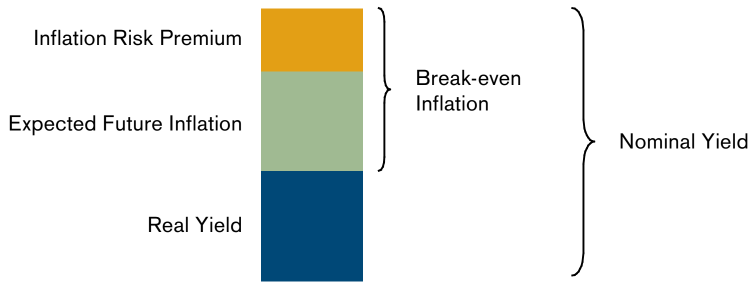
The above analysis highlights that inflation-linked bonds are capable of producing returns that are reasonably positively correlated to realised inflation over long time periods. However, over short time periods, they can still underperform inflation due to rising real interest rates and can decouple from it when real rates are volatile.

Nominal bonds provide investors with fixed nominal future cash flows. Investors are exposed to inflation risk when they invest in these investments, as the future real value of these cash flows are uncertain.

3.6.3 Nominal Bonds

Nominal bonds provide investors with fixed nominal future cash flows. Investors are exposed to inflation risk when they invest in these investments, as the future real value of these cash flows are uncertain. Figure 12 below shows the classic Fisher relationship between nominal and real bond yields.

FIGURE 12: FISHER RELATIONSHIP BETWEEN NOMINAL AND REAL BONDS



Nominal yields are composed of real yields, which are observed in the inflation-linked bond market; expected future inflation, which is relatively subjective and measured through surveys; and an inflation risk premium, which compensates investors for bearing inflation risk. Break-even inflation represents the inflation level that would need to be realised over the investment horizon for returns to be identical between inflation-linked and nominal bonds. It is measured as the difference between nominal and real yields, and is comprised of the sum of expected future inflation and the inflation risk premium. It tends to be highly positively correlated to actual inflation as shown by Table 7 below. Detailed annual graphs of this relationship for each economy are presented in Appendix C.

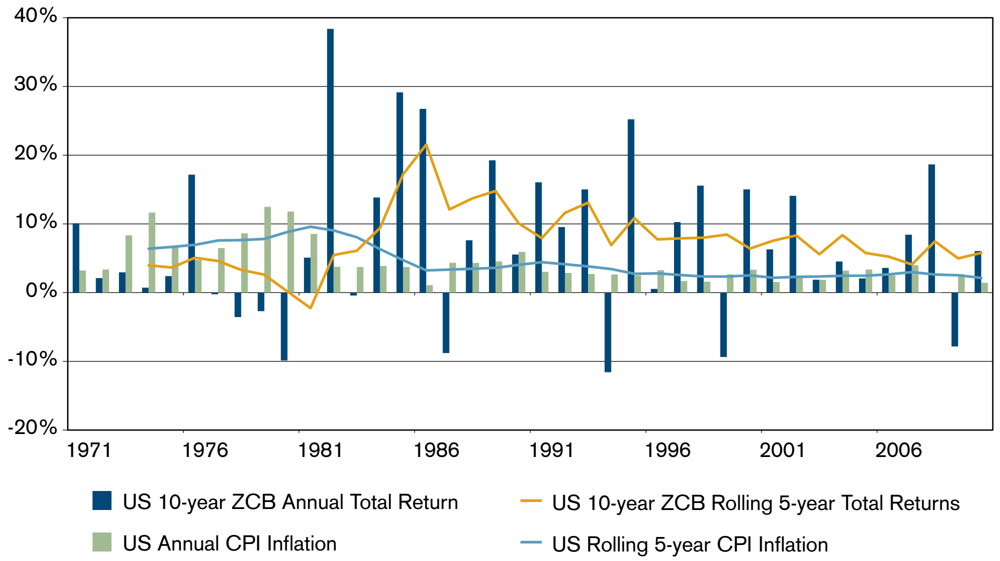
TABLE 7: CORRELATION OF REALISED INFLATION VERSUS BREAK-EVEN INFLATION FOR VARIOUS MARKETS		
ECONOMY	**PERIOD**	**CORRELATION TO INFLATION**
US	**1988 – 2010**	**0.67**
AUSTRALIA	**1986 – 2010**	**0.77**
UK	**1986 – 2010**	**0.75**

Numerous studies have been undertaken to assess the inflation risk premium for various markets and time periods.[23] The broad conclusions about the inflation risk premium derived from these are:

- It is relatively small, generally averaging below 50 bps.
- It varies over time in response to economic activity, actual inflation levels and future inflation uncertainty.
- It typically has an upward sloping term structure.

Figure 13 below shows the return history of the US nominal bond market relative to inflation since the early 1970s.

FIGURE 13: US 10-YEAR CONSTANT-DURATION ZERO-COUPON BOND TOTAL RETURNS VERSUS US CPI (SOURCE: MILLIMAN ANALYSIS BASED ON BLOOMBERG DATA)



Not surprisingly, during the periods of rising inflation of the 1960s, 1970s and early 1980s, nominal bonds significantly underperformed inflation. This reversed in the subsequent decades during periods of declining inflation and bond yields. Similar behaviour is also exhibited by the Australian and UK markets.

23 Refer to Hordahl (2008).

The following table outlines the return characteristics of the nominal bond markets in the US, Australia and the UK to 2010.

TABLE 8: 10-YEAR CONSTANT-DURATION ZERO-COUPON BOND TOTAL RETURNS BASED ON YIELDS OF US TREASURY BONDS, AUSTRALIAN TREASURY BONDS AND UK GILTS (SOURCE: MILLIMAN ANALYSIS BASED ON BLOOMBERG DATA)

ECONOMY	START YEAR	NOMINAL MEAN RETURN	REAL MEAN RETURN	STANDARD DEVIATION (NOMINAL)	PROBABILITY <0% (NOMINAL)	1-YEAR AUTO-CORRELATION	CORRELATION TO INFLATION
US	1971	7.5%	3.2%	11.2%	23%	-0.16	-0.37
AUSTRALIA	1970	8.5%	2.6%	12.2%	22%	-0.04	-0.17
UK	1971	9.2%	3.3%	13.5%	23%	-0.17	0.16

The above analysis highlights that nominal bonds are a poor hedge for inflation given their sensitivity to movements in real yields, expectations of future inflation and inflation risk premium. The US and Australian markets have shown that they are negatively correlated with inflation and can suffer from negative nominal returns on average almost one in every four years. Despite this, they are still capable of generating positive real returns over very long holding periods and full interest rate cycles.

3.6.4 Cash

Similarly to nominal bonds, cash guarantees short-term nominal cash flow payments. The following table outlines the return characteristics of the cash markets in the US, Australia and the UK to 2010.

TABLE 9: CASH RETURNS DERIVED FROM US FED FUNDS RATE (SOURCE US TREASURY), AUSTRALIAN 90-DAY BANK BILL RATE (SOURCE RBA), AND UK OFFICIAL CASH RATE (SOURCE BANK OF ENGLAND)

ECONOMY	START YEAR	NOMINAL MEAN RETURN	REAL MEAN RETURN	STANDARD DEVIATION (NOMINAL)	PROBABILITY <0% (NOMINAL)	1-YEAR AUTO-CORRELATION	CORRELATION TO INFLATION
US	1970	6.2%	1.9%	4.7%	0%	0.78	0.59
AUSTRALIA	1970	8.5%	2.6%	4.0%	0%	0.78	0.56
UK	1976	8.1%	2.7%	4.3%	0%	0.81	0.65

Although cash could generate negative real returns due to short sharp inflation spikes, historically it has been a very good inflation hedge, as it responds well to persistent inflation.

Although cash could generate negative real returns due to short sharp inflation spikes, historically it has been a very good inflation hedge, as it responds well to persistent inflation (i.e., has high positive correlation). However, on a forward-looking basis, the risk that short-term cash rates are persistently below realised inflation levels (i.e., negative real rates) needs to be considered, particularly for most developed markets after the 2008–2009 crisis.

3.6.5 Property

Property investments are sometimes considered to have inflation-hedging characteristics, as rent levels can be adjusted to reflect expectations of future inflation. However, empirical evidence from the most thorough studies undertaken on this topic by Hoesli et al. (2008) and Attie et al. (2009) suggest that property is mildly negatively correlated with inflation.

3.6.6 *Other Asset Classes*

Other asset classes may also provide returns that are positively correlated to inflation, such as commodities, gold and infrastructure. Whilst a more detailed analysis of these is beyond the scope of this research, Martin (2008) reviews the empirical literature for these assets as well as some others such as farmland, timber and intellectual property. He concludes that timber and farmland have the most encouraging inflation-protection characteristics of these asset classes.

3.6.7 *Summary*

The evidence presented and referenced here indicates that traditional asset classes have varying degrees of inflation protection. Over short-term holding periods, equities and nominal bonds tend to be very poor hedges of inflation, with some evidence showing that they can in fact be negatively correlated to inflation. Both asset classes also have significant risk of underperforming inflation in any given year. However, over long-term holding periods, the evidence suggests that they become increasingly positively correlated to inflation, generating meaningfully positive real returns. This is important as these real returns are the compensation that investors need to bear the risks associated with saving to finance future consumption.

Inflation-linked bonds tend to be moderately positively correlated to inflation, whilst cash tends to be quite strongly positively correlated to inflation. However, this comes at the cost of lower, yet still positive, real returns, which makes them less attractive for long-term investment horizons. Both asset classes are also still capable of underperforming inflation in any given year.

It is important to note that short- and long-term correlations to inflation and average real returns present an incomplete view of the risks faced by people in managing assets to meet consumption goals in an environment of price uncertainty. This is because actual outcomes are highly dependent upon the size and timing of cash flows (savings and withdrawals/income), as well the path of realised investment returns relative to inflation.

Short- and long-term correlations to inflation and average real returns present an incomplete view of the risks faced by people in managing assets to meet consumption goals in an environment of price uncertainty. This is because actual outcomes are highly dependent upon the size and timing of cash flows (savings and withdrawals/income), as well the path of realised investment returns relative to inflation.

Ideally, what is needed is a product that combines exposure to attractive risk premium, such as those associated with equities and nominal bonds, with inflation protection characteristics tailored to meet specific savings and consumption based cash flows. Such products are explored in section 4.

4 POTENTIAL INFLATION-PROTECTION PRODUCT DESIGNS

4.1 Manufacturing Inflation Risk

The previous section showed that inflation protection is currently provided to people in a number of ways. In contrast, this section explores new ways in which inflation protection may be provided to people through retail investment, insurance and pension products.

The central concept is that an investor allocates a large proportion of his or her wealth to traditional asset classes such as equities and fixed income that provide attractive expected excess returns (i.e., risk premium). The benefit structure of the product is designed to provide cash flows that are linked to inflation in some way in order to minimise or eliminate negative real returns. These cash flows can be in the form of either lump-sum maturity payments or ongoing annual payments for a specified term or for life.

Due to the fact that the size and timing of both pre-retirement savings cash flows and post-retirement income cash flows play an important role in meeting customer needs, actual benefit outcomes will be path-dependent and highly sensitive to short-term market and inflation dynamics.

This structure enables the investor to remain exposed to assets such as equities, which have the ability to produce positive real returns over long-term horizons. However, due to the fact that the size and timing of both pre-retirement savings cash flows and post-retirement income cash flows play an important role in meeting customer needs, actual benefit outcomes will be path-dependent and highly sensitive to short-term market and inflation dynamics. Thus, in order to match the nature and timing of consumers' cash-flow needs, it is important to mitigate or protect against the short-term market and inflation risks. This is the role that the inflation protection plays.

The provider manufactures these benefits through the use of replication and hedging techniques, which are discussed further in section 5. The benefits could be provided for on either a best-efforts or guaranteed basis. On a best-efforts basis, the end investor or policyholder assumes any residual risk associated with the investments and hedging strategy. In contrast, if the manufacturer provides the benefits on a guaranteed basis, then the manufacturer bears any residual risk, and will increase fees and charges for this benefit.

The end investor or policyholder can pay for this protection through either:

- Allocating a proportion of their assets to such a risk protection strategy (akin to purchasing an option) with the end payout subsequently reflecting the **implicit cost** of the benefit

- Allocating all assets to an investment portfolio and paying an additional **explicit charge** through a series of regular payments levied as either fixed nominal amounts or as a fixed percentages of account value

Both benefit designs and costs are economically equivalent (i.e., produce similar cash-flow outcomes), as the underlying replication methods and costs are equivalent. One further important distinction lies in whether guaranteed benefits cover solely market risks or whether they include insurance risks such as lapses and mortality. The latter risks can only be underwritten by insurance companies such as is typical for variable annuities, which may enable costs to be lowered or richer benefits to be provided due to the mechanism of cross-subsidisation (i.e., pooling effects) with respect to demographic and policyholder behaviour risks.

For the purposes of this report, we develop and discuss potential product designs using the variable annuity framework and terminology (i.e., the latter mechanism). Manufacturing costs are calculated for various features based upon annual fixed percentage charges of account value.

4.2 Pre-retirement Wealth Accumulation and General Savings

4.2.1 Product Description

Products providing guaranteed minimum accumulation benefit (GMAB) features are designed for policyholders with a specific investment horizon in mind. As discussed in section 2, for the pre-retirement population aged 20-60, retirement savings are exposed to inflation risk up to the point at which they need to be converted into income. In some countries such as the US where retirement savings are able to be accessed prior to retirement, doing so leads to an intense tax penalty. This effectively results in age 65 being a common maturity horizon for many people, and creates a need for capital protection over long periods of time up to this horizon age.

In its current form, the simplest GMAB product provides a guaranteed investment return at the end of a specified term. Traditionally, the benefit level is a fixed nominal amount and is specified when the policy is issued. Usually the GMAB guaranteed benefit level is set equal to the total premium paid by the policyholder. To protect against inflation risk, GMAB products can be designed to link the guaranteed benefit level to a specific price index level at maturity.

In its current form, the simplest GMAB product provides a guaranteed investment return at the end of a specified term. Traditionally, the benefit level is a fixed nominal amount and specified when the policy is issued.

Other product features can also be introduced to customise the benefit outcomes to meet specific customer needs or to fine-tune the trade-off between affordability (cost thresholds) and benefit generosity. These include:

- **Participation rates**: Determine the proportion of inflation that the policyholder benefits from. Participation rates that may be considered include 100%, 75%, and 50% levels.

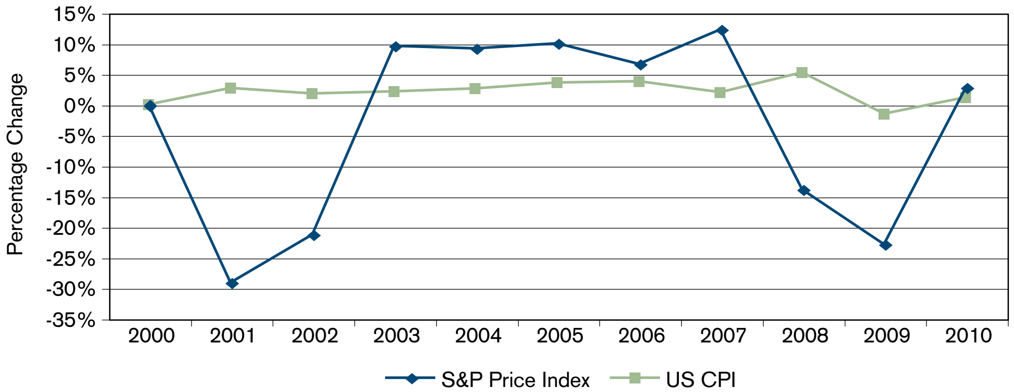
- **Nominal benefit caps and nominal benefit floors**: Determine the limits above and below which the inflation indexation doesn't apply. Products with 0% floors and 5% caps are typical of the features currently used in the defined benefit pension market.

Pre-retirees invest savings over the course of a working career and expect to generate returns in excess of inflation over this time horizon in order for living standards not to be adversely affected in the future. Taking into account the age range of the pre-retirees (20-60 years old), inflation-linked GMAB products designed for this population may have accumulation durations of up to 40 years. Possible products could include single-premium products with terms of 10-, 15-, or 20-years, or regular premium product with terms of 10, 15, 20, or 30 years.

4.2.2 Product Illustration

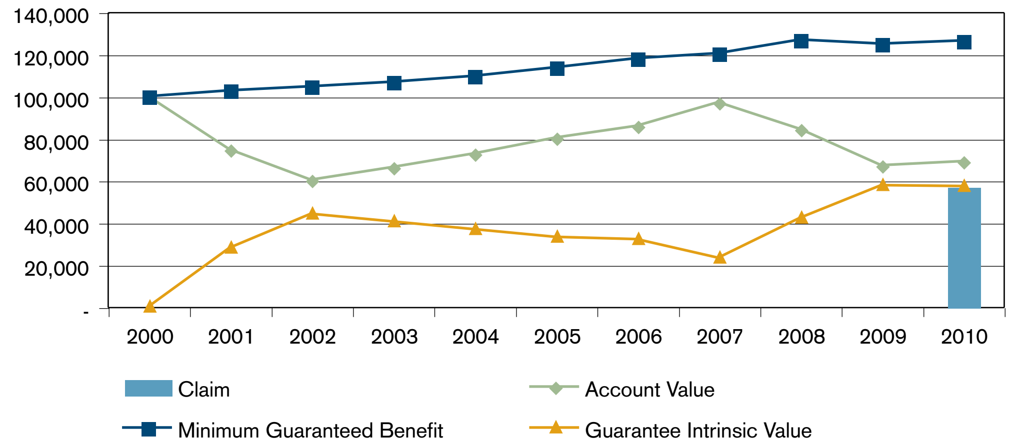
To illustrate how an inflation-linked GMAB product works, an historic scenario is used based upon the past 10 years of US capital market experience from August 2000 to August 2010. During this period the S&P 500 price index 10-year cumulative return was negative (-31%), and the US CPI index increased mildly by 26.3% or 2.4% p.a. Figure 14 below shows the S&P log return and US CPI inflation rate annually for the past 10 years.

FIGURE 14: ANNUAL S&P LOG RETURNS AND ANNUAL US CPI INFLATION RATE FROM 2000 TO 2010 (SOURCE: BLOOMBERG)



Consider a GMAB product with a 10-year term, issued in August 2000 and maturing in August 2010. For product illustration-only purposes, fees and expenses are ignored. The initial single premium is $100,000 and it is invested 100% in the S&P 500 price index. The GMAB guarantee benefit level is linked to the US CPI index. That is, the initial premium is multiplied by I_T/I_0, where I_t is the CPI index level at time t. The end benefit received by the policyholder is the greater of the account value of the invested portfolio or the inflation-linked guarantee benefit level at maturity (time T). This is illustrated in figure 15 below in the case of full inflation participation (a rate of 100%), no nominal return cap, and no nominal return floor.

FIGURE 15: POLICYHOLDER ILLUSTRATION FOR AN INFLATION-LINKED GMAB PRODUCT

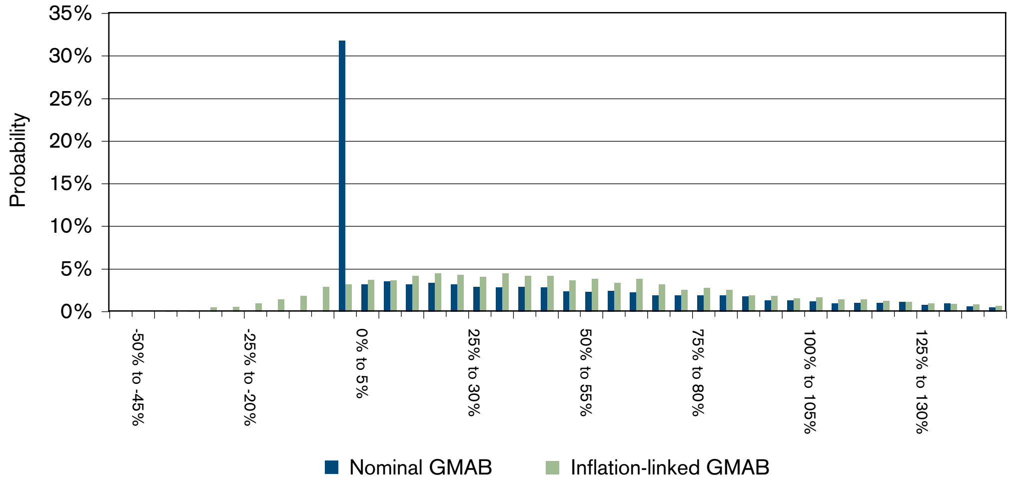


As shown in Figure 15, at maturity the account value has reduced to $69,140 while the inflation-linked guaranteed minimum benefit has increased to $126,338, which results in a guaranteed claim amount of $57,198. In contrast, for the standard 10-year nominal GMAB product with guaranteed benefit fixed at $100,000, the claim on maturity is significantly less at $30,860.

A non-guaranteed investor in the S&P would have experienced a decline in 30% of their portfolio in nominal terms, but a massive -45% return in real terms. The policyholder who purchased a simple nominal GMAB product 10 years ago would have fared a little better, having been protected against the market fall, but would still have suffered a very significant -21% return in real terms. However, for a policyholder who purchased the inflation-linked GMAB product 10 years ago, they would have been protected against both the market falls and rising inflation, achieving a 26% nominal return and a 0% real return which maintains their purchasing power.

One way to compare these two products is to analyse the distribution of outcomes in both a nominal and real return space. Figure 16 below shows this comparison by plotting the probability distribution functions (pdf) of the 10-year cumulative returns of each product (net of fees) for 5000 risk-neutral[24] scenarios used for valuation purposes.

FIGURE 16: PROBABLITY DISTRIBUTION FUNCTION OF 10-YR CUMULATIVE NOMINAL RETURNS FOR TWO GMAB PRODUCTS



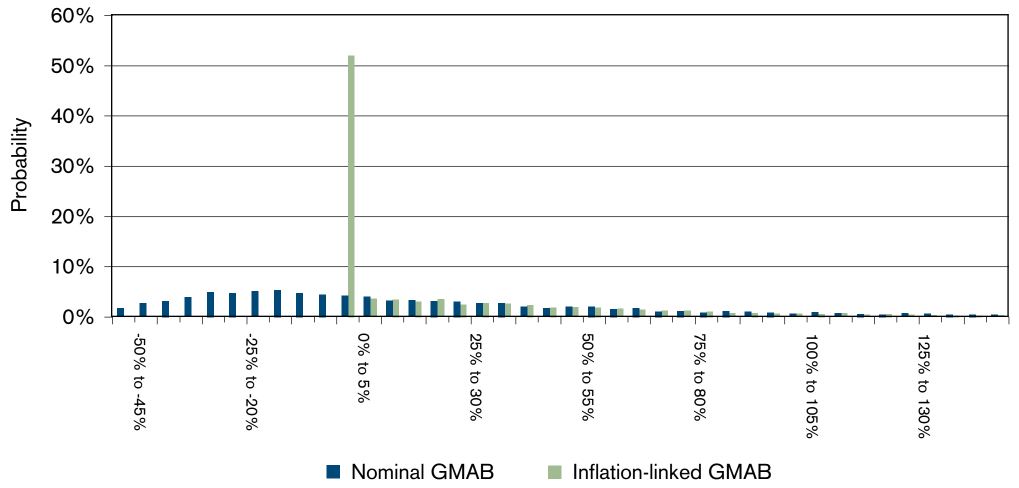
The spike in the pdf for the nominal GMAB in the 0% to 5% bucket indicates the significant chance that the account value can fall below the initial investment in nominal terms, and the associated return of the initial investment through the nominal guarantee mechanism. However, the inflation-linked GMAB product is more likely to provide positive nominal returns than the nominal GMAB product, whilst protecting against a deflationary environment.

The inflation-linked GMAB product is more likely to provide positive nominal returns than the nominal GMAB product, whilst protecting against a deflationary environment.

[24] This means that no risk premiums have been taken into account in the projections shown. A real-world projection would allow for risk premiums which would be relevant from an end investor's perspective, although it would make little difference to the relative comparison of outcomes between these products.

In contrast to this, figure 17 below again shows a comparable return distribution (pdf) of the two products, but this time translated into the real return space.

FIGURE 17: PROBABLITY DISTRIBUTION FUNCTION OF 10-YR CUMULATIVE REAL RETURNS FOR TWO GMAB PRODUCTS



There is a very material chance that the nominal GMAB can suffer a significant negative real return, whereas the inflation-linked GMAB is protected against these damaging events. Upside real return potential is comparable between the two products.

As can be seen, there is a very material chance that the nominal GMAB can suffer a significant negative real return, whereas the inflation-linked GMAB is protected against these damaging events. Upside real return potential is comparable between the two products.

4.2.3 Product Designs

Seven indicative single-premium GMAB products have been investigated based upon capital market conditions in December 2010. All of these GMAB products can be used for capital protection purposes with payoffs on maturity equal to the greater of account value and guaranteed base. The analysis is based upon a male policyholder with an initial premium of $100,000 invested at the end of December 2010 in a GMAB product. This premium is 60% invested in an equity fund and 40% invested in a bond fund managed to a duration of four years.

The first product is a standard nominal GMAB product with a guaranteed base set to the initial premium of $100,000. The second product has a defined guarantee level as well, but it is set at a higher level at the issue date based on the known risk neutral expectation for inflation at maturity $E[I_T]$, where E is the expectation of the CPI at the maturity date T. This means that the policyholder has a more attractive nominal guaranteed benefit that may be higher or lower than actual inflation over the investment horizon. There is no explicit inflation linkage in this product.

The last five products are inflation-linked GMAB products with other features. Product 3 provides a guaranteed benefit level indexed to inflation, identical to the product used in the policyholder illustration above. Product 4 is the same as product 3, but with an inflation participation rate of 50%. This means that the guarantee benefit level increases each year by 50% of any increase in the annual inflation rate. This provides the policyholder with partial inflation protection. Product 5 has a nominal return floor of 0% and no inflation cap. Product 6 has a nominal return floor of 0% and a cap of 5%. The last product has a term of 20 years instead of 10 years due to the policyholder being younger (45 years old vs. 55 years old).

These product features are summarised in Table 10 below.

TABLE 10: PRODUCT FEATURES OF INDICATIVE GMAB PRODUCTS

PRODUCT	DEFERRED GUARANTEED BASE	INFLATION RATCHET TERM	INFLATION RATCHET FLOOR (X)	INFLATION PARTICIPATION CAP (Y)	RATE (Z)	AGE
1	100,000	10	NONE	NONE	NONE	55
2	100,000 * E[IT]	10	NONE	NONE	NONE	55
3	INFLATION-LINKED GMAB (*)	10	NONE	NONE	100%	55
4	INFLATION-LINKED GMAB (*)	10	NONE	NONE	50%	55
5	INFLATION-LINKED GMAB (*)	10	0%	NONE	100%	55
6	INFLATION-LINKED GMAB (*)	10	0%	5%	100%	55
7	INFLATION-LINKED GMAB (*)	20	0%	5%	100%	45

$$\text{where GMAB}(*) = 100{,}000(1 + \min[\,\max\{\, z \times (\frac{I_T}{I_0} - 1), (1 + x)^T - 1\}, (1+y)^T - 1]).$$

4.2.4 Product Replication Costs

To investigate the relative costs of offering different guaranteed product features, a risk-neutral valuation approach is applied based on the widely used Jarrow-Yildirim model (Jarrow, 2000) for interest rate and inflation risk. In the Jarrow-Yildirim (JY) model, both the nominal and real interest rate variables evolve according to a Hull-White process. The Hull-White parameters governing this process are calibrated from historic constant maturity nominal and inflation swap rates. The risk-neutral expected growth of the price index derives from the difference between nominal and real rates. The pricing assumptions used for analysis in this report are outlined in Appendix A. As these costs are illustrative only,[25] they use a common mortality basis and flat lapse rate of 4% p.a.[26] for all products except the US GMAB. This product has some variation in lapse rate by term reflecting the impact of typical surrender charges, which is also useful to highlight the sensitivity of the products to lapse rates and to create some variation in results across the economies.

The cost of offering an inflation-based guarantee is determined primarily by market conditions, with other assumptions also being required for non-observable capital market parameters, demographic and policyholder behaviours. This cost is referred to as a hedge cost, which reflects the expected cost of manufacturing the guarantee through the use of dynamic replication and hedging methods. This is discussed in further detail in section 5 of this report.

The cost of offering an inflation-based guarantee is determined primarily by market conditions, with other assumptions also being required for non-observable capital market parameters, demographic and policyholder behaviours. This cost is referred to as a hedge cost.

25 They should not be relied upon to launch a particular product.

26 In practice, a dynamic lapse function would also be used to reflect more complex policyholder behaviours exhibited in particular market segments.

Figure 18 below illustrates the hedge costs for each of these products as at December 2010, for four major economies: Australia (AUS), United States (US), United Kingdom (UK), and the Eurozone (EU).

FIGURE 18: HEDGE COSTS (IN BPS P.A. OF ACCOUNT VALUE) OF GMAB PRODUCTS ACROSS FOUR ECONOMIES

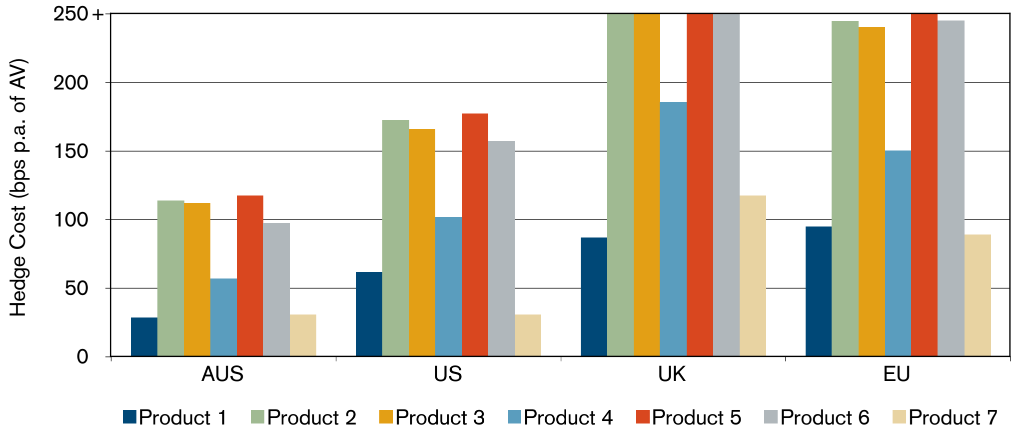


Table 11 below also outlines these hedge costs, although the second block of numbers calculates the marginal value of each product feature relative to the appropriate reference product.

TABLE 11: HEDGE COSTS (IN BPS P.A. OF ACCOUNT VALUE) OF GMAB PRODUCTS ACROSS FOUR ECONOMIES

	HEDGE COST (BPS P.A. OF AV)					MARGINAL COST OF FEATURE			
PRODUCT	AUS	US	UK	EU	REFERENCE PRODUCT	AUS	US	UK	EU
1	29	62	87	95					
2	114	172	>250	245	1	85	111	N/A	150
3	112	166	>250	240	2	-2	-6	N/A	-5
4	57	102	186	150	3	-55	-64	N/A	-90
5	118	177	>250	250	3	5	11	N/A	10
6	97	157	>250	245	5	-20	-20	N/A	-5
7	31	31	118	89	6	-67	-126	N/A	-156

Note that the hedge costs for some of the UK products exceed 250 bps, which is beyond the level at which they are likely to be viable.

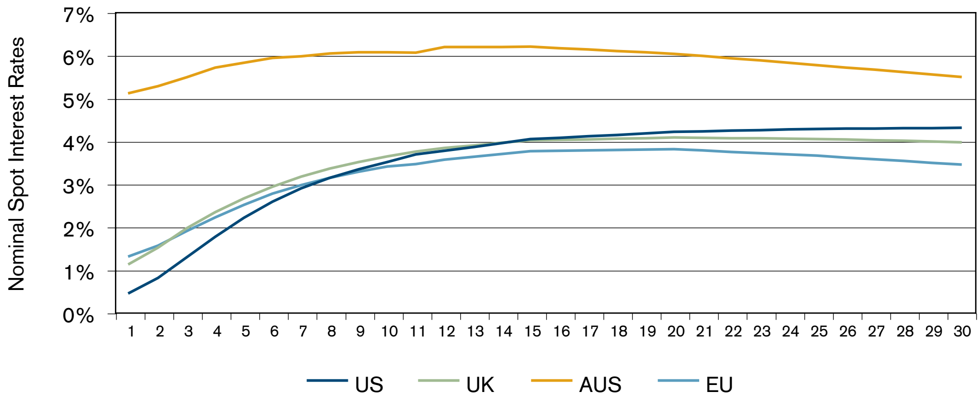
4.2.5 Key Observations

Several key observations can be made from the above hedge cost results.

1. Nominal interest rates are the primary driver of nominal GMAB hedge costs

For the standard nominal GMAB product (product 1), the difference among the hedge costs for different economies, AUS (29 bps), US (62 bps), UK (87 bps), and EU (95 bps), is primarily driven by the different nominal interest rate environments in the different economies. Figure 19 below plots the nominal interest rate term structures as at 31 December 2010 for each economy.

FIGURE 19: ZERO-COUPON INTEREST RATE TERM STRUCTURES BASED ON SWAPS AS AT 31 DECEMBER 2010



The rate environment in Australia could be considered to be relatively normal, with spot rates around 5% to 6%. The other three economies are in very low rate environments, with the US being the lowest, particularly in the short end. Low short- to medium-term interest rates lead to high GMAB hedge costs.

2. Lapse rate assumptions are an important secondary driver of GMAB hedge costs

Although the US has the lowest interest rate environment as at this date, it does not have the highest hedge costs. This is due to the different lapse rate assumptions used for this product. Significantly higher lapse rates from years 6 through 10 lead are assumed given surrender penalty schedules in this market. Lapse rates assumptions are an important consideration given the target market for such products, and can have a material impact on resulting hedge costs. Consideration should also be given to whether lapses are likely to be dynamic in nature.

Although the US has the lowest interest rate environment as at this date, it does not have the highest hedge costs. This is due to the different lapse rate assumptions used for this product.

3. Increasing the guarantee benefit/moneyness level increases hedge costs considerably even for relatively low levels of expected inflation

Product 2 has a much higher hedge cost compared to product 1 due to the higher fixed-guarantee benefit level relative to the 100,000 guarantee benefit level for product 1. Table 12 below outlines these levels and the 10-year expected inflation rates they imply for each economy.

TABLE 12: GUARANTEED BENEFIT LEVELS, 10-YEAR BREAK-EVEN INFLATION RATES AND 10-YEAR REAL YIELDS FOR FOUR ECONOMIES

	AUS	US	UK	EU
PRODUCT 2 GUARANTEED BENEFIT LEVEL	134,392	129,515	137,556	122,318
10 YEAR BREAK-EVEN INFLATION RATE	3.0%	2.6%	3.2%	2.0%

For the inflation-indexed GMAB products, the UK has higher hedge costs than the EU despite the EU having a lower nominal rate environment. This is due to the lower real rate levels for the UK relative to the EU as of 31 December 2010.

4. Real interest rates are the primary driver of inflation-linked GMAB hedge costs once moneyness levels have been taken into account

For the inflation-indexed GMAB products, the UK has higher hedge costs than the EU despite the EU having a lower nominal rate environment. This is due to the lower real rate levels (i.e., higher expected break-even inflation rate) for the UK relative to the EU as of 31 December 2010. The combination of extremely low real rates plus high break-even inflation rates means that the full inflation-indexed GMAB products are extremely expensive under the current environment. However, this may change in the future depending upon the Bank of England's monetary policy.

5. Inflation protection hedge costs are driven by higher moneyness levels, not inflation linkage

Not surprisingly, products 2 and 3 show relatively comparable hedge costs for all economies, due to the fact that hedge costs are assessed on a risk-neutral basis. The key difference between these two is that the inflation-indexed GMAB (product 3) provides inflation protection (i.e., no negative real returns), whereas the policyholder can still suffer a negative real return under the nominal GMAB (product 2). This shows that the act of linking the benefit level to an inflation-index is relatively low compared to the impact of the higher moneyness level (due to the impact of expected inflation on the guarantee balance over the horizon).

6. Inflation participation rates significantly influence hedge costs through impacts on moneyness

The difference between product 3 and 4 lies in the inflation participation rate. It is clear that decreasing the inflation participation rate would result in lower hedge costs due to lower expected guarantee claims. The relative reduction in hedging cost when the participation rate is reduced from 100% to 50% is shown in Table 13, as compared to the absolute reduction shown in Table 11. These reductions are in line with the relative break-even inflation rates for each economy as shown in table 12.

TABLE 13: RELATIVE REDUCTION IN HEDGE COST WHEN INFLATION PARTICIPATION RATE REDUCES FROM 100% TO 50%

	AUS	US	UK	EU
RELATIVE REDUCTION IN HEDGE COST	49%	39%	52%	38%

7. Inflation floors are a relatively cheap policyholder feature

The relative change in hedge costs of product 5 compared to product 3 enables the value of an inflation floor feature to be calculated. Applying an inflation floor increases hedge cost since the deflation risk is alleviated by the floor (negative nominal returns are effectively eliminated). In the analysis above, this feature increased hedge costs by around 5%, which seems relatively affordable. This feature is relatively cheap, as inflation needs to average less 0% over the entire term of the product. This feature will tend to become progressively more expensive as break-even inflation rates reduce to lower levels.

8. Inflation caps can be used to help reduce hedge costs

In contrast, an inflation cap reduces hedge costs by sacrificing higher inflation gains above the cap. In the analysis above, this feature reduced hedge costs by up to 18% for product 6 relative to product 5. As discussed in section 3, this is a popular feature in defined benefit pension schemes. Such a feature will produce a product that is attractive to consumers if they are mainly concerned about cumulative (i.e., point-to-point) inflation risk over a period, rather than the incidence or path of inflation during such a period. It will protect against inflation spikes so long as the cumulative cap is not breached.

Due to the opposite effect of the floor and cap, the inflation-linked GMAB product without a floor or cap is broadly comparable from a hedge cost perspective to a product with both a floor and cap (at the 0% and 5% levels respectively in this analysis). The floor/cap-bounded inflation-linked GMAB has the advantage of lower real rate risk at the expense of higher nominal rate risk. This is attractive from a risk management perspective in countries where the liquidity of inflation hedging instruments is thin.

9. Increasing the term of the guarantee significantly reduces hedge costs

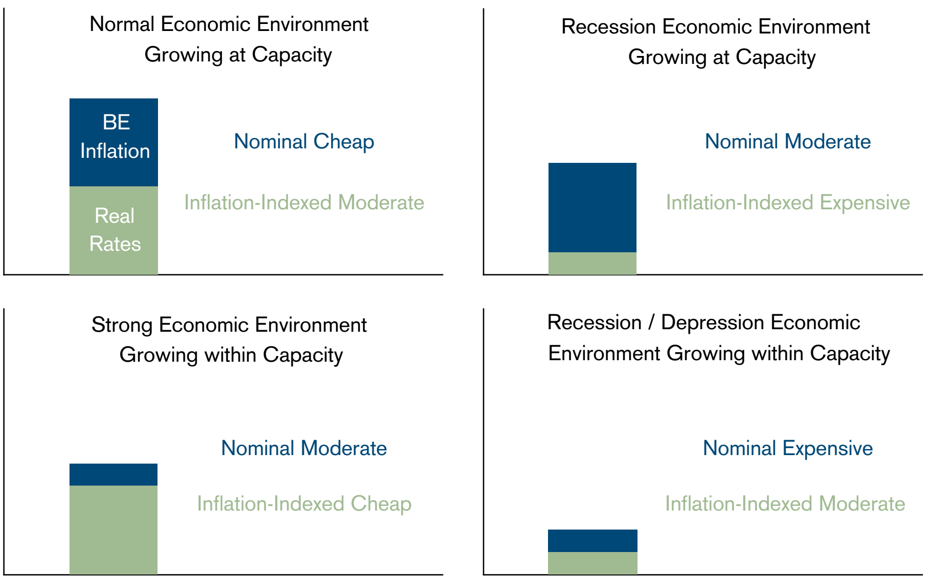
There is a significant reduction in hedge costs by extending the term of the guarantee, as illustrated by the difference between products 6 and 7. However, note that this is somewhat dependent upon market conditions, in particular the relative levels of long-term break-even inflation rates to real rates. This is particularly relevant for those saving for retirement over long periods during their career, where the importance of maintaining the real value of retirement wealth is very important.

10. Different capital market environments impact the relative value of nominal versus inflation guarantees

The different capital market environments exhibited by the four economies and the subsequent hedge costs for nominal and inflation-indexed products provide insight into the relative attractiveness of these two products. Nominal guarantee hedge costs are driven by the level of nominal interest rates, whilst inflation-indexed guarantee hedge costs are driven by the relative levels of real rates and break-even inflation rates. The impact of alternative economic and interest rate environments on the relative attractiveness of the hedge costs for the two products is summarised in Figure 20.

The different capital market environments exhibited by the four economies and the subsequent hedge costs for nominal and inflation-indexed products provide insight into the relative attractiveness of these two products.

FIGURE 20: IMPACT OF ALTERNATIVE INTEREST RATE ENVIRONMENTS ON RELATIVE HEDGE COSTS OF NOMINAL AND INFLATION-INDEXED PRODUCTS



Whilst the absolute level of inflation-indexed hedge costs will be higher than nominal hedge costs under all of these environments (technically whenever break-even inflation rates are positive), the relative differences and thus relative attractiveness are highly dependent upon the breakdown of nominal rates into real rates and break-even inflation rates. Inflation-indexed products will tend to be relatively less attractive in environments with high break-even inflation rates, but more attractive in environments of low break-even inflation rates. The absolute level of hedge costs for both products is dependent upon the level of real rates. In the extreme case where break-even inflation rates are negative (i.e. nominal rates below real rates), then inflation-indexed products would have lower absolute hedge costs relative to nominal products. As at the start of 2011, Australia is characterised by the top left environment, whilst the US, UK and Europe are characterised by the top right environment. However these will change over time as these countries move through various parts of the economic cycle. Japan would be an example of a country characterised by the lower right environment, and well managed developed or robust emerging economies would be characterised by the lower left environment.

4.3 Post-retirement Income Generation

4.3.1 Product Description

Post-retirement, people require retirement savings sufficient to meet their core expenditure needs, which could last in excess of 30 years. Different annuities exist in various markets that transform the accumulated wealth into retirement income streams to satisfy different needs of post-retirees, such as fixed annuities, increasing annuities, inflation-indexed annuities, unit-linked annuities and variable annuities. The challenge is to design a post-retirement income product that is able to generate attractive real income levels to protect against the effects of inflation.

The challenge is to design a post-retirement income product that is able to generate attractive real income levels to protect against the effects of inflation.

Guaranteed lifetime withdrawal benefit (GLWB) products provide guarantees that ensure policyholders receive minimum systematic annual withdrawals for life, even if the account value is depleted. The simplest GLWB guarantees a pre-specified fixed monetary amount of withdrawal each year. Developments over recent years have seen GLWB products provide guaranteed withdrawals as a fixed percentage of the guaranteed benefit base, which can be rolled up at a fixed rate, reset and/or ratcheted to the account value, if the account value has increased.

To protect against inflation, GLWB products can also be designed to link the guaranteed benefit base to a measure of the price level (an inflation-linked GLWB). Participation rates and local nominal benefit caps/floors can also be introduced to tune the trade-off between affordability and benefit generosity, in much the same way as discussed previously for GMABs.

4.3.2 Product Illustration

To illustrate how an inflation-linked GLWB works, we consider a policyholder who retired in 1990 and purchased a single-premium inflation protected GLWB product in August 1990. The premium paid is \$100,000 and invested 100% in the S&P index. The guaranteed benefit base (GBB_t), initially set equal to the premium paid of \$100,000, is linked to US CPI level (I_t) on each anniversary. Furthermore, if the account value (AV_t) is above the inflation-adjusted guaranteed benefit base, then the guaranteed benefit base will ratchet up to the account value. Formulaically:

$$GBB_t = \max(AV_t, GBB_{t-1} \times \frac{I_t}{I_{t-1}})$$

Each year the policyholder is entitled to a withdrawal of 4.0% of the beginning-year guaranteed benefit base. Due to this withdrawal the account value will be reduced by the dollar amount of this withdrawal, whilst the guaranteed benefit base remains unchanged. The withdrawal continues each year as long as the policyholder is alive. For simplicity, a 100% inflation participation rate, no nominal benefit floor or cap applies, and no benefit roll up has been assumed in this example. Figure 21 below illustrates the realised annual S&P log-return and the annual US inflation rate for the past 20 years.

FIGURE 21: ANNUAL S&P RETURNS AND US INFLATION RATE FROM 1990 TO 2010

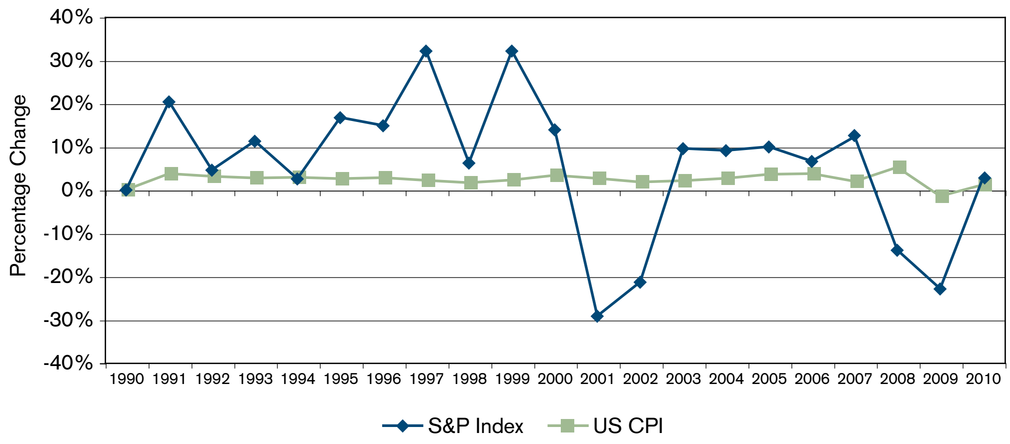


Figure 22 below presents the annual withdrawal (i.e., income), account value, and guaranteed benefit base for a policyholder who purchased the inflation-linked GLWB product in 1990.

FIGURE 22: POLICYHOLDER ILLUSTRATION: THE ANNUAL INCOME, ACCOUNT VALUE AND GUARANTEED BENEFIT BASE FOR A POLICYHOLDER WHO PURCHASED THE INFLATION-LINKED GLWB PRODUCT IN 1990

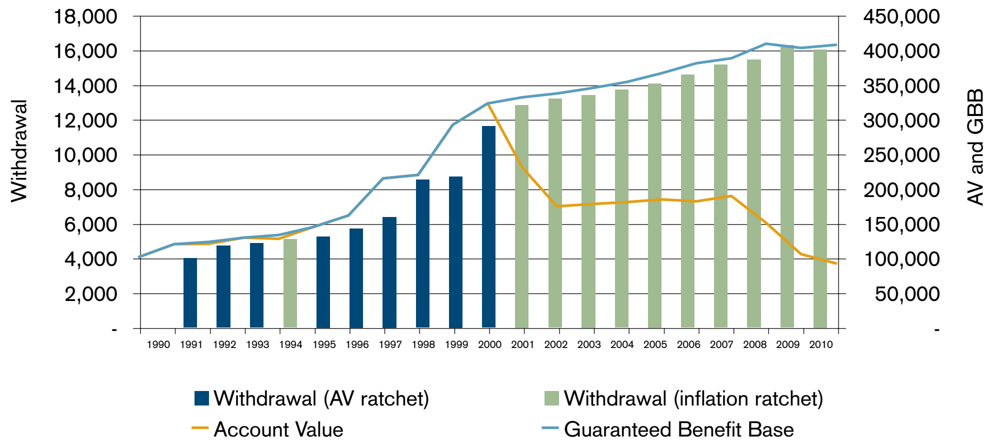


Figure 22 above illustrates how and when the annual withdrawal amount increases due to either an account-value-based ratchet (blue bars), or an inflation-based ratchet (green bars). In times of positive market performance, the account value increases and the policyholder participates in this via higher withdrawals, as well as receiving a higher lapse and death benefit (the account value). However, unlike a traditional fixed GLWB, when the account value decreases due to poor market performance, the annual withdrawal amount can still increase due to positive inflation.

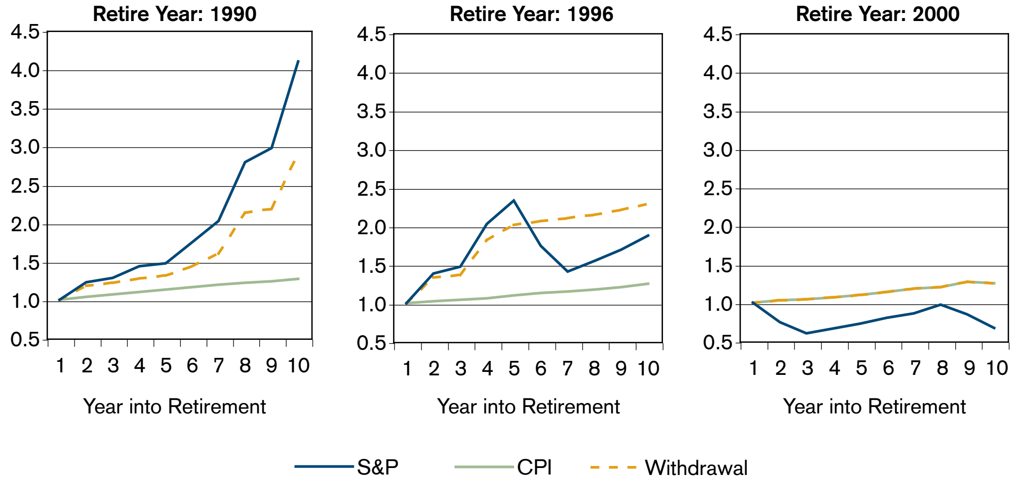
Due to participation in equity market growth, the income from the inflation-linked GLWB product outpaces inflation. For example, in 1991, the policyholder receives the first payment of $4,000, whilst in 2010, the policyholder received the 20th payment of $16,070, an increase of about 400%.

The ability of an inflation-linked GLWB product to provide growing real income during retirement is greatly impacted by exposure to and the performance of underlying investments such as the equity market.

However, during the same period, the CPI increased by only 64% (from 131.60 to 215.83). As a consequence, the inflation-linked GLWB product provides a significantly more valuable benefit.

The ability of an inflation-linked GLWB product to provide growing real income during retirement is greatly impacted by exposure to and the performance of underlying investments such as the equity market. A useful way to illustrate this is to examine the performance of the product under three alternative 10-year windows at difference start dates: 1990, 1996 and 2000. These are shown in Figure 23 below, where the S&P level, CPI level, and annual withdrawal level have all been normalised to a starting index of 1 for each period.

FIGURE 23: POLICYHOLDER ILLUSTRATION: NORMALISED S&P LEVEL, CPI LEVEL AND ANNUAL WITHDRAWAL FOR POLICYHOLDERS WHO PURCHASED THE INFLATION-LINKED GLWB PRODUCTS IN 1990, 1996 AND 2000, RESPECTIVELY



The three periods under investigation show relatively normal inflation environments. Under the worst equity market scenario, if a policyholder retired and purchased the GLWB product in 2000 (just before the tech wreck of 2000 and 2001), their retirement income would have increased solely due to inflation, sufficient enough to maintain the same living standard. Under the best equity market scenario, if a policyholder retired and purchased the GLWB product in 1990, their retirement income significantly exceeded inflation, thus leading to higher living standards. In contrast to these two extremes, if a policyholder retired and purchased the GLWB product in 1996, their retirement income would have increased due to the initially strong market growth, but then been protected during the subsequent market decline, by keeping pace with inflation over the latter half of the period.

4.3.3 Product Designs

Hedge costs have been calculated for a male policyholder aged 65 who invests $100,000 in December 2010 to purchase a GLWB product. Sixty percent of the premium is invested in an equity fund and forty percent is invested in a bond fund managed to a duration of four years. Similar to the GMAB product, fees allowed for in the products were 1.5% p.a. for the common base investment product, plus the hedge cost itself for each guarantee type. Constant lapses of 4% p.a. have been assumed across all products.

Six indicative single premium GLWB products with withdrawal rates of 4% p.a. have been investigated. The first two products are traditional GLWB products without any inflation protection. No ratchet is allowed for in the first product, whilst an annual ratchet is allowed for in the second and subsequent products. The remaining four products are inflation-linked GLWBs. The benefit base of these inflation-linked GLWB products can ratchet annually to the greater of the account value and the benefit base after inflation adjustment. The difference among these four inflation-linked GLWB products resides in different combinations of nominal benefit floor and cap levels. Table 14 below summarises the key features of these products.

TABLE 14: PRODUCT FEATURES OF SIX INDICATIVE GLWB PRODUCTS

PRODUCT	GUARANTEED BENEFIT BASE	RATCHET FREQUENCY	INFLATION RATCHET FLOOR (X)	INFLATION RATCHET CAP (Y)	INFLATION PARTICIPATION RATE (Z)
1A	100,000	NONE	NONE	NONE	NONE
2A	100,000	ANNUAL	NONE	NONE	NONE
3	INFLATION-LINKED GBB	ANNUAL	NONE	NONE	100%
4	INFLATION-LINKED GBB	ANNUAL	0%	NONE	100%
5	INFLATION-LINKED GBB	ANNUAL	0%	5%	100%
6	INFLATION-LINKED GBB	ANNUAL	0%	3%	100%

$$\text{where } GMAB(*) = \max\left(AV_t,\ GBB_{t-1}\left(1 + \min\left[\max\left\{ z \times \left(\frac{I_t}{I_{t-1}} - 1\right), x\right\},\ y\right]\right)\right).$$

4.3.4 Product Replication Costs

The costs of these guarantees have been calculated using the same methodology and basis as that used for the GMAB products above. Figure 24 below illustrates the hedge costs for each of these products as at December 2010, for four major economies: Australia (AUS), United States (US), United Kingdom (UK), and the Eurozone (EU).

FIGURE 24: HEDGE COSTS (IN BPS P.A. OF ACCOUNT VALUE) OF GLWBS FOR FOUR ECONOMIES

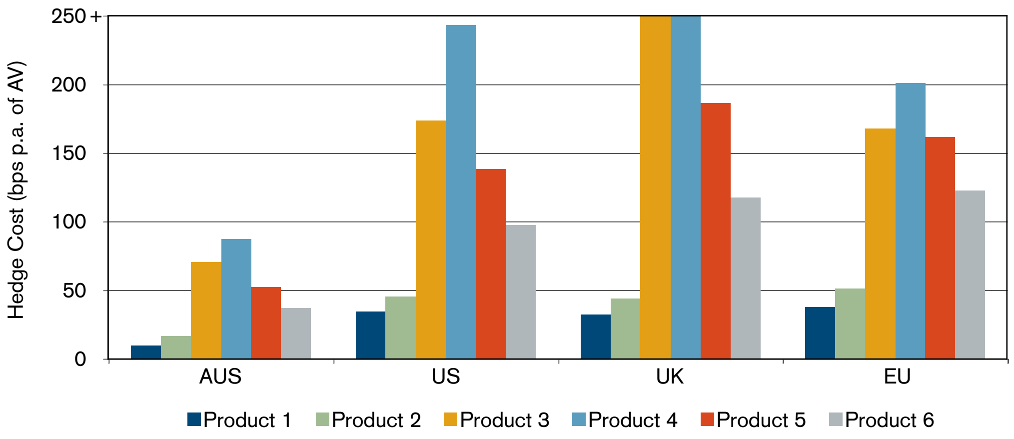


Table 15 below also outlines these hedge costs, although the second block of numbers calculates the marginal value of each product feature relative to the appropriate reference product.

TABLE 15: HEDGE COSTS (IN BPS P.A. OF ACCOUNT VALUE) OF GLWBS FOR FOUR ECONOMIES

	HEDGE COST (BPS P.A. OF AV)					MARGINAL COST OF FEATURE			
PRODUCT	AUS	US	UK	EU	REFERENCE PRODUCT	AUS	US	UK	EU
1A	10	35	33	38					
2A	17	46	44	52	1A	7	11	11	14
3	71	174	>250	168	2A	54	128	N/A	116
4	88	243	>250	201	3	17	70	N/A	33
5	53	139	187	162	4	-35	-105	N/A	-39
6	37	98	118	123	5	-15	-41	-69	-39

Note that the hedge costs for some of the UK products exceed 250 bps, which is beyond the level at which they are likely to be viable.

4.3.5 Key Observations

Several key observations can be made from the above hedge cost results.

1. **Inflation indexation increases the effective moneyness level, thereby increasing hedge costs. Reduced starting income levels are required to offset this effect.**

With the same initial withdrawal amount, the inflation-linked GLWB products show much higher hedge costs than the traditional nominal GLWBs, because the inflation-linked GLWBs are more likely to generate higher average income in the future due to the additional inflation ratchet feature.

With the same initial withdrawal amount, the inflation-linked GLWB products show much higher hedge costs than the traditional nominal GLWBs, because the inflation-linked GLWBs are more likely to generate higher average income in the future due to the additional inflation ratchet feature. In order to make a fairer comparison, the withdrawal rates of traditional GLWB products should be set to a higher level to achieve broadly the same hedge costs. Table 16 below illustrates the withdrawal rates that the two traditional GLWB products would need to offer for their hedge costs to be equivalent to the inflation-linked GLWB product 3 (with no cap, no floor and a 4% withdrawal rate).

TABLE 16: WITHDRAWAL RATES THAT MATCH THE HEDGING COSTS AMONG PRODUCT 1, 2, AND 3

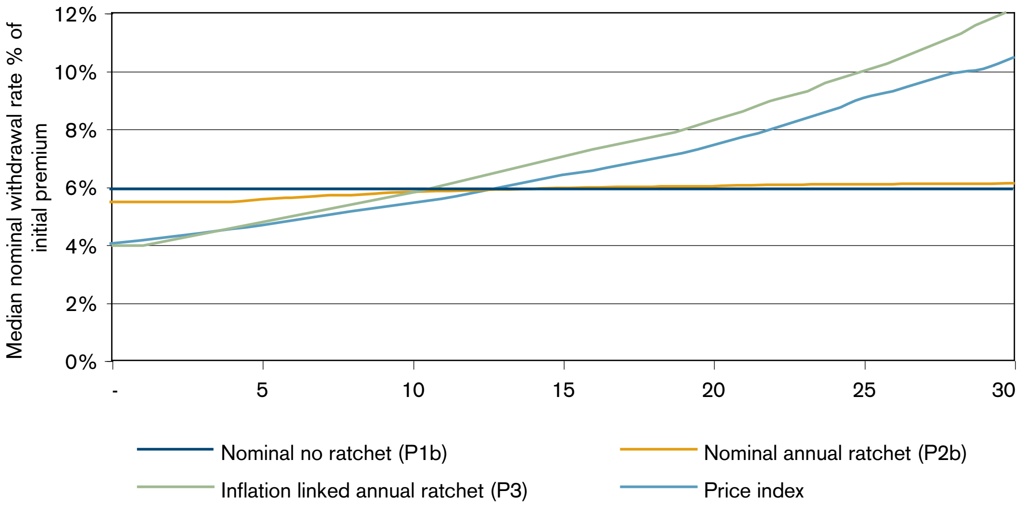
PRODUCT	AUS	US	EU
1B	5.9%	5.5%	5.3%
2B	5.4%	5.3%	5.1%
3	4.0%	4.0%	4.0%
HEDGE COST	71	174	168

This is conceptually equivalent to the pricing differential between fixed and inflation-indexed annuity rates/levels: inflation indexation leads to a lower starting income level relative to a fixed annuity. The trade-off between lower starting income levels and higher hedge costs for an inflation-indexed GLWM is a key product design decision.

2. Relative value proposition and comparisons need to be framed in terms of projected real income levels

Figure 25 below compares the projections of annual withdrawals for these three comparable GLWB products shown in Table 16 for the Australian economy.

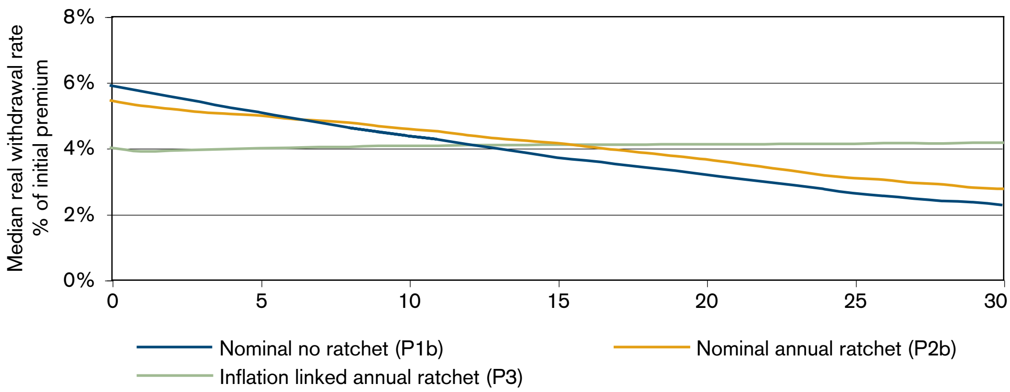
FIGURE 25: MEDIAN NOMINAL ANNUAL WITHDRAWAL (AS % OF INITIAL PREMIUM) FOR THE THREE HEDGE COST COMPARABLE GLWB PRODUCTS (SHOWN IN TABLE 16) VERSUS AVERAGE INFLATION FROM 1,000 SCENARIOS FOR THE AUSTRALIAN ECONOMY



Product 1b has flat cash flow for the life of the policy. The cash flows of product 2b relate to the median path of the maximum account values. These traditional GLWB products have higher withdrawal amounts at the beginning but their rates of increase are much slower than price rises over the long run. In other words, product 2b lacks inflation protection, which demonstrates that equity market growth alone is not always sufficient to maintain real income levels. On the other hand, the inflation-linked GLWB product has income growth above the price index.

Figure 26 below presents the above analysis but in real terms or today's dollar. This means that the withdrawal amounts have been discounted by the price index at each point.

FIGURE 26: MEDIAN REAL ANNUAL WITHDRAWAL (AS % OF INITIAL PREMIUM) FOR THE THREE HEDGING COST COMPARABLE GLWB PRODUCTS (SHOWN IN TABLE 16) VS. AVERAGE INFLATION FROM SAME 1,000 SCENARIOS (FROM FIGURE 25 ABOVE) FOR THE AUSTRALIAN ECONOMY.



When looked at in real terms, the value proposition of the inflation-indexed GLWB becomes very clear. It has an increasing real withdrawal rate in comparison to the other nominal GLWB products which have declining real withdrawal rates.

3. The reduction in starting income when comparing a nominal versus inflation linked benefit is less for a GLWB compared to a fixed annuity

It is also useful to compare GLWB products relative to their equivalent fixed annuity cousins. Fixed annuity income levels are determined by the inverse of a mortality based annuity rate. Table 17 below illustrates what the constant income levels are from both a nominal fixed annuity, an inflation-indexed annuity,[27] as well as the income levels from the equivalent GLWB products.

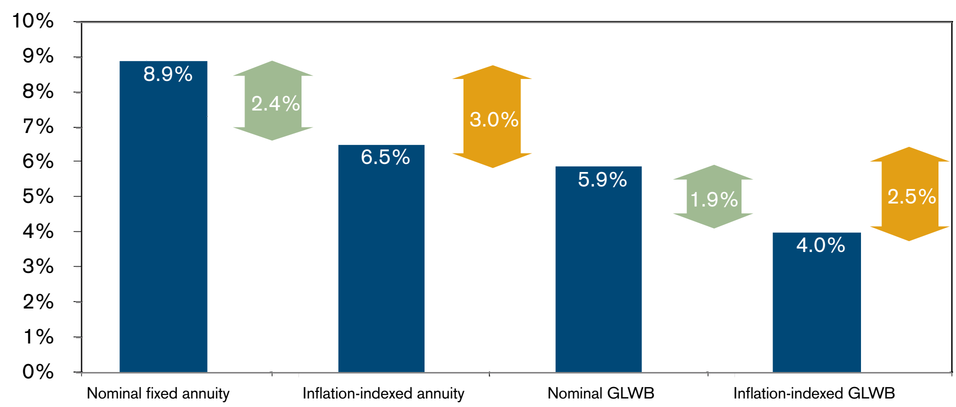
TABLE 17: INCOME LEVELS FOR LEVEL NOMINAL ANNUITIES, INFLATION-INDEXED ANNUITIES, NOMINAL GLWB AND INFLATION-INDEXED GLWB PRODUCTS FOR FOUR ECONOMIES

PRODUCT	AUS	US	UK	EU
NOMINAL FIXED ANNUITY	8.9%	7.1%	7.1%	6.8%
INFLATION-INDEXED ANNUITY	6.5%	5.2%	4.7%	5.4%
NOMINAL GLWB	5.9%	5.5%	6.0%	5.3%
INFLATION-INDEXED GLWB	4.0%	4.0%	4.0%	4.0%
DIFFERENCE - ANNUITIES	2.4%	1.9%	2.4%	1.5%
DIFFERENCE - GLWB	1.9%	1.5%	2.0%	1.3%
DIFFERENCE - NOMINAL	3.0%	1.6%	1.1%	1.5%
DIFFERENCE - INFLATION-INDEXED	2.5%	1.2%	0.7%	1.4%

27 Note that these annuity factors have been derived using a consistent pricing basis with the GMWB products, based on the swap curve. No allowance has been made for liquidity adjustments, margins or expense loadings. They do not reflect direct market prices of specific company products.

Figure 27 shows these results for the Australian market.

FIGURE 27: COMPARISON ON INCOME LEVELS FOR AUSTRALIAN ANNUITY PRODUCTS



The reduction in starting income when comparing a nominal versus inflation linked benefit is less for a GLWB compared to a fixed annuity. This may be an important factor in people's assessment of relative value of the product relative to alternatives.

Since a fixed annuity does not participate in equity market growth nor provide a death benefit, its income level can be used as a reference ceiling for comparable GLWB products, which do provide exposure to equity markets and death benefits. When a GLWB product has a withdrawal rate close to that ceiling, it is significantly more expensive due to a potential higher payout in the future arising from the ratchet feature.

Since a fixed annuity does not participate in equity market growth nor provide a death benefit, its income level can be used as a reference ceiling for comparable GLWB products, which do provide exposure to equity markets and death benefits.

The reference product for traditional nominal GLWB products is a nominal fixed annuity, whilst the reference product for inflation-linked GLWB products is an inflation-indexed annuity. The inflation-indexed annuity in the Australian economy provides a 6.5% income level, which is higher than the 4% withdrawal rate of the indicative inflation-linked GLWB products investigated. A natural result of this is that the hedge costs of the four indicative inflation-linked GLWB products for the Australian economy are reasonably attractive – below 100 bps p.a. In contrast, the withdrawal rates of the indicative GLWB products are close to those of inflation-indexed annuities in the other economies (e.g., 4% vs. 4.7% in the UK), which results in significantly higher hedge costs. This evidences the classic trade-off between relative product benefit attractiveness versus cost, a comparison which is frequently made between fixed annuities and nominal GLWB products. Clearly, hedge costs could be reduced to more manageable levels in these economies by reducing the guarantee benefit levels or other product features accordingly.

4. The use of features such as caps and floors can help manage hedge costs

Similarly to the GMAB product designs, for inflation-linked GLWB products introducing a nominal floor increases hedge costs while introducing a nominal cap reduces hedge costs. The 0% nominal floor (product 4) provides annual deflation protection to the policyholder, which could be perceived to be a very attractive feature in certain capital market environments by certain people. As at December 2010, introducing this feature increased hedge costs by around 25% to 50%. Given current low interest rate and inflation expectations, it is not surprising to see that this feature may be considered to be relatively expensive (although the end individual consumer is the ultimately judge of this). Figures 28 and 29 below illustrate median annual nominal and real withdrawal amounts (as a

Similarly to the GMAB product designs, for inflation-linked GLWB products introducing a nominal floor increases hedge costs while introducing a nominal cap reduces hedge costs.

percentage of initial premium) for four inflation-linked GLWBs versus average inflation for the future 30 years derived from the market conditions in December 2010.

FIGURE 28: MEDIAN NOMINAL WITHDRAWAL AMOUNT (AS A PERCENTAGE OF INITIAL PREMIUM) FOR THE FOUR INFLATION-LINKED GLWBS VS. MEDIAN INFLATION FROM 1,000 SCENARIOS FOR THE AUSTRALIAN ECONOMY

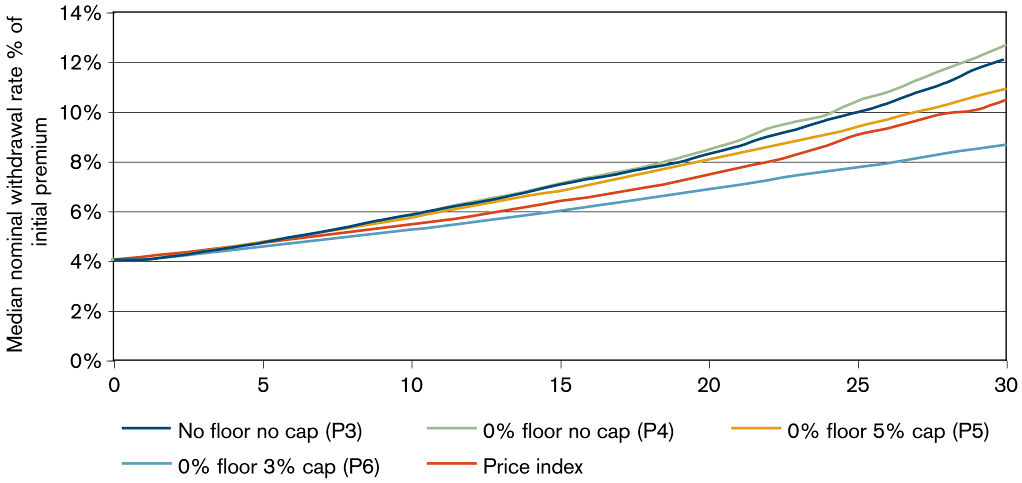
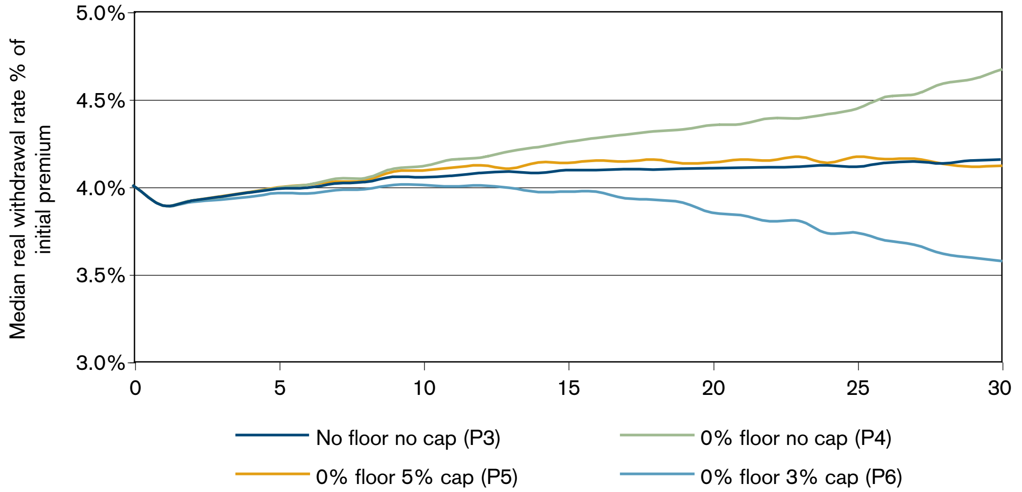


FIGURE 29: MEDIAN REAL WITHDRAWAL AMOUNT (AS A PERCENTAGE OF INITIAL PREMIUM) FOR THE FOUR INFLATION-LINKED GLWBS VS. MEDIAN INFLATION FROM THE SAME 1,000 SCENARIOS (AS ABOVE) FOR THE AUSTRALIAN ECONOMY



Adding the 0% floor does not appear to raise average nominal annual income levels in a significant way, in particular when compared to product 3 (with no floor or cap) where the value of the account value ratchet can be clearly seen relative to the price index. However, the value of this benefit becomes clearer when viewed in real terms, where it starts to outperform after the 10-year mark.

On the other hand, the GLWB with a 5% cap (product 5) or 3% cap (product 6) does decrease the hedge cost significantly but it comes at the cost of a potential reduction in the amount of inflation protection in the long run. Since the median annual withdrawal amount of a GLWB without a floor and cap is much higher than expected annual inflation, it would likely be possible to find a GLWB product with a relatively large cap without a floor, which would provide a balance between attractive hedge cost and sufficient inflation protection.

4.4 Risk Protection Designs

An alternative mechanism for the provision of inflation protection is to provide it within an investment vehicle, rather than an insurance one. Under such a product, a proportion of assets is allocated to an explicit inflation risk protection account that follows a replication strategy designed to produce equivalent end payout outcomes as those discussed above for an insurance vehicle.

An alternative mechanism for the provision of inflation protection is to provide it within an investment vehicle, rather than an insurance one. Under such a product, a proportion of assets is allocated to an explicit inflation risk protection account that follows a replication strategy designed to produce equivalent end payout outcomes as those discussed above for an insurance vehicle.

The key features of such a product are:

- The lack of any underwriter/guarantor eliminates a layer of costs relative to the insurance product relating to the cost of capital.
- No demographic or policyholder behaviour risks are transferred or underwritten in the product. The consequence of this is that the policyholder has ownership of and access to the funds in the inflation risk protection account at all times, including in the events of death and lapse.
- The policyholder bears the realised cost of manufacturing inflation risk protection through the end payouts achieved, rather than through an explicit additional charge. The former will typically be lower than the latter due to additional risk margins embedded in explicit charges.

The amounts that would be required to be invested in the inflation risk protection account under each of the GMAB capital protection products designed in section 4.2.3 are outlined in table 18.

TABLE 18: ASSET ALLOCATION TO INFLATION RISK PROTECTION ACCOUNT VERSUS HEDGE COSTS FOR THE AUSTRALIAN ECONOMY

PRODUCT	ASSET ALLOCATION TO INFLATION RISK PROTECTION ACCOUNT	GMAB HEDGE COST (BPS P.A.)
1	3.4%	29
2	13.2%	114
3	13.1%	112
4	6.8%	57
5	13.6%	118
6	11.4%	97
7	8.7%	31

Using product 1 by way of example, its economic hedge cost of 29 bps p.a. could be financed through annual charges, or equivalently financed through a protection strategy, with the protection account seeded with an initial amount of 3.4%. The inflation-linked capital protection products (3 through 7) could be equivalently manufactured with protection account allocations ranging from 7% to 14% to the inflation protection account.

One of the main attractions with protection-based structures is that they eliminate the potential for anti-selection policyholder behaviour effects, which may otherwise result in guarantee providers charging higher amounts to offset these effects and the capital required to support the risks. This

One of the main attractions with protection-based structures is that they eliminate the potential for anti-selection policyholder behaviour effects, which may otherwise result in guarantee providers charging higher amounts to offset these effects and the capital required to support the risks.

also makes them more attractive to customers who intend to stay in the product to utilise the long-term benefits, as they do not have to pay for the risk that other customers may behave differently.

4.5 Potential Product Design Structures

The above products have been designed to illustrate potential product designs that can provide the inflation protection that people require to meet long-term retirement related needs. There are a multitude of ways in which alternative products can be designed allowing for significant creativity to be applied to meet customer needs and wants in each market segment. This is particularly relevant for the UK markets, where such features will play an important role in creating attractive benefits for acceptable replication costs.

Table 19 below highlights the main product features that can be used to tailor potential products to meet both customer benefit needs and pricing sensitivities.

TABLE 19: ALTERNATIVE PRODUCT DESIGN FEATURES

PRODUCT FEATURE	DESCRIPTION
Guarantee benefit types	GMIB with a guaranteed inflation-indexed annuity benefit Fixed term GMWB Combination GMxB benefits Combination of real and nominal return guarantees
Guarantee benefit levels	x% of gross or net initial premium, with or without expected inflation
Guarantee withdrawal levels	Fixed percentage of indexed benefit base or real plus inflation component applied to fixed nominal base
Term of guarantee	Costs reduce for longer terms; fixed versus lifetime for longevity
Deferral periods	Use to tailor timing of payments to customer needs
Premium type	Regular, single, recurrent single variations
Ratchet type	Single or multiple risk factors (e.g., inflation and account value)
Ratchet frequency	Daily, quarterly, annual, every n years
Resets versus ratchets	Resets cheaper than ratchets
Floor levels	Attractive benefit for an increase cost
Cap levels	Used to help reduce costs
Cap and floor frequency	Cumulative useful for deferral periods, annual for payout periods
Participation rate	Tailored to provide attractive benefits and costs
Underlying assets	Increasing allocations to inflation correlated assets (e.g. inflation-indexed bonds) will tend to reduce costs as they are natural hedges
Volatility protection	Target volatility funds dependent also upon the level of expected inflation volatility

4.6 Reliances and Limitations

The hedge costs developed for and presented in this report will change with capital market conditions such as current interest rate levels, break-even inflation expectations, volatility parameters, policyholder characteristics, demographics and policyholder behaviour assumptions. They are used solely for illustrating and understanding alternative product designs and should not be relied upon for formal product development purposes.

5 RISK MANAGEMENT CONSIDERATIONS

5.1 Manufacturing Inflation Benefits Through Replication

The inflation benefits designed in section 4 can be manufactured using replication techniques. As these benefit structures are quite complex, it is highly unlikely that a single or portfolio of assets can be found and held on a static basis, that generate cash flows with the same risk factor dependencies as the benefit. Thus it is necessary to use dynamic replication and hedging techniques to manufacture these benefits.

Such replication techniques rely upon the availability of liquid derivative instruments that can be used to construct a hedge portfolio that can be dynamically rebalanced over time in line with evolving market conditions. The cost of constructing and rebalancing this portfolio is dependent primarily upon market conditions at outset (as well as other assumptions), subsequent transaction costs, rebalancing thresholds and frequencies. Derivative instruments are used for this purpose, given their liquidity and low transaction costs relative to trading in the physical market.

For institutions underwriting these risks through a guarantee, risk transfer may be available via reinsurance or on a more limited basis, static hedges. However, these methods also rely upon the availability of dynamic hedging techniques and instruments, as this is what the counterparty will be relying on to manage its balance sheet risk.

Dynamic replication involves constructing and rebalancing a portfolio of assets sensitive to the various market factors that drive the value of an option on inflation. Since swaps and futures are more plentiful than options, dynamic replication opens up a broader array of risks that can be hedged. Additionally options are often expensive because of limited two-way flow so dynamic replication facilitates more cost-effective hedging. Other derivatives can be used to mitigate other risk sensitivities such as equity futures, currency futures, and nominal interest rate swaps to hedge nominal interest rate risk. For a complete discussion on this topic, refer to Bentley et al. (2010).

Dynamic replication involves constructing and rebalancing a portfolio of assets sensitive to the various market factors that drive the value of an option on inflation. Since swaps and futures are more plentiful than options, dynamic replication opens up a broader array of risks that can be hedged.

This section investigates the ability of institutions to manufacture inflation risk based upon the availability and liquidity of appropriate derivative hedging instruments in various markets.

5.2 Inflation Hedging Instruments

5.2.1 Inflation-linked Bonds

The Massachusetts Bay Company issued the first inflation-linked bonds in 1780. However, it wasn't until the latter part of the 20th Century that a larger number of governments started to issue inflation-linked bonds. Today this market continues to grow. The major inflation-linked bond markets worldwide and their market capitalisation (USD billion) as at 2010 are shown in Table 20 below.

TABLE 20: SIZE OF INFLATION LINKED BONDS MARKETS (SOURCE: BARCLAYS)

COUNTRY	APPROXIMATE MARKET VALUE (US$B)	YEAR OF FIRST ISSUE
US	641	1997
UK	385	1981
FRANCE	214	1998
ITALY	134	2003
GERMANY	59	2004
JAPAN	59	2004
CANADA	52	1991
ISRAEL	38	1955
SWEDEN	37	1994
SOUTH AFRICA	28	2000
AUSTRALIA	18	1985

Additionally, there are growing inflation-linked bond markets in Brazil, Mexico, Argentina, Chile, Columbia, Uruguay, Poland, Iceland, Turkey and South Korea.

The importance of the inflation-linked bond market is that it provides a ready instrument for the party that is short inflation through a derivative to be able to lay this off, and thus can facilitate the development of a derivatives market in inflation.

In some markets, there is also a supply of non-government-issued inflation-indexed debt. The importance of the inflation-linked bond market is that it provides a ready instrument for the party that is short inflation through a derivative to be able to lay this off, and thus can facilitate the development of a derivatives market in inflation. As a result, it is not surprising that these countries are also the ones that have the most developed inflation derivatives market, particularly the UK, where the physical market has existed for around 30 years.

5.2.2 Inflation Futures

Although inflation futures are listed on the CME and Eurex exchanges, as of the start of 2011 there was no open interest in these contracts.

5.2.3 Inflation Swaps

The inflation swap market grew rapidly since its beginning in 1999, but slowed substantially with the financial crisis and the prospect of deflation. The inflation swap market brings together the inflation payers (governments, utility companies, infrastructure companies) with inflation-hungry investors (pension funds, insurance companies, asset managers). Swaps are used by these companies to manage inflation exposures and cash flow profiles.

As discussed above, inflation-linked bonds can facilitate the development of the inflation swap market, as they provide a means for dealers to lay off inflation risk. However, an inflation-linked bond market is not necessary for the development of an inflation swap market provided there is sufficient two-way interest to be able to pair up swap payers and receivers. Inflation swap markets may develop without the robust presence of inflation bonds, which can often be locked up in buy-and-hold accounts.

The following types of swap instruments are common for hedging inflation and real rate risk:

- **Zero-coupon inflation swaps** where counterparties exchange a cumulative inflation-linked cash flow against a fixed cash flow at maturity.
- **Real rate swaps** where counterparties exchange a floating nominal rate (e.g., LIBOR) annually against an inflation-indexed bond with annual coupons and maturity payment linked to inflation
- **Year-on-year inflation swaps** where counterparties exchange an inflation rate against a fixed rate every year
- **Year-on-year real rate swaps** where counterparties exchange a floating nominal rate against a fixed real rate plus inflation every year
- **Indexed annuity swap** where counterparties exchange annual payments escalating at a fixed escalation rate against an inflation-index, mimicking an indexed annuity bond
- **Capital-indexed swap** where counterparties exchange annual payments based on a quarterly floating nominal rate against a fixed real rate plus inflation, mimicking a capital-indexed bond

The largest inflation derivative market in the world is currently the European inflation swap market, for which the reference index is the Euro-HICP index. Table 21 summarises the liquidity of the various markets.

TABLE 21: LIQUIDITY OF VARIOUS INFLATION SWAP MARKETS (SOURCE: MILLIMAN RESEARCH)

COUNTRY	INDEX	INSTRUMENT	LIQUIDITY
US	CPI	ZC INFLATION SWAP	LIQUID OUT TO 30 YEAR MATURITIES
UK	CPI, RPI, LPI	ZC INFLATION SWAP	LIQUID OUT TO 50 YEAR MATURITIES
EUROPE	HICP	ZC INFLATION SWAP	VERY LIQUID OUT TO 10 YEAR MATURITIES; MODERATE LIQUIDITY OUT TO 30 YEAR MATURITIES
AUSTRALIA	CPI	ZC INFLATION SWAP, INDEXED ANNUITY SWAP, CAPITAL-INDEXED SWAP	MODERATE LIQUIDITY OUT TO 30 YEAR MATURITIES, WITH MOST LIQUIDITY AT 10-YEAR POINT

The above instruments are ideal for use in an inflation hedging program as they cover long durations and have relatively low transaction costs.

5.2.4 Inflation Volatility Products

Inflation volatility is also a risk factor that must be considered when incorporating inflation benefits within insurance vehicles. Left unhedged, exposure to high realised inflation volatility can have costly consequences to an insurer. The insurer can purchase direct hedges against high realised inflation volatility, asset allocation strategies can be employed to reposition assets reducing exposure to inflation volatility, or such risks can be left fully or partially outside of an insurance company guaranty.

Inflation volatility is also a risk factor that must be considered when incorporating inflation benefits within insurance vehicles. Left unhedged, exposure to high realised inflation volatility can have costly consequences to an insurer.

The inflation volatility market has developed gradually over the last decade in line with the inflation swap market. The following types of instruments have been developed to hedge inflation and real rate volatility risk:

- **Zero-coupon cap**: A zero-coupon inflation swap where the spot inflation rate is capped at a pre-specified level
- **Zero-coupon floors**: A zero-coupon inflation swap where the spot inflation rate is floored at a pre-specified level
- **Caplet**: A forward-starting zero-coupon inflation swap (or real rate swap) where the forward annual inflation rate (or real rate) in year t is capped at a pre-specified level
- **Floorlet**: A forward-starting zero-coupon inflation swap (or real rate swap) where the forward annual inflation rate (or real rate) in year t is floored at a pre-specified level
- **Year-on-year inflation cap**: A year-on-year inflation swap where every annual payment is capped at a pre-specified level (i.e., a portfolio of caplets of the same cap level)
- **Year-on-year inflation floor**: A year-on-year inflation swap where every annual payment is floored at a pre-specified level (i.e., a portfolio of floorlets of the same floor level)
- **Zero-coupon inflation swaptions**: These provide the right to buy or sell a zero-coupon (or year-on-year) inflation swap in n years time at a specified price.
- **Real rate swaptions**: These provide the right to buy or sell a real rate (or year-on-year) swap in n years time at a specified price.

Table 22 below summarises the liquidity of the main instruments traded in the various markets.

TABLE 22: LIQUIDITY OF VARIOUS INFLATION VOLATILITY MARKETS (SOURCE: MILLIMAN RESEARCH)

COUNTRY / REGION	INFLATION VOLATILITY INSTRUMENT AVAILABLE	LIQUIDITY
US	MOSTLY FLOORS, INCREASINGLY CAPS	MODERATE
UK	YEAR-ON-YEAR AND ZERO COUPON CAPS AND FLOORS	MODERATE
EUROPE	YEAR-ON-YEAR CAPS AND FLOORS (HICPX[28])	MODERATE
	BREAK-EVEN AND REAL RATE SWAPTIONS	LOW
AUSTRALIA	CAPS, FLOORS	LOW

5.3 Pricing

When pricing inflation-linked benefits, the key determinant of the valuation basis and assumptions is the nature of the replicating hedge strategy. As the availability and liquidity of inflation hedging instruments varies by market, so will the replicating hedge strategy.

When pricing inflation-linked benefits, the key determinant of the valuation basis and assumptions is the nature of the replicating hedge strategy. As the availability and liquidity of inflation hedging instruments varies by market, so will the replicating hedge strategy. However, across the main developed markets, the primary replication strategy will be based upon dynamic hedging with the use of both nominal and inflation swap instruments. These instruments define both the nominal and real risk-neutral rate for pricing purposes. Similarly, the price of inflation protection is defined by the current level of the break-even inflation rate.

Appendix A outlines the term structures of nominal, real and break-even rates for each economy, as of the end of December 2010, that were used to derive the hedge costs in section 4.

[28] HICP ex-tobacco.

Assumptions may also need to be made wherever market data is unavailable. This may include:

- Inflation volatility parameters
- Correlation parameters between inflation, real and nominal rates

Where market data is unavailable for calibration, use of either historic analysis or judgement of future expectations will be required. In the circumstance where inflation volatility risk is able to be hedged, then the implied inflation volatility rates should be used for market-consistent valuation purposes. This assumes that the volatility levels evident in the market reflect expectations and not abnormalities related to structural supply and demand imbalances. If it is not possible to hedge certain inflation-based risks, such as realised volatility, then alternative approaches could be explored to share some or all of the risk with the policyholder/investor. Mechanisms for such sharing include allowing for the right to change the underlying asset mix, increase charges in the future, or use of best efforts protection benefits as opposed to fully guaranteed ones.

5.4 Use of Real Return Assets in the Underlying Portfolio

An alternative risk management mechanism to manage the inflation risks in such products is to introduce inflation sensitive assets into the underlying investment portfolio. As shown in section 3.6, assets such as inflation-linked bonds and cash generate returns that are positively correlated to inflation. They thus provide a partial natural hedge that reduces inflation risk and hence lowers the quantity of inflation hedging required.

5.5 Limitations and Risks

The replication of inflation benefits using dynamic hedging techniques is not perfect and is subject to residual risk. Design of a suitable hedging and rebalancing strategy is critical in order to reduce residual risks. Products with inflation benefits necessarily involve more complex hedge designs, due to the interaction of the inflation hedge with other nominal interest rate hedges. The liquidity of the inflation derivative market is also less than that of other interest rate derivative markets, which may influence the design of suitable hedging strategies for current products, or the viability of product features in the future.

The replication of inflation benefits using dynamic hedging techniques is not perfect and is subject to residual risk. Design of a suitable hedging and rebalancing strategy is critical in order to reduce residual risks.

In contrast to this, as these derivative markets are undergoing relatively greater change compared to other interest rate derivative markets, new derivative products may emerge or become sufficiently liquid to justify their inclusion in a hedging program. This may result in reduced residual risk and enable new product features to become viable and to be offered to the retail market.

As always with any hedging program, suitable governance and robust operational processes are critical ingredients to minimising risks and capital, and to ensure long-term business success.

6 PRODUCT DELIVERY OPTIONS AND OPERATIONAL STRUCTURES

6.1 To Protect or Guarantee

Manufacturing benefits that are dependent upon inflation risk is possible via the techniques and instruments outlined in section 5. Such benefits can be provided to the policyholder on a *protected* or *guaranteed* basis. In the former case, the benefits are manufactured in an investment vehicle whereby the investor owns the allocation to inflation hedging assets and bears the associated market risk. In this form, inflation risk protection is an asset allocation decision and is manufactured through a dynamic asset allocation process. In the latter alternative approach, an institution underwrites the benefits by guaranteeing them to the investor. This guarantee is provided as a rider benefit on top of an investment portfolio and is financed through an additional explicit charge. In this form, inflation risk protection is viewed more explicitly as a risk management overlay decision with an explicit cost.

Table 23 below compares and contrasts the characteristics of these two alternative product forms.

TABLE 23: COMPARISON OF PROTECTION VERSUS GUARANTEE PRODUCT MECHANISMS

CHARACTERISTIC	PROTECTION	GUARANTEE
Inflation protection benefits	Identical	Identical
Decision type	Asset allocation	Risk overlay
Investment portfolio	Partial allocation due to allocation to inflation hedge assets	Fully invested
Derivative hedge assets	Owned by investor via investment portfolio	Owned by guarantor institution
Policyholder inflation protection liquidity	Yes, inflation hedge assets can be liquidated at any time	No, inflation hedge assets held on institutional balance sheet
Manufacturing cost	Reflected in benefit outcome on weighted asset allocated	Hedge cost covered by explicit guarantee charge
Additional charges	Annual management charges, administration charges	Annual management charges, administration charges, cost of capital charges

6.2 Insurance Risks

The policyholder might face reduced cost of protection in the structure of an insurance product rather than an investment product. For example, income levels that lifetime annuities can provide are higher than those that can be supported by bonds of equivalent terms, because annuity payments cease in the event of death. However, it is important to be aware that the policyholder is giving up the death benefit that the equivalent investment product would provide.

Bundling market-based protection with demographic risk protection such as mortality, longevity, health, income protection etc, requires an insurance wrapper. The benefit of this structure is that all forms of protection can be provided on a guaranteed basis, providing greater up-front certainty around the level of protection given. The downside is that it will typically cost more in order to cover the guarantee providers cost of capital and the final benefits are subject to an element of counterparty credit risk.

Bundling market-based protection with demographic risk protection such as mortality, longevity, health, income protection etc, requires an insurance wrapper. The benefit of this structure is that the all forms of protection are provided on a guaranteed basis, providing greater up-front certainty around the level of protection given.

6.3 Economic Capital Considerations for Guarantee Providers

If an insurance company offers an inflation-guaranteed product, it would be required to hold economic capital on its balance sheet for bearing the risk. It would then seek to charge an additional amount to policyholders to hold this capital, reflective of the amount of capital required, and the excess required return on its capital (i.e., required return less the cash rate).

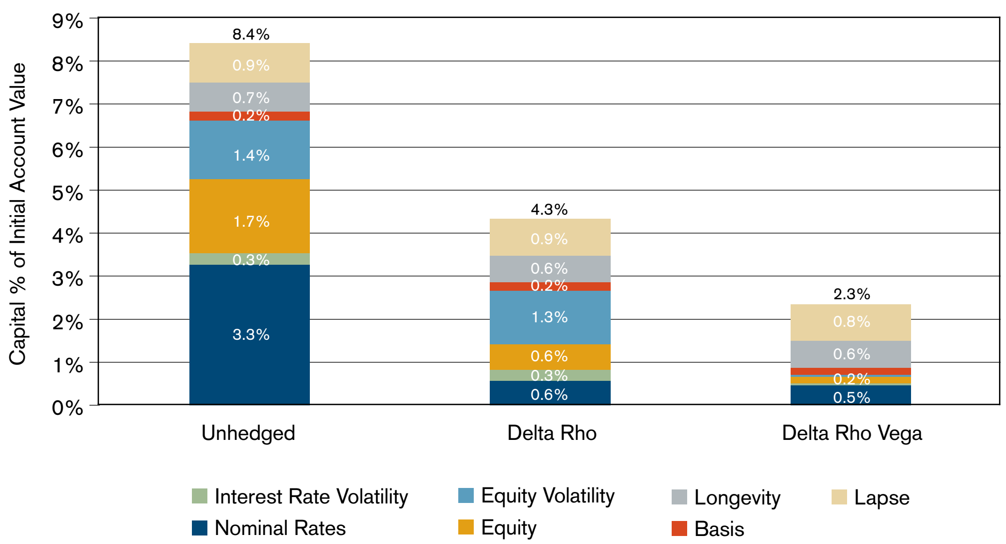
Illustrative economic capital amounts have been derived for the following two GLWB products:

- Product 2a: Nominal GLWB with a guaranteed withdrawal rate of 5.4%
- Product 3: Inflation-linked GLWB with a guarantee withdrawal rate of 4%

Both of these products are based on the Australian economy, and have attractive and equal hedge costs of 71 bps p.a. For the purposes of this paper, economic capital has been derived based upon the Solvency II standard formula methodology and basis[29] for an unhedged, delta rho hedged, and delta rho vega hedged strategy. The basis and assumptions used for this analysis are outlined in Appendix B. In practice, a range of capital requirements would be calculated based upon organisation, market and regulatory specific requirements. The delta hedge uses equity futures, the rho hedge uses nominal and real interest rate swaps, and the vega hedge uses equity options and interest rate swaptions.

Figures 30 and 31 show the illustrative economic capital that results from these two products. Please note these Figures are indicative only and may vary according to product design, hedge design, market conditions, and the local regulatory capital methodology and basis.[30] Total economic capital results are decomposed by risk factor, and are presented showing diversification benefits reallocated on a pro-rata basis.

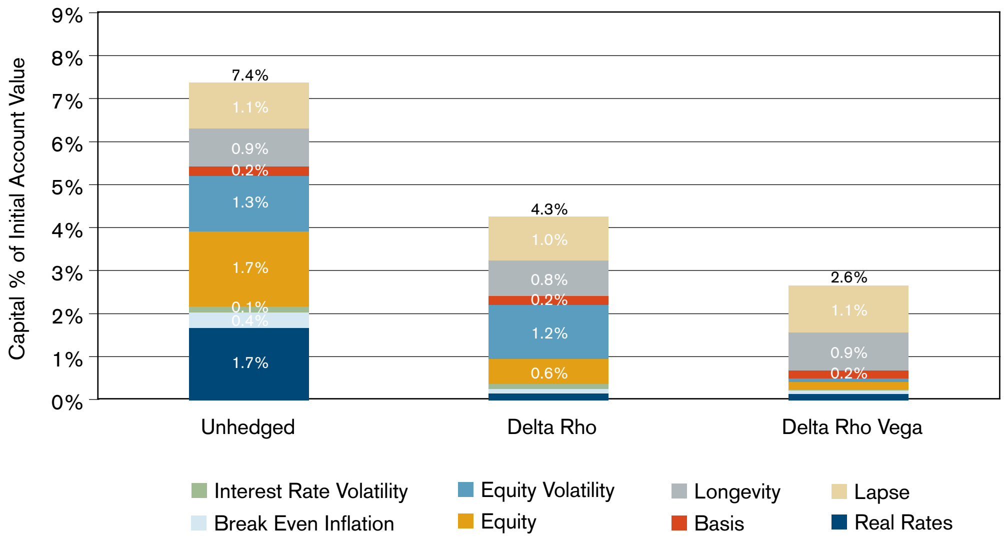
FIGURE 30: ILLUSTRATIVE ECONOMIC CAPITAL FOR THE NOMINAL GLWB PRODUCT BY HEDGE STRATEGY



29 Refer to CEIOPS (2010).

30 In particular, interpretations have been made relating to the latest Solvency II guidance where there is no specific guidance on how to interpret various stresses when operating in a real rate and break-even inflation framework. Assumptions have also been made relating to hedge effectiveness for some of the stresses, although these are based upon knowledge gained through extensive practical experience with operational hedge programs.

FIGURE 31: ILLUSTRATIVE ECONOMIC CAPITAL FOR THE INFLATION-LINKED GLWB PRODUCT BY HEDGE STRATEGY



The key observations from these results are:

- Economic capital is lower for the inflation-linked GLWB relative to the nominal GLWB due to the reduction in interest rate risk in moving from a nominal interest rate to a real interest rate framework. Nominal interest rate risk can be considered to contain both real rate and inflation risks. Break-even inflation risk is very low for the inflation-linked GLWB, as increases (or decreases) in nominal payouts are largely offset by higher (or lower) discount factors.
- Market risks dominate insurance risks in unhedged economic capital.
- A delta rho hedge strategy is quite effective in reducing most market risk; however, volatility is still relatively significant.
- A delta rho vega hedge strategy is very effective in reducing market risk.

The capital requirements of inflation-linked products such as GLWBs are comparable to equivalent nominal guaranteed products. Thus there is no economic capital impediment to their development wherever their nominal product cousins can justifiably exist.

The conclusion from this analysis is that the capital requirements of inflation-linked products such as GLWBs are comparable to equivalent nominal guaranteed products. Thus there is no economic capital impediment to their development wherever their nominal product cousins can justifiably exist.

6.4 Operational and Business Models Options

In order to develop and manage inflation-based products, various operational and business model options are available. The key operational activities that potentially require or justify specialist management include:

- Product design and pricing
- Designing a hedging program
- Capital treatment and assessment
- Operating a hedging program on an around-the-clock, real-time basis
- Production of management information to monitor the hedging program
- Administering collateralisation or pooled structures and processes to ensure fiduciary duties are met

Each of these operational activities can be undertaken under the following business models:

- **Outsourcing**: This is a viable solution for those companies who lack the expertise, experience and resource capacity in any or all of the above activities.

- **Internal**: For those companies of sufficient size that have the necessary expertise, experience and resource capacity in any or all of the above activities.

- **Partnership**: For organisations that have some expertise, experience and resource capacity to undertake some of the activities but require assistance with others.

Weighing up the various product designs, risk management strategies and operational business models can be an involved process. Understanding the relative pros and cons of each solution will ultimately help build an efficient, sustainable and competitive solution.

Weighing up the various product designs, risk management strategies and operational business models can be an involved process. Understanding the relative pros and cons of each solution will ultimately help build an efficient, sustainable and competitive solution.

7 APPENDIX A: PRICING ASSUMPTIONS

The following pricing assumptions were used to derive the hedge costs produced in this report.

Fees: 1.5% p.a. plus hedge cost

Mortality table: UK RMC00 Male Post-retirement

Deterministic lapse rates set at 4% p.a. for each product, except for the US GMAB product, which assumes lapse rates as outlined in the following table (driven by surrender penalty schedules in this market):

TABLE 24: LAPSE RATE ASSUMPTIONS FOR US GMAB PRODUCT

DURATION	LAPSE RATE
1-5	3%
6	20%
7+	10%

Equity volatilities for all economies were assumed to be 25% across all durations. Nominal interest rate, real interest rate, and break-even inflation rate term structures derived from swaps as at 31 December 2010.

FIGURE 32: NOMINAL INTEREST RATE TERM STRUCTURES AS AT 31 DECEMBER 2010

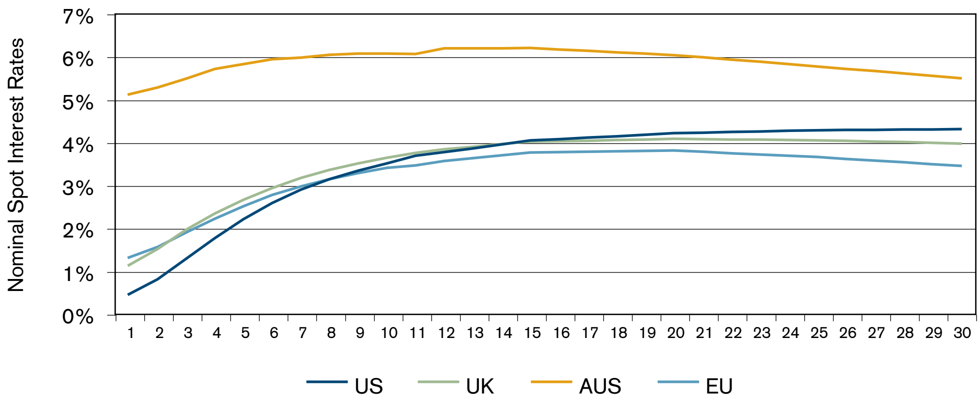


FIGURE 33: REAL INTEREST RATE TERM STRUCTURES AS AT 31 DECEMBER 2010

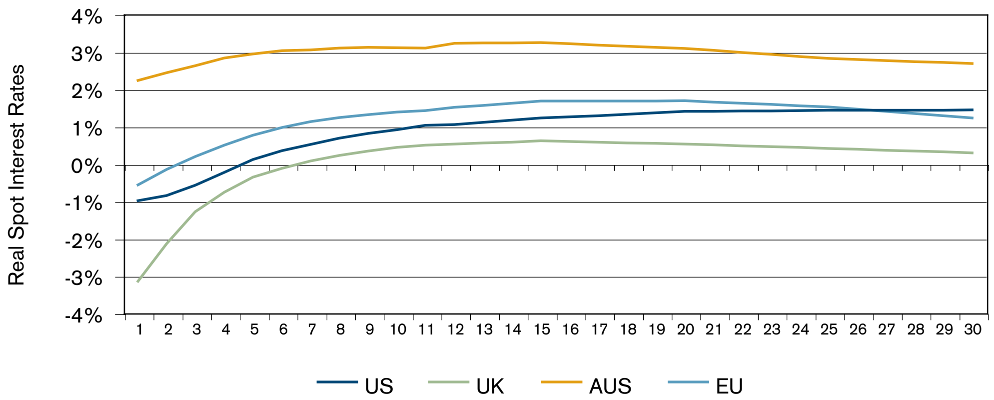


FIGURE 34: BREAK-EVEN INFLATION TERM STRUCTURES AS AT 31 DECEMBER 2010

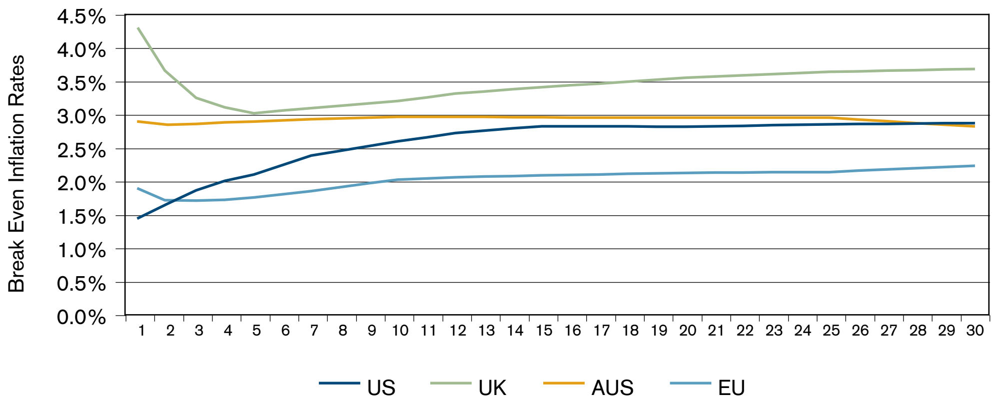


TABLE 25: JY MODEL CORRELATION MATRIX

	AUS	US	UK	EU
REAL, INFLATION	-24%	-50%	-11%	-17%
NOMINAL, INFLATION	44%	48%	47%	39%
NOMINAL, REAL	25%	-8%	-27%	40%

TABLE 26: HULL-WHITE MODEL PARAMETERS

	AUS	US	UK	EU
MEAN REVERSION NOMINAL	3.0%	3.0%	3.0%	3.0%
VOLATILITY NOMINAL	1.3%	1.3%	1.0%	0.8%
MEAN REVERSION REAL	3.0%	3.0%	3.0%	3.0%
VOLATILITY REAL	1.0%	1.1%	1.2%	0.8%

TABLE 27: INFLATION VOLATILITY ASSUMPTIONS

	AUS	US	UK	EU
VOLATILITY OF INFLATION	1.1%	2.5%	2.1%	1.4%

Excess equity returns above cash were assumed to have zero correlation with all other variables. Bond returns were modelled with respect to the stochastic interest rate processes, with an assumed duration of four years.

8 APPENDIX B: ECONOMIC CAPITAL ASSUMPTIONS

The indicative economic capital estimates presented in section 6.3 have been derived based upon the Solvency II QIS5 framework. This framework assesses the impact on capital from various immediate stresses to the relevant risk factors. The equity stresses used are as follows.

- Equity levels: -30% relative
- Equity volatility: +125% relative (not explicitly specified by QIS 5)

As per the QIS5 basis, the results from these two stresses are added together, on the assumption that they are perfectly positively correlated.

Solvency II only specifies stresses to nominal interest rates, and does not decompose this into separate real interest rate and inflation break-even stresses. In order to do this, it has been assumed that the relative nominal spot rate stresses are identically applied to both real spot interest rates and spot break-even inflation rates. The worst-case scenario (from a capital perspective) has been assumed whereby these two stresses are perfectly positively correlated (+1). For an internal model approach, additional analysis would need to be undertaken to calibrate these two risk factors stresses, as well as their covariance for aggregation, which is beyond the scope of this paper. The following table shows the up and down stresses applied to the spot interest rates.

TABLE 28: INTEREST RATE STRESSES

TERM	SHOCK DOWN =SPOT*(1+X)	SHOCK UP =SPOT*(1+X)	TERM	SHOCK DOWN =SPOT*(1+X)	SHOCK UP =SPOT*(1+X)
1	-75%	70%	16	-28%	31%
2	-65%	70%	17	-28%	30%
3	-56%	64%	18	-28%	29%
4	-50%	59%	19	-29%	27%
5	-46%	55%	20	-29%	26%
6	-42%	52%	21	-29%	26%
7	-39%	49%	22	-30%	26%
8	-36%	47%	23	-30%	26%
9	-33%	44%	24	-30%	26%
10	-31%	42%	25	-30%	26%
11	-30%	39%	26	-30%	26%
12	-29%	37%	27	-30%	26%
13	-28%	35%	28	-30%	25%
14	-28%	34%	29	-30%	25%
15	-27%	33%	30 +	-30%	25%

Note that bond fund values are also impacted by the interest rate stress.

Swaption volatility has been assumed to increase by 4% in absolute terms (note that this is not explicitly specified by QIS5). This risk is assumed to be perfectly positively correlated to interest rate risk.

Other stress assumptions include:

- Longevity risk: -25%
- Lapse risk: -50%
- Basis risk: -3% stress to account values, with no change in index levels

The correlation between the various market risks is as follows:

TABLE 29: CORRELATION ASSUMPTIONS FOR MARKET RISKS

RISK FACTOR	EQUITY	INTEREST RATE	BASIS
EQUITY	1	0.5	0
INTEREST RATE	0.5	1	0
BASIS	0	0	1

The correlation between the various life underwriting risks is as follows:

TABLE 30: CORRELATION ASSUMPTIONS FOR LIFE UNDERWRITING RISKS

RISK FACTOR	LONGEVITY	LAPSE
LONGEVITY	1	0.25
LAPSE	0.25	0

The correlation between the market and life underwriting risks is as follows:

TABLE 31: CORRELATION ASSUMPTIONS BETWEEN MARKET AND LIFE UNDERWRITING RISKS

RISK FACTOR	MARKET	INSURANCE
MARKET	1	0.25
INSURANCE	0.25	0

Counterparty default risk has been ignored on the assumption that it is expected to be immaterial for the hedge assets, which are assumed to be collateralised. Operational risk has been excluded from the analysis, as this is company specific and thus very difficult and potentially misleading to include in this indicative analysis.

9 APPENDIX C: BREAK-EVEN VERSUS REALISED INFLATION

The following figures show the annual 10-year bond break-even inflation rates versus realised CPI inflation for the US, Australian and UK economies.

FIGURE 35: US BREAK-EVEN INFLATION VERSUS US REALISED CPI INFLATION

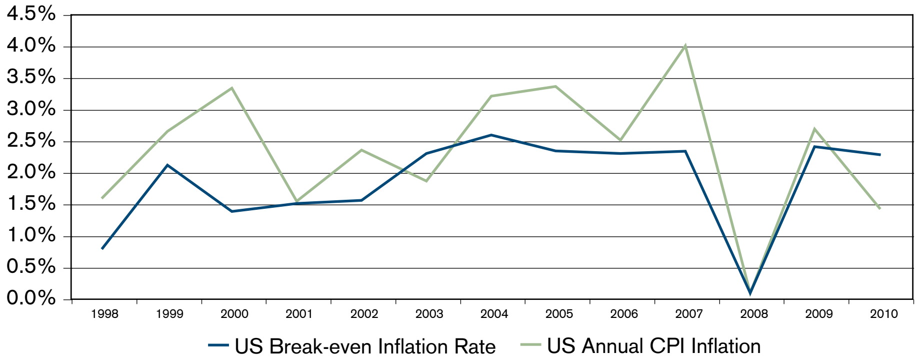


FIGURE 36: AUSTRALIAN BREAK-EVEN INFLATION VERSUS US REALISED CPI INFLATION

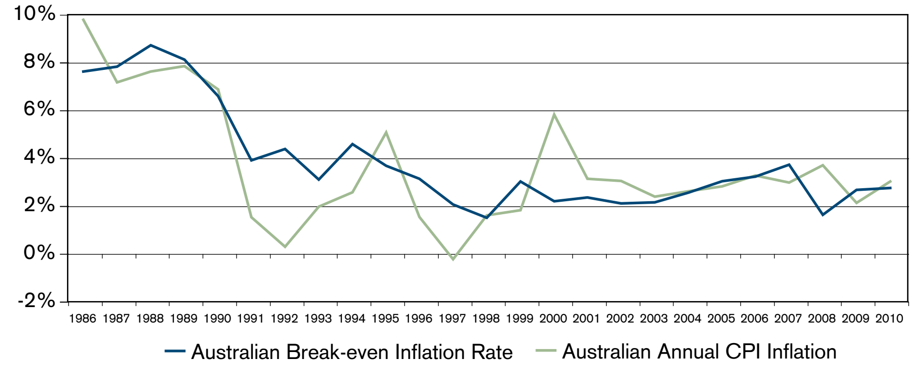
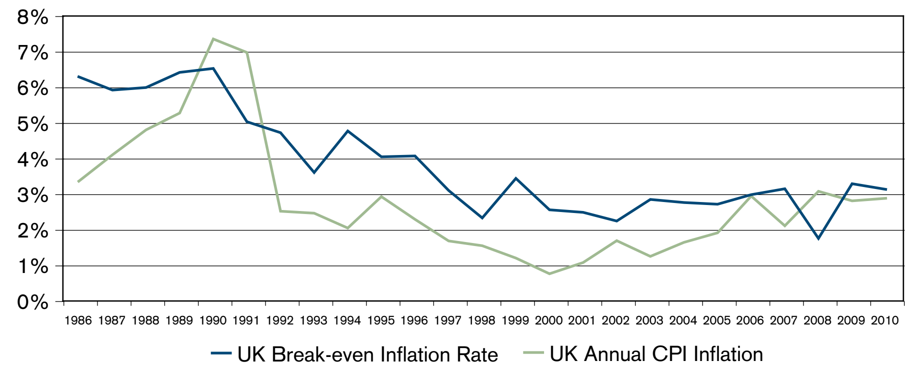


FIGURE 37: UK BREAK-EVEN INFLATION VERSUS US REALISED CPI INFLATION



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