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Challenge ·Inflation ·Opportunity

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Abstract

We lie awake at night tormented by the gap between yields and inflation. Commonly-used inflation forecasts pose some challenges when it comes to estimating the gap. Typically, these inflation forecasts are made at different times to yield forecasts, causing an informational misalignment – which can lead to volatility in the gap.

The market for index-linked bonds has deepened in recent years so a market-based estimate of future inflation is possible. In the first instance, we test a market-based inflation forecast for pricing longer-tailed insurances where stability of premium is a material consideration. Pushing further, a market-based inflation forecast may have application in long-tail valuation. It can be a legitimate way to determine liability using a market-based "gap", as opposed to other approaches which are heavily reliant on convenient assumptions.

Key words: challenge; inflation; opportunity; gap; cosmetic; real yield

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1 INTRODUCTION AND BACKGROUND

1.1 Introduction

Inflation rates are key assumptions for many actuarial jobs. They are particularly important in long-term schemes such as those represented at the Injury and Disability Schemes Seminar (IDSS). For schemes with future payments in the distant future, the compounding effect of inflation means that changing assumptions has a very large impact.

The setting of inflation assumptions is therefore important. It is also important to consider the relationship between inflation assumptions and discount rates; an insurance liability is typically discounted to present values after inflation assumptions are applied. It is the 'gap' between inflation and discount rates (the real interest rate)[1] which is effectively applied to the cashflows.

In some ways the setting of inflation assumptions (and implied real interest rates) is easy; compared to the era before formal inflation targeting, rates are now pretty stable. However, important challenges remain. The long-term compounding nature of inflation means that small assumption changes can have large impacts on distant cashflows. Further, the range of approaches used in actuarial work suggests that we lack consensus on best practice.

This paper aims to review the key principles of inflation assumption setting, and explore some recent developments. Of particular note, the increasing issuance of indexed bonds now provides an opportunity to better incorporate market expectations into our assumptions. We develop a market-based measure of future inflation and compare this to commonly used estimates from a professional forecaster.

The rest of Section 1 briefly covers core background to inflation assumptions. Section 2 covers more recent developments. Section 3 looks at sources of inflation expectations and compares performance. Finally, Section 4 gives recommendations for setting assumptions.

1.2 Current sources of inflation assumptions

Current common approaches include:

- Historical rates – Looking at average inflation rates (since the introduction of government inflation targeting in 1993) gives a plausible basis for the future. These sometimes take different forms; for example, a 'fixed-gap' approach uses the historical gap between inflation and discount rate, whereas fixed inflation uses historical inflation levels directly.
- Formula-based approaches – These are extensions to historical rates that recognise patterns in past inflation and apply these to current conditions. An example includes Miller (2010), which moves inflation up or down in response to discount rate movements, based on historical correlations.

[1] The real interest rate refers to nominal interest rates minus inflation (typically consumer price index inflation). This difference can be close to zero or even negative when nominal interest rates are low, as is currently the case.

- Economic forecasters – Deloitte Access Economics (DAE) produces detailed forecasts quarterly, which have widespread use among actuaries. Other forecasts are available too, and discussed in Section 3.

1.3 Use of inflation in injury and disability schemes

Virtually all payment types in an injury or disability scheme are subject to inflation. There are various inflation indices maintained by the Australian Bureau of Statistics (ABS):

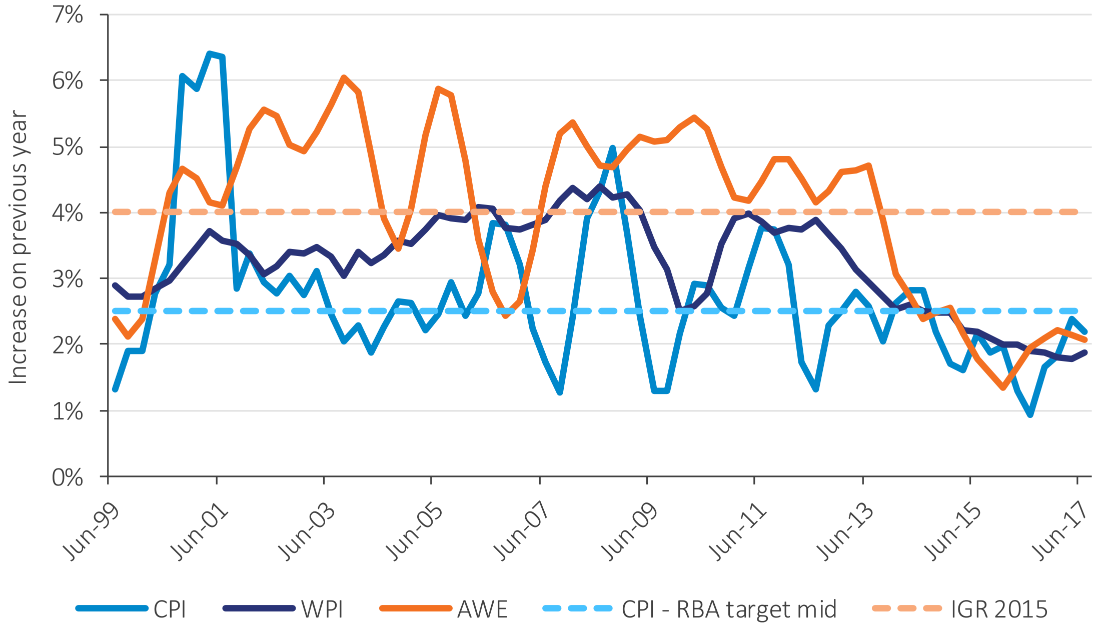
- **Consumer price index (CPI) –** This is an index that tracks prices for a basket of goods, weighted to reflect average consumer spending. It is made up of 11 major subcategories, each of which can be considered an index in its own right.
- **Wage price index (WPI), or labour price index –** This is an index that tracks the cost of wages over time, controlling for changes in the quality and quantity of the underlying work.
- **Average Weekly Earnings (AWE) –** This index tracks average gross weekly wages across employee jobs in Australia.
- **Other indices –** The ABS maintains a number of other indices. These include trimmed mean and weighted median versions of the CPI; these are more stable and are more important for the Reserve Bank of Australia's (RBA) inflation targeting.

Of these, CPI is the most commonly cited in the media and forms the basis of inflation targeting in Australia. It is used in insurance schemes to inflate cash flows that follow consumer spending trends. AWE is also very common for scheme valuations; it tends to grow faster than CPI, and is more representative in the growth rate of cash flows linked to wages such as weekly benefits.

CPI, WPI and AWE annual changes are shown in Figure 1 below, and have averaged 2.7%, 3.2% and 4.0% respectively since June 1999. The historical inflation rate has tended to track the RBA's target band (between 2% to 3%) relatively well over time. Similarly, the AWE average is very close to the 4% assumption commonly used, such as in the 2015 intergenerational report[2]. These measures of inflation have been lower in recent years, which is discussed further in Section 2.1.

[2] https://treasury.gov.au/publication/2015-intergenerational-report/

Figure 1 Historical inflation rates over time



This paper does not attempt to give a full background to inflation rates and their uses in injury and disability schemes. These topics are covered elsewhere. Miller (2016) provided a summary of how inflation indices are compiled and their limitations. Some other Australian papers relevant to inflation in actuarial contexts include:

- Inflation risk in general insurance (De Ravin and Fowlds, 2010)
- Inflation forecasting (Miller, 2010)
- Superimposed inflation (Pearson and Beynon, 2007)
- Extreme events in inflation (Ahlgrim and D'arcy, 2012).

The paper by Miller (2010) is particularly relevant here. It focused on medium term inflation assumptions and explored the relationship between changes in discount rates and changes in inflation. It found little evidence for adopting a 'fixed gap', where changes in discount rates are fully reflected by matching changes to inflation rates. Rather, it found that CPI was relatively immune to bond yield changes (little inflation variation with yields), however there was a detectable relationship for AWE; a portion (up to about 30%) of bond yield changes were reflected in AWE.

1.4 Success of RBA CPI inflation targeting

One of the most important observations is also one of the more obvious; the RBA has been very effective over time in ensuring annual CPI changes[3] have been close to their target band of 2-3%. This strategy, and the band itself, was formalised in 1993. This result is consistent with CPI expectations in Section 3; most sources expect the RBA to continue to achieve inflation rates within this inflation band.

[3] More formally, the trimmed mean and weighted median forms of CPI

There has been some discussion about new types of monetary policy targets, such as targeting nominal income growth[4], or more directly recognising unemployment rates. However, the success of inflation targeting in achieving economic stability and growth, particularly in Australia, suggests that such changes are unlikely in the short to medium term.

1.5 Difficulty in projecting in AWE

In contrast to CPI, AWE inflation has proven more difficult to forecast:

- While CPI is explicitly targeted, there is no corresponding 'target' for AWE. Wage growth is usually viewed as CPI plus a premium equalling productivity growth. However, even this is a simplification, as it is distorted by factors like the level of income going to wages (as opposed to profits), or the changing number of hours worked.
- There are cyclical runs of above-average and below-average wage growth. This is evident in Figure 1, where above average growth during the mining boom years of 2003 to 2011 are counterbalanced by below average growth since 2013.
- These swings are even more dramatic across states, where local economic conditions can vary tremendously. The very high wage growth years in the mining boom for Western Australia and Queensland have reversed in recent years.
- Average wages, while easier for the ABS to measure, can be distorted by changes in inequality of the distribution of incomes. Median wages have probably grown at a slower rate than average wages over the past two decades (see Miller 2016).
- From 2012, the ABS moved from quarterly to half-yearly collection of AWE statistics. This adds to the volatility of the time series and uncertainty between releases. It also creates timing issues when combined with other forecasts. We refer to this as informational misalignment, where timing of ABS data combined with timing of economic forecast reports lead to an incomplete view of short-run inflation.

1.6 Regulatory considerations

Various standards apply to the setting of inflation and discount rates in different contexts. We do not cover these here, but we give an instructive example. AASB1023 (which covers accounting rules for general insurance contracts) requires discount rates use risk-free rates, and that government bonds may be appropriate where observable. It requires that "appropriate allowance is made for future claim cost escalation when determining the central estimate of the present value of the expected future payments", and provides wage and price inflation as examples of such escalation.

[4] See for example http://www.afr.com/news/economy/monetary-policy/rba-inflation-target-has-run-its-course-says-mckibbin-20170718-gxdm1p

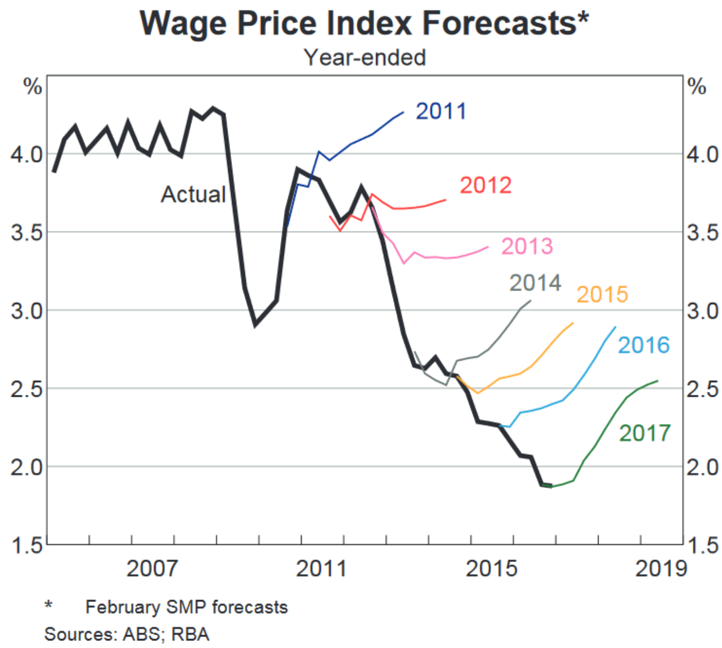
2 MORE RECENT DEVELOPMENTS

There are several recent trends that affect our considerations on inflation. We discuss these here, before looking at options for assumption setting in Section 3.

2.1 Low yields and low wage growth

Figure 2 is taken from Bishop and Cassidy (2017). It contrasts the historical WPI with the annual forecasts made by the RBA. Wage growth has been stubbornly lower than expected, despite consistent expectations that it would revert towards historical averages. The equivalent forecasts for AWE and CPI show the same pattern of overestimation.

Figure 2 WPI historical trends and RBA forecasts, taken from Bishop and Cassidy (2017)



Additionally, we have seen bond yields similarly remain low in recent years – at levels lower than observed during the GFC; see Figure 3.

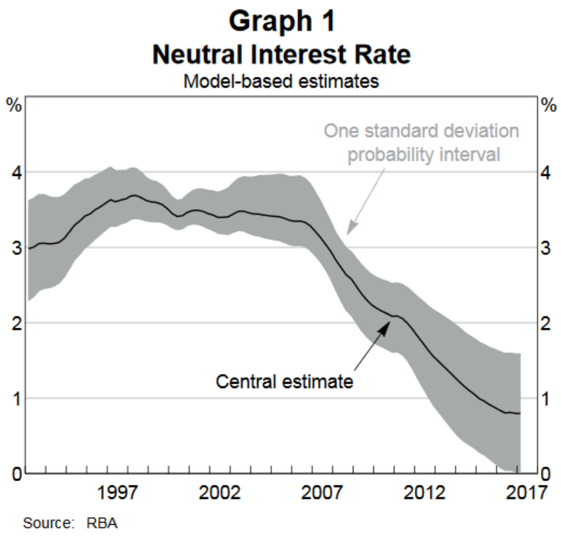
Figure 3 5-year spot rate, Commonwealth Government bonds

We observe:

- » The experience shows that monetary policy is in part imported from overseas; although Australia's economy has avoided recession and remains relatively robust, maintaining interest rates at historical average levels has not been possible. While overseas rates are low, Australian rates will also be reduced, or risk significant currency appreciation and capital movements.
- » The alignment of low yields with low wage growth supports the idea that lower rates are associated with low growth. However, the relative sizes still do not support a 'fixed gap' approach; 5-year bond rates have been about 3-4% below historical levels, while AWE has been about 2% lower.
- » There is genuine belief that some of the change reflects the 'new normal'. Recent RBA minutes suggested that they believe the neutral interest rate (the level at which monetary policy is neither expansionary or contractionary) is 3.5%, a two-percentage point drop over a decade[5]. Figure 4 below shows the decline in the real interest neutral rate, as modelled by the RBA (McCririck and Rees, 2017) Such changes are driven by factors such as higher levels of household debt and a global savings glut. If this is the case, we would expect the decrease to extend across the yield curve and for yields to not return to levels seen in the early 2000s.

[5] https://www.rba.gov.au/monetary-policy/rba-board-minutes/2017/2017-07-04.html

Figure 4 Modelled (real) neutral interest rate. Taken from McCririck and Rees, 2017



2.2 Duration of nominal bonds

When selecting long-term inflation assumptions and discount rates, it used to be the case that there was significant uncertainty in the long-term risk-free rate. The longest bond term was for many years about a decade, whereas scheme liabilities could extend for significantly longer than this.

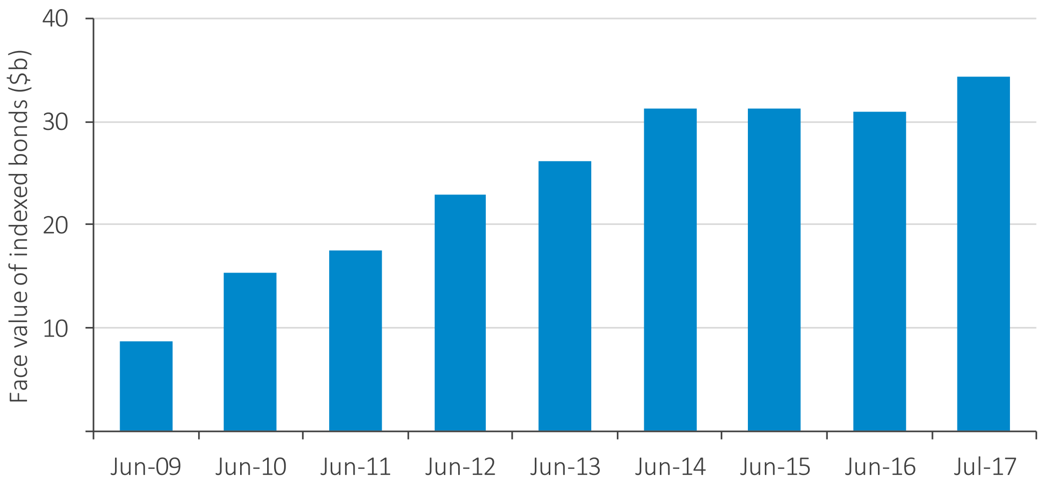
This required actuaries to extend out the yield curve. Sometimes 'kinky' extrapolations were adopted that quickly reverted to a convenient rate, adding stability where there was uncertainty. Mulquiney and Miller (2014) studied yield curve extrapolation, looking at Australian and international experience, plus hedging arguments, to show that any reversion to convenient rates should be slow and smooth.

Fortunately, such extrapolations are no longer necessary except for lifetime care schemes. The Australian Government has increased the amount of debt on offer, and significantly lengthened the terms on offer. The longest dated nominal bond currently has redemption in 2047, a term of 30 years, and 50-year bonds have been discussed as a possibility.

2.3 Deepening of the inflation linked bond market

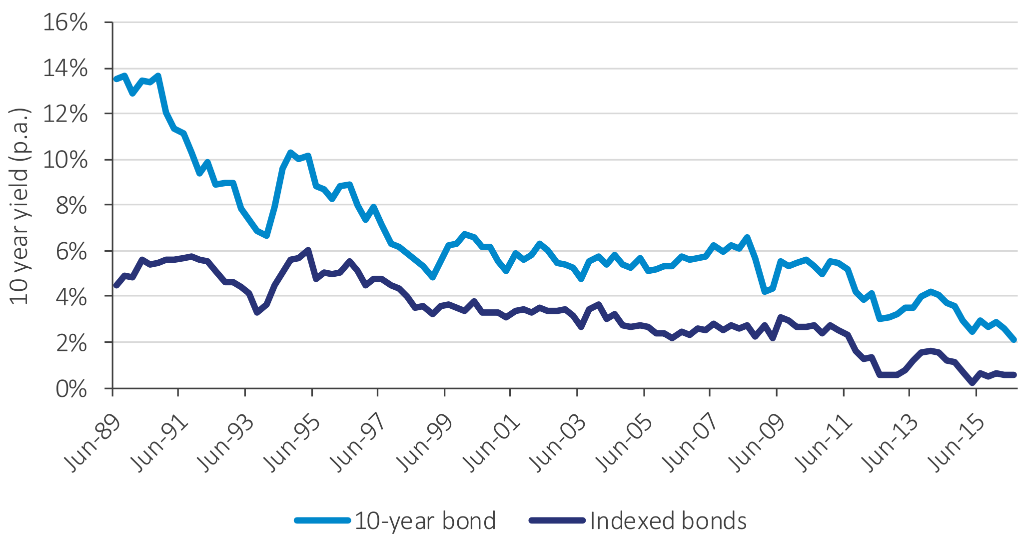
In addition to longer-term nominal bonds, the government has significantly expanded the issuance of indexed bonds. This is shown in the figure below, where in July 2017 the face value of such bonds was $34b, with the latest maturity date in 2040. The Australian Office of Financial Management is targeting between 5-10% of new issuance to be indexed. These are tied to CPI inflation, with the principal and coupon payments increased in line with measured changes to CPI.

Figure 5 Face value of issued indexed bonds



Further evidence that the market now has depth is that the prices for index bonds now move more tightly with nominal bonds. Figure 6 shows that variation in bond yields is greater than changes in long-run inflation expectations. Prior to 2007 index bonds yields did not vary much with nominal yields – the price indexed bonds remained stable. The correlation between the two curves in the six years to June 2007 was 0.4. This correlation in the eight years to June 2017 is now 0.97, a marked difference. The amplitude of movement of the indexed bond in this period is 75% of the nominal, which can be crudely interpreted as three-quarters of nominal bond variation relates to real interest rate changes, and the remainder inflation expectations.

Figure 6 10-year spot yields for nominal and indexed bonds



In theory, such bonds offer an objective way to gauge market inflation expectations. Miller (2010) reviewed the feasibility of using inflation linked bonds for setting inflation assumptions. They were not deemed suitable then because they were thinly traded and overpriced. With the deepening of the market (and the shift of inflation hedging away from over-the-counter derivatives to using such bonds), we believe this is no longer the case. The practical use of such bonds is discussed in more detail in Section 3.

2.4 Professional obligations

Most professional standards require appropriate allowance for claims inflation. Such requirements are typically less prescriptive than the equivalent discount rate assumptions, reflecting:

- The different inflationary patterns seen in different schemes, including different levels of superimposed inflation, and
- The relative lack of objective market instruments on which to base such assumptions.

There has been a working group looking at economic assumptions under PS300 set up by the Actuaries Institute. This included consideration of the use of 'asset-based' discount rates in actuarial work, the potential use of index-linked bonds and the need to reflect the economic reality of the day.

Another important development is the release of IFRS17, which are international accounting standards that will apply to insurance liabilities. While not entirely prescriptive, some key features are:

- A requirement to consider liquidity premiums in discount rate assumptions; this will generally have the effect of increasing the real interest rate assumptions used for insurance liabilities
- That inflation and discounting assumptions depend on market instruments. Where they don't they should not be inconsistent with market observations. For example, inflation assumptions should not be inconsistent with observable discount rates.
- Recognition that there is a correlation between inflation and discount rates.

2.5 Ongoing tension between liability stability and market faithfulness

One of the themes that arises repeatedly is the principle of liability stability. For an unfunded insurance liability, its value over time is stable if real interest rates (the difference between discount rates and the applied inflation rates) are stable. In such cases, stakeholders often prefer approaches that emphasise this stability.

There is a paradox here, in that stability in the liability estimate does not mean stability in the net asset position where a scheme is holding assets well-matched to the liabilities (e.g. nominal bonds with similar duration). In such cases keeping real interest rates stable for the liability will maximise the volatility of the net asset position; since the liability moves relatively little with market forces, the assets (which are easily marked to market) will vary a lot.

We offer some opinions on this tension:

- To the extent that there is uncertainty, we believe it can be reasonably argued that assumptions within that uncertainty band can favour stability. However, there are now tighter limits on this flexibility:

- Inflation-linked bonds reduce uncertainty in inflation expectations.
- Research (such as Miller, 2010) suggests that fixed-gap approaches are not supported by evidence.

» The flexibility in the previous point means that different financial assumptions could be applied to different schemes, even by the same actuary. We are not overly fond of this outcome and favour approaches that are consistent across valuations – this is more consistent with the professional requirement that actuaries offer impartial advice.

» The current environment of low real interest rates means that 'stability' based approaches have the effect of understating liabilities. While there is genuine debate around how much of the current environment is temporary, we do not support ignoring economic realities.

For the remainder of this paper, we dismiss 'fixed gap' and 'fixed inflation' assumptions as contrary to evidence and thus inappropriate. We turn our focus to reasonable forecasts of inflation expectations: market-based estimates and estimates by professional forecasters.

3 INFLATION EXPECTATIONS AND INDEXED BONDS

Having dismissed approaches that aim to stabilise the liability as inappropriate, this section looks at reasonable inflation forecasts more closely. We develop a market-based inflation forecast and compare it to another commonly used inflation forecast from Deloitte Access Economics (DAE).

3.1 Original motivation for the analysis

The following analysis is an adaptation of work completed by Taylor Fry for the Motor Accident Insurance Commission Queensland (MAIC). The work with MAIC is leading a discussion on forecasting inflation for the pricing of CTP insurance. Specifically, Taylor Fry reviewed whether Deloitte Access Economics (DAE) forecasts are the best option for projecting inflation in Queensland CTP claim costs considering:

- The volatility in the economic gap each quarter
- The persistent overestimation of future wage inflation over the past five years.

Figure 7 shows the volatility in the advised gap at the quarterly premium review for Queensland CTP. The gap for Queensland CTP is determined using Queensland AWE and a mean term of approximately four years between underwriting and payment.

Figure 7 Advised economic gap at quarterly premium reviews

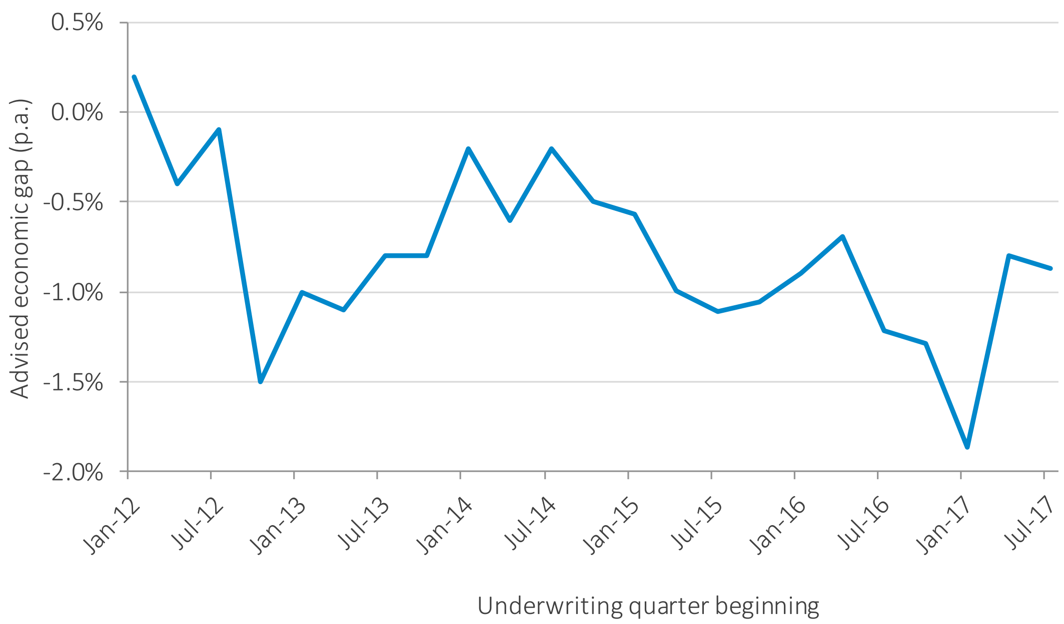
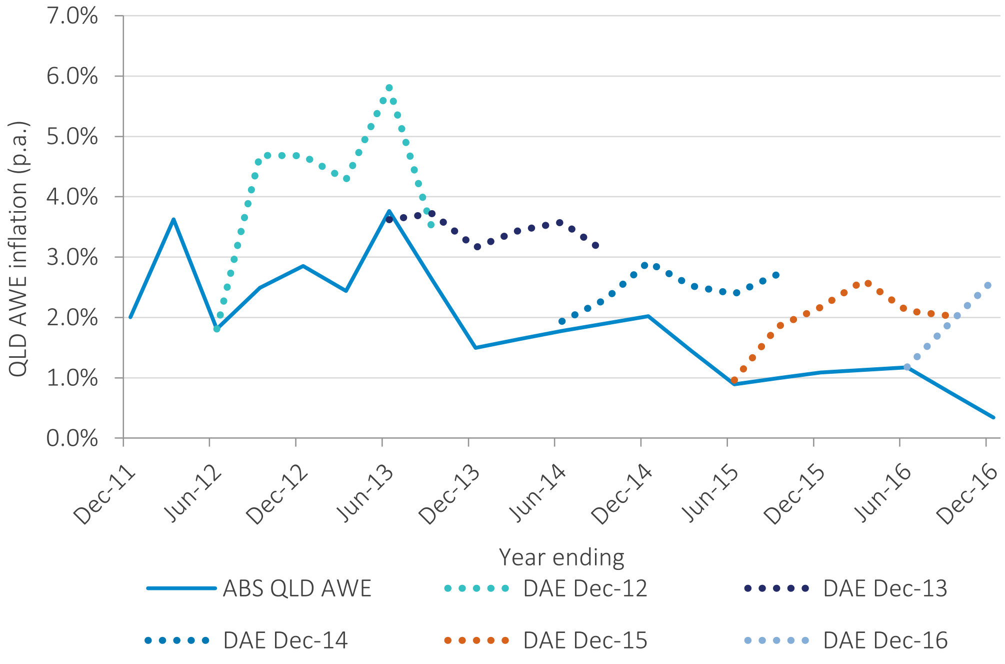


Figure 8 shows the adopted forecast of future wage inflation implied by the DAE QLD AWE series since June 2012. DAE have persistently forecast QLD AWE more than realised inflation over recent years. This not a criticism directed specifically at DAE; in fact, it echoes the RBA's overestimation (as reproduced in Figure 2).

Figure 8 Comparison of DAE QLD AWE inflation forecasts with realised QLD AWE inflation



For this paper, we look at informational alignment and forecast accuracy:

- **Informational alignment –** DAE releases inflation forecasts quarterly based on information up to the end of the experience quarter. Actuaries will typically use the yields of Commonwealth Government bonds at a later date. In the instance of Queensland CTP, yields are used from the last month of the quarter. For a year-end valuation, actuaries will often use yields from the last day of the quarter. As such, the economic environments in which the corresponding inflation forecasts and yields are made may differ. That is, the yields contain up-to-date economic information whereas the inflation forecasts do not. This informational misalignment may contribute to the volatility shown in Figure 7.
- **Forecast accuracy –** The actual AWE inflation has been less than anticipated by the DAE forecasts over the past five years, as shown in Figure 8.

As discussed in Section 1 and elaborated on below, forecast accuracy is unlikely to be resolved entirely: most forecasts, including market-based forecasts, have overestimated inflation over the past five years. We draw attention to these issues because a discussion of inflation estimates must consider forecast accuracy when comparing professional forecasts to market-based forecasts.

We do not consider volatility of the gap to be problematic in and of itself. We expect volatility to be reflected in the gap where caused by changes in the economic situation. However, we consider volatility caused by informational misalignment or from attributes of the forecast methodology as spurious and needless. It is this volatility we intend when discussing volatility in the gap each quarter.

3.2 Measures of inflation expectations

Inflation forecasts can be sourced directly. Table 1 summarises the main features inflation forecasts available in Australia:

- Surveys of professional forecasters
- Surveys of consumers
- Market-based forecasts.

Table 1 Measures of inflation expectations

Types	Description	Advantages	Disadvantages
Survey of professional forecasters	» Surveys of economists and union officials » Publications from professional firms such as Deloitte Access Economics[6] (DAE) and Consensus Economics[7].	» Based on opinions of well-informed individuals » Measures have long and consistent time series for econometric modelling.	» Expectations of firms and households may matter more for wage and price setting decisions » Frequency of surveys is low (up to four times a year) or the length of forecast is short (up to two years) » Suffers from informational misalignment.
Surveys of consumers	» Survey of consumers to measure expectations » Melbourne Institute measure inflation expectations of consumers.	» In theory, consumer and business expectations are highly relevant as they are decision makers in the economy and tend to act on their expectations (Armantier, et al., 2015).	» Consumer expectations do not line up well in practice – consumers tend to be mentally anchored around round numbers such as 5% or 10%, or overly responsive to price of certain goods (e.g. petrol prices) (Ballantyne, et al., 2016). » Suffers from informational misalignment.

[6] http://www.deloitteaccesseconomics.com.au/
[7] http://www.consensuseconomics.com/

Types	Description	Advantages	Disadvantages
Market-based measure	» Inflation swap – Fixed rate on inflation swaps which are over the counter (OTC) derivatives » Inflation-indexed Treasury bonds – Face value indexed to AUS CPI. The difference between the nominal and inflation-indexed bonds is the inflation expectation.	» Market participants have substantial financial resources at stake, so they are likely well informed and have strong incentives to form accurate predictions » An inflation-indexed bond measure has a long-term series, suitable for econometric modelling » Prices are available for a range of investment horizons, allowing the construction of a term structure of inflation expectations » Information included in the forecast can align with nominal yield curve.	» Scarcity, liquidity and inflation risk premiums may cloud the interpretation of both the level and movements in inflation expectations, although this can also be an advantage depending on how scarcity, liquidity and inflation risk premiums are to be treated (see below for more details) » Only available for national CPI.

Despite the expertise that contributes to professional forecasts such as those from DAE, a market-based measure is appealing. The inflation implied by index bonds is a composite of the "expert opinion" of those with money on the line. Moreover, only a market-based approach can reduce volatility in the gap attributable to informational misalignment. In other words, this approach provides consistency between discount rates and inflation assumptions.

3.3 Considerations when using indexed-linked bonds to forecast inflation

We can derive an inflation forecast from market instruments. Specifically, we can make forecasts of the Australian Consumer Price Index (AUS CPI) using the **difference**

between nominal yields and real yields. Based on the current literature on inflation forecasts, market-based approaches have the following advantages and disadvantages:

» Advantages

- Daily price data so yields and inflation estimates can be aligned
- Statistically at least as accurate as professional forecasters in the short term (Adeney, et al., 2017, and Grothe and Meyler, 2015)
- Consistent with the approach used by the RBA (Jacobs and Rush, 2015).

» Disadvantages

- The indexed bond market in Australia is only moderately deep
- Market prices may be influenced by additional premia – so the difference between nominal and real yields requires adjustment before they reflect inflation expectations.

The analysis below will demonstrate the advantages. The disadvantages deserve further discussion here.

As discussed in Section 2.3, the indexed bond market in Australia has deepened over the past seven years. We believe indexed bonds are now viable market measures.

Accommodating the additional premia is more challenging because literature on estimates of these is scarce:

» **Scarcity or liquidity premium** – The yields of inflation-indexed bonds may contain a component of scarcity or liquidity premium relative to nominal bonds. There are conflicting views in the literature on this point:

- There may be a scarcity of index-linked bonds in the sense that they are attractive to investors but there are not very many bonds to be purchased. Any scarcity premium for index-linked bonds relative to nominal bonds which is reflected in yields will result in an upward bias in the market-based measure of inflation expectations unless it is removed. A NERA Economic Consulting Report 2007[8] estimated about 20 basis points for the scarcity premium at that time. We have not been able to source any more up-to-date estimates although in a general sense we expect it to have reduced over time as more index-linked bonds have been issued.
- The market for inflation-indexed bonds may not be very liquid compared to nominal bonds, in the sense that investors may not be confident that they can sell their index-linked bonds when they need to, and so are not prepared to pay as much for them as they would otherwise. This is discussed in the two RBA publications (Finlay and Olivan, 2012) (Finlay and Wende, 2011). Any liquidity premium for index-linked bonds relative to nominal bonds which is reflected in yields will result in a downward bias in the market-based measure of inflation expectations unless it is removed. The 2016 RBA bulletin (Moore, 2016) discusses the use of inflation swaps to estimate the liquidity premium, on the basis that swaps are more liquid. They show a graph of the difference in 10-year breakeven inflation rates given by index-linked bonds and inflation swaps over

[8] https://www.aer.gov.au/system/files/Attachment%20to%20Alinta's%20submission%20-%20NERA%20report%20(March%202007).pdf

time which suggests a liquidity adjustment of 20 basis points in 2010-2012, rising to 40 basis points at the end of 2016.
- The scarcity and liquidity adjustments are in opposite directions. We do not believe they can exist at the same time and be offset. Balancing the merits of the two is outside our area of expertise.

» **Inflation risk premium** – The real yield may contain a component of inflation risk premia:

- Issuers of index-linked bonds may demand compensation for assuming the risk of lower or higher than expected inflation.
- Any inflation risk premium will upwardly bias the market-based measure of inflation expectations unless it is removed.
- There is strong evidence from the literature that inflation risk premium varies over time (Shiller, 1981, Fama and French, 1988, and Wright, 2011). Some regular estimates of premiums are published, such as by the Cleveland Federal Reserve[9].

We have set the sum of these premia to zero for our analyses. This assumption is not intended to imply we believe that these premia are offsetting. This assumption is a combination of convenience and conviction:

» If we assume that these premia are constant over time – a practical default assumption given the information available – then the size of these premia do not affect our measurement of the quarterly movement in the gap. Thus, it is convenient for us to dismiss the premia as a problem for somebody with more expertise in the area than us.

» The average 10-year inflation rate over the past eight years (assuming no premium) is 2.3% p.a. This is sufficiently close to the centre of the RBA target (and actual inflation) that it provides such premiums are small, to the extent that they exist.

» Moreover, we are not convinced that these premia are appropriate for setting a discounted liability. For matching the cashflows of an indexed liability, the asset manager is hostage to whatever price confronts her and the "pure" inflation rate (with premia removed) is irrelevant. To elaborate:

- These premia would be paid (or received) by any investor should they wish to purchase an asset such as indexed-linked bonds to replicate the expected claims payments. The values of equal and opposite cash flows should themselves be equal and opposite, as otherwise arbitrage opportunities would arise. We understand the argument that bonds are more liquid than insurance liabilities, but no liquidity adjustment is *currently* made to the nominal bond yields used to discount other general insurance liabilities[10].
- Effectively, from the date of underwriting, an insurer with an intention to match assets to liabilities becomes less interested in the actual or "pure" inflation forecast, and more interested in the "break-even" inflation forecast. This break-even inflation forecast is just the difference between the real and nominal yields implied by the relevant financial instruments.

[9] https://www.clevelandfed.org/our-research/indicators-and-data/inflation-expectations.aspx.
[10] Notwithstanding recent changes proposed in IFRS17

By setting our premia to zero, we have tentatively endorsed the replicating portfolio argument. While we find this argument compelling, the prescription of liquidity adjustments under AASB17 may neuter our position.

3.4 Estimating a market-based CPI forecast

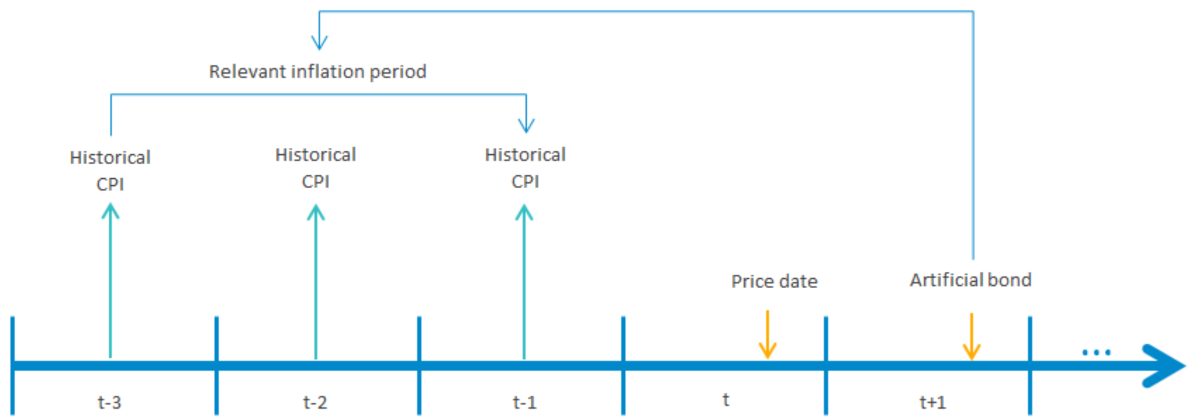
Here we describe an approach to the derivation of an inflation expectations curve, similar to how many currently estimate a yield curve for discount rate assumptions. Treasury indexed bonds are used to provide a market-based estimate for AUS CPI. These market instruments have the advantages of being priced by well-informed stakeholders and have a long price history that is suitable for econometric modelling.

Historical Treasury inflation-indexed bond yields are provided by the RBA, in "Table F16 – Indicative Mid Rates of Australian Government Securities"[11]. This table is updated daily. Aligning the timing of information on discount and inflation estimates it *may* contribute to improved forecast accuracy and/or stability.

In "Table F16", yields are available for a range of investment horizons. Theoretically, this allows the construction of a term structure of inflation expectations/yield curve. However, the indexed bond market in Australia is much shallower that the nominal bond market. At any given time, there are only about five to seven outstanding indexed bonds compared to more than 20 nominal bonds. In a one year time horizon, it is quite common to have a nominal bond maturing, but it is not the case for indexed bonds. This makes the fitting of the yield curve challenging for indexed bonds, especially in the short term where the curve is extrapolated. To address this, we have used the design of the indexed bond to create an artificial bond in the short term to provide an extra data point for the yield curve to fit to.

For a Treasury indexed bond at quarter t, the indexation that we apply to the next coupon payment (assuming it is being paid at quarter $t+1$) is the semi-annual change in the CPI over the two quarters ending in the quarter which is two quarters prior to the quarter of the next coupon payment. In this case, this relevant inflation period is $t-3$ to $t-1$. This is illustrated in Figure 9.

Figure 9 Relevant inflation period for a bond at time t+1



[11] Available at http://www.rba.gov.au/statistics/tables/#interest-rates

This implies that at any given price date t, all the relevant information to determine the yield of an indexed bond expiring at the next quarter is available. The CPI observations would have been released by ABS, and we can extract the nominal yield at time $t+1$ from the yield curve which has been constructed with sufficient data points. The real yield is calculated as:

$$Yield_{Artifical\ indexed\ bond} = Yield_{Nominal} - Annualised\ inflation\ over\ relevant\ period$$

As at 7 March 2017, the nominal yield at time 0.25 is 1.47% p.a. The relevant inflation period is the quarter June 2016 to December 2016. Over this period, the average quarterly inflation rate is 0.64% = (110.0/108.6 – 1)/2. The annualised rate is 2.58% p.a. The artificial indexed bond at time 0.25 would have a real yield of 1.47% - 2.6% = -1.11% p.a.

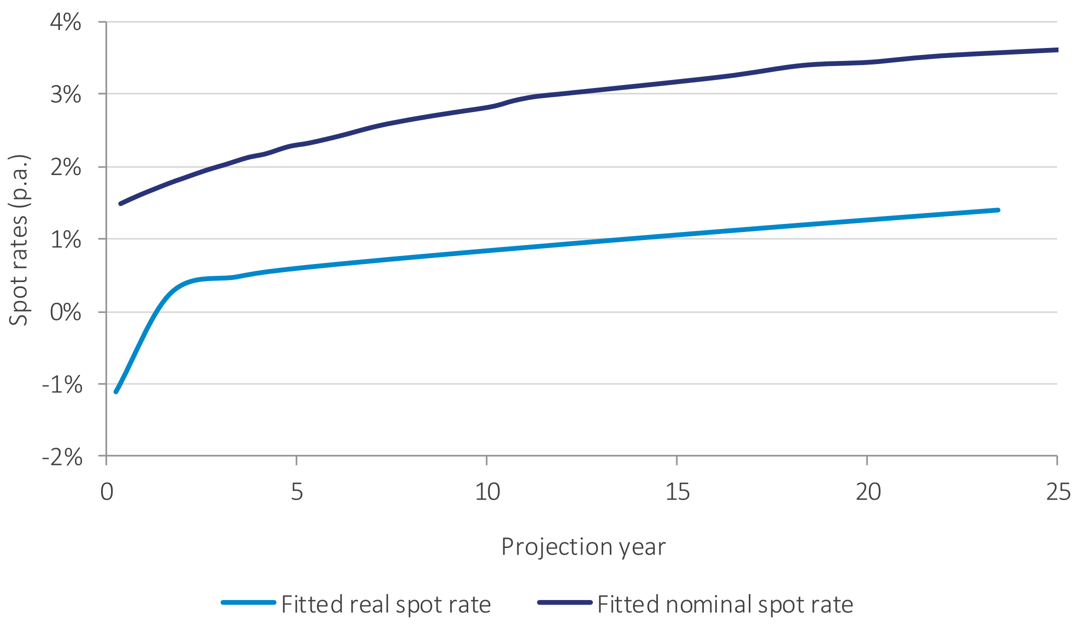
A constrained cubic spline model is used to fit the yield curve, based the set of bond yields, coupon rates, and terms to maturity. This approach is consistent with the approach to fitting the nominal yield curve (Miller and Yip, 2017), with a small adjustment from semi-annual coupon payments to quarterly coupon payment, as per the design of all Treasury indexed bonds. The benefits of this approach are three-fold:

1. It provides a smooth yield curve to minimise arbitrage opportunities
2. It is accurate and fits data points well
3. It has a reversion property to a pre-specified long-term rate to account for maturity terms beyond observable bond prices.

For the real yield curve, the target long-term rate is the difference between the long-term nominal yield and RBA target inflation of 2.5% p.a.

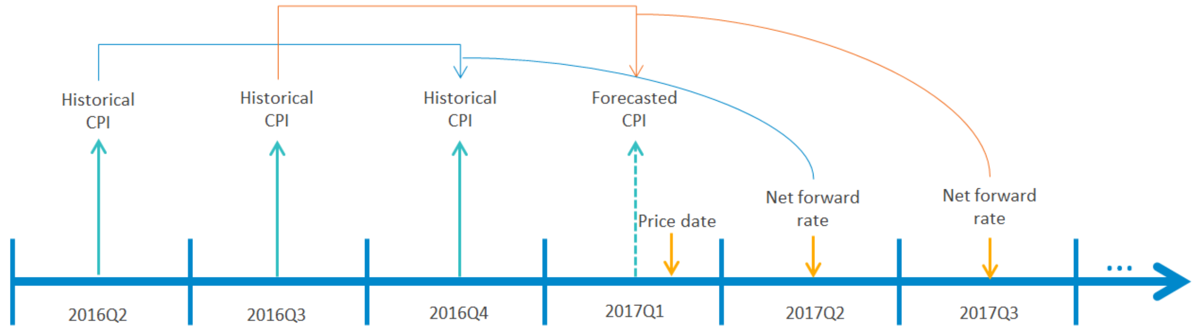
Figure 10 below shows the actual and fitted real and nominal yield curves as at 7 March 2017.

Figure 10 Fitted real and nominal yields as at 7 March 2017



From the fitted yield curves, we can extract quarterly forward nominal and real rates from the price date. The logic to create the artificial bond at time 0.25 can be reversed to back out the implied CPI index using the forward rate. This process is illustrated in Figure 11.

Figure 11 Calculation of AUS CPI from forward rates



Firstly, we determine the forward net rate which is the difference between the nominal and real forward rates. This rate represents the inflation over the relevant period. In the diagram above, the net forward rate at 2017Q2 represents the inflation over the 2016Q2 – 2016Q3 period. Similarly, the net forward rate at 2017Q3 represents the inflation over the 2016Q3 and 2017Q1 period. Using this information, we can then calculate the implied CPI for 2017Q1:

$$CPI_{2017Q1} = CPI_{2016Q3} * (1 + \frac{Net\ forward\ rate_{2017Q3}}{2})$$

The division by 2 is to convert an annualised forward rate to a half-yearly inflation figure. Future CPIs can then be recursively calculated in a similar process.

As at 7 March 2017, the latest CPI figures were 109.4 and 110.0 for 2016Q3 and 2016Q4 respectively. The estimated net forward rate at time 0.5 is 1.77% p.a. The forecasted CPI at 2017Q1 is then 109.4 * (1 + 1.77%/2) = 110.4. The corresponding estimate from Deloitte Access Economics (DAE) is 110.6.

3.5 Forecasts compared

We compare market-based AUS CPI forecasts with DAE AUS CPI forecast. The market-based inflation forecasts are from the same day as the yields used for the discount rate and estimated as described in the previous section. The DAE inflation forecasts are those released during the quarter using information from previous quarters.

The purpose of this comparison is to assess volatility in the CPI gap from using each inflation forecast. Additional volatility by using the DAE inflation forecasts can be attributed to either forecast inaccuracy or informational misalignment – we do not distinguish. This is discussed further following the results.

By way of example, Figure 12 shows the actual AUS CPI and compares:

» Our projected market-based AUS CPI forecast (as at 7 March 2017)
» The DAE projected AUS CPI (the DAE forecast was released in early January 2017)

which would be coupled with the discount rate as at 7 March 2017 to determine the CPI gap. This delay between the DAE economic forecast release and the premium setting is typical for Queensland CTP insurance premium setting. We expect that outstanding claim liability estimates – with discount rates set at the end of the quarter – will often have a longer delay.

Figure 12 Actual and projected AUS CPI as at 7 March 2017

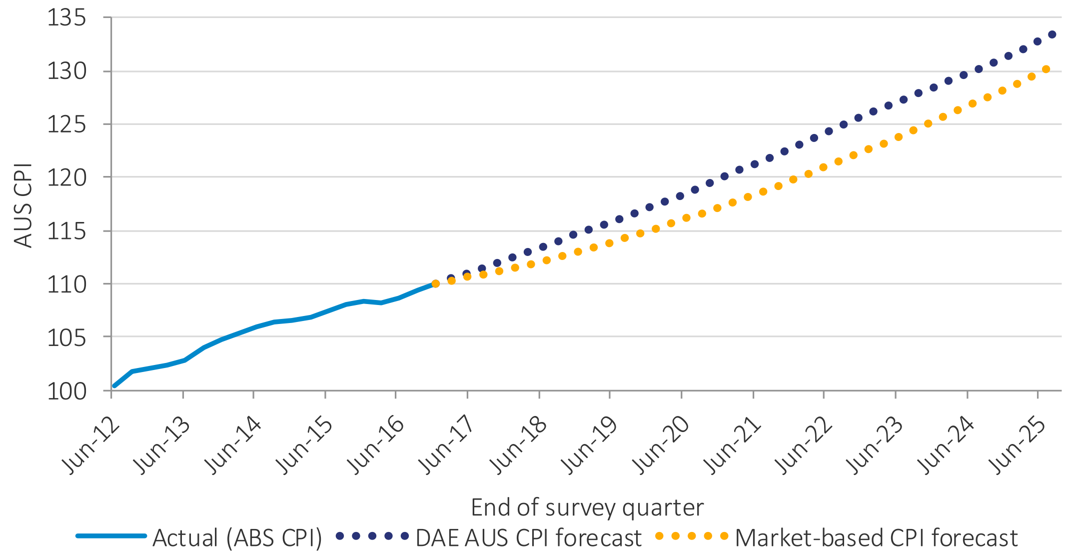
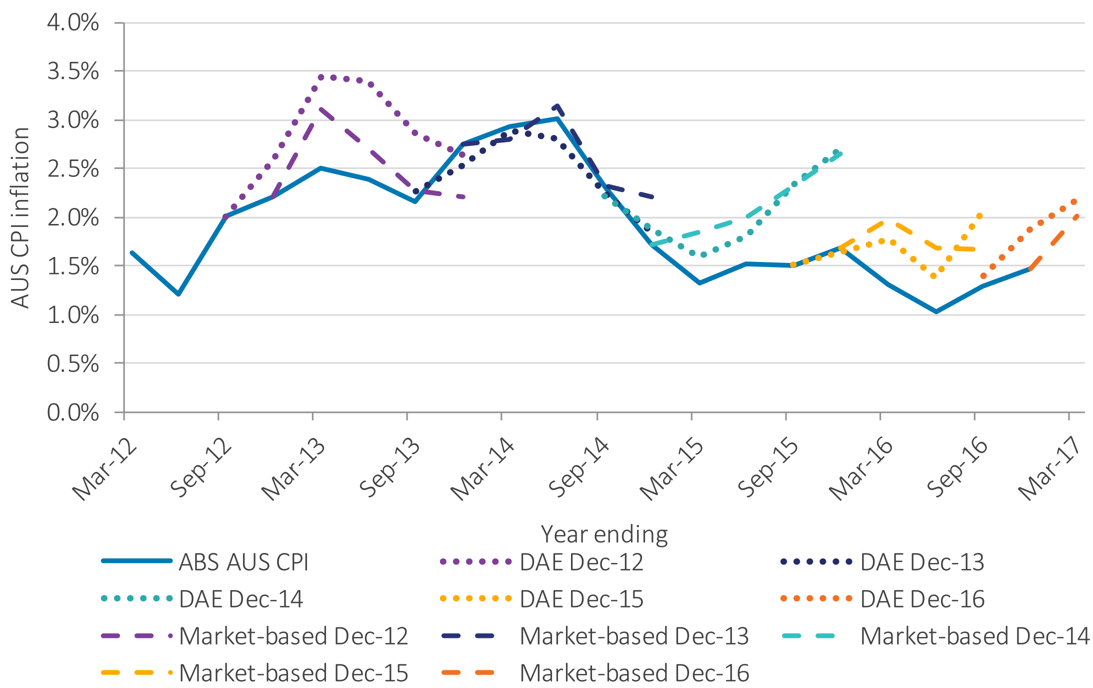


Figure 13 shows the AUS CPI inflation rate forecasts at each year compared to the realised CPI inflation rate. Each DAE forecast starts one quarter earlier because DAE do not have access to most recent actual ABS AUS CPI data when they release their forecasts. Both DAE and the market-based forecasts have been higher than realised AUS CPI inflation in most recent years.

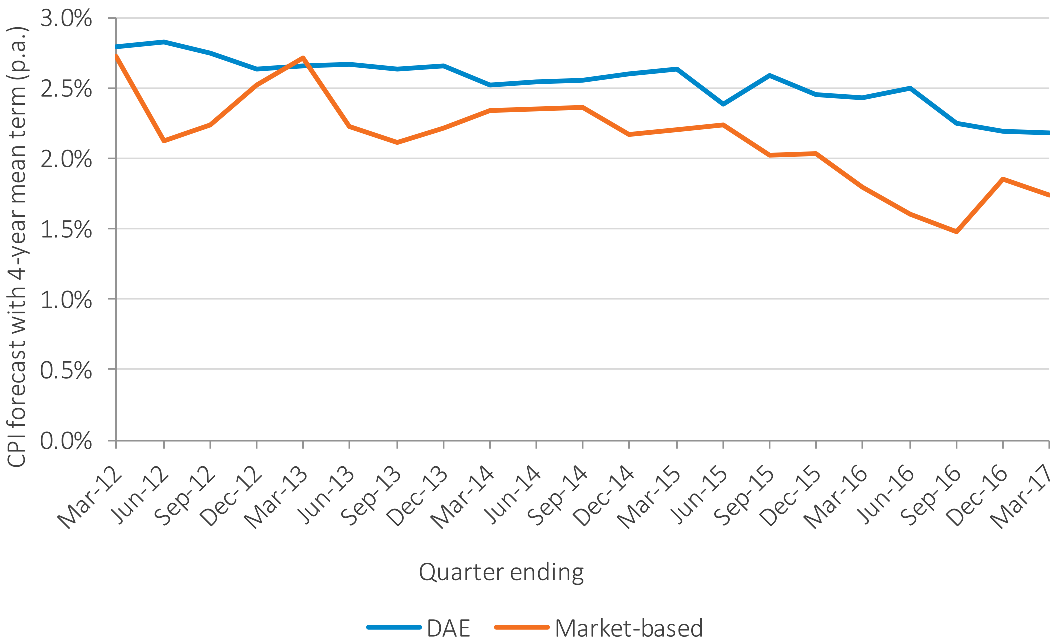
Figure 13 Comparison of DAE and market-based AUS CPI forecasts with realised CPI



Since 2014, both methods have overestimated eventual CPI inflation by similar amounts over the first few quarters. However, the DAE AUS CPI forecasts have given consistently higher inflation forecasts over the longer term.

To show this, Figure 14 compares the DAE and market-based CPI forecasts using a mean term of 4 years (the Queensland CTP payment pattern[12]). We use the rate of inflation implied by the DAE forecast rather than the index directly to remove error associated with forecasting prior to release of the actual ABS AUS CPI data for the previous quarter. We present each inflation forecast as an equivalent flat rate that produces an equal liability estimate. For example, the DAE inflation forecast applied to the Queensland CTP payment pattern in Mar-17 is equivalent to applying a flat rate of 2.2% p.a.

Figure 14 CPI forecast with 4-year mean term



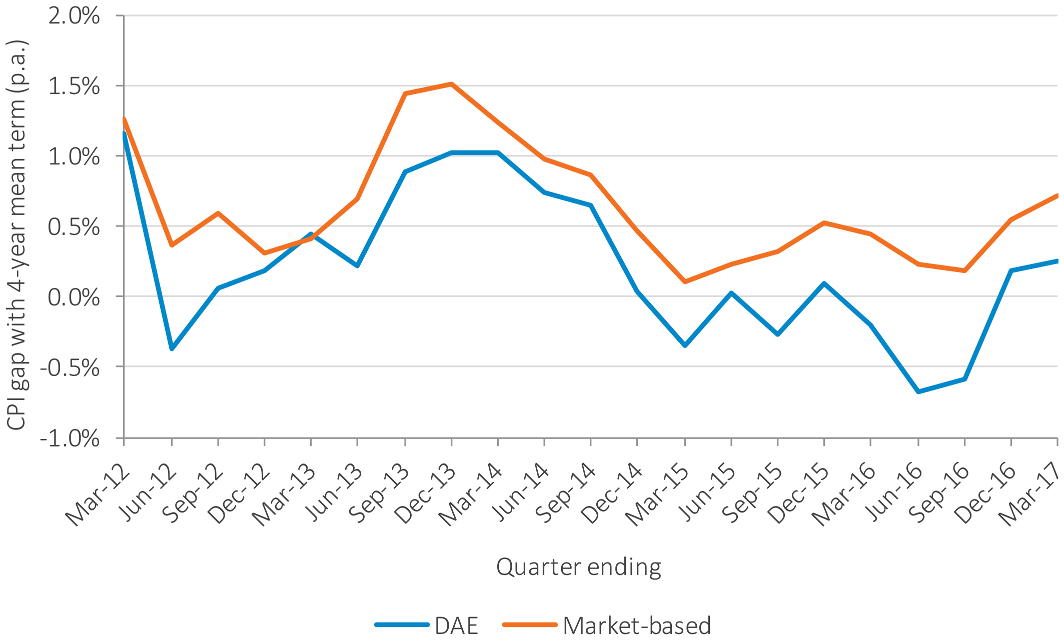
The DAE forecasts produce a higher inflation rate than the market-based inflation forecasts by an average of 0.5% p.a. The difference is especially curious when considering that DAE inflation is a measure of "pure" inflation whereas the market-based inflation is a measure of "break-even" inflation. A market-based measure of "pure" inflation rate would be lower than the "break-even" inflation rate if the inflation risk premium and scarcity premium exceed the liquidity premium. We cannot imagine a scenario where premia consistently excuse the 0.5% p.a. difference between the two forecasts.

The market-based inflation forecast is noisier than the DAE forecast at a 4-year mean term. However, this variation is correlated to the equivalent nominal bond spot rate. Figure 15 shows the CPI gap for each quarter. Here, the CPI gap is the difference

[12] For this paper, we use the same payment pattern for all estimates of the 4-year mean term. The 4-year term assumes all payments are made within 12 years.

between flat discount rate[13] and flat CPI inflation rate + 2.5% p.a. superimposed inflation[14]. The DAE CPI gap is noisier than the market-based CPI gap. The higher volatility present when using the DAE AUS CPI forecast may be due to informational misalignment.

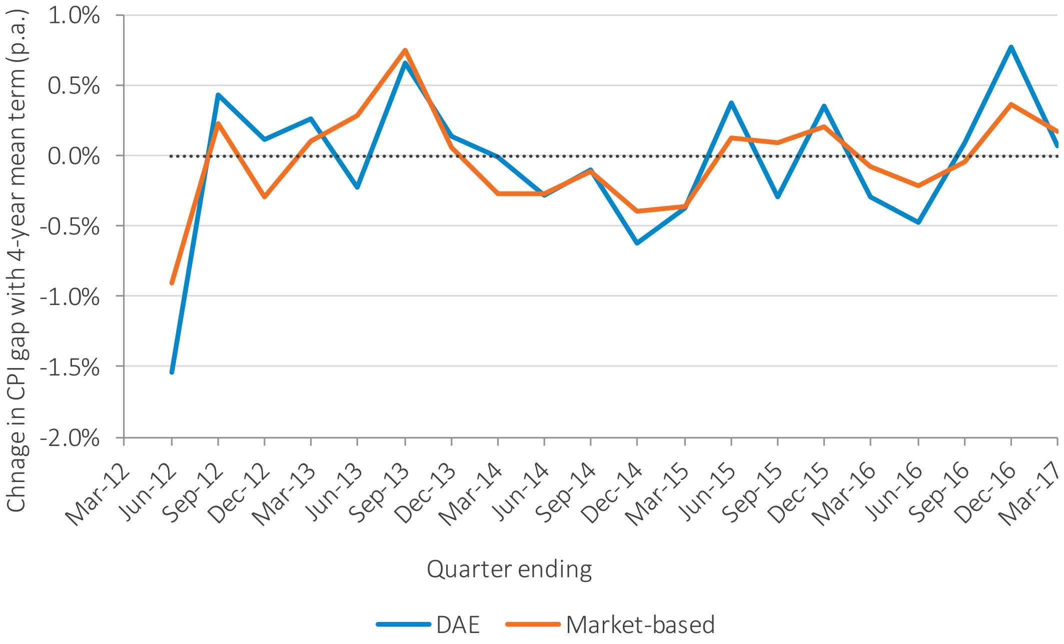
Figure 15 CPI gap with 4-year mean term



This becomes clearer when we look at the change in CPI gap from quarter to quarter in Figure 16. The volatility of the market-based CPI gap is 0.2% (30% of the quarterly volatility of the DAE CPI gap) lower than the DAE CPI gap.

[13] Like the flat inflation rate described above, we determine an equivalent flat discount rate that produces a liability estimate equal to applying the yield curve.
[14] This is consistent with what was used premium setting for Queensland CTP insurance at the time. It is a level shift of both series so it does not affect interpretation.

Figure 16 Quarterly change in CPI gap with 4-year mean term



A market-based inflation forecast produces a more stable gap than the DAE inflation forecast **in the circumstances studied above**. This may be because the market-based estimate is more accurate, or because it is more up-to-date (it incorporates information in a timelier manner than the DAE estimates can). Either way, using the market measure provides better accuracy and a more stable gap, so should be preferred by practitioners.

The previous results were consistent with the Queensland CTP insurance mean term of four years. Figure 17 and Figure 18 show that this result is true for 2-year mean terms and 8-year mean terms respectively[15].

[15] In each instance, the flat inflation rate and flat discount rate are determined using a payment pattern with mean term of 2 and 8 years. The 2-year pattern assumes all payments are made within 5 years. The 8-year term assumes all payments are made within 18 years.

Figure 17 Quarterly change in CPI gap with 2-year mean term

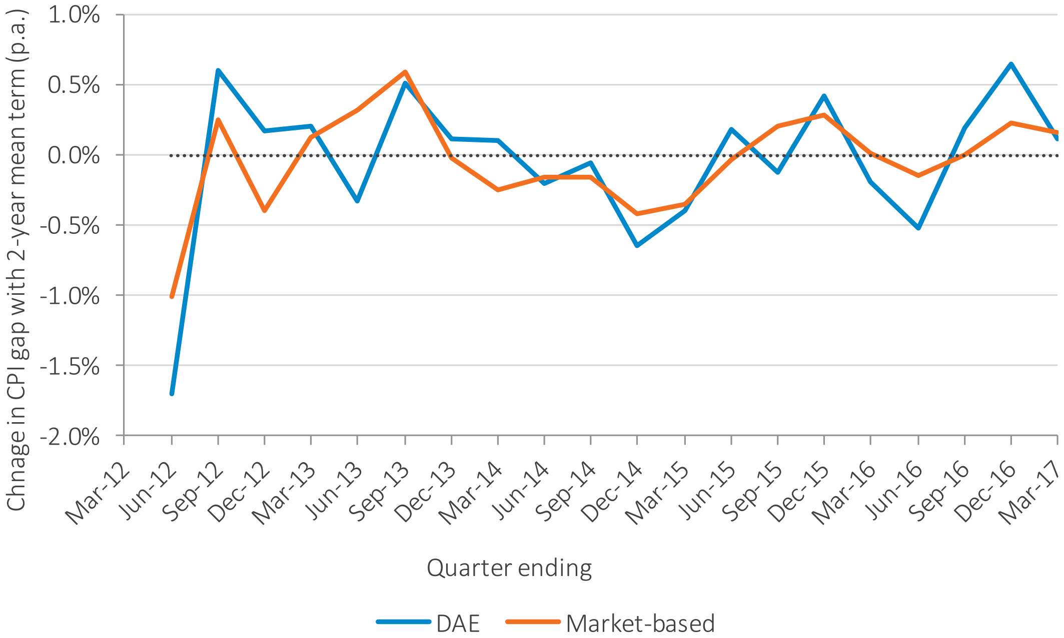
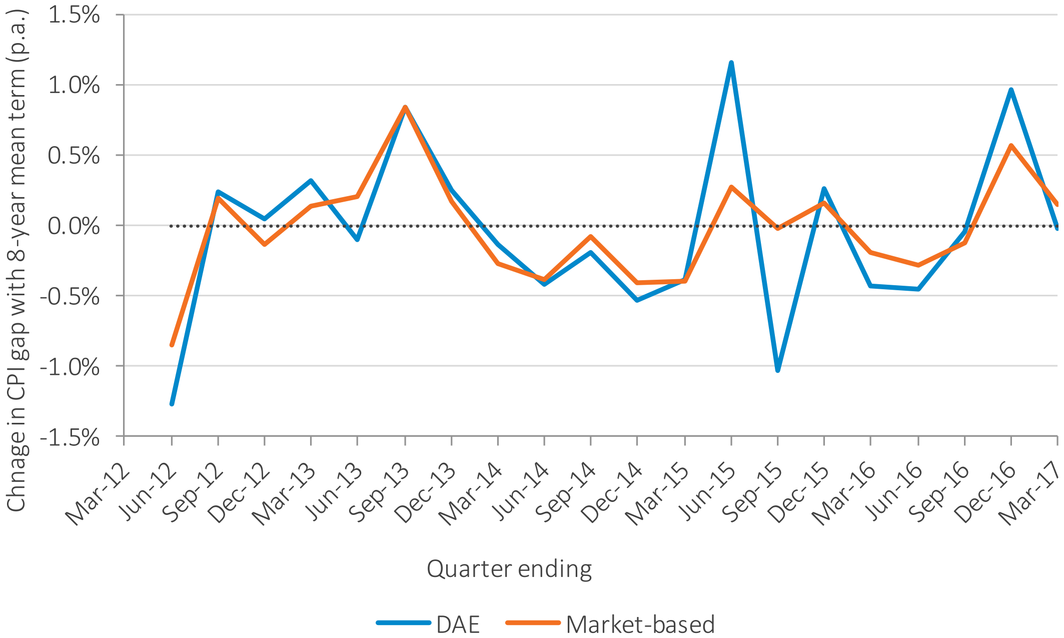


Figure 18 Quarterly change in CPI gap with 8-year mean term



The results are similar. The volatility of the market-based CPI gap is 0.2% lower than the DAE CPI gap. The two series track each other more closely with the 8-year mean term, apart from an anomalous DAE forecast in Jun-15 affecting Mar-15 to Sep-15. This closer tracking is because both series are relying more heavily on the constant long-term inflation assumption.

3.6 Difficulties in moving from CPI to WPI/AWE forecasts

So far, we have concentrated on CPI because this is directly attainable from index-linked bonds. Attaining AWE or WPI forecasts requires another adjustment. There are no appropriate financial instruments from which we can directly infer a market-based forecast for WPI/AWE[16]. As such, we discuss how a market-based AUS CPI forecast can be adjusted to get a market-based AWE forecast, whether for a state like Queensland or nationally. We refer to the difference between the AUS CPI and AWE as "real wage growth". Our analysis focuses on Queensland (QLD), as per our comment at the start of section 3.

This remains an unsolved problem but we will use the rest of this section to frame the discussion and encourage further work.

In the medium to long-term, real wage growth should be roughly equal to productivity growth. Other factors, such as the portion of national income going to wages, and the average number of hours worked, should be flat with a long enough time horizon. In the 2000s however, Australia's real wages grew at a faster rate than productivity growth due to a boom in the terms of trade from strong global demand for resources from the mining industry (D'Arcy and Gustafsson, 2012). With the easing of the terms of trade since 2010 and a fall in mining investment, a range of economic factors have contributed to low wage growth in Australia, such as subdued growth in labour demand and below average consumer price inflation expectation (Jacobs and Rush, 2015). This economic environment makes an estimation of real wage growth difficult, as evident by the fact that the actual wage inflation has been less than anticipated by both the RBA and DAE forecasts over the past five years.

We consider three methods for deriving a AWE forecast from a market-based CPI forecast:

- **Constant real wage growth** – The first is a simplistic assumption to assume constant real wage growth. The Commonwealth Government's 2015 Intergenerational Report assumes a rate of productivity growth of 1.5% p.a.[17]. However, this figure is based on what was observed through the 2000s and may be an overestimation in the current environment[18]. Furthermore, the figure is on a national basis and it is unclear whether this can be applied to individual state market. However for illustrative purposes, we use a 1.5% p.a. real wage growth adjustment in the discussion below.
- **Real wage growth implied by professional forecaster** – Professional forecasters, such as DAE, produce AWE and CPI forecasts. We can apply the implied real wage growth adjustment from DAE to the market-based AUS CPI forecast. This re-introduces some informational misalignment in the estimate of productivity growth. We illustrate the effect of the real wage growth implied by DAE further below.
- **Independent QLD AWE forecast** – In theory, a model AWE could be built as a function of the market-based CPI forecast (including lagged CPI) and other

[16] Although we note that the government has a natural hedge for such bonds in the form of income taxes.

[17] See Page xi of the Executive Summary at http://www.treasury.gov.au/~/media/Treasury/Publications%20and%20Media/Publications/2015/2015%20Intergenerational%20Report/Downloads/PDF/2015_IGR.ashx

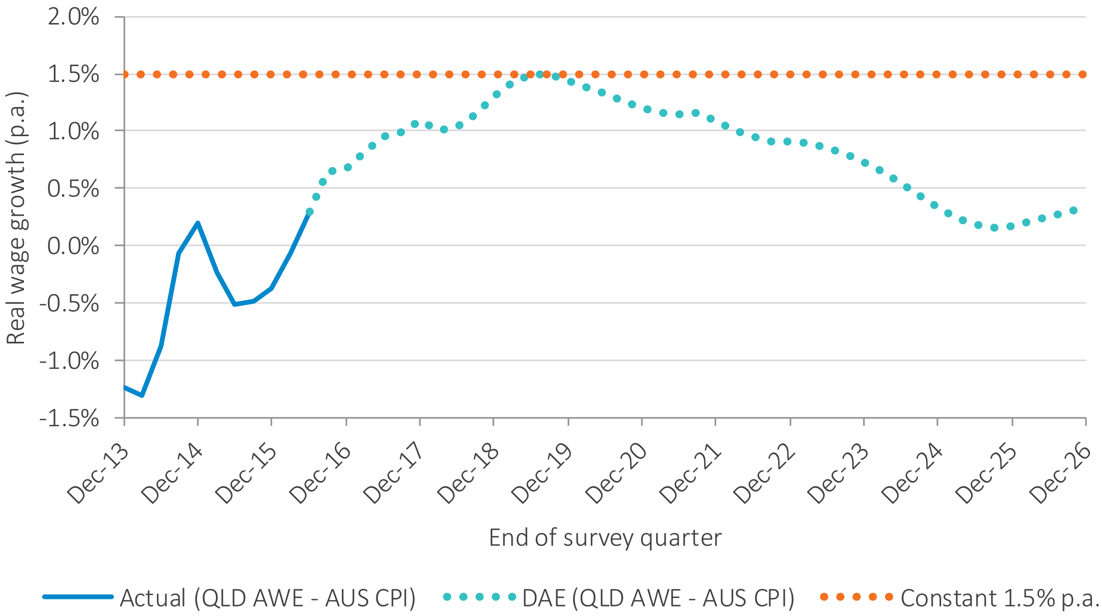
[18] While weak wage growth would suggest weaker productivity growth, some emerging evidence suggests productivity growth over the past five years has been up at historical levels (Campbell and Withers, 2017)

economic variables. Designing, testing and applying an independent AWE forecast is a substantial exercise, and a potential topic for further research.

Figure 19 shows the difference between QLD AWE and AUS CPI forecasts as at 7 March 2017:

» Constant real wage growth of 1.5% p.a.
» Real wage growth implied by the DAE releases in January 2017.

Figure 19 Real wage growth on 7 March 2017 with 4-year mean term

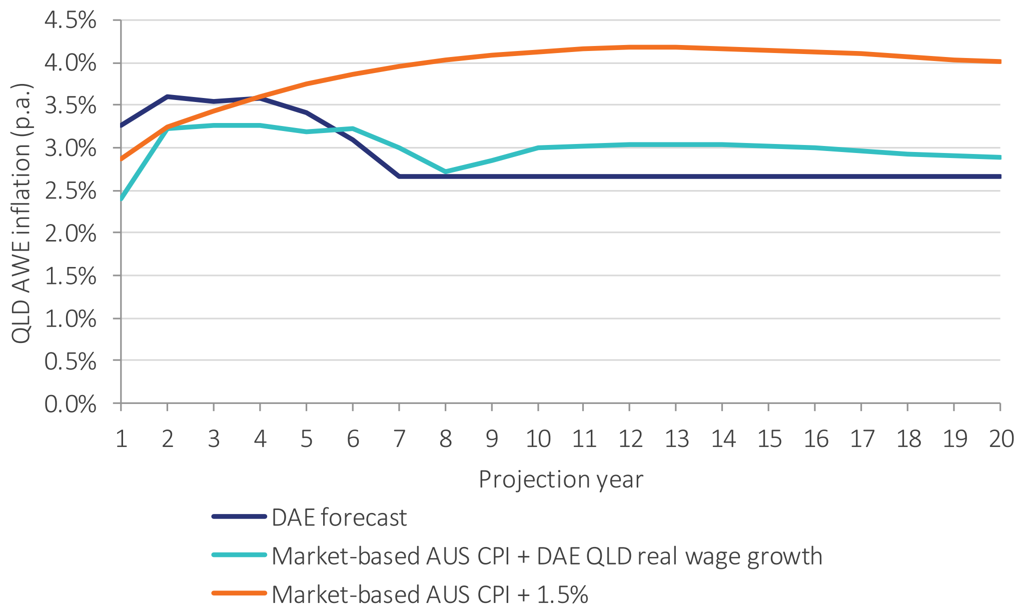


A constant real wage growth of 1.5% p.a. provides a QLD AWE growth much higher than real wage growth implied by DAE. This perhaps shows nothing more than 1.5% p.a. real wage growth is ambitious in the current environment. A more conservative constant rate may be desirable. However, arriving at a credible objective figure and deciding when to change it is difficult.

Starting with the market-based AUS CPI forecast put forward in the previous section (dotted yellow line), Figure 20 shows projections for QLD AWE as at 7 March 2017:

» Market-based AUS CPI forecast + 1.5% (orange line)
» Market-based AUS CPI forecast + DAE real wage growth (teal line)
» The DAE QLD AWE forecast on 7 March 2017 (indigo line).

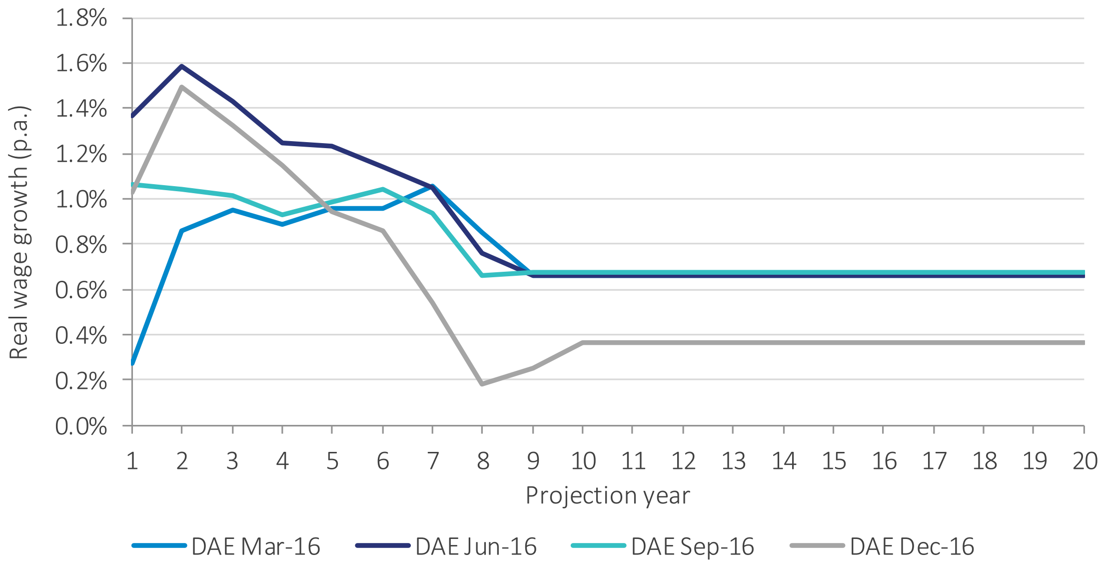
Figure 20 QLD AWE inflation projection as at 7 March 2017



Applying the real wage growth implied by DAE forecasts to a market-based AUS CPI estimate produces a different result to using DAE QLD AWE forecast directly. The direct method has a higher inflation rate for the first five years and a lower inflation rate thereafter.

On closer examination, the real wage growth implied by the DAE forecasts changes markedly between surveys. This is shown in Figure 21. This means that the introduction of DAE real wage growth forecasts can be expected to generate needless[19] volatility.

Figure 21 DAE real wage growth from 2016 series

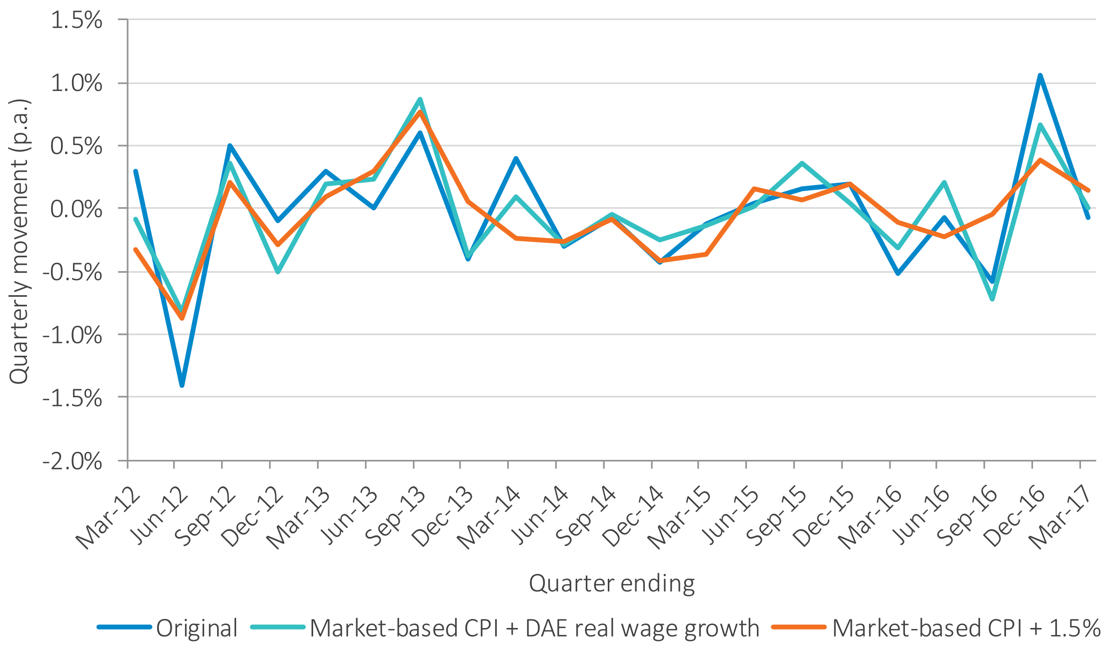


[19] *Needless* in the sense that it is not a reflection of changes in economic conditions. The multidimensional macroeconomic model used by DAE tends to produce changes in inflation forecasts (particularly AWE) between quarters, even when there is little new market information directly concerning inflation. This effect is common to complex macroeconomic models, but does create volatility for people using one or two indices for regular time series projections.

We conduct a limited test to see how each method addresses the volatility of the gap. We re-estimate all advised gaps for the five underwriting years up to 2017Q3 and look at the quarterly movement. Figure 22 shows the quarterly movement in the gap using:

» DAE QLD AWE forecasts
» Real wage growth implied by DAE forecasts applied to a market-based AUS CPI forecast
» The constant real wage growth of 1.5% p.a. applied to a market-based AUS CPI forecast (although the size of the constant real wage growth adjustment is not relevant for the change comparison because the change observed relates entirely to the change observed in the market-based CPI forecast).

Figure 22 Quarterly change in AWE gap with 4-year mean term



Using a constant real wage growth removes a lot of volatility from the gap. However, we do not believe the constant gap of 1.5% p.a. sourced from the 2015 Intergenerational Report is sufficiently responsive to emerging shorter term economic conditions. We prefer that any adjustment be forward looking, rather than based on past real growth.

Unfortunately, there does not appear to be a meaningful reduction in the volatility of the gap by using the real wage growth implied by DAE forecast applied to a market-based AUS CPI forecast. The difference between DAE's AUS CPI and QLD AWE forecasts introduces as much volatility as using the DAE QLD AWE forecast directly. We have tested some variations to using the DAE forecast real wage growth directly, by averaging it to get a constant adjustment for each forecast. However, this does not reduce the volatility appreciably unless we ignore the forecasts for the first two projection years, which is difficult to justify.

We have made some progress towards an AWE forecast that is more closely tied to nominal bond yields, and are currently investigating other sources of forward looking real wage growth forecasts for further development. We like the simplicity of a constant real wage growth for two reasons:

- More nuanced forecasts are unlikely to be as responsive to emerging economic conditions[20] as the discount rate and market-based inflation rate. Any benefits of a nuanced real wage growth forecast would need to exceed this disadvantage.
- A perfect representation of a specific WPI/AWE inflation does not perfectly capture the real target: future claim cost growth. A superimposed inflation allowance is often added on top of AWE allows for the differences between AWE and claim cost growth. The finesse required to obtain a nuanced real growth rate may be superfluous given the simplicity of the superimposed inflation allowances that tend to be applied on top.

A satisfying resolution to real wage growth will affect most actuaries. We encourage others to participate in this research.

[20] We acknowledge that the DAE implied real wage growth does change a lot each quarter, but we do not think that this in response to emerging economic conditions – see previous footnote.

4 RECOMMENDATIONS

4.1 Discount rates

Nominal discount rates are easily observable in the market and most standard yield curve fitting approaches give good estimates for 30-years. This is sufficient for most uses.

There is little further research that needs to be done on this topic, except for considerations surrounding IFRS17, when liquidity premiums must be considered.

4.2 CPI inflation

We've illustrated how CPI inflation can be estimated from indexed-linked bonds consistent with how nominal discount rates are estimated from the yield curve. **Where insurance schemes inflate cash flows that follow consumer spending trends, we recommend a yield fitting approach like the one illustrated.** We'd go as far to say that constructing a CPI forecast from market instruments is exclusively consistent with IFRS17 and a professional obligation. This paper and Mulquiney and Miller (2012) combined will provide practitioners with the tools they need to produce these forecasts.

As shown in Section 3, nominal and index-linked bonds can contain information to the same date. For most applications, professional forecasts of inflation do not contain the up-to-date information contained in the nominated yield curve. Consequently, we observe less volatility in the gap if we use index-linked bonds.

As discussed in Section 2, using a fixed gap between discounting and inflation is not supported by evidence: correlation between these series is far from perfect. We would not recommend such approaches in situations where market-consistent inflation is required.

We defer any recommendation on the use of scarcity, liquidity and inflation risk premia when making CPI forecasts. We remain unconvinced that these should be considered at all, believing that break-even inflation rate could be used directly for valuation purposes. However, some greatly respected actuaries disagree on this matter and wording in various standards support a central estimate interpretation. While estimation of these premia is difficult, we believe their combined effect is small, so practitioners should not use the open nature of this argument as fodder against using market instruments altogether.

4.3 AWE inflation

AWE inflation assumptions are harder, but we believe it best to tie them to CPI in some way, given their strong correlation and the ability to estimate CPI expectations directly from the market.

Our recommended options are:

» Don't use a complex forecast of real wage growth for valuations where the role of superimposed inflation is important, it may be more direct to estimate higher superimposed inflation as a loading on CPI, rather than AWE.

» Consider combining a long-run assumption with short-run trends A simple time series analysis will give AWE projection curves of the type shown in Figure 2. They will typically start at current levels and revert over some period to the long-term difference over CPI (+1.5% say). Again, we'd recommend doing this with reference to CPI forecasts.

There is still work to be done in this area and we encourage others to get involved.

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Note: All weblinks accessed in September or October 2017 unless otherwise stated.

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