MARSDEN JACOB ASSOCIATES

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Final report

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A Marsden Jacob Report

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The NTC is developing a forward-looking cost base for heavy vehicle charges. It is intended that the model be used as a basis for setting heavy vehicle charges from 2026-27 onwards.

Marsden Jacob has been engaged to develop a methodology for setting the return on capital and inflation parameters to include in the forward-looking cost model in a way that avoids, as far as reasonable, short-term changes in interest rates and inflation causing volatility in the revenue requirement calculated with the model.

This report provides our assessment and recommendations for the following key elements for use in forecasting heavy vehicle charges:

- Inflation and forecasting inflation
- Approach to calculating the cost of capital
- Source of debt data – national vs state-based
- Approaches to true-ups due to variations in the actual and forecast revenue requirement.

The following provides a summary our key recommendations.

1.1 Recommended approach for forecasting inflation

Based on our assessment, the overall best (and most accurate) method for forecasting inflation for a three-year regulatory period is combined use of the RBA forecast rate and the RBA Target Rate, being:

- Year 1: the RBA's forecast rate using the forecast closest to the start of the year
- Year 2: the RBA's Target Rate of 2.5%
- Year 3: the RBA's Target Rate of 2.5%.

This approach conforms to regulatory practice in Australia, in combining these two inflation forecasts.

1.2 Recommended approach for calculating the cost of capital

We assessed options for calculating the cost of (100% debt) capital including:

1. Current Rate
2. Simple trailing average over ten years
3. Trailing average with a weighted average term to maturity approach

4. Hybrid approach combining options 1 and 3.

Based on our assessment, we consider that the overall best (and most accurate) approach to setting the cost of debt capital is the Hybrid approach. Under this approach, we combine historical data with the current rate. Under this approach for years 2 and 3 of the pricing period, some historical data drops off as some of the debt matures and rolls over, with the weight shifted onto the current rate, as a predictor of the rate on the debt that will roll over.

Compared to the Current Rate, the Hybrid Method more accurately reflects the cost of existing debt that will not mature during the pricing period (by using a trailing average rather than the current rate), while using the same predictor (the current rate) for debt that will mature during the pricing period.

Compared to the trailing average rate, the Hybrid Method embodies a better predictor of the cost of new debt (by using the current rate rather than a trailing average rate) whilst equally accurately reflecting the cost of existing debt that will not mature during the pricing period.

1.3 Recommended approach for the source of debt data

We assessed various options for sourcing debt data, including options for use of Commonwealth and state-based debt data. Based on our assessment we recommend use of only Commonwealth Government Security (CGS) bonds.

While this will likely underestimate the cost of capital, because some funding comes from state governments and the rate on this debt appears to be generally higher, using CGS yields is appropriate as only this data is publicly available and it avoids the complexities in estimating the share of funding that does not come from the federal government. We note that other regulators, including state-based regulators, in other industries generally use CGS yield data, even where borrowing by state-owned entities is obtained from state governments.

2. Introduction and key assumptions

2.1 Introduction

The NTC is developing an implementation-ready forward-looking cost base (FLCB or building blocks model) for heavy vehicle charges. It is intended that the model be used as a basis for setting heavy vehicle charges from 2026-27 onwards. The NTC is aiming to develop a model that can produce a revenue requirement for a pricing period of three years in the future.

The NTC intends to use the borrowing cost of federal and/or state governments as a representation of the cost of capital in the model. Calculating the cost of debt capital and accounting for inflation are important parts of the model. Model outputs have been shown to be sensitive to changes in the cost of debt capital and inflation parameters. Marsden Jacob has been engaged to develop a methodology for setting the cost of debt capital and the inflation parameters in a way that avoids, as far as reasonable, short-term changes in interest rates and inflation causing volatility in the revenue requirement calculated from the model. The methodology is intended for calculating a cost of debt capital for each state and territory and local government, and a national value for inflation parameters as inputs into the model.

This report provides our assessment and recommendations for the following key elements for use in forecasting heavy charges:

- Inflation and forecasting inflation
- Approach to calculating the cost of debt capital
- Source of debt data – national vs state-based
- Approaches to true-ups due to variations in the actual and forecast revenue requirement.

2.2 Key criteria for options assessment

The NTC has outlined that the methodology should incorporate the following key criteria:

- Be as simple as possible and replicable
- reflect the way a prudent government or private sector organisation would manage a debt portfolio over time and therefore accurately reflecting governments' cost of debt capital and the inflation parameters
- achieves a reasonable level of stability over time (reducing volatility)
- be based on publicly available information, or information that government treasuries (or other government departments) are willing and able to provide to the NTC on a regular basis.

We have also included consistency with accepted regulatory practices as an additional consideration when assessing options.

2.3 Key assumptions

In developing options for the cost of debt capital and inflation, we have incorporated the following key assumptions:

- In estimating the cost of capital for roads, the NTC is assuming that the gearing level will be 100% debt, 0% equity
- Cost of debt for government road agencies does not include a debt risk premium or any debt raising costs
- Anticipated inflation will be incorporated into forecast prices.
- The Building Block model will be in nominal terms, and therefore the revenue requirement includes an inflation indexation deduction.
- Prices will be set at the start of the regulatory period and not be adjusted until the end of the regulatory period
- Prices are to reflect actual costs, and therefore any forecasting errors will then be passed onto heavy vehicle charges through adjustments at the end of the period.

3. Inflation

In this section we provide an assessment of whether to and how to allow for inflation. We then examine options for forecasting inflation for a three-year regulatory period.

3.1 Allowing for inflation

The first issue is whether (and how) to allow for inflation. Standard regulatory practice in Australia (including the AER, 2020a, page 10; 2020b, pp. 10-11) is to inflate the RAB at the end of the current pricing period in accordance with actual CPI inflation over the pricing period, and therefore to deduct from revenues (for the current pricing period) the forecasted amount of this asset revaluation, and to adjust the nominal revenues in accordance with CPI inflation so as to maintain their real value.

The primary purpose of adjusting the RAB is to ensure that the depreciation component of revenue is maintained in real terms over time (assuming straight line depreciation), and therefore that the revenue burden upon successive generations of consumers is approximately equalized in real terms.[1]

The NTC is proposing to inflate the RAB over time, so as to ensure that the depreciation component of the HVCs is equal in real terms over time.

3.2 Forecasting Inflation

Allowing for inflation in the way discussed in the previous section requires an inflation forecast. The NTC's criteria that are relevant to such forecasts are:

- simplicity,
- stability over time,
- accuracy, and
- based upon publicly available information.

To these criteria, we suggest adding conformity with Australian regulatory practice unless there is good cause to deviate from it.

3.3 Comparison of forecast methods

Following standard practice, the accuracy of the different inflation forecast methods is assessed using the root mean square of the forecast errors (RMSE), being the square root of the average of

[1] Equalising the depreciation component of the revenue burden for consumers at different points in time requires that this component of revenues at different points in time have the same purchasing power for consumers, which requires that this component of revenues grows at the inflation rate in the basket of final goods and services purchased by consumers in aggregate, which is the CPI inflation rate. So, the CPI inflation rate should be used for inflating the RAB over time. For purposes of forecasting opex or capex, PPI inflation rates would be more appropriate.

the squared forecast errors. The RMSE is a measure used to measure the accuracy of the predictions. It shows how far predictions fall from measured true values.

A summary of RMSE results over the period 1993 to 2023 for three alternative methods is shown in Table 1.[2]

- Method 1: RBA forecasts. RBA forecasts are used for one and two years ahead.
- Method 2: RBA Target Rate. The midpoint of the RBA's target inflation band (2.5%) is used for all future years.
- Method 3: Random Walk. For any future year, the forecast for inflation is the actual rate in the latest year.

Further detail on the calculation of the RMSE under each of these methods is described in the following sections.

Table 1: RMSE Results for Various Forecasting methods and years – 1993 to 2023

Forecast year	1	2	3	4	5
Method 1: RBA forecast	1.41 (0.89)	1.68 (1.06)			
Method 2: RBA Target Rate	1.61 (1.18)	1.64 (1.21)	1.59 (1.11)	1.61 (1.11)	1.54 (0.96)
Method 3: Random Walk	1.76 (1.51)	2.15 (1.74)	2.33 (1.92)	2.15 (1.75)	1.87 (1.26)

Table 1 also shows (in brackets) the results from the same methods presented in Lally (2020, section 4.2), over the earlier period 1994-2019, in the course of assessing the AER's inflation forecasting approach. In all cases the RMSE figures using the 1994-2023 data are significantly higher, due to this additional 2020-2023 data being dominated by the largest inflation shock since the introduction of inflation targeting in 1993 coupled with the inability of all methods to anticipate it. However, the ordering of the results is similar; the RBA's forecasts are still clearly the best for the first year ahead, the RBA's Target Rate is marginally superior to the RBA's forecasts for the second year ahead (reversing the earlier ranking), and the Target Rate is still clearly best for the third, fourth and fifth years ahead.

The slight superiority of the Target Rate over the RBA's forecasts for two years ahead, rather than being slightly inferior in the earlier analysis, is due to the significantly inferior performance of the RBA's two-years ahead forecast in the 2021-2023 inflation shock. All of this suggests that the most accurate method for a forecast period of three years would be to use the RBA's forecast for one-year ahead coupled with the Target Rate for the second and third years ahead (the "combined

[2] The calculations appear in rows 36 and 37 of the attached excel spreadsheet "Inflation Forecast Data".

approach"). If one were also interested in forecasts for four and five years ahead, the RBA's Target Rate would also be the best for those years.

If forecasts must be made six months before the start of the pricing period, to set heavy vehicle charges, then forecasts are required from 0.5 to 1.5 years ahead, 1.5 to 2.5 years ahead, etc. The RMSEs should lie approximately half way between columns 1 and 2 of Table 1, columns 2 and 3 of Table 1, etc. The best forecasts are then still the RBA for the first forecast period and the RBA's Target Rate for the later forecasts.

Lally (2020, Table 2) also presents results from a number of other forecasting methods, being those of Consensus Economics for up to ten years ahead, a mean-reversion model for one year ahead, and the model of Finlay and Wende (2012) for one year ahead. The first of these forecasts is not publicly available, and the other two are quite complex. Furthermore, their RMSE results were inferior to the "combined approach." So, they are not further examined here.

Lally (2020, sections 3.1 and 3.2) also examines two forecasting methods using market prices. One of these is the geometric difference between the interest rates on Commonwealth Government Securities (CGS) and inflation-indexed Treasury bonds, on the basis that the difference in their interest rates is all or mostly due to expected inflation. However, it is likely to be a biased estimator of expected future inflation, and to a degree that varies over time, because the yield on the indexed-bonds incorporates a premium to compensate for their inferior liquidity and the yield on the CGS bonds contain a premium to compensate for the real yield on these bonds being risky (because future inflation is uncertain).

The same issues arise in respect of using the fixed payment in an inflation swap to forecast inflation (one party pays at the maturity of the contract an amount P set at the commencement of the contract and simultaneously receives the realised rate of inflation over the term of the contract, whilst the other party is in the opposite position, so that P is an inflation forecast). Using RMSE tests of forecasting accuracy, Lally (2020, Table 3) concludes that the inflation forecasts from these bonds and swaps over the life of these financial instruments (5-10 years were examined) are far inferior to use of the RBA's Target Rate (2.5%). So, again, they are not further examined here.

3.3.1 Method 1: RBA forecasts

The first of these is the RBA forecasts, for one and two years ahead (or one and 1.5 years ahead prior to November 2007). These are provided in the RBA's Statements of Monetary Policy (SMP) and earlier counterparts.[3] For the SMPs from November 2007, the RBA provides a forecast for the following calendar year and the calendar year after that. By contrast, prior to November 2007, the RBA's excel file only presents forecasts for the next calendar year and the year ending six months later.

3 The SMPs are available at https://www.rba.gov.au/publications/smp/2019/nov/. The earlier forecasts 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.

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, we propose that calendar years are used as the period to be forecast and source the forecasts from the relevant November SMP. So, for example, the one-year ahead SMP forecast for the 2023 calendar year is drawn from the November 2022 SMP.

For the period 2000-2006, the forecasts for method 1 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 year ahead and 1.5 years ahead). The actual inflation rates for the relevant years are drawn from RBA data.[4]

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 one year ending 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 2021 SMP for the second year ahead (calendar 2023: 2.5%) and that in the November 2022 SMP for one year ahead (calendar 2023: 4.75%); the actual inflation rate for 2023 was 5.4%, yielding forecast errors of 5.4% - 4.75% for the one-year ahead forecast and 5.4% - 2.5% for the two-year ahead forecast.

For the one-year ahead forecasts, for the calendar years 1994-2023, the RMSE is 1.41% as follows:

$$RMSE = \sqrt{\frac{(2.6-3.0)^2 + \cdots \ldots \ldots \ldots + (5.4-4.75)^2}{30-1}} = 1.41$$

Repeating the process for the 'second' year ahead forecasts yields an RMSE of 1.68%. This process is favourable towards the RBA 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 the 1994-2006 years were deleted from the analysis for all forecasts, then valuable

4 The inflation data is taken from column C of Table G3 on the website of the Reserve Bank of Australia (http://www.rba.gov.au/statistics/tables/#inflation-expectations). All data and forecasts are in an attached excel file.

information would be lost. We have, therefore, retained these 1.5 year ahead RBA forecasts as if they were two-year ahead forecasts.

3.3.2 Method 2: RBA Target Rate

A second possible forecasting method is the midpoint of the RBA's target inflation band (2.5%). Therefore, for the one-year ahead forecasts, the forecasts are all 2.5% and the actual outcomes are those for 1994 (2.6%) through to 2023 (5.4%). The resulting RMSE is 1.61%. For the second year ahead forecasts, 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 1.64%. Following this process, for forecasting for the third, fourth, and fifth years ahead, RMSE results are 1.59%, 1.61%, and 1.54% respectively. The difference in results is purely an artefact of deleting progressively more observations at the beginning of the time series.

3.3.3 Method 3: Random Walk

A third possible forecasting method is the Random Walk approach. For any future year, the forecast for inflation is the actual rate in the latest year. For example, the inflation rates in 1994, 1995, and 1996 were 2.6%, 5.1% and 1.5% respectively. So, the Random Walk forecast at the end of 1994 for 1995 would be 2.6%, and the forecast error would be 5.1% - 2.6%. For the second year ahead, the forecast is still the actual rate in the latest year (2.6%), and the forecast error is then 1.5% - 2.6%. The resulting RMSE for forecasting one year ahead is 1.76%, and the results when forecasting further ahead are even higher as shown in Table 1.

3.4 Recommended approach for forecasting inflation

Based on our assessment using the RMSE, the most accurate method for forecasting inflation is a combined approach that combines method 1 and 2. Specifically, the combined approach for forecasting inflation for the three-year pricing period comprises:

- Year 1: the RBA's forecast rate using the forecast closest to the start of the year
- Year 2: the RBA's Target Rate of 2.5%
- Year 3: the RBA's Target Rate of 2.5%.

In respect of simplicity over time, the RBA's Target Rate for all future years (i.e. solely using method 2) would be marginally better than the combined approach. Both the combined method and sole use of the RBA's Target Rate are equally good in respect of using publicly available information. In respect of stability over time, the RBA's Target Rate for all future years would be the better approach. However, there is no benefit to sacrificing forecast accuracy for stability over time in the inflation forecasts because other sources of instability in revenues over time exist (including instability in the nominal cost of capital). While it is desirable to address sources of instability, the most efficient way to do so is to smooth revenues (as a final step in the analysis) rather than attempting to individually address the various sources of instability.

The combined method is therefore recommended. Combining these two inflation forecasts conforms to regulatory practice in Australia. For example:

- AER – adopts the RBA's forecast rates for years 1 and 2, followed by a glide path to the RBA's Target Rate of 2.5% in year 5 of the regulatory period[5]
- ESC (for regulated water businesses) – adopts the RBA's forecast inflation rates for years 1 and 2 of the regulatory period, and the RBA's Target Rate of 2.5% for years 3-5 of the regulatory period (approach has varied in recent reviews)[6]
- IPART – adopts the RBA's forecast inflation rate for year 1, followed by the target rate of 2.5% for the remaining years of the regulatory period[7]
- QCA – adopts the RBA's forecast rates for years 1 and 2, followed by a glide path to the RBA's Target Rate band, depending on the year 2 rate[8]
- ESCOSA (for SA Water) – 2-year RBA forecast then a linear glide path over 5 years to the RBA's Target Rate of 2.5%[9]
- ICRC (for Icon Water) – 2-year RBA forecast then a linear glide path over 5 years to the RBA's Target Rate of 2.5%[10].

[5] AER, Regulatory Treatment of inflation – final position paper, December 2020, p.6.
[6] ESC, 2023 water price review – Guidance paper, October 2021, p.40-41.
[7] IPART, Review of our WACC method, February 2018, section 7.
[8] Queensland Competition Authority, Inflation forecasting – final position paper, October 2021.
[9] ESCOSA, SA Water Regulatory Determination, final determination – statement of reasons, June 2020, section 7.
[10] ICRC, Regulated water and sewerage services 2023-28, May 2023, section 6.

4. Calculating the cost of debt capital

In this section we assess the approaches to calculating the cost of debt capital for a three-year pricing period.

In using bond yield data for the purposes of setting the allowed cost of debt capital, a fundamental issue concerns the temporal nature of the data chosen at the beginning of the pricing period: past, current or forecast.[11]

4.1 Calculating the cost of debt capital

To evaluate approaches to calculating the cost of debt we have identified a set of feasible options for calculating the cost of debt. These are summarised in Table 2. We assess these options in further detail below.

Table 2: Cost of debt options for consideration

Approach	Description
Current Rate approach	The cost of debt would be reset at start of each pricing period using the 'current' data, e.g. 40 days prior to the resetting of the cost of debt. Each year of the pricing period would have the same cost of debt applied.
Simple trailing average over ten years	The cost of debt would be reset at the start of each pricing period using an average of historical cost of debt data, over the 10 year period generally used by Australian regulators. Each year of the pricing period would have the same cost of debt applied. At the start of the next pricing period the cost of debt would then be updated with the last 10 years of actual cost of debt data.
Trailing average – weighted average term to maturity approach	Calculated in a similar way to the simple trailing average, the averaging period is calculated using the weighted average term to maturity (from date of issue) of the relevant bonds.
Hybrid of historical trailing average and Current Rate	The cost of debt is calculated with weights applied to both historical costs of debt and the current rate, with weights differing across the years of the pricing period.

[11] A further possibility would be to use interest rate data arising within the pricing period as it becomes available, as the AER (2023, page 22) does, by using an annually adjusted ten-year trailing average of the ten-year cost of debt. However, this implies updating of the allowed cost within the pricing period and this is precluded for the NTC because heavy vehicle charges are fixed at the beginning of the pricing period for its duration.

4.1.1 How cost of debt options work in practice

In this section, we outline how the proposed cost of debt options would work in practice for a three-year regulatory period. Consistent with the key assumptions, we have also assumed that the cost of debt will be set at the start of the regulatory period only, and not adjusted on an annual basis.

Current Rate approach

Under the Current Rate approach, the cost of debt would be reset at start of each pricing period using an average of recent actual data, e.g. 40 days prior to the resetting of the cost of debt. This cost of debt would stay constant for each of the years in the regulatory pricing period.

In this example, the cost of debt is set for 2024 to 2026, using the 10-year Commonwealth bond rate for December 2023[12].

Table 3: Cost of debt – Current Rate approach

	Cost of Debt		
40 day average cost of debt – December 2023	2024	2025	2026
4.2%	4.2%	4.2%	4.2%

Simple trailing average over ten years

Under this approach, the cost of debt would be reset at start of each pricing period using an average of the last 10 years of actual 10-year cost of debt data, consistent with standard practice amongst Australian regulators. This averaging approach reflects the standard practice for a prudent borrower to stagger the maturity dates of their debt, to protect against unusual conditions in debt markets at the debt maturity dates. The cost of debt is equally weighted across each of the 10 years – Appendix 2 provides further analysis of trailing average weightings and concludes that equal weighting should be used.

The same trailing average rate would apply in each year of the pricing period. The averaging period for each year could be decided by the NTC, e.g. average of whole year vs final month. In this example, as above, we have used 10-year Commonwealth bond rates from December in each year. Table 4 outlines how a simple 10-year trailing average would be calculated for the 2024 to 2026 period. Therefore, the cost of debt for each of the three years in the regulatory period would be set at 2.5%.

[12] This rate appears in column E of Table F2.1 on the website of the RBA: https://www.rba.gov.au/statistics/tables/.

Table 4: Cost of debt – Simple trailing average approach over ten years

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Cost of Debt
10-year bond yields	3.00%	2.90%	2.80%	2.60%	2.40%	1.20%	1.00%	1.60%	3.60%	4.20%	
Weightings											
2024	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	**2.5%**
2025	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	**2.5%**
2026	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	**2.5%**

Trailing average – Weighted Average Term to Maturity

Under this approach, we aim to better reflect the standard practice of a prudent government borrower to stagger the maturity dates of their debt, to mitigate risks associated with all debt maturing at a similar time.

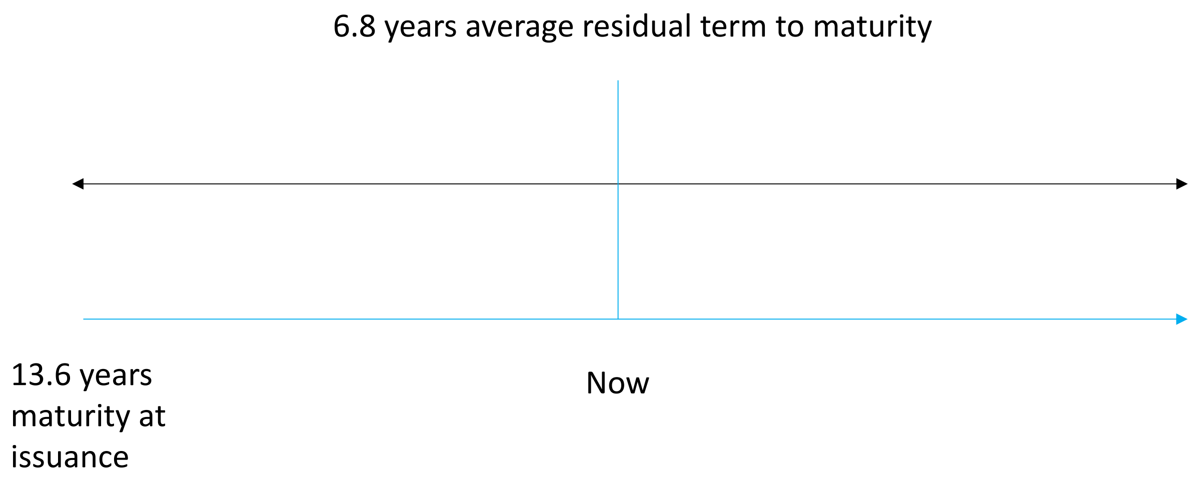
As of May 2023, the Commonwealth Government debt comprises Treasury Bonds, Treasury Indexed Bonds Notes, and Treasury Notes, with weights of 92%, 4% and 4% respectively, and the maturity dates on the individual bonds and notes is well spread out over time (The Treasury, 2023, Tables 7.3 – 7.6). The reported weighted-average term to maturity of these Bonds is seven years (ibid, page 246), and nine years for the Indexed Bonds (ibid, page 247). It is also apparent from the maturity dates for these bonds shown in The Treasury (2023, Tables 7.4 and 7.5) that these weighted-average terms to maturity are the remaining term to maturity from the reporting date of May 2023 rather than from date of issuance of the bonds. In addition, the weighted-average residual term to maturity for the Treasury Notes (from the reporting date) is about 0.25 years (ibid, Table 7.6). So, across these bonds in aggregate, the weighted-average residual term to maturity is about seven years, as follows:

$$0.92(7\ yrs) + 0.04(9\ yrs) + 0.04(0.25\ yrs) = 6.8\ yrs$$

Following the same procedure, the weighted-average residual term to maturity for Victorian State Government debt is 7.4 years.[13] For the purposes of setting an allowed cost of capital, the relevant statistic is the weighted average term to maturity at issuance rather than the residual term from the current point in time (see the AER, 2023, page 196), and the former would be approximately twice as great because the expected residual term to maturity on a randomly selected date within the life of a bond would be half the term to maturity at issuance. This implies a weighted-average term to maturity at issuance of about 13.6 years for CGS and 14.8 years for Victorian Government debt. This is depicted for CGS in the diagram below.

[13] See Treasury Corporation of Victoria: https://www.tcv.vic.gov.au/tcv-bonds/outstanding-borrowing/amount-on-issue.

Figure 1: Weighted average residual term to maturity



By comparison, private sector regulated firms also stagger their debt maturity dates and have a weighted average term to maturity at issuance of about ten years (AER, 2023, page 196). Thus, a cost of debt that was reflective of the way that government entities manage their debt would be a trailing average cost of debt with a weighted average term to maturity at issuance of about 14 years.

Table 5 outlines how a simple 14-year trailing average would be calculated for the 2024 to 2026 period (using ten-year bond yields in each December as a proxy for the yields on 14-year bonds, as above). Therefore, the cost of debt for each of the three years in the regulatory period would be set at 3.0%.

Table 5: Cost of debt – Weighted Average term to maturity trailing average approach

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Cost of Debt
10-year bond yields	5.6%	3.8%	3.2%	4.3%	3.0%	2.9%	2.8%	2.6%	2.4%	1.2%	1.0%	1.6%	3.6%	4.20%	
Weightings															
2024	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	**3.0%**
2025	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	**3.0%**
2026	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	**3.0%**

Hybrid approach option 1 – Trailing Average and Current Rate

Since some existing debt will mature and be rolled over during the pricing period, we have considered a Hybrid approach which combines the use of historical data with the current data.

Under a Hybrid approach, and assuming all bonds mature just before the beginning of the pricing period (such as December) or at points at the same time of earlier years, the cost of debt for the first year of the pricing period would be an equally-weighted trailing average of the yields on 14-year bonds (in December of each year), over the 14 years up to the beginning of the pricing period. For the second year of the pricing period, the same approach implies an equally-weighted average of the yields on 14-year bonds (in December of each year), over the 13 years up to the beginning of the pricing period and the first year of the pricing period (with the yield in that first future year forecasted using the yield at the beginning of the pricing period or a better predictor). For the third year of the pricing period, the same approach implies an equally-weighted average of the yields on 14-year bonds (in December of each year), over the 12 years up to the beginning of the pricing period and the first two years of the pricing period (with the yields in these two years forecasted using the yield at the beginning of the pricing period or a better predictor).

This is similar to OTTER's latest decision on the cost of debt included in water and sewerage services provided by Taswater.[14] These rates would apply to the RAB at the beginning of each relevant year.

Appendix 3 provides some analysis of alternative predictors for future bond yields, and concludes that use of a mean reversion model generates predictions that are slightly more accurate than use of the current rate but they are more complex. So, the best choice is unclear. We assume use of the current rate predictor throughout the rest of this paper.

Under this approach, the cost of debt is calculated as follows:

- Year 1: 13 years trailing average (92.9% weight), and 1 year for the Current Rate (7.1% weight)
- Year 2: 12 years trailing average (85.7% weight), and 2 years for the Current Rate (14.3% weight)
- Year 3: 11 years trailing average (78.6% weight), and 3 years for the Current Rate (21.4% weight).

Table 6 provides an outline of how the Hybrid approach would work for the cost of debt. This approach assumes that debt matures at the end of each year. Therefore, the cost of debt for each of the three years in the regulatory period varies slightly (2.9 to 3%).

Table 6: Cost of debt – Hybrid approach 1

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023 – On the day rate	Cost of Debt
10-year bond yields	5.6%	3.8%	3.2%	4.3%	3.0%	2.9%	2.8%	2.6%	2.4%	1.2%	1.0%	1.6%	3.6%	4.20%	
Weightings															

[14] OTTER, Investigation into TasWater's prices and services for the period 1 July 2022 to 30 June 2026, Final report, May 2022, p.82-88.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023 – On the day rate	Cost of Debt
2024	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	3.0%
2025		7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	14.3%	2.9%
2026			7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	21.4%	2.9%

Hybrid approach 2 – Trailing average and Current Rate

An extension of the previous hybrid option, this approach assumes that bonds mature (on average) six months into the year, and the new rate would apply to the newly issued debt for the remaining six months of the year. To account for this, the weight on the first historical year is reduced by 50% and the difference applied to the current rate (as a predictor of the new rate on rollover), which results in the following:

- Year 1 Cost of Debt is 13.5 years trailing average (96.4% weight), and 0.5 years Current Rate (3.6% weight)
- Year 2 Cost of Debt is 12.5 years trailing average (89.3% weight), and 1.5 years Current Rate (10.7% weight)
- Year 3 Cost of Debt is 11.5 years trailing average (82.1% weight), and 2.5 years Current Rate (17.9% weight).

Table 7 outlines how the Hybrid approach 2 would work in practice for the 2024-26 period. The cost of debt for each of the three years in the regulatory period varies slightly (2.9% to 3%).

Table 7: Cost of debt – Hybrid approach 2

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2023 – On the day rate	Cost of Debt
10-year bond yields	5.6%	3.8%	3.2%	4.3%	3.0%	2.9%	2.8%	2.6%	2.4%	1.2%	1.0%	1.6%	3.6%	4.2%	4.2%	
Weightings																
2024	3.6%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	3.6%	3.0%
2025		3.6%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	10.7%	2.9%
2026			3.6%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%	17.9%	3.0%

4.1.2 Estimating the forecast error with the cost of debt

Using the Hybrid approach to estimate the cost of debt will result in forecast errors. This is because some of the existing debt will mature within the pricing period, and therefore require rollover at a new interest rate that must be forecast.

Using historical ten-year CGS bond yields in December of each year, the largest absolute one-year ahead forecast errors over the period 1993-2022 are for the years 1993, 1998 and 2007. These are shown in Table 8. Across these three most extreme cases, the forecast errors in the cost of debt as a proportion of the aggregate cost of debt (FEP_3, FEP_4 and FEP_5) are only 3% – 7%.

Typical cases would be even less than these extreme cases and expressing the forecast errors as a proportion of the required revenues for a pricing period (rather than just the aggregate cost of debt) would reduce them even further. This suggests that errors in forecasting the interest rates paid on new debt arising within a three, four or five-year pricing period (for rollovers), when using the interest rate at the beginning of the pricing period as the forecast, would be very unlikely to be a material proportion of the aggregate cost during the pricing period. In addition, the use of the mean reverting model may reduce the forecast errors in the cost of debt even further – see Appendix 3.[15]

More details on the method used to calculate the forecast errors in Table 8 are provided in Appendix 4.

Table 8: Forecast errors for the cost of debt

Year	Forecast	Interest Rate Forecast Errors				FEP_3	FEP_4	FEP_5
	One year ahead	One year ahead	Two years ahead	Three years ahead	Four years ahead			
1993	6.68%	3.36%	1.57%	0.64%	-0.54%	5%	6%	7%
1998	4.85%	1.89%	0.69%	0.97%	0.55%	3%	4%	4%
2007	6.21%	-1.99%	-0.74%	-0.65%	-2.38%	3%	4%	5%
Average						4%	5%	5%

4.1.3 Comparison of methods for estimating the cost of debt

To examine the application of the different cost of debt methodologies and their impact on the accuracy of the cost of debt, we have compared how each method would calculate the cost of debt over a three-year regulatory period. In this example, we assume the three-year pricing period began at the end of December 2019, when the prevailing ten-year rate was 1.20% (December 2019 average) and the 14-year trailing average (for December rates) was 3.81%.[16] Consistent with the key

[15] If forecasting is done six months before the beginning of the pricing period, the first forecast is 1.5 years ahead rather than one year, the second forecast is 2.5 years ahead rather than two years, etc. The resulting figures in the last column of Table 8 would become 8%, 5%, and 5%, with an average of 6%, i.e., only slightly higher.

[16] This is the largest such discrepancy between the two rates in the data series. Ten rather than 14-year yields are used here because they are easier to access in the RBA tables. See column J of Tab 1 of the attached excel spreadsheet "Other Data"

assumptions, we have assumed that the cost of debt rates for each of the three years are set at the commencement of the regulatory period. Additionally, we assume there is a constant debt level of $1.4b comprising 14 tranches of 14-year debt, each of $100m with one rolling over each year.

Using this approach and assumptions, the estimated cost of debt under the three methods is shown in Table 9. More detail on these calculations is shown below.

Table 9: Example of the Estimated Cost of Debt under Different Cost of Debt Methods

	Year of the pricing period			Cost of Capital - $M
	PP1	PP2	PP3	
Hybrid Method	3.81%	3.49%	3.13%	$146.0
Current Rate	1.2%	1.2%	1.2%	$50.4
Trailing Average	3.81%	3.81%	3.81%	$160.0

Hybrid method

Using the Hybrid approach, as outlined in section 4.1.1, the results are shown in the first row of Table 9:

- For the first year of the pricing period (PP1), the cost of capital would be .0381*$1.4b = $53.3m.
- For the second year (PP2), the initial 3.81% trailing average rate drops off the rate 14 years before PP1 (5.70%) and adds the current rate of 1.2% as a predictor of the rate at the end of PP1, to yield a new trailing average of 3.49%, and hence a cost of debt for the second year of .0349*$1.4b = $48.9m.
- For the third year (PP3), the revised trailing average of 3.49% drops off the rate 13 years before PP1 (6.21%) and adds the current rate of 1.2% as a predictor of the rate at the end of PP2, to yield a new trailing average of 3.13%, and hence a cost of debt of .0313*$1.4b = $43.8m.
- The total cost of debt under this approach over the three years is $146.0m.

Current rate only

Alternatively, sole use of only the current rate (1.2%) would yield:

- .012*$1.4b = $16.8m per year, and therefore $50.4m over the three years

The resulting estimate for the cost of debt of $50.4m is only about 35% of that under the Hybrid method ($146.0m). The Current Rate method is less accurate because it applies the current rate (1.2% in the example) to existing debt that does not mature during the pricing period and therefore continues to incur costs that were established up to 14 years earlier.

Trailing average

Alternatively, sole use of only the trailing average rate at the beginning of PP1 (3.81%) would yield, as shown in the last row of Table 9:

- .0381*$1.4b = $53.34m per year, and therefore $160.0m over the three years

This cost of debt estimate of $160.0m is 10% higher than that from the Hybrid Method. The Trailing Average method is less accurate than the Hybrid model because it applies the trailing average rate at the beginning of PP1 (3.81%) to PP2 and PP3 when it is only applicable to PP1. The Trailing Average method is also less accurate because it also uses the same trailing average rate (which is on average seven years old) as a predictor for future rates instead of using the much better predictor of the current rate.

As shown in Appendix 3, when using the current yield to forecast (say) two years ahead, the RMSE of the forecast errors is 1.41%. By contrast, when using the 14-year trailing average (whose data is on average seven years old) to forecast the same future yield, the forecasting interval is nine years (rather than two years) and the RMSE of these forecasting errors is much larger (2.39%).

The Hybrid method is free of all of the problems with the Current Rate method and the Trailing Average method. In particular, it uses the correct rate for all existing debt that does not mature during the three-year pricing period, and the best predictor for new debt that will arise from rollovers during this period. If the forecasts must be made six months before the start of the pricing period, to set road user charges, then forecasts are required from 0.5 to 1.5 years ahead, 1.5 to 2.5 years ahead, etc. The relative merits of the three methods are essentially the same, but the "Current Rate" will then be old by six months and therefore it embodies slightly larger forecast errors for future rates.

4.1.4 Approaches used in other jurisdictions

There is precedent for using the Current Rate approach, though the general trend of regulators has been to move away from a Current Rate approach to trailing average approaches. Examples of cost of debt approaches in other jurisdictions include:

- The weighted average term to maturity is used by the AER for regulated energy businesses in which it calculates a 10-year weighted average maturity date using corporate bonds[17]
- The ESC for Victorian water businesses[18], ICRC for Icon Water[19], QCA[20], and ESCOSA[21] for SA Water all use a 10-year trailing average
- IPART uses the midpoint between current (4 years) and long-term trailing average (10 years)[22]
- OTTER – applied a hybrid approach to cost of debt for TasWater in its 2022 decision, combining the trailing average and the Current Rate. OTTER also only adjusts prices for TasWater at the beginning of the regulatory period, and does not make annual adjustments for CPI and cost of debt[23].

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[17] AER, Rate of Return Instrument – Explanatory statement, February 2023, p.22.
[18] ESC, 2023 water price review – Guidance paper, October 2021, p.40.
[19] ICRC, Regulated water and sewerage services 2023-28, May 2023, section 6.
[20] QCA, Rate of Return Review, November 2021, section 5.5.
[21] ESCOSA, SA Water Regulatory Determination, final determination – statement of reasons, June 2020, section 7.
[22] IPART, Review of our WACC method, February 2018, section 4.
[23] OTTER, Investigation into TasWater's prices and services for the period 1 July 2022 to 30 June 2026, Final report, May 2022, p.82-88.

4.1.5 Our assessment against the criteria

The NTC's criteria that are relevant to this issue are simplicity, reflective of the way that a prudent government or private-sector organisation would manage its debt portfolio, stability over time, accurately reflecting the governments' cost of capital, and based on publicly-available information.

Table 10 provides a summary traffic light assessment of the cost of debt options, against the relevant criteria, where:

- Green – meets the criteria
- Amber – partially meets the criteria
- Red – Does not meet the criteria.

Table 10: Assessment of cost of debt options

Option	Simplicity	Reflects prudent debt management and hence accuracy	Stability	Based on publicly available information	Consistent with regulatory practice
Current Rate approach	Green	Red	Red	Green	Amber
Trailing average – ten-year average	Green	Amber	Amber	Green	Green
Trailing average – weighted average term to maturity	Green	Amber	Green	Green	Green
Hybrid approach	Amber	Green	Green	Green	Green

In respect of simplicity, the Current Rate is simpler than any trailing average, but some trailing averages are almost as simple as the Current Rate. As shown above, an equally weighted trailing average of the ten-year rates over the ten years up to the beginning of the pricing period is reasonably simple to calculate. However, the Hybrid approach is more complex to calculate compared with the other methods assessed.

In respect of stability over time, trailing averages are more stable than the Current Rate and stability increases with the length of the trailing average. For example, using three-year and ten-year CGS yields in December 1993–2023, the standard deviation of the three-year CGS yields is 2.17% whilst the standard deviation of the three-year trailing average of these yields is 1.97%, which is a 9% reduction in standard deviation. For the ten-year yields and the ten-year trailing average, the corresponding figures are 2.03% and 1.32%, which is a 35% reduction in standard deviation.[24] This reduction occurs because the trailing average process bear some similarity to averaging across randomly selected data from a population, and averages of that kind are less variable than the underlying data (in accordance with the Central Limit Theorem) with the standard deviation of the average declining in proportion to the square root of the number of years in the averaging process, i.e.,

$$\sigma(average\ over\ N\ years) = \frac{\sigma(raw\ data)}{\sqrt{N}}$$

For the ten-year data, this formula implies that the standard deviation of the ten-year trailing average would be 2.03%/√10 = 0.64%. The fact that the actual standard deviation of the trailing average (1.32%) lies between these two figures of 2.03% and 0.64% reflects the fact that this trailing average is not a random sample of ten observations from the raw data but an average of the last ten data points and these data points exhibit some pattern over time.

In respect of reflecting prudent debt management of government entities, and therefore accuracy, the best approach to setting the cost of debt would be an approach that reflected the contemporaneous maturity composition of the relevant government's debt, and recognises that some of the debt gradually rolls over through the three-year pricing period; this is the Hybrid approach.

In respect of being based on publicly available information, all approaches considered here meet this criterion.

Based on our assessment, we consider that the Hybrid model best meets these criteria overall. It is based on publicly-available data, and is almost as simple to use as the Current Rate. It is also approximately reflective of how government manages its bond portfolio. For the same reason it is a much better approximation to the actual cost incurred by governments. It is also much more stable over time than sole use of the Current Rate, but (as noted in respect of inflation forecasts in the previous section) stability over time in a parameter estimate is not very important because stability in total revenues is achieved through smoothing them (as discussed in section 6). This suggests that the Hybrid Method is far superior to use of the Current Rate.

In addition, and relative to sole use of the trailing average rate, the Hybrid Method better reflects prudent debt management by government and therefore produces a more accurate estimate of the NTC's cost of capital. Additionally, while it is slightly more complex, it is similar on the other criteria. It therefore also seems preferable to sole use of the trailing average. This Hybrid approach is consistent with Australian regulatory practice. For example, the OTTER (2022, page 86) uses this approach.

[24] These standard deviations are shown in cells B38, C38, F38 and G38 of Tab 1 of the attached excel spreadsheet "Other Data".

4.1.6 Recommended approach for calculating the cost of debt

Assuming that bond maturities are spread equally over a year rather than at only one point in each year, we consider that the best approach to calculating the costs of debt is the Hybrid approach 2, as described in section 4.1.1 which is as follows:

(1) For the first year of the pricing period (PP1), apply a weight of 1/14th (7.1%) to the average annual yields on 14-year CGS bonds over each of the 13 years up to the beginning of PP1, and apply half of that weight (1/28th or 3.6%) to the average annual yield on 14-year bonds in the year preceding that 13 year period, and apply the same half weight (1/28th or 3.6%) to the average yield on 14-year CGS bonds in the month immediately preceding the commencement of PP1 as a predictor of the new yields on the bonds that will mature during PP1.[25]

(2) Following the same principle, for the second year of the pricing period (PP2), apply a weight of 1/14th to the average annual yields on 14-year CGS bonds over each of the 12 years up to the beginning of PP1, and apply half of that weight (1/28th) to the average annual yield on 14-year bonds in the year preceding that 12 year period, and apply the remaining weight (3/28th) to the average yield on 14-year CGS bonds in the month immediately preceding the commencement of PP1 as a predictor of the new yields on the bonds that will mature during PP1 and PP2.

(3) Following the same principle, for the third year of the pricing period (PP2), apply a weight of 1/14th to the average annual yields on 14-year CGS bonds over each of the 11 years up to the beginning of PP1, and apply half of that weight (1/28th) to the average annual yield on 14-year bonds in the year preceding that 11 year period, and apply the remaining weight (5/28th) to the average yield on 14-year CGS bonds in the month immediately preceding the commencement of PP1 as a predictor of the new yields on the bonds that will mature during PP1, PP2 and PP3.

[25] In respect of the bonds issued in the 13 years before the commencement of PP1, none will mature during PP1 and therefore all of their costs are relevant to PP1. In respect of the bonds issued in the year before this 13 year period, they will on average mature six months into PP1, and be rolled over there, with the result that their yields pre rollover are relevant for six months of PP1 and the new yields upon them rolling over are relevant to the other six months of PP1, which implies 1/28th weight on each of these old and new yields. The new (future) yields are estimated using the yield observed in the month immediately preceding PP1.

5. Source of debt data

The key criteria in selecting the most appropriate cost of debt data is finding the data that reflects the cost of debt, and whether the data is publicly available (and therefore easily updated on a periodic basis).

We considered the following as feasible options for sourcing the cost of debt data:

- Option 1: CGS rates (from the RBA) for all 8 jurisdictions
- Option 2: CGS rates (from the RBA) for Commonwealth and local, and CGS rates adjusted for credit ratings for state and territories
- Option 3: CGS rates (from the RBA) for Commonwealth and local, and actual bond rates for states and territories (sourced from State and Territory Treasuries)
- Option 4: Hybrid of Option 2 and 3.

5.1 Our assessment

5.1.1 Issues with alternative approaches

Given that roading investments are funded by both the federal and state governments, the most accurate approach to estimating the cost of debt would be to estimate a weighted average of the costs of federal and state government debt, weighted by their contributions to road expenditure. These weights would vary over time. This approach is complex as it requires collecting information on bond yields for each government and then weighting by the road expenditures of each government.

A simpler approach would be to use data from only federal government bonds as it avoids collecting information from state and territory governments and weighting the bond yields by road expenditures. A drawback of this approach is that these simplifications would understate the cost of debt because the bond yields for state and territory governments are more than for the Commonwealth. For example, the RBA presents data on NSW bonds over the period from June 1977 to May 2013, and the average yield on these ten-year bonds over that period exceeds that of ten-year CGS bond yields by 0.50% (9.28% versus 8.78%).[26]

Another challenge with estimating the cost of debt is the accessibility of publicly-available Australian information on bond yields, over the 14 year period up to the present time. The public accessibility of

[26] Data from Table F2 on the RBA's website: https://www.rba.gov.au/statistics/historical-data.html.

this data appears to be limited to CGS bonds.[27] A possible solution to this problem would be to assess whether there is a strong relationship between the yield differential on NSW/CGS bonds over the period up to May 2013 (when yield data are available on both bonds) and the differential in their credit ratings and, if so, couple that relationship with yields on CGS bonds since May 2013 to estimate the yields on the bonds of each of the state governments. Unfortunately, there does not seem to be any strong relationship in the pre-May 2013 data.

For example, over the period from February 2003 to October 2012, the federal government S&P bond rating was AAA.[28] Over the same period the NSW S&P rating was likewise.[29] However, over the same period, the yield on ten-year NSW bonds exceeded that on CGS bonds by as little as 0.16% and as much as 1.29%. Thus, in the absence of publicly available state government bond yield data over each of the past 14 years and the inability of credit ratings to explain yield differentials on state and federal bonds, the data should be limited to CGS bonds.

Therefore, the best proxy for the desired 14-year bond yield is that on CGS 14-year bonds. The RBA provides information on bond yields for various bonds with maturities out to 2051, and the relevant bonds are those with maturity dates on either side of the desired date, with interpolation over these. For example, on 17 January 2024, the desired (14 year) bond matures on 17 January 2038 and the relevant bonds are those maturing on 21 April 2037 and 21 June 2039 with yields of 4.34% and 4.43% respectively.[30] The interval separating the maturity dates on the two bonds is 791 days and the desired date of 17 January 2038 is 271 days into that. So, using linear interpolation, the estimated yield for a bond maturing on 17 January 2038 is 4.37% as follows:

$$4.34\left(\frac{791-271}{791}\right)+4.43\left(\frac{271}{791}\right)=4.37$$

These interpolated yields are tedious to calculate. So, one might use ten-year bond yield data augmented by 14-year data once every three months. For example, in respect of 2023, the ten-year yield averaged over that year was 3.95% and the margin of 14-year yields over ten-year yields averaged over Feb 15, May 15, August 15 and November 15 was 0.20%, so the 14-year yield averaged over the entire year is estimated at 4.15%.[31]

5.1.2 Recommended approach for the source of debt data

The use of only CGS data will likely underestimate the cost of capital for the NTC because some funding comes from state governments and the rate on this debt seems to be higher (as indicated by the CGS/NSW rates up to May 2013, as noted on the previous page). However using only CGS yields

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[27] The RBA website shows yields on NSW bonds, but only up to May 2013 and only for maturities of 3, 5 and 10 years, and not for any other states: see Table F2 on the website of the RBA: https://www.rba.gov.au/statistics/tables/#interest-rates. The websites of the state government Treasury departments do not report these yields over more than very recent points in time, which is inadequate because a 14-year trailing average is required. For example see Interest Rates | Treasury Corporation of Victoria (tcv.vic.gov.au).

[28] See https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/FlagPost/2013/February/Australias_credit_rating

[29] See https://www.kanganews.com/images/archived/stories/magazines/2012decsup/ratingsknsupnov12.pdf.

[30] See Table F16 on the RBA's website: https://www.rba.gov.au/statistics/tables/#interest-rates.

[31] See Appendix 5 for details on this process.

is appropriate as only this data is publicly available and it avoids the complexities in estimating the share of funding that does not come from the federal government.

Furthermore, unlike private sector businesses, any shortfalls in revenues relative to costs in public sector commercial operations are (or very likely to be) met by increasing taxes, with the result that the borrowing rate incurred by government in undertaking commercial operations is lowered and the full cost of capital is then the borrowing rate plus the effect of this potential cost to taxpayers. The total would be the borrowing cost paid by government if taxpayer bailouts did not occur. Quantifying the additional borrowing cost in this scenario is not possible.

We note that other regulators, including state-based regulators, in other industries generally use corporate bond yield data even where borrowings by state-owned entities come from state governments:

- ESC (regulated water businesses) – 10-year BBB-rated corporate bond yield data from the RBA[32]
- AER – a weighted average of BBB-rated and A-rated corporate bond yields from the RBA, Bloomberg and Thomson Reuters[33]
- IPART – 10-year BBB rated corporate bond yield data from the RBA[34]
- QCA – 10-year corporate bond yield data from the RBA with credit rating on a case-by-case basis[35]
- ESCOSA (SA Water) – 10-year BBB-rated corporate bond yield from the RBA[36]
- ICRC (Icon Water) – Average of 10-year BBB corporate bond yields from the RBA and Bloomberg[37].

[32] ESC, 2023 water price review – Guidance paper, October 2021, p.40.
[33] AER, Rate of Return Instrument – Explanatory statement, December 2018, Section 10.
[34] IPART, Review of our WACC method, February 2018, section 4.
[35] QCA, Rate of Return Review, November 2021, section 5.5.
[36] ESCOSA, SA Water Regulatory Determination, final determination – statement of reasons, June 2020, section 7.
[37] ICRC, Regulated water and sewerage services 2023-28, May 2023, section 6.

6. References

AER, 2020a. *Discussion Paper Regulatory Treatment of Inflation*, [Document title] (aer.gov.au).

_____ 2020b. *Final Position: Regulatory Treatment of Inflation*, https://www.aer.gov.au/system/files/AER%20-%20Final%20position%20paper%20-%20Regulatory%20treatment%20of%20inflation%20-%20December%202020.pdf.

____ 2023. *Rate of Return Instrument*: *Explanatory Statement*, https://www.aer.gov.au/system/files/AER%20-%20Rate%20of%20Return%20Instrument%20-%20Explanatory%20Statement%20-%2024%20February%202023_1.pdf

Lally, M., 2020. "Review of the AER's Inflation Forecasting Methodology", report prepared for the AER, www.aer.gov.au.

OTTER, 2022. *Investigation into Taswater's Prices and Services for the Period 1 July 2022 to 30 June 2026*, https://www.economicregulator.tas.gov.au/Documents/22%20618[v4]%20%202022%20Water%20and%20Sewerage%20Price%20Determination%20Investigation%20-%20Final%20Report%20v4%20(1%20June%202022).pdf.

The Treasury, 2023. *Budget 2023-24: Budget Paper No. 1, Budget Strategy and Outlook*, https://budget.gov.au/content/bp1/index.htm .

Van Horne, J., 1984. *Financial Market Rates and Flows*, 2nd edition, Prentice-Hall, Englewood Cliffs.

Appendix 1. Purpose of inflation adjustments

This appendix elaborates upon the effect of the inflation adjustments, starting with regulated businesses. To do so, suppose that the nominal cost of capital is 8% and inflation is expected to be 3% over the next (annual) regulatory period. In addition, and in the interests of simplifying the analysis, suppose that there is no opex, taxes, capex or depreciation. We define payoffs as the cash payoff plus the end of year value of the business, to determine the nominal and real rates of return on the business. Letting A denote the current value of the RAB and i denote the actual rate of inflation over the next year, the nominal payoffs to the firm in one year are the nominal revenues (.08A less expected inflation on the RAB of .03A, adjusted for inflation) plus the inflation-adjusted end of year RAB as follows:

$$Payoffs = REV + RAB = \left[(.08A - .03A)\frac{(1+i)}{(1.03)}\right] + A(1+i)$$

The higher is inflation in the next year (*i*), the higher is both revenues in the year and the end of period RAB, with the latter inducing higher subsequent revenues, so as to maintain the real level of revenues. The nominal rate of return over the period (R) is the payoffs divided by the initial RAB, less 1:

$$R = \frac{\frac{(.08A - .03A)}{1.03}(1+i) + A(1+i)}{A} - 1 = \frac{(1.08 - 1.03)}{1.03}(1+i) + i$$

The real rate of return (R_R) is 1 plus the nominal rate of return *R*, divided by (1 + *i*), less 1:

$$R_R = \frac{(1.08 - 1.03)}{1.03} = \frac{1.08}{1.03} - 1$$

So the real rate of return for the business is invariant to inflation, and is equal to the real cost of capital (1 plus the nominal cost of capital divided by 1 plus expected inflation, less 1). So, if the current RAB were $1,000m and actual inflation were 6%, the revenues at the end of the first period before the inflation adjustment would be $1,000m(0.08 – 0.03) = $50m, and inflation adjusting them would yield $50m(1.06)/(1.03) = $51.5m, and the end of period RAB would be $1000m(1.06) = $1060m. The nominal rate of return would then be ($51.5m + $1060m)/$1000m – 1 = 0.111, and the real rate of return would then be 1.111/(1.06) – 1 = 0.0485. The latter rate is equal to the real cost of capital and is unaffected by the actual inflation rate.

In respect of heavy vehicle charges (HVC), the nominal payoffs in one year are the nominal HVC (.08A less expected inflation on the RAB of .03A) plus the inflation-adjusted end of year RAB plus the inflation forecast error, as follows:[38]

$$Payoffs = HVC + RAB + ERROR = (.08A - .03A) + A(1 + i) + A(.03 - i)$$

This nominal payoff is not affected by the actual inflation rate *i*, as the upward impact on the RAB is offset by the forecast error correction. For example, if the current RAB was $1,000m, and the expected inflation rate was 3%, and the actual inflation rate was 6%, the HVC would be $1,000m(.08 - .03) = $50m (regardless of actual inflation), the RAB would be $1,060m and the deduction from future HVC for the inflation forecast error would be $30m. The total payoffs would be $1,080m. If the actual inflation rate matched the forecast of 3%, the forecast error would disappear and the RAB would be $1,030m. The total payoffs would still be $1,080m, and therefore unaffected by the actual inflation rate.

The HVC as presented here, being .08*A* less expected inflation on the RAB of .03*A*, is mathematically equivalent to applying the real cost of capital to the RAB and then inflating this real revenue by the forecast inflation. The proof is as follows, where [ ] is the real cost of capital (0.0485):

$$HVC = .08A - .03A = 1.08A - 1.03A = 1.03A\left[\frac{1.08}{1.03} - 1\right] = 1.03A(0.0485)$$

This may be considered easier to explain to road users than applying the nominal cost of capital of 8% and then deducting expected inflation of 3%.

38 The revenues are not inflation-adjusted as in the regulatory situation, by dividing by 1.03 and multiplying by (1 + i), because the revenues could not then be fixed for the pricing period at the beginning of that period. Despite not making this inflation correction, the NPV = 0 test is still satisfied, i.e., the present value of the payoffs is still equal to the initial RAB of A.

Appendix 2. Trailing average weightings

Standard practice in using trailing averages of the cost of debt is to equally weight the individual years in the trailing average. This assumes that the entity's debt level is constant. However, the debt level of entities usually grows over time due to inflation and real growth in the economy. A trailing average that reflected this growth in the debt level would have higher weights on the most recently issued debt. In respect of the NTC, its debt is subsumed within the debts of various governments (state and federal) and therefore it is not possible to directly assess whether its debt is growing over time. An alternative approach is to examine the latest aggregate RAB, depreciation and capex of Australian roading projects: $102b, $10.2b, and $14.8b respectively. Of the capex, $10.2b is to replace existing assets (being the depreciation) and therefore the remaining $4.6b is for new projects, which represents about 5% of the RAB. So, new debt per year is approximately 5% of existing debt. Thus debt grows at approximately 5% each year. This is similar to the nominal growth in Australia's GDP per year, and is therefore very plausible. So, the trailing average weights that reflected this growth in debt would grow at 5% per year over a 14-year period, i.e., .051 in the first year through to .096 in the 14th year.

To investigate the error in estimating the cost of debt resulting from using equal weights (of 7.1% for each of the 14 years), suppose that all debt matures in December of each year, and therefore the cost of debt incurred over the first year of a pricing period would be the trailing average of the December rates in the preceding 14 years. This is calculated for each of the years 2007-2023, with the calculation for (say) 2007 using data in December 1993 – December 2006. Using equal weights, and then weights that grow at 5% per year, the maximum difference in the resulting trailing averages for the cost of debt is 0.27% in 2020, arising from an equally weighted trailing average of 3.47% and the differentially weighted trailing average of 3.20%.[39] Furthermore, over time, the differences should average out because interest rates tend to oscillate around a long-run average and therefore all trailing averages of those interest rates will also oscillate around the same long-run average.

In the interests of simplicity, and also because the resulting error is likely to be small, we recommend the use of equal weights when calculating a trailing average. This implies that we act as if the governments' debt level is not growing, and therefore that capex matches depreciation so that the RAB is not growing over time. The trailing average rate therefore applies to the RAB at the beginning of each year of the pricing period and also to the forecasted capex.

[39] See column D of Tab 1 of the attached Excel spreadsheet "Other Data".

Appendix 3. Predictors of future bond yields

Our analysis has assumed that the best predictor of future bond yields is the latest available rate (the current rate). In this appendix, we examine various approaches to predicting future bond yields.

The first option to consider for predicting bond yields invokes the Expectations Hypothesis concerning the term structure of interest rates. For example, on 17 January 2023, the yields on one-year and 15-year CGS were 3.21% and 3.87% respectively.[40] These two yields imply a rate of return (the "Forward Rate" $F_{1,15}$) earned from the maturity date of the one-year bond to that of the 15-year bond that leaves the investor as well off from the one-year bond followed by this Forward Rate as they would be if they instead initially purchased the 15-year bond, and is the solution to the following equation:

$$(1.0387)^{15} = (1.0321)(1 + F_{1,15})^{14}$$

The result is $F_{1,15}$ = 3.92%. The Expectations Hypothesis says that, in choosing now between a one-year bond and a 15-year bond, investors are indifferent to the uncertainty about the rates available in one year upon the maturity of the one-year bond, and therefore yields would be such that the expectation now of the payoff on a one-year bond followed by a 14-year bond would equal the payoff on the currently available 15-year bond. So, the expectation now of the yield available in one year on a 14-year bond would equal the Forward Rate of 3.92%:

$$E(Y_{14}) = F_{1,15}$$

So, the forward rate (which can be determined today) would be a predictor now of the yield available in one year on a 14-year bond. However, the term structure of interest rates is also determined by other factors such as "liquidity premiums" (see van Horne, Ch. 5), and these other factors would have to be estimated and allowed for in deducing an estimate of future yields from the current term structure. For example, if the term structure were determined solely by expectations and a liquidity premium (P), then:

$$F_{1,15} = E(Y_{14}) + P$$

So, if F = 3.92% and P = 0.5%, then the expectation now of the yield on a 14-year bond in one year would be 3.42%. However, estimates of these other factors are very subjective and therefore so too would any estimate of the yield on a particular bond at some future time.

The second option for predicting future bond yields is the current rate. Using the ten-year CGS rate in December of a year (1993-2023) to predict the rate one year later, the prediction errors have an RMSE of 1.21% and this grows the further into the future one predicts (1.41% when predicting two years ahead, 1.56% when predicting three years ahead, etc).[41] This implies that using past rates to predict future rates would be inferior to using the current rate. For example, if one used the rate one

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[40] Data from Table F16 on the RBA's website, with yields determined by interpolation from the yields on bonds with maturities either side of the desired maturity dates of 17 January 2024 and 17 January 2038.

[41] See columns N, R, V, Z and AD of Tab 1 of the attached Excel spreadsheet "Other Data".

year ago to predict the rate one year from now, the interval over which one would be predicting would be two years (with an RMSE of 1.41%) and this would be worse than using the current rate as the predictor (with a one-year prediction interval and therefore an RMSE of 1.21%).

The third option for predicting bond yields is to assess whether there is mean reversion in the yields, i.e., unusually high values tend to be followed by lower values, and unusually low values tend to be followed by higher ones, so that extreme values tend to revert towards the mean value. This is assessed by regressing the yield in December of a year (Y_1) on the yield one year earlier (Y_0), using December data from 1993-2023. The result is the following regression model:[42]

$$Y_1 = 0.773 + 0.82Y_0$$

If there was no mean reversion, the constant in this regression model would be zero and the coefficient on Y_0 would be 1. The fact that the coefficient on Y_0 is less than 1 is evidence of mean reversion, and it is marginally statistically significantly different from 1 ($p = .08$, i.e., the probability of the estimated coefficient on Y_0 of 0.82 being at least as far from 1 as it is, if there was no mean reversion in the underlying population, would be 8%). In view of this, we assess the forecast accuracy of the model. For example, inserting the December 1993 yield of 6.68% into the regression model (as the Y_0 value) produces a prediction for the December 1994 yield of 6.25%. The actual value for December 1994 was 10.04%, so the forecast error is 3.79%. Using this December data for 1993-2023, the RMSE of the prediction errors is 1.14%.[43] This is marginally superior to using the current rate as the one-year ahead predictor (RMSE of 1.21%), consistent with there being some evidence of mean reversion.

In respect of forecasting two years ahead, the one-year ahead forecast would be inserted back into the regression model to generate a forecast two years ahead. For example, inserting the December 1993 yield of 6.68% into the model (as the Y_0 value) generates a one-year ahead forecast of 6.25%, and inserting this figure back into the model (as the new Y_0 value) generates a two-year ahead forecast of 5.90%. The actual yield for December 1995 was 8.25%, so the forecast error is 2.35%. Using this December data for 1993-2023, the RMSE of the prediction errors is 1.18%. This is superior to using the current rate as the predictor two years ahead (RMSE of 1.41%). Repeating the process for three years ahead, the RMSE of the prediction errors for the mean reversion model is 1.22% whilst that from using the current rate as the predictor is 1.56%.[44] The mean reversion model is therefore consistently more accurate than using the current rate but the superior accuracy using the data here is only marginally statistically significant.

The choice is then between use of the current rate and the mean reversion model. The NTC's criteria that are relevant to this issue are simplicity, stability over time, accurately reflecting the governments' cost of capital, and based on publicly-available information. The current rate is superior in terms of simplicity (and therefore ease of comprehension by road users) whereas the mean reversion model may generate more accurate forecasts, and they would be slightly more

[42] The data is in columns F and M of Tab 1 of the attached Excel spreadsheet "Other Data", and the regression results are in Tab 4.
[43] See columns D and E of Tab 3 of the attached Excel spreadsheet "Other Data".
[44] See columns G to M of Tab 3 of the attached Excel spreadsheet "Other Data".

stable over time (because extreme values of the current rate would be replaced by slightly less extreme ones). The better choice is unclear.

Appendix 4. Estimating forecast errors for the cost of debt

This Appendix explains the method for estimating the forecast errors for the cost of debt shown in Table 8.

Suppose the firm's existing debt was borrowed just before the beginning of the current pricing period, one year previously, two years previously, …13 years previously, in equal amounts of $100m, for a total of $1.4b, and each tranche has a term to maturity at issuance of 14 years.[45] In addition, suppose the average interest rate at date of issuance over these 14 tranches is 4%, implying an aggregate cost of capital for the first year of the pricing period of $56m.

Of these 14 tranches, only three will mature within the pricing period, and therefore require rollover at a new interest rate. For the tranche maturing in just under three years, and rolled over then, the new interest rate will apply only briefly before the pricing period ends and therefore the change in the rate would be inconsequential. For the tranche maturing in just under two years, and rolled over then, the new interest rate would apply for only the last year of the pricing period. For the tranche maturing in just under one year, and rolled over then, the new interest rate would apply for the last two years of the pricing period. The other 11 tranches will have an average interest rate close to that of the 14, so we suppose the former is also 4% as any deviation from this would have no material effect on the result here.

The interest rates at issuance of the three tranches that mature within the pricing period could each be quite different to the average of the other 11, but any deviation from this would have no material effect on the result here, so we suppose these rates are also 4%. Let k_1 denote the new interest rate on the tranche that matures in just under one year and k_2 the new interest rate on the tranche that matures in just under two years. In addition, let F denote the current interest rate, which acts as the forecast for each of k_1 and k_2.[46] For the three years of the pricing period, the actual and forecast costs of capital in dollar terms in each year are then as shown in the first three rows of Table 11.

Table 11: Actual and Forecast Cost of Debt ($million)

	Actual Cost	Forecast Cost
Yr 1	56	56
Yr 2	$52 + 100k_1$	52 + 100F

—

45 This implies a constant debt level. As discussed in Appendix 2, a more typical situation would involve debt growing over time to reflect inflation and capex being more than mere replacement. However, as shown there, the errors from assuming a constant debt level are small.

46 In Appendix 3 we identify a more accurate but also more complex predictor than the current rate. In the interests of simplifying the analysis here, the current rate is used as the predictor.

	Actual Cost	Forecast Cost
Yr 3	$48 + 100k_1 + 100k_2$	48 + 100F + 100F
Yr 4	$44 + 100k_1 + 100k_2 + 100k_3$	44 + 100F + 100F + 100F
Yr 5	$40 + 100k_1 + 100k_2 + 100k_3 + 100k_4$	40 + 100F + 100F + 100F + 100F

Over years 1 – 3, the aggregate forecast error in $ terms (*FE*), being the actual cost less the forecast cost, arises from the two tranches relating to k_1 (two at $100m in the top left section of the table) and the single tranche relating to k_2 (one at $100m on the left side of the table), each with their corresponding forecasts on the right hand side of the table. The total forecast error is as follows:

$$FE_3 = \$200m(k_1 - F) + \$100m(k_2 - F) \qquad (1)$$

The probability distribution of possible values for $(k_1 – F)$ and $(k_2 – F)$ can be estimated from the ten-year CGS bond yields in December of each year from 1993-2022 [47]. In particular, the bond yield in December of any year is a forecast (F) of both the yield one year later (k_1) and one year after that (k_2).[48] This provides 30 values for $(k_1 – F)$ and the 30 associated values for $(k_2 – F)$.

An extremely untypical result here would arise from the December 1993 ten-year CGS rate (6.68%), which would act as a predictor of the rate one year later (10.04%), yielding a prediction error $(k_1 – F)$ of 3.36%; this is the largest absolute one-year ahead prediction error in this data series. The same December 1993 rate of 6.68% also acts as predictor of the rate two years later (8.25%), which yields a prediction error $(k_2 – F)$ of 1.57%.[49] Inserting the prediction errors in this very extreme case into equation (1) yields an aggregate forecast error in the total cost of debt as follows:

$$FE_3 = \$200m(.0336) + \$100m(.0157) = \$8.3m$$

Furthermore, the aggregate forecast cost across years 1 – 3 is $168m, by adding up the forecast interest payments in years 1 -3 in the right hand side of Table 11 and assuming F is 4%.[50] The forecast error of $8.3m, as a proportion of this forecast cost of about $168m, is 5% (denoted FEP_3), and almost certainly the error would be smaller than this extreme case.

In respect of a pricing period of four years, the actual and forecast costs for rollovers are as shown in the left hand side of Table 11, for years 1 – 4, where k_3 is the new interest rate that arises in just

[47] We use ten rather than 14-year yields in this analysis because the former are more easily accessed from the RBA tables. The results would not be materially different if 14-year yields were used.
[48] Data from Table F2 on the website of the RBA: https://www.rba.gov.au/statistics/tables/#interest-rates. See attached excel file.
[49] These two prediction errors appear in columns O and S of Tab 1 of the attached excel spreadsheet "Other Data".
[50] Deviations from F = .04 would not materially affect this figure of $168m. For example, if F were 5%, the total forecast cost would be $171m rather than $168m.

under three years' time. The forecast counterparts to these debt tranches appear on the right hand side of the table. The total forecast error for a four-year pricing period (actual cost – forecast cost) is as follows:

$$FE_4 = \$300m(k_1 - F) + \$200m(k_2 - F) + \$100m(k_3 - F) \qquad (2)$$

In respect of the possible values for $(k_1 - F)$, $(k_2 - F)$ and $(k_3 - F)$, as before, an extremely untypical result here would arise from the December 1993 ten-year CGS rate (6.68%), which would act as a predictor of the rate one year later (10.04%), yielding a prediction error $(k_1 - F)$ of 3.36%; this is the largest absolute one-year ahead prediction error in this data series. The same December 1993 rate of 6.68% also acts as predictor of the rate two years later (8.25%), which yields a prediction error $(k_2 - F)$ of 1.57%. The same December 1993 rate of 6.68% also acts as predictor of the rate three years later (7.32%), which yields a prediction error $(k_3 - F)$ of 0.64%.[51] Inserting the prediction errors in this very extreme case into equation (2) implies an aggregate forecast error in the cost of debt over a four-year period as follows:

$$FE_4 = \$300m(.0336) + \$200m(.0157) + \$100m(.0064) = \$13.9m$$

Furthermore, the aggregate forecast cost across years 1 – 4 is \$224m, by adding up the forecast interest payments in years 1 - 4 in the right hand side of Table 11 and assuming F is 4%.[52] The forecast error of \$13.9m, as a proportion of this forecast cost of about \$224m, would then be 6% (denoted FEP_4), and almost certainly the error would be smaller than this extreme case.

In respect of a five-year pricing period, the actual and forecast costs for rollovers are as shown in the left hand side of Table 11, for years 1 – 5, where k_4 is the new interest rate that arises in just under four years' time. The forecast counterparts to these debt tranches appear on the right hand side of the table. The total forecast error for a five-year pricing period (actual cost – forecast cost) is as follows:

$$FE_5 = \$400m(k_1 - F) + \$300m(k_2 - F) + \$200m(k_3 - F) + \$100m(k_4 - F) \quad (3)$$

In respect of the possible values for $(k_1 - F)$, $(k_2 - F)$, $(k_3 - F)$ and $(k_4 - F)$, as before, an extremely untypical result here would arise from the December 1993 ten-year CGS rate (6.68%), which would act as a predictor of the rate one year later (10.04%), yielding a prediction error $(k_1 - F)$ of 3.36%. The same December 1993 rate of 6.68% also acts as predictor of the rate two years later (8.25%), which yields a prediction error $(k_2 - F)$ of 1.57%. The same December 1993 rate of 6.68% also acts as the predictor of the rate three years later (7.32%), which yields a prediction error $(k_3 - F)$ of 0.64%. The same December 1993 rate of 6.68% also acts as predictor of the rate four years later (6.14%), which

[51] These three prediction errors appear in columns O, S and W of Tab 1 of the attached excel spreadsheet "Other Data".
[52] Deviations from F = .04 would not materially affect this figure of \$224m.

yields a prediction error (k_4 – F) of -0.54%.[53] Inserting the prediction errors in this very extreme case into equation (3) implies an aggregate forecast error in the cost of debt over a five-year period as follows:

$$FE_5 = \$400m(.0336) + \$300m(.0157) + \$200m(.0064) + \$100m(-.0054) = \$18.9m$$

Furthermore, the aggregate forecast cost across years 1 – 5 is $280m, by adding up the forecast interest payments in years 1 - 5 in the right hand side of assuming F is 4%. [54] The forecast error of $18.9m, as a proportion of this forecast cost of about $280m, would then be 7% (denoted FEP_5), and almost certainly the error would be smaller than this extreme case.

[53] These four prediction errors appear in columns O, S, W and AA of Tab 1 of the attached excel spreadsheet “Other Data”.
[54] Deviations from F = .04 would not materially affect this figure of $280m.

Appendix 5. Estimating the cost of debt on 14 year CGS bonds

This Appendix explains the process for estimating the 14-year cost of debt for 2023. This process will be required for each year included in the cost of debt calculation. We start with 15 February 2023. On this date, a CGS bond with 14 years remaining to maturity would have to mature on 15 February 2037. The CGS bonds maturing closest to and on either side of this date are Treasury Bonds (TB) 145 and 144, with maturity dates of 21 June 2035 and 21 April 2037 respectively, with yields on 15 February 2023 of 3.867% and 3.950% respectively.[55] The interval separating the maturity dates of these two bonds is 669 days and the desired date of 15 February 2037 is 604 days into that period. So, the later maturing bond's yield of 3.950% warrants a weight of 604/669 and the other bond's yield of 3.867% warrants the remaining weight of 65/669, leading to an estimate of the yield on a bond maturing on 15 February 2037 of 3.94% as follows:

$$y = \left(\frac{65}{669}\right)3.867\% + \left(\frac{604}{669}\right)3.950\% = 3.94\%$$

In addition, on this date of 15 February 2023, the yield on a ten-year CGS bond was 3.73%.[56] The premium on the 14-year bond was then 0.21%.

This process is repeated for 15 May 2023, on which date a CGS bond with 14 years left to maturity would have to mature on 15 May 2037. The CGS bonds maturing closest to and on either side of this date are TB144 and TB147, with maturity dates of 21 April 2037 and 21 June 2039 respectively, with yields on 15 May 2023 of 3.678% and 3.797% respectively. The interval separating the maturity dates of these two bonds is 791 days and the desired date of 15 May 2037 is 24 days into that period. So, the later maturing bond's yield of 3.797% warrants a weight of 24/791 and the other bond's yield of 3.678% warrants the remaining weight of 767/791, leading to an estimate of the yield on a bond maturing on 15 May 2037 of 3.68% as follows:

$$y = \left(\frac{767}{791}\right)3.678\% + \left(\frac{24}{791}\right)3.797\% = 3.68\%$$

In addition, on this date of 15 May 2023, the yield on a ten-year CGS bond was 3.43%. The premium on the 14-year bond was then 0.25%.

[55] Data from columns AN and AO in Table F16 on the RBA's website: https://www.rba.gov.au/statistics/tables/.
[56] Data from column E of Table F2 on the RBA's website: https://www.rba.gov.au/statistics/tables/.

Repeating this process for 15 August 2023 also uses TB144 and TB147, with yields on 15 August 2023 of 4.401% and 4.484% respectively. The weights on these two bonds to obtain the desired maturity date of 15 August 2037 are 675/791 and 116/791 respectively, leading to an estimate of the yield on a bond maturing on 15 August 2037 of 4.41% as follows:

$$y = \left(\frac{675}{791}\right) 4.401\% + \left(\frac{116}{791}\right) 4.484\% = 4.41\%$$

In addition, on 15 August, 2023, the yield on a ten-year bond was 4.25%, and therefore the premium on the 14-year bond was 0.16%.

Repeating this process for 15 November 2023 also uses TB144 and TB147, with yields on 15 November 2023 of 4.666% and 4.768% respectively. The weights on these two bonds to obtain the desired maturity date of 15 November 2037 are 583/791 and 208/791 respectively, leading to an estimate of the yield on a bond maturing on 15 August 2037 of 4.69% as follows:

$$y = \left(\frac{583}{791}\right) 4.666\% + \left(\frac{208}{791}\right) 4.768\% = 4.69\%$$

In addition, on 15 August, 2023, the yield on a ten-year bond was 4.53%, and therefore the premium on the 14-year bond was 0.16%.

The average over these four premiums (0.21%, 0.25%, 0.16% and 0.16%) is 0.20%. Over the entire 2023, the average of the daily yields on ten-year CGS bonds is 3.95%. The estimate for the average yield on 14-year bonds over 2023 is then 3.95% + 0.20% = 4.15%.

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