REVIEW OF THE AER'S INFLATION FORECASTING METHODOLOGY

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EXECUTIVE SUMMARY

The AER currently estimates expected inflation in Australia over a ten-year period using the RBA's forecasts for the first two years, the midpoint of the RBA's target range (2.5%) for the remaining eight years, and a geometric mean of these values. This paper seeks to assess the best method for estimating expected future inflation, with particular reference to recent empirical evidence. The primary conclusions are as follows.

Firstly, given that the AER's regulatory cycle is five years, the NPV = 0 principle implies that the AER ought to be estimating expected inflation over each of the next five years rather than over the next ten years. Secondly, market prices (comprising the break-even rates and swap prices) are likely to be biased estimators of expected future inflation, and to a degree that varies over time. Thirdly, using standard RMSE tests of forecasting accuracy, the RBA's Target is far superior to the use of market prices for forecasting inflation over 5-10 years, and therefore market prices can be rejected. Fourthly, across the range of other approaches considered (comprising forecasts by the RBA, forecasts from Consensus Economics, the RBA's Target rate, a Random Walk model, a mean reversion model, and the model of Finlay and Wende), the lowest RMSE of the forecast errors comes from the RBA's forecasts for the first and second years ahead, and the RBA's Target for all other future years, which corresponds to the AER's current approach.

Fifthly, this RMSE analysis uses a long time series of data, and therefore assumes stability in the underlying process (which involves mean reversion to or close to the RBA's Target of 2.5%). If the underlying situation has changed, these tests would not be useful. Thus, it is necessary to assess whether the underlying situation has changed, especially since inflation has fallen below the Target for the past several years. The best information on this question comes from Consensus Economics, who (as of April 2020) forecast reversion to that Target over the next few years. Lastly, and because reversion back to the RBA's Target is currently expected to be unusually slow, there is a case for the AER adopting a slow glide path from the RBA's forecasts to the Target providing that scenarios in which reversion back from a low figure is unusually slow (to the disadvantage of the businesses) are not likely to be matched by scenarios in which reversion back from a high figure is unusually slow (to the advantage of the businesses).

1. Introduction

This report is concerned with estimating expected inflation for various future periods of time, i.e., for each future period, the mean of the probability distribution of all possible outcomes over that period, with the probability distribution reflecting the best currently available information. The AER currently estimates expected inflation over a single period of ten years, using a geometric mean over the RBA's forecasts for each of the first two years and the midpoint of the RBA's target rate (2.5%) for the remaining eight years. This paper seeks to assess the best method for estimating expected inflation, with particular reference to recent empirical evidence. As with all regulatory parameter estimates, the fundamental requirement is that the parameter estimate(s) satisfy the NPV = 0 principle, and I therefore commence by examining the implications of this principle for this parameter.

2. Implications of the NPV = 0 Principle for the Treatment of Inflation

The NPV = 0 principle states that price or revenue caps must be set so that the present value of the resulting revenues less cash costs is equal to the initial investment in the regulated activities. This does not imply that inflation should be dealt with in a particular fashion, but it limits the options for doing so to those options that conform with this principle.

Consider the following highly simplified scenario that broadly corresponds to the AER's approach. Regulated assets are purchased now for A_0, with a life of more than one year, the regulatory cycle is one year, prices are set at the beginning of each year, and the resulting revenues are received at the end of each year. In addition, there is no opex, capex, depreciation or taxes. Finally, the regulatory asset base (RAB) is inflated at the end of each regulatory cycle in accordance with realized inflation, and the only source of uncertainty is this inflation rate. Letting REV_1 denote the revenues in year 1, i_1 the inflation rate over the first year, and k_{01} the appropriate discount rate for the first year, the NPV = 0 principle says that the present value of REV_1 and the RAB in one year must be equal to A_0:

$$A_0 = \frac{E(REV_1) + A_0[1 + E(i_1)]}{1 + k_{01}} \qquad (1)$$

Solving for the expected revenues yields

$$E(REV_1) = A_0 k_{01} - A_0 E(i_1) \quad (2)$$

So, expected revenues comprise the nominal cost of capital applied to the initial RAB, net of expected inflation over the next year applied to the initial RAB.

Now suppose the regulatory cycle is five years with revenues received at the end of each year. Letting REV_t denote the revenues in year t, i_t the inflation rate over year t, and k_{05} the appropriate discount rate for the entire five-year period, the NPV = 0 principle says that the present value of $REV_1, \ldots REV_5$, and the RAB in five years must be equal to A_0:

$$A_0 = \frac{E(REV_1)}{1 + k_{05}} + \frac{E(REV_2)}{(1 + k_{05})^2} + \ldots + \frac{E(REV_5) + A_0[1 + E(i_1)][1 + E(i_2)] \ldots [1 + E(i_5)]}{(1 + k_{05})^5}$$

Solving yields

$$E(REV_1) = A_0 k_{05} - A_0 E(i_1) \quad (3)$$
$$E(REV_2) = A_0[1 + E(i_1)]k_{05} - A_0[1 + E(i_1)]E(i_2) \quad (3)$$
$$\ldots$$
$$E(REV_5) = A_0[1 + E(i_1)]..[1 + E(i_4)]k_{05} - A_0[1 + E(i_1)]..[1 + E(i_4)]E(i_5) \quad (3)$$

This reveals that values for $E(i_1) \ldots E(i_5)$ are each required rather than an estimate of expected inflation over the next ten years or even the next five years.

The AER (2020, pp. 10-12) offers contradictory rationales for the inflation deduction in the revenue equations. Initially, it argues that the deduction in (say) equation (2) is to offset (on average) the inflating of the RAB in equation (1). It then asserts that the deduction is to convert the nominal WACC in these revenue equations to a real WACC and, given its use of the ten-year WACC, it therefore estimates the expected inflation rate over ten years so that the terms match. The claim concerning conversion from nominal to real is not correct; conversion would require division in accordance with the expectation version of the Fisher formula rather than subtraction. The correct rationale is that noted first by the AER.

Furthermore, for a five year regulatory cycle and within these revenue equations, the discount rate is for a term matching the regulatory cycle (five years) and the expected inflation rates are for each of the next five years. However, in its revenue setting for regulatory situations (that involve five year terms), the AER (2020, pp. 11-12) uses a discount rate with a ten-year term and consistent with this uses an estimate of expected inflation over the same term. This violates the NPV = 0 requirement.

Furthermore, even if the AER used the ten-year WACC, it does not follow that it should estimate expected inflation over the same period. If the term structure for WACC were upward sloping, and that for expected inflation were likewise, using an estimate for expected inflation for ten years rather than for years 1…5 would likely mitigate the error from using a ten rather than a five-year WACC. However, the term structure for WACC is generally upward sloping whilst that for expected inflation is as likely to be downwards as upwards sloping. So, the use of a ten-year WACC does not warrant use of ten-year expected inflation.

Notwithstanding these comments, it is true that equation (2) can be expressed equivalently as follows:

$$E(REV_1) = A_0[1 + k_{01}] - A_0[1 + E(i_1)]$$

$$= A_0\left[\frac{1 + k_{01}}{1 + E(i_1)} - 1\right][1 + E(i_1)]$$

$$= A_0 k_{R01}[1 + E(i_1)]$$

where k_{R01} is the real counterpart to the nominal WACC k_{01} via the Fisher equation.[1] So, expected revenues comprise the real WACC applied to the asset base at the beginning of the year, and are then compounded up for expected inflation. In this case one might argue that if k_{R01} were defined over a longer period than the one-year regulatory cycle (such as for ten years), the nominal WACC k_{01} should be converted to its real counterpart using expected inflation over a ten year period, and therefore that the same expected inflation rate should substitute for $E(i_1)$ in the last equation. However, the last equation above is still mathematically equivalent to equation (2), and equation (2) derives from equation (1), and

[1] Similar analysis applies to the revenue equations for the five-year regulatory situation, as shown in equations (3).

equation (1) unambiguously requires $E(i_1)$to be the expected inflation rate over one year rather than ten years. The preceding comments therefore still apply: the error in using a WACC for longer than the regulatory cycle is not ameliorated by doing the same for the expected inflation rate.

To illustrate these points, consider the one-year regulatory situation reflected in equations (1) and (2). Since the WACC term structure is generally upward sloping, suppose $WACC_1 = .05$ whilst $WACC_{10} = .06$. I consider three scenarios relating to the term structure for expected inflation. The first scenario involves $E(i_1) = .025$ and the same for all other years out to year 10, in which case the geometric mean rate out to ten years is also .025. If $E(REV_1)$ is set correctly in accordance with equation (2), then

$$E(REV_1) = .05A_0 - .025A_0 = .025A_0$$

The present value (PV) of the revenues and the expected RAB in one year is then as follows:

$$PV = \frac{.025A_0 + 1.025A_0}{1.05} = A_0$$

which satisfies the NPV = 0 requirement (PV = A_0). By contrast, if $WACC_{10}$ =.06 is wrongly used in setting expected revenues in equation (2), $E(REV_1) = .06A_0 - .025A_0 = .035A_0$ and therefore the PV rises to 1% above A_0 as follows:[2]

$$PV = \frac{.035A_0 + 1.025A_0}{1.05} = 1.01A_0$$

If expected inflation for the next ten years is also wrongly used in equation (2), there is no change because the term structure for expected inflation is flat. The results are shown in the first row of Table 1. The second scenario involves $E(i_1) = .01$ while the expected rates for all other years out to year 10 are .025, i.e., reversion to the RBA's target rate in one year. The geometric mean of these rates is .0235. If $E(REV_1)$ is set correctly in accordance with equation (2), then $E(REV_1) = .05A_0 - .01A_0 = .04A_0$ and the NPV = 0 requirement is satisfied

[2] The use of the wrong WACC in equation (2) does not flow over to the denominator in the PV equation because expected revenues can be set in any way by the regulator whilst the present valuing of them must obey the laws of financial economics, in which a cash flow arising in one year requires discounting using the one-year WACC.

as before. If $WACC_{10} = .06$ is wrongly used in equation (2), $E(REV_1) = .06A_0 - .01A_0 = .05A_0$ and therefore the PV rises to 1% above A_0 as follows:

$$PV = \frac{.05A_0 + 1.01A_0}{1.05} = 1.01A_0$$

If expected inflation for the next ten years (of .0235) is also wrongly used in equation (2), then $E(REV_1) = .06A_0 - .0235A_0 = .0365A_0$ but the expected growth in the RAB over the next year is still 1%, so the PV falls to 0.3% below A_0 as follows:

$$PV = \frac{.0365 + 1.01A_0}{1.05} = 0.997A_0$$

This mitigates the PV error from using the wrong WACC, in this scenario. These results are shown in the second row of Table 1. Finally, the third scenario involves $E(i_1) = .04$ while the expected rates for all other years out to year 10 are .025, i.e., reversion to the RBA's target rate in one year. The geometric mean of these rates is .0265. The results in this scenario are also shown in Table 1, and show that using the wrong expected inflation rate now aggravates rather than mitigates the WACC error.

Table 1: PV Errors from Various Scenarios and Revenue-Setting Policies

	Correct Policy	WACC Error	WACC & $E(i)$ Error
Scenario 1	0	1%	1%
Scenario 2	0	1%	-0.3%
Scenario 3	0	1%	2.2%

Table 1 reveals that, in setting expected revenues, the PV error in using the WACC for the next ten years rather than for the regulatory cycle but correctly using the expected inflation rates for the years within the regulatory cycle yields revenues in excess of those required to satisfy the NPV = 0 requirement (assuming a typical upward sloping WACC term structure). By contrast, if the regulator also errs in using expected inflation for the next ten years when setting expected revenues, the PV error arising from using the wrong WACC will be unaffected if the term structure for expected inflation over the next ten years is flat, mitigated if the term structure for expected inflation over the next ten years is upward sloping, and aggravated if the term structure for expected inflation over the next ten years is downward sloping. Thus, across the three scenarios overall, using the wrong expected inflation rate does not mitigate the WACC error.

3. Approaches to Estimating the Expected Inflation Rate

3.1 Bond Yields

For a realized nominal rate of return R and realized inflation rate i over the same period, the realized real rate of return is by definition

$$r = \frac{1+R}{1+i} - 1 \tag{4}$$

It follows that

$$1 + R = (1 + r)(1 + i) \tag{5}$$

If r and i are uncorrelated it follows that

$$1 + E(R) = [1 + E(r)][1 + E(i)] \tag{6}$$

which is referred to as the Fisher equation. Importantly, rates R and r are on the same asset. A variant on this involves promised yields rather than expected rates of return, and similar rather than identical assets. Letting R_N denote the current yield on one-year CGS and R_R that on one-year Indexed Treasury bonds, equation (6) suggests that:

$$1 + R_N = (1 + R_R)[1 + E(i_1)] \tag{7}$$

Since R_N and R_R are observable, an estimate of $E(i_1)$ can then be deduced from equation (7). This approach is called the "Treasury Bond" method and the resulting estimate of the expected inflation rate is called the "break-even inflation rate". However, equation (7) does not follow from (6), and (6) does not follow from (5) when r and i are correlated. Accordingly, the estimate of $E(i_1)$ arising from equation (7) may be biased unless certain assumptions hold.

Firstly, it is assumed that nominal and indexed bonds are available with the same maturity dates. However, as noted by Finlay and Olivan (2012, page 50), there do not typically exist nominal and indexed bonds with the same maturity date, and therefore interpolation would be required to generate yields over the same period.[3] Furthermore, even if the maturity dates matched, the set of maturity dates for indexed bonds is so limited that interpolation would be required to generate break-even inflation rates for the desired terms of 1, 2,…5 years. This interpolation will induce errors in the estimate of expected inflation, because the term structure of interest rates is not in general linear whilst interpolation typically assumes linearity. The errors are unlikely to be substantial but the need to do this introduces a highly undesirable degree of subjectivity into the exercise.

Secondly, it is assumed that the indexed bonds compensate for inflation over the period from the current moment in time until their maturity. However, inflation-indexed bonds are subject to lags in correcting for inflation. This too will induce errors in the estimate for expected inflation but again this is not substantial. For example, suppose investors require a real rate of return of 3%, a bond promises \$103 in one year with inflation adjustment in accordance with the change in the inflation index from three months ago to nine months hence (three month lag), the inflation rate over the latter period will be 2% whilst inflation over the next year will be 2.2%, and these rates are perfectly anticipated by investors. In this case, the nominal payoff on the bond will be \$103(1.02), the real payoff will be \$103(1.02)/1.022, and the current price P must be such that the real yield to maturity is 3%:

$$\frac{\left[\frac{\$103(1.02)}{1.022}\right]}{P} - 1 = .03$$

This implies P = \$98.804 and use of this price coupled with the promised payment of \$103 before the inflation adjustment would lead to an estimate for the real rate required by investors over the next year of 3.22%. So, the real yield required by investors would be overestimated by 0.22% and substitution of this yield of 3.22% into equation (7) would lead to expected inflation being underestimated by 0.22%. This example is intentionally extreme

[3] At the present time (June 2020), the only maturity dates for inflation-indexed bonds with maturities no more than five years hence are August 2020 and February 2022, and the nearest maturity dates for nominal bonds are November 2020 (three months later) and December 2021 (three months earlier). Data from Table F16 on the website of the Reserve Bank of Australia (https://www.rba.gov.au/statistics/tables/#interest-rates).

in order to dramatise the point. However, empirical estimates (Grishchenko and Huang, 2012, Table 2) reveal that the effect is no more than 0.04%.

Thirdly, it is assumed that the nominal and indexed bonds have the same liquidity. However, the indexed bonds are less liquid than the nominal bonds, in the sense that the volume of outstanding indexed bonds is much lower and the ratio of turnover to outstanding bonds is also lower (Devlin and Patwardhan, 2012, Chart 1). So, R_R incorporates a premium for inferior liquidity relative to CGS. Letting p denote this premium, equation (7) should instead be as follows:

$$1 + R_N = (1 + R_R - p)[1 + E(i)]$$

Using equation (7) rather than this equation therefore induces an underestimate of expected inflation. Empirical estimates of the illiquidity premium are highly variable. For example, D'Amico et al (2009, Figure 8) estimates the illiquidity premium on US indexed bonds to have declined from about 1.5% in 1999 to zero in 2005 and then risen to 0.5% in 2007. With an illiquidity premium of 0.50%, the resulting underestimate of the expected inflation rate would also be 0.50%. By contrast, Grishchenko and Huang (2012, Table 7) estimates the premium on US indexed bonds over the 2000-2008 period at less than 0.10% on average (and not exceeding 0.35%). In addition, Haubrich et al (2015, pp. 1622-1623) estimates the premium on US indexed bonds over the 1998-2011 period as large (up to 1.5%) prior to 2004, large also in the 2008-2010 period (up to 2.0%), and otherwise essentially zero. All of this implies that underestimates of expected inflation using the "break even" rate as a result of this illiquidity premium could be large at some points in time.

Fourthly, it is assumed that investors are indifferent to the inflation risk on nominal bonds. Assuming (reasonably) that investors are interested in the real rather than the nominal return on a bond, the indexed bonds are risk-free whilst the nominal bonds are risky because the real return on them depends upon the actual inflation rate that arises during the period. For example, a nominal bond promising 5% delivers a real return of 5% if inflation is 0% and a real return of zero if inflation is 5%. It is commonly supposed that this inflation risk raises the nominal yield on these nominal bonds (Devlin and Patwardhan, 2012, page 5), i.e., the "inflation risk premium" is commonly supposed to be positive. However, the sign of this premium depends upon whether inflation is positively or negatively correlated with favourable economic states, and this is a contentious question (Bekaert and Wang, 2009, pp, 779-780; Grishchenko and Huang, 2012, pp. 5-6).

To elaborate on the issue of the correlation between inflation and economic states, I assume (reasonably) that investors are interested in the real rather than the nominal return on any asset. If the discrete-time CAPM applies, it would then apply in real terms, and the risk-free rate would be that on indexed bonds. Letting R_R denote this real risk-free rate, R_{RN} the real rate of return on nominal bonds, and R_{RM} the real rate of return on the market portfolio, the expected real return on nominal bonds would be as follows:

$$E(R_{RN}) = R_R + \frac{E(R_{RM}) - R_R}{Var(R_{RM})} Cov(R_{RN}, R_{RM}) \tag{8}$$

If inflation is positively correlated with R_{RM}, then R_{RN} would be negatively correlated with R_{RM} and therefore $E(R_{RN})$ would be less than R_R, i.e., the inflation risk premium within R_N would be negative. So, R_N coupled with R_R and equation (7) would provide a downward biased estimate of expected inflation. To illustrate this, suppose R_R = .033 and $E(R_{RN})$ = .03 in accordance with equation (8). Letting i denoting the actual rate of inflation over the period in question, the real rate of return on nominal bonds R_{RN} is related to the nominal yield on these bonds R_N as follows:

$$1 + R_{RN} = \frac{1 + R_N}{1 + i}$$

It follows that:

$$1 + E(R_{RN}) = (1 + R_N) E\left[\frac{1}{1 + i}\right]$$

and therefore that

$$1 + R_N = \frac{1 + E(R_{RN})}{E\left[\frac{1}{1 + i}\right]} \tag{9}$$

Suppose further that the actual inflation rate i is equally likely to be 1% or 3%, and therefore the expectation in the denominator of equation (7) is 0.9805. Since $E(R_{RN})$ = .03, it follows from equation (9) that R_N = .0505. Substituting this into equation (7) along with R_R = .033 yields an estimate of expected inflation of 1.7%. By contrast, since i is equally likely to be

1% or 3% in this example, the expected rate of inflation is 2%. So, the use of equation (7) would lead to an underestimate of the expected inflation rate of 0.30%.

Finally, equation (7) incorrectly specifies the relationship between R_N and R_R even if investors are indifferent to inflation risk. In the latter scenario, the expected real return on nominal bonds would be equal to the promised real yield on indexed bonds, i.e.,

$$E\left[\frac{1+R_N}{1+i}\right]=1+R_R$$

which implies that

$$1+R_N=\frac{1+R_R}{E\left[\frac{1}{1+i}\right]} \tag{10}$$

This is equivalent to equation (7) only if there is no uncertainty about inflation. For example, suppose that the promised real yield on indexed bonds is 3.3% and inflation is equally likely to be 1% or 3% as in the previous example. Substitution into equation (10) yields R_N = .0536, and substitution of this into equation (7) along with R_R = .033 yields an estimate for expected inflation of 1.99% rather than the correct value of 2.0% in this example. As is apparent from the example, this is not a significant issue. This is referred to in the literature as the "convexity adjustment" (Grishchenko and Huang, 2012, page 18).

The most important of these problems are the liquidity premium on indexed bonds and the inflation risk premium on nominal bonds. The net effect of these two phenomena could be positive or negative, leading to either upward or downward bias in estimating expected inflation from equation (7). In particular, if the inflation risk premium is positive, the net effect of these two premiums could be positive or negative. Alternatively, if the inflation risk premium is negative, the effect of these two premiums will be to induce downward bias in the estimate of expected inflation from equation (7). Upon surveying recent empirical evidence, Bekaert and Wang (2009, page 788) conclude that the estimates of the inflation risk premium are "mostly positive, can be large, and vary considerably over time". They also note that larger estimates come from longer data series, which raises the possibility that there has been a regime shift in recent times from a positive premium to a negative one, and the authors even raise this possibility (Bekaert and Wang, 2009, page 780). By contrast, Grishchenko and

Huang (2012, page 6) conclude that "..there appears no consensus so far in the (empirical) literature as to not only the magnitude of the inflation risk premium but also its sign."

More recently, using Australian data over the period 1992-2010, Finlay and Wende (2012, Figure 3) estimate the net effect of these two phenomena at from 2.5% to -1.0% over both five and ten year periods. In addition, using US data over the shorter and more stable inflationary period from 2000 to 2008, Grishchenko and Huang (2012, Table 6) estimate the net effect to be negative, statistically significant, and up to 0.50% depending upon the term of the bonds used and the method for estimating expected inflation. Grishchenko and Huang (2012, section 5.3) also conclude that the net premium changed from negative to approximately zero in 2004. In addition, Fleckenstein et al (2014) find that there are large discrepancies between the price of nominal bonds and a package of indexed bonds and derivative contracts (inflation swaps) with the same payoffs. They conclude that the cause of this is mispricing in the bond markets, and the mispricing in terms of interest rates has been up to 1.8% (ibid, Figure 2). All of this suggests that the "break-even inflation rate" is liable to be a poor estimator of the expected inflation rate.

Attempting to correct it for the effect of risk and illiquidity would also yield a poor estimator because the appropriate corrections for these two effects are very unclear. Furthermore, any such correction could be worse than no such correction. For example, if the net effect of these two issues is an overestimate of expected inflation of 0.20%, but is mistakenly estimated to be an overestimate of 0.50% with the result that the break-even rate is reduced by 0.50%, the error is then an underestimate of 0.30%, which is worse than the 0.20% overestimate resulting from making no adjustment.

If these problems tended to net out over successive regulatory cycles, they would be less concerning. However there is no reason to suppose that this would occur, i.e., the method is likely to be biased over the life of the assets. Thus, significant violations of the NPV = 0 principle are possible from the use of the "break-even" inflation rate.

3.2 Inflation Swaps

An estimate of expected inflation can also be obtained from the fixed rate in zero-coupon inflation swaps, which involves one party (the Inflation Receiver) paying at the maturity of the contract a rate set at the commencement of the contract (P) and receiving at contract maturity the realized rate of inflation over the term of the contract, whilst the other party (the Inflation Payer) is in the opposite position. This fixed rate P is treated as an estimate of expected inflation.

As with the break-even rate, the two principal problems are premiums for inflation risk and illiquidity. Consider inflation risk. Letting P_c denote the present value of P, the nominal rate of return to an Inflation Receiver would then be $(i/P_c) - 1$, the real rate of return would then be $[i/P_c(1+i)] - 1$. Following equation (8), the expected real rate of return on this asset in accordance with the CAPM (in real terms) would be as follows:

$$E\left[\frac{i}{P_c(1+i)}\right]-1 = R_R + \frac{E(R_{RM})-R_R}{Var(R_{RM})}Cov\left[\frac{i}{P_c(1+i)}, R_{RM}\right] \tag{11}$$

Since the payment P at the maturity date of the contract is fixed in nominal terms, its present value P_c is P discounted at the nominal risk-free rate R_N, and therefore

$$E\left[\frac{i}{\frac{P}{(1+R_N)}(1+i)}\right] = 1 + R_R + \frac{E(R_{RM})-R_R}{Var(R_{RM})}Cov\left[\frac{i}{P_c(1+i)}, R_{RM}\right]$$

To a close approximation this is

$$\frac{E(i)}{P}E\left[\frac{1+R_N}{1+i}\right] = 1 + R_R + \left[\frac{E(R_{RM})-R_R}{Var(R_{RM})}\right]Cov\left[\frac{i}{P_C(1+i)}, R_{RM}\right]$$

i.e.,

$$\frac{E(i)}{P}[1+E(R_{RN})] = 1 + R_R + \left[\frac{E(R_{RM})-R_R}{Var(R_{RM})}\right]Cov\left[\frac{i}{P_C(1+i)}, R_{RM}\right]$$

So

$$\frac{E(i)}{P} = \frac{1 + R_R + \left[\frac{E(R_{RM})-R_R}{Var(R_{RM})}\right]Cov\left[\frac{i}{P_c(1+i)}, R_{RM}\right]}{1+E(R_{RN})}$$

Invoking the CAPM (in real terms) again, following equation (8), this is as follows:

$$\frac{E(i)}{P} = \frac{1 + R_R + \left[\frac{E(R_{RM}) - R_R}{Var(R_{RM})}\right] Cov\left[\frac{i}{P_c(1+i)}, R_{RM}\right]}{1 + R_R + \left[\frac{E(R_{RM} - R_R}{Var(R_{RM})}\right] Cov(R_{RN}, R_{RM})}$$

$$= \frac{1 + R_R + \left[\frac{E(R_{RM}) - R_R}{Var(R_{RM})}\right] Cov\left[\frac{i}{P_c(1+i)}, R_{RM}\right]}{1 + R_R + \left[\frac{E(R_{RM} - R_R}{Var(R_{RM})}\right] Cov\left(\frac{1+R_N}{1+i}, R_{RM}\right)} \tag{12}$$

If the inflation rate i is positively correlated with the real market return R_{RM}, then the covariance term in the numerator of equation (12) will be positive and that in the denominator will be negative. So the inflation swap price P will be less than $E(i)$, and therefore P will be a downward biased estimator of expected inflation. Letting RP denote this risk premium

$$P = E(i) + RP$$

So, if $E(i) = .03$ and $P = .02$, using P to estimate $E(i)$ yields an underestimate of $E(i)$ of .01.

Turning now to the issue of illiquidity, Devlin and Patwardhan (2012, page 6) note that these contracts have poor liquidity in the event of one party seeking an early exit, and suggest that this would affect the swap price P. This would require parties on one side (buyers or sellers) to compensate parties on the other side, which is possible if the former group were hedgers. This would raise or lower P depending upon whether buyers or sellers provided the compensation to the other group, and therefore would cause P to underestimate or overestimate expected inflation.

As with the break-even rate, the net effect of these premiums for risk and illiquidity is unclear. So, the swap price is likely to be a poor estimator of expected inflation, as would the swap price subject to any attempted correction for these effects.

3.3 RBA Inflation Target

Another approach to forecasting inflation is use of the midpoint of the RBA's target band for inflation (2.5%). Inflation targeting commenced in Australia in early 1993. For the calendar years 1994 – 2019, the arithmetic average of the annual inflation rates was 2.49% per year.[4] This demonstrates that the RBA has been extremely successful (on average). However, there has been considerable variation around this, with an estimated standard deviation of 1.2%. Furthermore, there has been noticeable clustering in outcomes both above and below the average. In particular, the annual rates were below 2.5% in every quarter from September 1996 to December 1999, and in every quarter since September 2014, whilst they exceeded 2.5% in every quarter from March 2000 to December 2003. Expressed more formally, the annual rates appear to be a mean-reverting process. So, if the rate is above (below) 2.5%, it is expected to remain so for some period. Regressing calendar year rates (in percentage terms) on the preceding year's value yields the following result:

$$i_t = 1.962 + 0.21 i_{t-1} \tag{13}$$

This is a mean-reverting model, and expressing it in the following equivalent form reveals that rates revert to a mean of 2.48% (which is almost identical to the RBA's Target):

$$i_t = i_{t-1} + 0.79(2.48 - i_{t-1})$$

So, given the latest inflation rate, this model predicts the rate for the next year, which is fed back into the model to predict the rate one year later, and so on. For example, if the latest rate is 4%, the prediction for next year is 2.8%, and for the year after is 2.6%. Similarly, if the latest rate is 1%, the prediction for next year is 2.2%, and for the year after is 2.4%. So, this model implies that reversion to the mean is largely achieved within two years. However, the *p* value on the second coefficient in equation (13) is high (0.31), and therefore the resulting predictions are not statistically compelling (i.e., wide confidence intervals). This may be due to the limited set of annual observations. Using quarterly data instead yields

$$i_t = 0.509 + 0.175 i_{t-1} \tag{14}$$

[4] Data from column C of Table G1 on the website of the Reserve Bank of Australia (http://www.rba.gov.au/statistics/tables/#inflation-expectations).

with a p value on the second coefficient of 0.07. This is statistically much more compelling. Equation (14) is equivalent to the following mean-reverting model, in which (quarterly) rates revert to a mean of 0.617% (equivalent to 2.49% per year):

$$i_t = i_{t-1} + 0.825(0.617 - i_{t-1})$$

For example, if the latest rate is 1% for the quarter, equivalent to 4% per year, the prediction for next quarter is year is 0.68%, followed by 0.63% and then 0.62%. Similarly, if the latest rate is 0.25% for the quarter, equivalent to 1% per year, the prediction for the next quarter is 0.55%, followed by 0.60%, 0.61% and then 0.62%. So, this model implies that reversion to the mean is largely achieved within a year.

Consistent with this statistical evidence of mean reversion, credible short-term forecasts of inflation have differed from 2.5%. For example, the RBA's survey of market economists' one-year ahead inflation expectations have ranged from 1.8% to 5.5% over the period for which this survey has been conducted, whilst those for two years ahead have ranged from 1.8% to 4.9%.[5] Thus, even if there has been no regime change, for the purposes of estimating expected inflation over the next year and possibly longer, the RBA's inflation target would be unsatisfactory because it implicitly predicts immediate reversion to 2.5%.

3.4 Model Based Forecasts

Econometric models can also be used to forecast inflation. The simplest such models use only past data. One such example is a random walk, i.e., using the latest observation as the forecast. A more sophisticated approach using only past data is the mean reverting model, as described in the previous section. An even more sophisticated approach is that of Finlay and Wende (2012), based upon Australian data over the 1992-2010 period, using yields on nominal and inflation-indexed bonds along with economists' forecasts of inflation, and requiring 20 parameters to be estimated. A similarly sophisticated approach is that of Grishchenko and Huang (2012), using US data over the period 2000-2008. A drawback from such sophisticated approaches is the unlimited number of potential models. So, if the AER

[5] Data from Table G3 on the website of the Reserve Bank of Australia (http://www.rba.gov.au/statistics/tables/#inflation-expectations).

chose one such model, it would invite regulated businesses and consumer groups to provide their preferred models.

3.5 Survey Evidence

Another approach is to use survey evidence from credible forecasters. For example, the RBA reports its survey of market economists' one-year and two-year ahead inflation expectations. These subjective forecasts could be expected to outperform more mechanical approaches (the approaches described above) because any merit in such mechanical approaches could be expected to be incorporated into the subjective forecasts. As a former central banker, Vahey (2017, page 7) affirms this point, with explicit reference to central banks monitoring of the break-even inflation rate. However, no such forecasts are publicly available for more than two years ahead.

3.6 Survey Evidence Coupled with the Inflation Target

Another approach to forecasting inflation would be to use the RBA's forecasts and/or survey evidence for the years for which they are available in conjunction with the RBA's Target for the remaining years. This is the AER's current approach, in which it uses the RBA's forecasts for the first two years (the period for which they are available) coupled with the RBA's Target of 2.5% for the remaining years of the ten-year forecasting period. So long as the RBA's one-year and two-year ahead forecasts are superior to the RBA's Target, this estimator will be superior to exclusive use of the Target.

4. Empirical Analysis

4.1 Previous Analysis

Tulip and Wallace (2012, Table 1) use data from 1993 – 2011 to assess the forecast accuracy of a range of inflation forecasting methods for one year ahead and for the second year ahead. For one year ahead, the root mean squared error (RMSE) for the RBA's forecasts is 0.89%, 1.41% for the RBA's Target, and 1.90% for the Random Walk. For the second year ahead, the results are 1.27%, 1.36% and 2.19% respectively. All of these differences are statistically significant except for that between the RBA forecasts and the Target for the second year ahead. In respect of the RBA's forecasts, Tulip and Wallace (2012, Table 4) also report that the biases are immaterial and are not statistically significant. Tulip and Wallace (2012, Table 2) also report that the RMSE of the RBA's forecasts are only marginally superior to those provided by other private sector forecasters and the differences are not statistically significant. The superiority of these judgmental forecasts over the mechanical forecasts (Target and Random walk) is unsurprising because the merits of any forecasts that are mechanical could be expected to be impounded into the judgmental forecasts.

Finlay and Wende (2012, Figure 2) present forecasts of inflation for 1992-2000, based on a combination of break-even inflation rates and surveys of forecasters. However they do not present any formal test of the forecast accuracy of this predictor, and this will be done in the next section.

Mathysen (2017, Figure 3) presents three different time-series of estimates of the ten-year break-even inflation rate in Australia, over the period 2000-2016. For all three series, the results oscillate around the average realized inflation rate of 2.6% since March 2000 (which in turn is close to the RBA's Target of 2.5%) but the results in each series are extremely variable over time, even within the course of a few months (with the most extreme change being a drop from 3.8% to 1.5% in early 2008). By contrast, since March 2000, the average realized inflation rate over a ten-year period has not changed by more than 0.3% over the course of six months.[6] This suggests that the premiums for risk and illiquidity within the break-even rates fluctuated substantially over time and/or investors overreacted to short-term changes in inflation when estimating the long-term future rate; in either case, the break-even rate would seem to be a poor estimator for expected inflation. Mathysen does not present any formal test of the forecast accuracy of these break-even rates, and this will be done in the next section.

Mathysen (2017, Figure 15) also presents a time-series of ten-year swap prices and the ten-year break-even rate, over the period October 2009 – June 2016. The swap prices were much less volatile over time than the break-even inflation rate (and almost entirely within the RBA's inflation band). However the time series of swap prices was above the average realized inflation rate throughout the entire period analysed, and by about 1% for the first half of the time series, which suggests that they are significantly biased up as predictors. The swap price also generally exceeded the contemporaneous break-even rate (by about 0.30% in the last half of the time series). Since both purport to reflect market expectations of future

[6] Data from column C of Table G1 on the website of the Reserve Bank of Australia (http://www.rba.gov.au/statistics/tables/#inflation-expectations).

inflation embedded in market prices, this persistent discrepancy undercuts the credibility of both of them. Again, Mathysen does not present any formal test of the forecast accuracy of the swap rate, and this will be done in the next section.

4.2 Additional Tests

I commence by extending the work of Tulip and Wallace (2012) to include data to 2019, and to present forecasts for future years beyond the second year where possible. The RBA provides the RBA forecasts used by these authors, up to 2011, which arise from the RBA's Statements of Monetary Policy (SMP) and earlier counterparts.[7] I have checked these reported forecasts against the SMPs, and a number of discrepancies are apparent, most particularly that for the year ended December 2012, for which the November 2011 SMP (page 66) gives 3.25% whilst the RBA's excel file (at CK101) gives 2.56%.[8] Accordingly, I source the RBA's forecasts from the SMPs as far back as they provide them (November 2007), and earlier from the RBA's excel file. For the SMPs from November 2007, the RBA provides a forecast for the following calendar year and the next calendar year. By contrast, prior to that, the RBA's excel file only presents forecasts for the next calendar year and the year ending six months later.

By definition, a forecast must be provided prior to the commencement of the period for which the variable is forecasted, and it should be as close as possible to the commencement of that period. Since the SMP forecasts presented from November 2007 are for years ended December and June, I elect to use calendar years as the period to be forecast and source the forecasts from the relevant November SMP. So, for example, the SMP forecast for the 2019 calendar year is drawn from the November 2018 SMP. For the period 2000-2006, the forecasts are taken from the RBA's excel file for November of that year. For the period 1993-1999, they are taken from the RBA's excel file for December of that year. Furthermore, for this total period 1993-2006, the RBA's annual forecasts in their excel file extend only as far as the first half of the second calendar year following the forecast. So, the forecasts presented in November or December of a year that are used here are for the following calendar year, and for the year ending six months later (which are forecasts for one

[7] These are provided in the fourth tab ("CPI – 4 Quarter Change") of the excel file named "Forecast Data by Event Date" on the Bank's website: https://www.rba.gov.au/publications/rdp/2012/2012-07-data.html.

[8] The SMPs are available at https://www.rba.gov.au/publications/smp/2019/nov/.

year ahead and 1.5 years ahead). The actual inflation rates for the relevant years are drawn from the RBA data noted in footnote 5.

To illustrate, the first forecasts used are those presented in December 1993, for calendar 1994 (3.0%) and the year ended June 1995 (2.8%), with the former being a forecast for one year ahead and the latter being a forecast for 1.5 years ahead. The actual inflation rate for calendar 1994 was 2.6% and that for the year ended June 1995 was 4.5%. So, in respect of these forecasts presented in December 1993, the one year ahead forecast error (for calendar 1994) was 2.6% - 3.0% whilst the 1.5-year ahead forecast error (for the year ended June 1995) was 4.5% - 2.8%. The last forecasts used are that in the November 2017 SMP for the second year ahead (calendar 2019: 2.25%) and that in the November 2018 SMP for one year ahead (calendar 2019: 2.25%); the actual inflation rate for 2019 was 1.8%, yielding forecast errors of 1.8% - 2.25% for both the one and two-year ahead forecasts.

The RMSE for the forecast errors are then determined. For the one-year ahead forecasts, over the forecast calendar years 1994-2019, this is 0.89% as follows:

$$RMSE = \sqrt{\frac{(2.6-3.0)^2 + \cdots \ldots \ldots \ldots + (1.8-2.25)^2}{26-1}} = 0.89$$

Over the shorter period of 1994-2011, the result is 0.96%, which differs from Tulip and Wallace's (2012, Table 1) figure of 0.89% over the same period. Possible explanations for the difference are the use of different forecasts in the period 2007-2011, because I source the SMPs directly rather than from the RBA's excel file, and differences in the forecast periods and the dates of the forecasts (which Tulip and Wallace do not provide). Repeating this process for the 1.5 to 2.0 year ahead forecast errors yields an RMSE of 1.06% for 1994-2019 and 1.19% for 1994-2011 compared with 1.27% by Tulip and Wallace (2012, Table 1). These RMSE results for 1994-2019 are shown in Table 2 below.

This process is favourable towards the RBA's forecasts for the 'second' year ahead because these forecasts for the first half of the data series are not for the second year ahead but for a one-year period ending 1.5 years ahead. However, if these years (1994-2006) were deleted from the RMSE calculation for the RBA's second year ahead forecasts, the result would not be comparable with all other forecasts. Alternatively, if all such years were deleted from the analysis, then valuable information would be lost. I therefore retain these 1.5 year ahead RBA forecasts.

A second possible forecasting method is use of the RBA's target inflation rate of 2.5%. So, for the one-year ahead forecasts, the forecasts are all 2.5% and the actual outcomes are those for 1994 (2.6%), …….2019 (1.8%). The resulting RMSE is 1.18%. For the second year ahead, the process is the same except that the forecasts commence at the beginning of 1994 with a forecast then of the actual rate for 1995. The resulting RMSE is 1.21%. For forecasts for the third, fourth, fifth and tenth years ahead, using the same approach, the RMSE results are 1.11%, 1.11%, 0.96% and 0.64%. The difference in results is purely an artefact of deleting progressively more observations at the beginning of the time series coupled with the fact that these rates were unusually variable. All of these results are shown in Table 2 below.

A third possibility is use of the Random Walk approach: the one-year ahead forecast for inflation in a particular year (t) is the outcome in the previous year, the second year ahead forecast for inflation in year t is the outcome in the penultimate year, and so on. The RMSE results are shown In Table 2 below.

A fourth possibility is the forecasts by Consensus Economics, which provides forecasts for calendar years out to ten years ahead and has done so over the 1994-2019 period. For most of this period, forecasts were generated bi-annually in early October and early April. Since forecasts should precede the period forecasted, and to the least possible extent, I therefore utilize the Consensus forecasts in October to forecast the outcomes in the following calendar years. For example, the forecasts in October 1993 for 1994 and 1995 were 3.3% and 3.9% respectively. The actual outcomes were 2.6% and 5.1% respectively, yielding forecast errors of 2.6% - 3.3% for one year ahead and 5.1% - 3.9% for the second year ahead. The RMSE results are shown in Table 2 below.

A fifth possibility is the Mean Reversion model in equation (14), in which the quarterly inflation in the December quarter is used to forecast the next quarter's inflation, which is then used to forecast the next quarter's inflation, and so on for the next two quarters; these four quarterly forecasts are then summed to yield the forecast for the calendar year. Following this process, the quarterly inflation of 0.2% for Dec 1993 yields a forecast for 1994 of 2.38%.

Since inflation for 1994 was 2.6%, the resulting forecast error was 0.22%. The RMSE of these one-year ahead forecast errors over the 1994-2019 period is 1.17, as shown in Table 2. Since reversion to the target is forecast to occur by essentially the end of the first year, this approach would yield essentially the same results as use of the Target for forecast years beyond the first, and therefore these results need not be calculated. This process is prejudiced in favour of the Mean Reversion model because the data used to test the forecasts is also used to estimate the parameters in the model; the model then has knowledge of the data that is being forecasted. Despite this advantage, it is still outperformed by the RBA's forecasts, which reinforces the conclusion that the latter are superior.

A sixth possibility is the model of Finlay and Wende (2012), who present forecasts of inflation for 1992-2010, based on a combination of break-even inflation rates and surveys of forecasters (ibid, Figure 2). I couple their estimates for the one-year ahead inflation rate as at mid 1993, mid 1994, ….mid 2010 with the realized inflation rate for the following year (year ending June 1994,….year ending June 2011). The bias in the forecasts (0.1%) is immaterial (and statistically insignificant) whilst the RMSE of the forecast errors is 1.35%.[9] The time period examined is similar to that by Tulip and Wallace (2012), whose RMSE for the RBA's forecasts for one-year ahead is 0.89%, and therefore the RBA's forecasts are significantly superior. Furthermore, since Finlay and Wende's forecasts are based on a combination of break-even inflation rates and survey estimates from Consensus Economics, and the latter are comparable in forecast accuracy to the RBA's forecasts (see Tulip and Wallace, 2012, Table 2), it follows that the RBA's forecasts are significantly superior to break-even rates. This is unsurprising because the break-even rate is a poor forecaster (due to illiquidity and risk components) and any merits from this approach could be expected to be impounded into the RBA's forecasts.

As shown in Table 2, for the first and second years ahead, the lowest RMSE is from the RBA forecasts. For all other forecast years, the lowest RMSE is from use of the Target. The result for the first and second years ahead are unsurprising; the RBA outperforms the Random Walk because the latter fails to recognize that inflation rates are mean reverting, the RBA outperforms the Target because the latter implicitly assumes that mean reversion occurs

[9] Since the results from attempting to read off the data from Finlay and Wende (2012, Figure 2) are too imprecise I sought the data from the RBA and it was kindly supplied.

immediately, the RBA outperforms Mean Reversion because the speed of mean reversion fluctuates over time and the RBA has some insights into these fluctuations, and the RBA outperforms Consensus because the RBA has some insights that Consensus does not have. If I substitute the Target RMSE result for one-year ahead (1.18%) for all other terms, on the grounds that the results for the longer term forecasts are an artefact of the data as discussed above, the Consensus forecasts would then be best for the fifth and tenth years ahead. However the Consensus results for these later years have the implausible feature that they are significantly better than for shorter terms. Again, this is an artefact of these longer-term forecasts involving deletion of the unusually variable inflation rates in the first few years in the time series. So, the best forecasts still seem to be those of the RBA for the first and second years ahead, and the Target for all other years. This corresponds to the AER's current approach. This process is mildly prejudiced in favour of the RBA's forecasts for the 'second' year ahead because some of the data is for a year ending 1.5 years ahead rather than two years ahead, but the superiority of the RBA's forecasts over this interval is sufficiently strong to mitigate that concern.[10]

Table 2: RMSE Results for Various Forecasting Methods and Years

Forecast Year	1	2	3	4	5	10
RBA	0.89	1.06				
Target	1.18	1.21	1.11	1.11	0.96	0.64
Random Walk	1.51	1.74	1.92	1.75	1.26	1.69
Consensus	1.06	1.34	1.33	1.27	0.98	0.78
Mean Reversion	1.17					
Finlay & Wende	1.35					

I now turn to the break-even rate. The RBA presents a series of ten-year break-even rates from 1986.[11] Each rate is a predictor of the geometric mean inflation rate over the following

[10] Treating the RBA's second year ahead forecasts as instead being for a year ending 1.75 years ahead on average, and extrapolating from the RMSE results of 0.89% for one year ahead and 1.06% for a year ending 1.75 years ahead, the RMSE for the second year ahead is 1.12%. This is still superior to any other method.

[11] The values appear in column H of Table G3 on the website of the Reserve Bank of Australia (https://www.rba.gov.au/statistics/tables/#inflation-expectations). From 1996, the maturity dates of the two bonds are matched using interpolation and/or extrapolation of the term structure.

ten years, and these rates can be compared to the actual geometric mean over each such ten year period. For example, the break-even rate in December 1993 (of 3.0%) is a predictor of the geometric mean inflation rate over the period 1994-2003 inclusive (which was 2.64%). The forecast error is then 0.36%. Using the December break-even rates from Dec 1993 (shortly after inflation targeting commenced) to Dec 2009 (after which the realized counterpart to the ten-year prediction is not yet available), the RMSE of the forecast errors is 0.86% as follows:

$$RMSE = \sqrt{\frac{(2.64 - 3.0)^2 + \cdots \ldots \ldots \ldots + (2.11 - 2.8)^2}{17 - 1}} = 0.86 \qquad (15)$$

This RSME cannot be compared to the RMSE values in the last column of Table 2 because the latter involve forecasts and outcomes for the tenth year ahead rather than for the average over the next ten years. To enable comparison with the RBA's Target, I repeat the calculation in equation (15) except that the forecast for each ten-year period is the RBA's Target of 2.5% rather than the ten-year break-even rate immediately preceding that ten-year period. The resulting RMSE is 0.34. So, the RBA's target is vastly superior to the break-even rate. Furthermore, repeating the calculation in equation (15) except that the forecast for each year is the average inflation rate over the previous four years (with the first forecast being for 1997-2006 using data from 1993-1996), the resulting RMSE is 0.85%. So, the breakeven rate cannot even outperform a four-year historical average. These results are shown in Table 3.

Turning to the swap rate, the longest time series that I am aware of is presented by the RBA (2019, page 56), starting in Dec 2006 and involving 5-10 year swap prices. I assume the average such term is seven years, and therefore use the December swap prices from 2006 to 2012 (3.5%, 3.7%, 2.5%, 3.1%, 3.1%, 3.1% and 3.0%) to forecast the geometric mean inflation rate over the following seven years. Each such forecast can be compared to the actual geometric mean over that seven year period. For example, the swap rate in December 2006 (of 3.5%) is a forecast of the geometric mean inflation rate over the period 2007-13 inclusive (which was 2.77%). The forecast error is then 0.73%. The RMSE of the forecast errors is 1.01% as follows:

$$RMSE = \sqrt{\frac{(2.77 - 3.5)^2 + \cdots \ldots \ldots \ldots + (1.87 - 3.0)^2}{7 - 1}} = 1.01 \qquad (16)$$

Again, I compare this with the use of the Target rate as a forecast of the geometric mean outcome over the next seven years, by replacing the swap prices in equation (16) with the Target of 2.5%. The resulting RMSE is 0.42%. So, again the Target vastly outperforms the market price. So does the four-year past average. The results are shown in Table 3.

Table 3: RMSE Results for Forecasting the Geometric Mean Inflation Rate

	Seven Yr Horizon	Ten Yr Horizon
RBA Target	0.42%	0.34%
Four-Year Past Average	0.75%	0.85%
Break-even Inflation Rate		0.86%
Swap Rate	1.01%	

In summary, Table 3 shows that the RBA's Target is far superior to the use of market prices, and therefore the choice of methodology can be limited to the methods examined in Table 2. Across these options in Table 2, the best approach is use of the RBA's forecasts for the first and second years ahead, and the RBA's Target for all other future years, which corresponds to the AER's current approach. This analysis uses a long time series of data, and therefore assumes stability in the underlying process (which involves mean reversion to or close to the RBA's Target of 2.5%). If the underlying situation has changed, these tests would not be useful. Thus, judgement must be exercised on the question of whether the underlying situation has changed, especially since inflation has fallen below the Target for the past several years. The best information on this question comes from Consensus Economics, who (as of April 2020) forecast reversion to that Target over the next few years.

5. Review of Submissions

SA Power Networks (SAPN: 2019a) argues that, since the AER's last review of this matter, inflation expectations have declined dramatically to the extent that long-term expectations have de-anchored from the RBA's target rate, and therefore that the AER's current reliance upon the RBA's inflation target of 2.5% is no longer justified. In support of this claim, SAPN (2019a, page 5) notes that the ten-year break-even inflation rate and five to ten year inflation swap prices are both at historical lows (of 1.4% and 2.0% respectively), as shown in their figures. However, as discussed previously, these estimators are likely to be biased to an extent that fluctuates through time, and the empirical evidence is that they are vastly inferior to use of the RBA's Target. Furthermore, since SAPN focuses upon their current low values, it is also useful to examine the predictive success of earlier extreme values for these prices.

Consider first the ten-year break-even rate. Of its numerous fluctuations, the most extreme exclusive of the current value are as shown in Table 4 below along with the average realized rate over the subsequent ten-year period.[12] The errors in all cases are very large and consistent with overreacting to short-term changes in inflation and/or the presence of significant time variation in the risk and illiquidity premiums. Given this very poor forecasting record when forecasting extreme values, the credibility of its current very low value (1.4%) as a forecast for the next ten years is minimal.

Table 4: Test of Inflation Predictions in the Ten-Year Break Even Rate

Time	Forecast	Forecast Period	Realisation	Error
Sept 1994	4.7%	1995-2004	2.6%	2.1%
Dec 1998	1.6%	1999-2008	3.1%	-1.5%
June 2008	3.9%	2009-2018	2.1%	1.8%
Dec 2008	1.5%	2009-2018	2.1%	-0.6%

Turning now to the five to ten year swap prices, this series (presumably taken from the RBA, 2019, page 56) spans a much shorter period than the ten-year break-even rate and therefore the set of extreme values exclusive of the current value is smaller as shown in Table 5. In addition, since the series presented by SAPN conflates swap prices over the five to ten year period rather than using prices for only one term, I test the forecasts using the average

[12] I presume the break-even rates are drawn from column H in Table G3 on the website of the Reserve Bank of Australia (https://www.rba.gov.au/statistics/tables/#inflation-expectations), and therefore extract the data from the latter table.

realized rate over the following seven years. As shown in Table 5, the forecasting record is again poor and therefore the credibility of its current low value (2.0%) as a forecast for the ten seven years is minimal.

Table 5: Test of Inflation Predictions in the Five to Ten Year Swap Rate

Time	Forecast	Forecast Period	Realisation	Error
End 2006	3.5%	2007-2013	2.8%	0.7%
Early 2008	4.5%	2008-2014	2.6%	1.9%
End 2008	2.5%	2009-2015	2.3%	0.2%

SAPN (2019a, page 4) also notes that the RBA's forecasts have been too high for the past several years, and therefore should no longer be relied upon. However, the issue is not whether the RBA's forecasts are 'good' or 'bad' but which forecasting methodology is best, and SAPN offers no evidence on that matter. By contrast, the previous section of this paper has empirically assessed possible forecasting methods, using a long time series of information, and concluded that the AER's current approach is the best. Use of such long-term data assumes that the underlying regime has not changed, i.e., that inflation rates are still mean reverting to about 2.5%. Evidence from Consensus Economics continues to support this scenario.

SAPN (2019a, page 9) also notes that the yield on nominal government bonds is currently very low and implies that this is further evidence of inflation expectations currently being very low. However, the yield on nominal government bonds reflects both the real yield and expected inflation, and therefore the better indicator of expected inflation is the yield on the nominal bonds net of that on inflation-indexed bonds. This is the break-even inflation rate and SAPN has already made submissions on that matter, as discussed above.

Electricity Networks Australia (ENA, 2019, page 8) notes that the ten-year break-even inflation rate is at the historically low level of 1.3% and concludes that the AER's current approach (which places primary weight on the RBA's target of 2.5%) is unsatisfactory. However, the deficiencies in the break-even rate as a predictor of future inflation have been demonstrated earlier. Furthermore, the previous section of this paper has empirically assessed possible forecasting methods, using a long time series of information, and concluded that the AER's current approach is the best. Use of such long-term data assumes that the underlying regime has not changed, i.e., that inflation rates are still mean reverting to about 2.5%. Evidence from Consensus Economics continues to support this scenario.

ENA (2019, page 10) also lists a series of short-term forecasts of inflation reported by the RBA, claims that all are at or close to their lowest levels ever, and therefore implies that the AER's current approach is unwarranted. However the contemporaneous RBA forecasts (from the November 2019 SMP) are also unusually low: the one-year forecast of 1.75% is the lowest in a November SMP over the entire 1993-2019 period. Since the AER uses the RBA's forecasts for the next two years, the ENA are not citing any information that the AER is not already effectively using.

ENA (2019, pp. 12-13) also notes that the annual inflation rate has been under the 2.5% Target for the last 20 quarters, and that this is the longest such occasion since Inflation Targeting began. It then argues that reversion back to 2.5% will not then occur within two years, and therefore that the AER's current methodology is deficient. More compelling information on this matter comes from Consensus Economics, who forecast (as of April 2020) that reversion to 2.5% will not occur until 2026. The issue then is whether the AER should change its current methodology to reflect this unusually slow reversion. An apparently simple means of doing so would be to adopt a glide-path from the RBA's two-year ahead forecast to the Target rate of 2.5%. However, this gives rise to two problems: over what period should the AER glide back to 2.5%, and under what conditions should the AER do so if it does not do so always. Both are extremely subjective. The AER's current approach avoids this subjectivity, and it will satisfy the NPV = 0 requirement so long as these situations in which reversion to the Target is unusually slow are symmetric, i.e., scenarios in which reversion back from a low figure is unusually slow (to the disadvantage of the businesses) are matched by scenarios in which reversion back from a high figure is unusually slow (to the advantage of the businesses). I do not hold a view on whether such symmetry exists. If the AER believes symmetry exists, it should retain its current approach. Otherwise, there is a case for the AER's adopting a longer glide-path back to the Target.

QTC (2019) favours the ten-year break-even rate as a predictor of future inflation, leading to a significantly lower estimate of expected inflation than the AER. However, as argued earlier, this estimator is very poor in part because it is biased by the presence of an inflation risk premium within the yield on nominal CGS. Remarkably and perversely, QTC recognizes this particular problem despite promoting this break-even methodology.

QTC (2019) goes on to present estimates of NPAT for Ergon Energy and Energex over the 2021-2025 period, which are negative for both firms for all years. These estimates are all based on the AER's estimate for expected inflation over the next ten years of 2.45%. As argued in section 2 above, the appropriate estimates for expected inflation should be specific to each year and, in the presence of RBA forecasts over the next two years that are significantly below the Target, the AER's estimate is too high for each of these years examined by the QTC.

Jemena (2020) proposes that the AER use a "more market-based approach" or an average of this and its current approach, to ensure that it delivers positive cash dividends to equity holders. Jemena's reference to market-based approaches is presumably a reference to the break-even rate and/or swap prices, but Jemena presents no evidence on why these models should be favoured. Furthermore, the evidence presented above is that they are vastly inferior to the AER's current approach. Jemena's also appears to be suggesting that a methodology for estimating expected inflation should be chosen according to its impact on the allowed cost of equity. These are separate issues.

6. Conclusions

This paper has assessed the best method for estimating expected future inflation in Australia, with particular reference to recent empirical evidence, and the principal conclusions are as follows.

Firstly, given that the AER's regulatory cycle is five years, the NPV = 0 principle implies that the AER ought to be estimating expected inflation over each of the next five years rather than over the next ten years. Secondly, market prices (comprising the break-even rates and swap prices) are likely to be biased estimators of expected future inflation, and to a degree that varies over time. Thirdly, using standard RMSE tests of forecasting accuracy, the RBA's Target is far superior to the use of market prices for forecasting inflation over 5-10 years, and therefore market prices can be rejected. Fourthly, across the range of other approaches considered (comprising forecasts by the RBA, forecasts from Consensus Economics, the RBA's Target rate, a Random Walk model, a mean reversion model, and the model of Finlay and Wende), the lowest RMSE of the forecast errors comes from the RBA's forecasts for the first and second years ahead, and the RBA's Target for all other future years, which corresponds to the AER's current approach.

Fifthly, this RMSE analysis uses a long time series of data, and therefore assumes stability in the underlying process (which involves mean reversion to or close to the RBA's Target of 2.5%). If the underlying situation has changed, these tests would not be useful. Thus, it is necessary to assess whether the underlying situation has changed, especially since inflation has fallen below the Target for the past several years. The best information on this question comes from Consensus Economics, who (as of April 2020) forecast reversion to that Target over the next few years. Lastly, and because reversion back to the RBA's Target is currently expected to be unusually slow, there is a case for the AER adopting a slow glide path from the RBA's forecasts to the Target providing that scenarios in which reversion back from a low figure is unusually slow (to the disadvantage of the businesses) are not likely to be matched by scenarios in which reversion back from a high figure is unusually slow (to the advantage of the businesses).

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