Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020

Appendix 4 Rate of Return

Submitted by DBNGP (WA) Transmission Pty Limited

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Economic Regulation Authority
WESTERN AUSTRALIA

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Appendix 4 Rate of Return

1. This Appendix considers DBP's proposal for estimating the rate of return.

Regulatory Requirements

2. Rule 87 in the NGR sets out the requirements for the rate of return.

3. The overarching objective for the Authority's consideration of the rate of return proposed by DBP is provided by rule 87(3) of the NGR:

> The allowed rate of return objective is that the rate of return for a service provider is to be commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to the service provider in respect of the provision of reference services.

4. The allowed rate of return objective is intended to be consistent with the National Gas Objective:[1]

> Most importantly, the new rules allow the regulator (and the appeal body) to focus on whether the overall rate of return meets the allowed rate of return objective, which is intended to be consistent with the NEO, the NGO and the RPP.

5. Rule 87 includes a number of sub-rules which refer to matters the regulator is to have 'regard' to, when determining the allowed rate of return, including:

> 87. Rate of return
>
> …
>
> (5) In determining the allowed rate of return, regard must be had to:
>
> (a) relevant estimation methods, financial models, market data and other evidence;
>
> (b) the desirability of using an approach that leads to the consistent application of any estimates of financial parameters that are relevant to the estimates of, and that are common to, the return on equity and the return on debt; and
>
> (c) any interrelationships between estimates of financial parameters that are relevant to the estimates of the return on equity and the return on debt.
>
> …
>
> (7) In estimating the return on equity under subrule (6), regard must be had to the prevailing conditions in the market for equity funds.
>
> …
>
> (11) In estimating the return on debt under subrule (8), regard must be had to the following factors:
>
> (a) the desirability of minimising any difference between the return on debt and the return on debt of a benchmark efficient entity referred to in the allowed rate of return objective ;
>
> (b) the interrelationship between the return on equity and the return on debt;

[1] Australian Energy Market Commission, *Rule Determination: National Electricity Amendment (Economic Regulation of Network Service Providers) Rule 2012: National Gas Amendment (Price and Revenue Regulation of Gas Services) Rule 2012*, 29 November 2012, p. 23.

(c) the incentives that the return on debt may provide in relation to capital expenditure over the access arrangement period, including as to the timing of any capital expenditure; and

(d) any impacts (including in relation to the costs of servicing debt across access arrangement periods) on a benchmark efficient entity referred to in the allowed rate of return objective that could arise as a result of changing the methodology that is used to estimate the return on debt from one access arrangement period to the next.

6. In addition, rule 87 of the NGR sets out a number of additional requirements for the allowed rate of return, including that it:

- is to be determined such that it achieves the allowed rate of return objective (NGR 87(2));
- subject to NGR 87(2) and therefore also NGR 87(3), the allowed rate of return for a regulatory year is to be:
  - a weighted average of the return on equity for the access arrangement period in which the regulatory year occurs and the return on debt for that regulatory year (new NGR 87(4)(a));
  - determined on a nominal vanilla rate of return that is consistent with the estimate of the value of imputation credits (new NGR 87(4)(b));
- results in a return on debt for a regulatory year which contributes to the achievement of the allowed rate of return objective (NGR 87(8)) which is either the same in each year of the access arrangement period or which varies in each year through the application of an automatic formula (NGR 87(9) and NGR 87(12));
- incorporates a return on debt that would be required by debt investors over a relevant time period (whether shortly before the access arrangement decision, or on average over an historical period, or some combination of the two approaches) (NGR 87(10)).

DBP's Proposed Revisions

7. DBP's approach to estimating the rate of return is provided in the Supporting Information to the Proposed Revisions to the DBNGP Access Arrangement that was submitted by DBP to the Authority on 31 December 2014.[2]

8. DBP noted that its submission has been developed using the following four guiding principles: [3]

- following the ERA's Rate of Return Guidelines wherever possible;
- keeping information "live" through the process for as long as possible so that final results are informed by all relevant information;
- empirical assessment and cross checking of all modelled parameters and model outputs and a generally data-driven process of analysis; and

2 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015

3 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. ii.

- minimal use of judgment, restricted to the end-points of the analysis when no more can be learned by considering relevant data.

9. The following sub-sections provide more detail on DBP's proposal for the rate of return, with a particular emphasis on the proposed revisions which depart from the Authority's Rate of Return Guidelines.[4] DBP also responded to the Authority's position set out in the ATCO Gas Distribution System Draft Decision, which was released prior to DBP's submission of its proposed revisions.[5]

Benchmark efficient entity

10. DBP follows the Authority's position in the Guidelines in respect of the definition of the benchmark efficient entity, using:

- the set of energy firms to determine the return on equity:
  - Envestra;
  - APA;
  - DUET;
  - Hastings Diversified Utility Fund;
  - AusNet Services (previously, SP AusNet); and
  - Spark Infrastructure; and
- the set of BBB-rated debt (exclusive of finance firms, but including foreign bonds issued by Australian firms) to determine the return on debt.

Gearing

11. DBP proposes gearing of 60 per cent debt to regulated asset value, in line with the requirements set out in the Authority's Rate of Return Guidelines.

Averaging period

12. DBP's indicative estimates for its proposed revisions are based on the 40 trading days to 30 September 2014. DBP note the averaging period would be updated for the Final Decision.

Risk free rate

13. DBP submits that the Authority's use of the 5 year risk free rate is inappropriate, as:[6]

- the theoretical material by Lally used by the Authority to justify its position do not contain assumptions which are reflective of the real world; and
- the 5 year risk free rate does not meet the requirements of NGR 74(2), viz:[7]

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4 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013.

5 Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid- West and South-West Gas Distribution System*, 14 October 2014.

6 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 14.

7 NGR 74.

74 Forecasts and estimates

(1) Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.

(2) A forecast or estimate:

(a) must be arrived at on a reasonable basis; and

(b) must represent the best forecast or estimate possible in the circumstances;

stating that:[8]

> If the requirement in the NGR to reflect relevant market information is to be adhered to, it seems difficult to understand how the ERA could note, and then discard, such information, in favour of a theoretical model. …We conclude with DBP's preferred [10 year rate] approach to the tenor of the risk-free rate matches that which has become the norm in other regulatory jurisdictions.

14. With regard to estimating the risk free rate, DBP utilise a different approach to that set out in the Guidelines:[9]

> We follow the ERA's approach of using linear interpolation, but instead of using just two bonds straddling the terminal date (ten years in our case) we use all bonds, with decreasing weights the further a bond is from the target date. We understand this approach is consistent with that used by firms regulated by the AER, and it produces no difference in the number for the risk free rate in our data compared to using only two bonds. We use multiple bonds because each bond contains potentially different information, and it does not seem appropriate to discard information from particular bonds. The ERA follows a similar philosophy in respect of the debt risk premium, where it uses a wide range of bonds and not just the ones closest to the target tenor.

15. DBP's estimate of the risk free rate is 3.54 per cent.[10] DBP advise that this is 'a single market value based on a single 40-day estimating period', and as such does not have a confidence interval.

Return on Equity

16. DBP has proposed the following departures from the Authority's Rate of Return Guidelines in relation to the return on equity.[11]

- *First*, at Stage One, DBP considered that if models are to have a role in empirical estimation of the return on equity, they must not only have a theoretical grounding, they must also be capable of being shown to be empirically relevant. DBP argued that the Authority has undertaken only a theoretical assessment of models at this Stage, but has not undertaken an empirical assessment of model outcomes to assess their relevance.
  - DBP submitted its "model adequacy test" to allow such an empirical assessment. DBP argued that this test is based upon the notion that, when model predictions are compared with actual subsequent

8 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 14.

9 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 80.

10 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 80.

11 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. iii.

outcomes, the predictions should not exhibit any statistically significant upward or downward bias.

- *Second*, at Stage Two and Three, DBP noted that two departures from the Guidelines have been made: (i) ranges, rather than point estimates (as is done in the Guidelines), have been used in the application of each relevant model; and (ii) in estimating the risk free rate used in all models for the return on equity, a ten-year term is used rather than the five-year term used by the Authority in the Guidelines.
- *Third*, at Stage Four, DBP examined the results from models used to calculate the return on equity at Stage Two and Stage Three of the Authority's five-stage process with a series of cross checks. DBP argued that the Authority appears to have reservations in its Guidelines concerning the cross checks it proposes and that the Authority only used them sparingly, with a focus only on elements of the Sharpe Lintner CAPM, rather than the overall return on equity.
- *Fourth*, DBP argued that the cross check should be operationalised. DBP submitted this can be done using the notion first suggested by Merton (1974) that debt and equity are options on the same underlying asset, and can thus be priced as options.

17. In relation to the return on equity, DBP in its submission highlights three key areas:[12]

- *First*, DBP's key departures from the Guidelines, including a "model adequacy test" which serves to illustrate more clearly the different roles that different models of the return on equity ought to play.
- *Second*, a discussion of the data used in the implementation of DBP's model adequacy test, as applied to each of the relevant models it assesses.
- *Third*, discussion of DBP's calculation of the return on equity, and tests of the parameters of the relevant models used.

18. DBP also notes that a final estimate of the return on equity is not available due to the nature of the cross checks that DBP employed. DBP's approach focuses on an empirical test which is applied to all models, and extract from the rest results for all models, ranges of outcomes which can be shown, empirically, to be statistically unbiased and thus meet the Allowed Rate of Return Objective (**ARORO**). DBP then submits that that range is then passed forward to give a range of outcomes for the return on equity that can be shown to be statistically unbiased and thus meet the ARORO. DBP then considers that the range is narrowed by using the range of outcomes which arise from its consistency test between debt and equity, so that the outcome is both unbiased and consistent with the calculated cost of debt. DBP notes:[13]

> DBP's approach then is not a matter of simply calculating a point estimate value for each element of a single model – in the case of SL-CAPM, the beta, MRP and the risk-free rate. Indeed a key point of DBP's AA Proposal is that the AEMC required regulators to move away from this mechanistic approach and that regulators have largely ignored this aspect of the relevant recent rule change in both the development of rate of return guidelines and regulatory decisions made since the rule change in 2013.

12 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 42.

13 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Response to ERA Issues Paper, Submission: 26*, 2 June 2015, p. 5.

19. Each of the above key issues is discussed in turn below.

Principles and theory

20. DBP submits that evidence suggests that the Sharpe Lintner CAPM, as implemented by the Authority, is statistically downward biased. DBP contend that it is not sufficient for the Authority to exercise its judgment to apply an outcome at the higher end of the Sharpe Lintner CAPM model range, when it has conducted no adequate analysis to determine whether such an application would be sufficient to deal with the acknowledged downward bias of the preferred model.[14]

21. DBP argues that the problems associated with the application of the Sharpe Lintner CAPM (whether as implemented by the Authority or as that model has traditionally been implemented) suggest that other models have been rejected too quickly by the Authority. DBP considered that where all models have some flaws, then it is much more difficult to reject all but one of those models.[15]

22. DBP then concludes that unless other financial models can be demonstrated as being plainly irrelevant to determining the allowed rate of return, it will be necessary to include them in the staged analysis the Guidelines contemplate.[16]

23. DBP then proposes two means by which that may be done.[17]

> First, all potentially relevant financial models (that is, any model that cannot be relatively easily dismissed as being of no assistance whatsoever) could be included at Stage One, and worked through a process of analysis contemplated by the AEMC which assesses their relevance against the ARORO.
>
> Second, an alternative course would be to adopt the SL-CAPM as the foundation of the analysis and ascertain whether, as applied to a benchmark efficient entity with a similar degree of risk to that which applies to DBP in relation to the provision of the reference services, that achieves the allowed rate of return objective as required by NGR 87(2). In seeking then to apply that model, some adjustments would be required to seek to deal with the deficiencies that are shown to exist. Those adjustments may involve drawing upon other models.

24. DBP notes that the two approaches may really be doing the same thing and DBP adopted the first of these two approaches.[18]

Stage One - Identify relevant material and the role of that material

25. DBP argues that a financial model will be of utility in the exercise of directly estimating the return on equity in Stages Two and Three, if the following criteria can be met:[19]

[14] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 44.

[15] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 44.

[16] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 44.

[17] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 44.

[18] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 45.

[19] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 45.

a) the model can be shown to have a firm grounding in the relevant economic theory. That is, models that are proposed must have a solid theoretical underpinning in the literature, and/or have a sufficiently robust history of estimation in the literature. If they do not, then the models might be formed purely through some data-mining exercise and be unlikely to lead to robust, reliable results;

b) that the direct application of the model is demonstrably capable of contributing to the achievement of the ARORO and is consistent with the key principles and objectives govern the process - the RPPs and the NGO. That is, the empirical outcomes produced by a model can be shown to have sound predictive abilities in respect of the return on equity.

26. DBP then argues that if only the first of the two criteria are met, while the model may still be relevant, its role should be confined to performing a cross check of the outcome of models that pass both criteria above, which is done in Stage Four of the Authority's process.[20]

27. DBP is of the view that:[21]

> Our main point of departure from the ERA in deciding the relevant models to be used in Stages Two and Three is not in respect of the logic of our approach, but rather in the rigour of the criteria adopted to assess “relevance” and the role of relevant models in the estimation process.

28. DBP notes that the Authority has also identified criteria of relevance (i.e. models require a strong theoretical foundation). However, DBP argues that the second of DBP’s criteria – which involves an empirical assessment of models and their outputs is not expressly identified in any of the Authority’s criteria.[22]

29. DBP argues that the second criterion is critical for assessing the role that each relevant model will have in Stages Two and Three for a number of reasons. *First*, DBP considers that a model must not only be good in theory, but it must have sound predictive capability. *Second*, if the second criterion is not adopted, then the rejection of all other models at this Stage of the process is inconsistent with the requirements of the NGL and the NGR.[23]

A model’s relevance - theory and principle – first criterion

30. DBP has conducted an assessment to consider whether or not each of the models, including the Sharpe Lintner CAPM, the Black CAPM, the Fama-French model, and the Dividend Growth Model are relevant in theory and principle for determining a return on equity consistent with the ARORO. DBP notes that the Dividend Growth Model is not subject to DBP’s model adequacy test because it is difficult to obtain a long time series of relevant variables for this model.[24]

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20 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 46.

21 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 46.

22 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 46.

23 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 46.

24 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 47.

31. Based on CEG's report, DBP submits that the Black CAPM and Fama French model are both relevant models from at least a theoretical and principled basis, and should be considered to provide relevant information. In addition, DBP argue that existing empirical work suggests that empirical estimations of the Sharpe Lintner CAPM are unlikely to provide relevant information.[25] DBP then argues that reliance on a model which has theoretical support, buttressed by an ad-hoc adjustment to beta to address known problems of bias without ever testing the efficacy of this adjustment is unlikely to provide estimates of the return on equity which can be shown to meet the ARORO.

A model's role – the model adequacy test – second criterion

32. DBP submits that it has developed a step in the process (known as *the model adequacy test*) which involves taking each of the models that are relevant as a matter of theory and principle (i.e., Sharpe Lintner CAPM, the Black CAPM, and the Fama-French model), using them to forecast different points in time in the past, and comparing those forecasts to actual data. DBP submits that a model which, statistically, is shown not to be reliable in predicting actual outcomes (using historical data) seems unlikely to be appropriate as the sole relevant model going forward.[26]

33. DBP is of the view that:[27]

> The main purpose of using an asset pricing model, particularly in a regulatory context, lies in the ability of that model to predict the expected return on equity for the coming access period. An important question to ask, and indeed the question the ERA itself asked when using its Diebold Mariano tests is how well a model makes predictions about the required rate of return. The degree to which a prediction is "good" or "bad" could be a matter of precision; how close it gets to the "true" answer, and this is the basic premise behind the Diebold Mariano test.

DBP's Model Adequacy Test

34. DBP's model adequacy test proceeds as follows.[28] *First*, DBP takes a financial model and parameterises it using data up to a point in time. *Second*, DBP uses it to make a prediction on future returns. *Third*, DBP compares predicted with actual returns and records any error. *Fourth*, having done that, DBP then compares the errors over many periods and many different portfolios to understand whether they are, on average, zero.

35. In applying the models, DBP assumes that the available data are an adequate reflection of the states of the world likely to prevail for investors. DBP defines an "error" of the model as a difference between predicted and actual outcomes. DBP argues that, if the error of a model is on average statistically different from zero, then that bias is sufficiently significant. In that case, there is only a one or five per cent likelihood that the model could deliver an unbiased outcome. DBP argues that it is, in this respect, truly a model adequacy test; i.e. it does not show which models are

[25] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 48.

[26] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 49.

[27] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 50.

[28] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 51.

best, but rather identifies those financial models which, without material adjustment, could not deliver an NPV=0 outcome.[29]

36. DBP also submits that the statistical tests being used to test for bias are the t-test (for individual portfolios) and the Mincer-Zarnowitz (1969) and Wald test (for a collection of portfolios.

37. DBP considers that:[30]

> "Models" tested in the above approach need not be simply "the SL-CAPM", or "the Black CAPM", but could be combinations of models (say a model which uses these two models with a 60/40 weighting) or particular ways of implementing a model. As an example, we test the SL-CAPM using the 95th per centile of an estimate of the distribution of an ordinary least squares (OLS) estimator for beta rather than an estimate of the mean of the distribution (the OLS point estimate). We use the 95th percentile because this is the way the ERA has implemented the SL-CAPM and it has done so purportedly to remove the downward bias associated with estimates of the return on equity that the SL CAPM produces for low-beta stocks. In what follows, for simplicity, we will label these estimates, "95th per centile estimates of beta". All that is required is that models be formed in such a way that can be generalised. It is worthwhile noting that, at no point in time do we find a problem, propose a solution and then assert that this solution has solved the relevant problem; every solution becomes a new model, which is tested in exactly the same way.

38. Based on the above findings from its model adequacy test, DBP concludes that the Fama French model is not an adequate model to use in Stages Two and Three. DBP considers that this model (in addition to the Sharpe Lintner CAPM, which is also found not relevant) might play a role as cross checks, but should not play a role in the estimation of the return on equity in Stages Two and Three of the Authority's process.[31]

A final model: the Black CAPM

39. DBP advises that two things guide it in determining the final model to be used: (i) a model with statistical robustness; and (ii) a model that departs as little as possible from the ERA's Guidelines.[32]

40. On the basis of its so-called "model adequacy test" (to test the predictive capacity of the models), DBP submits that only Black CAPM passes this test and the model then becomes relevant for the purpose of estimating a return on equity.

41. In addition, DBP is of the view that:[33]

> In principle, we could have implemented the Black CAPM directly. We might also have used adaptations of the FFM (like using different points on confidence intervals for its betas, or forming the portfolios in a way more favourable to the model). However, doing

[29] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 51.

[30] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 51

[31] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 66.

[32] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 67.

[33] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 67.

so would have involved a more significant departure from the Guidelines than is perhaps necessary. Instead, we have endeavoured to maintain the basic framework of the SL-CAPM, whilst using information from the results we obtain above for the Black CAPM. This involves adjusting the estimate of beta by more than choosing a different point on a confidence interval for the parameter.

42. Starting with the Sharpe Lintner CAPM, DBP replaces beta by the so-called *Betastar* which can be expressed as shown in equation 1 below: [34]

$$\beta^*_{jt} = \left(1 - \frac{\hat{z}_{0t}}{\hat{z}_{mt}}\right)\hat{\beta}_{jt} + \frac{\hat{z}_{0t}}{\hat{z}_{mt}} \qquad (1)$$

where:

- z_{0t} is an estimate of the zero-beta premium computed using data from before month t;
- z_{mt} is an estimate of the market risk premium computed using data from before month t; and
- β_{jt} is an estimate of the beta of portfolio j computed using data from before month t

43. DBP submits that a forecast of the return required on portfolio j in excess of the risk-free rate that uses a bias-adjusted beta estimate is:

$$\hat{z}_{jt} = \beta^*_{jt}\,\hat{z}_{mt} \qquad (2)$$

44. Substituting *Betastar* as presented above into this equation and the following final equation is derived:

$$\hat{z}_{jt} = \hat{z}_{0t} + \hat{\beta}_{jt}\left(\hat{z}_{mt} - \hat{z}_{0t}\right) \qquad (3)$$

45. DBP notes that the above equation expresses a forecast of the return required on portfolio j in excess of the risk-free rate that uses an empirical version of the Black CAPM.[35]

46. DBP submits that:[36]

In making use of the framework or formula of the SL-CAPM in this way, whilst incorporating key information not gleaned from empirical estimation of parameters of the SL-CAPM (namely the empirical beta), we are not in fact making a significant departure from regulatory practice. Despite different regulators starting a process of

34 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 68.

35 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 68.

36 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 68.

empirical estimation of beta in 2009 (Henry, 2009), regulators have not historically used these empirically-estimated betas, but have instead used the formula of the SL-CAPM substituting in their own beta estimates formed by other means. For example, in DBP's last access arrangement, despite acknowledging the work of the AER in obtaining empirical estimates of beta that suggested a range of 0.4 to 0.7, the ERA chose to continue its past practice of using a beta of 0.8 (ERA, 2011, paragraph 486-82).

47. DBP then concludes that:[37]

> Our approach of using the SL-CAPM formula and a beta formed exogenous to the SL-CAPM is no different from standard practice amongst regulators and in the wider commercial world, except that we have chosen **a particular means of adjusting beta which we can show has a solid theoretical basis,** and we actually test the results of our model formed in this way. [emphasis added]

48. To form a range for Betastar, DBP selects the 20th percentile and the 99th percentile and the results are presented below.[38]

Table 1 Beta and Betastar

Estimate Type	Estimate
Beta	0.55
Betastar	1.11
20th percentile of betastar (lower bound of unbiased results)	0.94
99th percentile of betastar (upper bound of unbiased results)	1.57

Source: DBP analysis. Note that the standard error for betastar is 0.195

49. Further details of the DBP's model are summarised in Appendix 4A.

Stages Two and Three - Identifying parameter values and estimating the return on equity

50. DBP submits that it is important to keep information "live" through the process, and only exercise judgment at the end.[39] DBP argues that the judgment should be exercised, as far as possible, at the end of the process of assessment. In simple terms, the regulator should allow the data to carry it as far as it is possible to go with the data alone, before a reasonable range is arrived at for the rate of return:[40]

> We acknowledge that finance data has a very low signal to noise ratio and that the data alone will never deliver a point estimate of the overall rate of return for equity. There will always be a need for a regulator to pick a point from a range, and this will always be an issue of regulatory judgment. However, this judgment should be exercised, as far as possible, at the end of the process of assessment.

37 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 69.

38 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 77.

39 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 52.

40 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 53.

51. DBP then advises that:[41]

> Accordingly, at Stages Two and Three, we form estimates that are ranges, and bring these ranges forward into our assessment at Stage Four.

52. However, DBP advises that both the risk free rate and the MRP are carried forward based on the point estimates:[42]

> As with the MRP, DBP propose that this [risk free rate] be carried forward as a point estimate to Stage Three of the estimation process, meaning the range for the return on equity is formed by the range in beta.

Stage Four - cross checks

53. DBP submits that:[43]

> In respect of Stage Four in the ERA's five-stage process, we make one departure, and one addition to the Guidelines. The departure involves the assessment of parameter estimates within given models. We believe assessment of parameter estimates in their own right is important, but we consider this more logically fits into Stage Two of the ERA's process where parameter estimates are made in the first instance. This would be particularly important if, at some stage in the future, multiple models are estimated at Stage Three, and then weighted to form a final estimate of the return on equity which is tested at the ERA's Stage Four, because it may be difficult to ascertain at Stage Four whether it is parameter estimates or models which cause problems in the cross check stage if the models have been amalgamated into some kind of weighted average.
>
> Thus, we consider checks of parameters as part of the process of Stage Two, and leave assessment of overall model results (and/or other data) to Stage Four. We consider this a minor change because the relevant checks still occur at some stage, and this is the most crucial element.

54. DBP argues that some of the cross checks adopted by the Authority are not cross checks per se but rather are directly relevant only to inputs to the Sharpe Lintner CAPM.[44]

55. DBP then submits that:[45]

> We do reach firm conclusions about how this check should be implemented in practice, and have devoted part of Chapter 6 to describing our conclusions about how the premium on risky debt can be used to check model results for the premium on risky equity, and vice versa.

Model outputs as cross checks

56. DBP reports a range of model results as one set of cross checks (Table 2).

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[41] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 53.

[42] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 81.

[43] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 53.

[44] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 54.

[45] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 55.

Table 2 DBP's model results for cross check

Source	Result
Jemena proposal	
SL-CAPM	10.01%
Black CAPM	10.62%
Fama-French Model	10.87%
Dividend Discount Model	10.92%
ATCO proposal	
Required return for average firm on the market	11.2%
SL-CAPM	9.9%
Fama-French Model	10.8%
Dividend Discount Model	10.9%
Previous ERA regulatory decisions for ATCO	10.41 - 12.72%
GGT proposal	
GGT model	12.28%
SFG range from return on debt	9.66-12.97%
Incenta on expert assessments of low beta firms	9.6 to 14.3% (average = 11.8%)
Actual returns for Portfolios One and Three (betas of 0.53 and 0.57 respectively)	7.5 to 8.2 percentage points above 10-year risk-free rate (11.04 to 11.74% with current risk-free rate of 3.54%) (Table 5)
Ernst & Young (2012) review of independent experts	2.2% above AER regulatory decisions (AER Jemena: 8.1+2.2=10.3%)
SFG (2013) review of independent experts	1-2% above "mechanistic" SL-CAPM (implies for AER Jemena 9.1% to 10.1%)

Source: Jemena (2014), ATCO (2014), Ernst & Young (2012), Incenta (2014)

57. DBP submits that the Black CAPM, as implemented through its own betastar model, is relevant given its model adequacy test, and is therefore used for calculating the permissible ranges of the return on equity in stages two and three of the Authority's process.

58. In addition, DBP considers that:[46]

> The SL-CAPM has relevance as a theoretical model, but the extent of the downward bias means that empirical estimates using it have limited relevance even as a cross-check. Other models are of some relevance as a part of the cross-checking process, particularly the Fama-French model (which, whilst not a perfect model, does not suffer from the problems of bias which affect the SL-CAPM (as that model is applied in the traditional sense or in the way the ERA has applied it in the guidelines). The DGM (which we did not test) is also a relevant model for the purposes of cross checking the reasonableness of the return on equity. Moreover, estimates made by market professionals, such as brokers, may also have relevance as cross-checks, and the actual returns made by firms with the same level of systematic risk as the BEE ought also to be considered relevant as a cross check.

46 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 55.

Consistency between debt and equity

59. DBP submits that achieving the ARORO requires a consideration of the interrelationship between the return on debt and the return on equity.[47] DBP considered that, at the very least, each of NGR 87(5)(b) and (c), suggest some degree of consistency or similarity of approach to estimating the return on equity and the return on debt.

60. DBP argues that this view is also consistent with the approach preferred by the AEMC that, in determining the allowed rate of return, the Authority is required to consider how the return on debt and the return on equity combine to create the allowed rate of return and that the two components are not to be considered in isolation.[48]

61. DBP engages SFG to provide expert advice in relation to the relationship between the cost of debt and the return on equity. SFG argues that the linkage between the required return on debt and equity to the benchmark firm appears to be central to the NGR 87(5) requirements to have regard to all relevant evidence, consistency, and interrelationships between parameters for equity and debt.[49]

62. Based on its analysis, DBP ascribes to SFG's conclusion that, given the debt risk premium, internal consistency requires that the equity risk premium must be at least 6.0 per cent.[50]

63. Further details of the SFG's analysis with respect to the relationship between the cost of debt and the return on equity are presented in Appendix 4C of this Draft Decision.[51]

SFG's approach

64. In its report exploring the relationship between the required return on debt and equity, prepared for DBP in December 2014, SFG argues that:[52]

> There is an interrelationship between the return on equity and the return on debt because both equity and debt securities depend on the assets of the same firm. Debt and equity simply represent different claims over the same assets. Consequently, there is an interrelationship between the return on equity and the return on debt, the estimate of one is relevant to the estimate of the other, and the two estimates must be consistent with each other.

65. SFG also observes that the linkage between the required returns on debt and equity in the same benchmark firm appears to be central to the NGR 87(5) requirements to

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47 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 85.

48 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 84.

49 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 1.

50 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 18.

51 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 1.

52 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 1.

have regard to all relevant evidence, consistency, and interrelationships between parameters for equity and debt.[53]

66. SFG references Merton (1974), reporting his conclusion that equity and debt are contingent claims over the assets of the same firm. Both become less valuable as the assets of the firm decline in value and both become more valuable as the assets of the firm rise in value. Both are linked to the value of the assets of the firm. Thus, if there are certain factors that drive changes in the value of the assets of the firm, those same factors will drive the returns to debt and equity in that firm. SFG argue that this means that there is a positive relationship between the return on debt and the return on equity in the same firm.[54]

67. SFG agrees with the Authority's decision that a return on equity should exceed the return on debt and that prevailing market conditions should also be taken into account when determining whether the relativities between the return on debt and equity are reasonable at the time regulatory decisions are made. However, SFG argue that:[55]

> Such a comparison is one of the necessary preconditions for consistency – given that equity in the benchmark firm must be riskier than debt in the same benchmark firm at the same point in time, it must be the case that the required return on equity is higher than the required return on debt. However, this is not a sufficient condition for consistency – it is possible that the estimates of the required returns on equity and debt are inconsistent even though the return on equity is higher than the return on debt.

68. SFG advises that – based on Merton (1974) model – equity is considered as a call option on the value of the firm. SFG note that Merton (1974) models the equity of a firm as a call option on the firm's assets, with a strike price equal to the face value of the firm's debt.[56]

69. In addition, SFG notes that debt is considered as a put option on the value of the firm. SFG observe that lenders to a firm can be modelled as owning a riskless bond and being short (i.e. having sold) a put option on the firm assets.[57]

Modern application of the contingent claims framework

70. SFG considers that one of the key insights of the Merton framework is that the equity risk premium and the debt risk premium, as illustrated in Campello, Chen and Zhang (2008) paper, must be linked by:[58]

$$E\left[r_e\right]-r_f=\Omega_{e,d}\left(E\left[r_d\right]-r_f\right) \tag{4}$$

[53] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 1.

[54] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 2.

[55] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 4.

[56] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 6.

[57] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 6.

[58] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 6.

Where $\Omega_{e,d}$ represents for the elasticity of equity relative to debt:

$$\Omega_{e,d} = \frac{\partial E/E}{\partial D/D} \tag{5}$$

71. In addition, SFG reports that Friewald, Wagner and Zechner (2013) examined the relationship between returns on debt and equity within the Merton framework. SFG consider that, from this study, the elasticity is equal to the ratio of the volatilities:

$$\Omega_{e,d} = \frac{\sigma_e}{\sigma_d} \tag{6}$$

72. Based on the above considerations, SFG concludes that:[59]

> The linkage between the required returns on debt and equity in the same benchmark firm appears to be central to the NGR 87(5) requirements to have regard to all relevant evidence, consistency, and interrelationships between parameters for equity and debt. The Merton model provides the standard framework for modelling the linkage between the required returns on debt and equity in the same firm. The Merton framework shows that there are clear linkages between the required return on equity, the required return on debt, the elasticity between equity and debt and the relative volatilities of equity and debt.

73. SFG then argues that the above framework can be used in a regulatory setting as a check of the consistency between the allowed return on equity, a check of the interrelationships between parameters that are common to the return on equity and the return on debt, and as a check on the overall reasonableness of the allowed return on equity relative to the allowed return on debt.[60]

74. SFG proposes two different approaches in which the checks can be performed. *First*, an allowed return on debt and an empirical estimate of elasticity jointly provide information about what would be a reasonable range for the required return on equity. *Second*, an allowed return on debt and an allowed return on equity jointly imply a particular elasticity, which can then be tested against elasticity benchmarks for the regulated firm.[61]

75. In its report, SFG emphasises that it does not suggest that this framework can be used to obtain a single point estimate of the required return on equity from the analysis of primary data.[62] SFG argued that the Merton framework is very useful when considering the relationship between the required return on equity and the required return on debt for the same firm and that this framework provides valuable insights into the relativity between these two quantities.[63]

59 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 13.

60 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 13.

61 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 14.

62 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 14.

63 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 14.

SFG's estimation

76. SFG reports that the Schaefer and Strebulaev (2008) paper empirically examined the ability of the Merton model to explain the relationship between equity and debt risk premiums in the same firm. In this study, the so-called "hedge ratio", which is the inverse of the Merton elasticity, is presented:

$$h_e = \frac{\partial E/E}{\partial D/D} = \frac{1}{\Omega_{e,d}} \tag{7}$$

77. It follows that:

$$h_e = \left(\frac{1}{\Delta} - 1\right)\left(\frac{1}{L} - 1\right) \tag{8}$$

where Δ represents the derivative of equity value with respect to the value of the assets of the firm and L is the market value leverage.

78. SFG considers that, within the Merton framework, the Δ parameter is in the form of the standard call option delta originally derived by Black and Scholes (1973):

$$\Delta = N(d_1) \tag{9}$$

where $N(\bullet)$ represents the cumulative normal distribution function and:

$$d_1 = \frac{\ln(V/D) + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}} \tag{10}$$

where V is the value of the firm, D is the face value of the firm's debt, T is the time to maturity of the firm's debt, and σ is the volatility of the return on the firm's assets.

79. SFG then concludes that the Merton elasticity (which is the inverse of the hedge ratio) varies directly with the equity delta and market value leverage.[64]

80. SFG uses the Schaefer and Strebulaev (2008) approach to estimate Merton hedge ratios for a range of input parameters. SFG's base case parameter estimates include:[65]

- a risk free rate of 3.6 per cent;
- an amount of debt of 60 per cent of the value of the assets of the firm;
- a term of debt of 10 years; and
- the volatility of 40 per cent – on the return on the firm's assets.

64 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 14.

65 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 14.

81. SFG then presents its estimates of the elasticity in three scenarios: (i) the elasticity is sensitive to the term of debt and to the risk-free rate; (ii) the elasticity is also sensitive to the volatility of the returns on the firm's assets; and (iii) for debt of 10 years, the elasticity is sensitive to the risk-free rate and volatility.[66]

82. Based on its estimates for the above three scenarios, SFG concludes that there is no reasonable combination of parameters that produces an elasticity parameter value below 6.0. In addition, SFG argues that this places a constraint on the relativity between the expected returns on debt and equity.[67]

SFG's application of the above estimate of the elasticity to the regulatory framework

83. SFG considers that 6 is a reasonable lower bound for elasticity.[68]

84. SFG uses the Authority's cost of debt from its Draft Decision on ATCO of 5.2 per cent, including a spread of 1.80 per cent.[69] SFG argues that the 1.8 per cent represents a promised spread and not an expected spread. As such, SFG considers that the promised spread of 1.80 per cent can be converted into the expected spread via a deduction for expected default.

85. Using Standard & Poor's default rate on BBB+ corporate bonds of 0.15 per cent per year over the last 30 years, together with an average recovery rate of 50 per cent for BBB+ corporate bonds, SFG's calculations indicate that the expected return on debt is 4.4 per cent.[70]

86. SFG then concludes that the adjustment for expected default is 0.8 per cent, which is the difference between the cost of debt of 5.2 per cent and the expected return on debt of 4.4 per cent. SFG argues that the adjusted debt spread, or the expected return on debt is 1 per cent, which is the difference between the spread of 1.8 per cent and the adjustment for expected default of 0.8 per cent.[71]

87. Based on the above considerations, SFG quantifies the lower bound reasonableness test is as follows.

$$E[r_e]-r_f > \Omega_{\min}\left(E[r_d]-r_f\right)_{\min} \tag{11}$$

$$E[r_e]-r_f > 6\times 1.0\% = 6.0\%.$$

66 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 16.

67 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 17.

68 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 17.

69 The Authority notes that the estimate of 1.80 per cent, which is the estimated 10 year spread to swap, does not represent for a debt risk premium in the calculation of the WACC. The Authority's calculation indicated that the (regulated) debt risk premium is 2.27 per cent, which is the difference between the 10-year cost of debt of 5.215 per cent and the estimated 5-year risk free rate of 2.95 per cent (paragraph 895 on page 202 of the Authority's Draft Decision on ATCO).

70 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 18.

71 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 18.

88. SFG then concludes that, given the debt risk premium, internal consistency requires that the equity risk premium must be at least 6.0 per cent.[72]

SFG's application of its proposed framework to the DBP submission

89. SFG notes that it was instructed by DBP that its proposed total cost of debt is within the range of 5.66 per cent to 5.77 per cent (net of any new issue premium and the 15 basis points for debt issuance costs). SFG then considers the following calculations to derive the equity risk premium for DBP.[73]

90. *First*, a range of the debt risk premium of 2.13 per cent to 2.24 per cent is calculated. This range is based from the cost of debt of 5.66 per cent to 5.77 per cent and the risk-free rate of 3.54 per cent.

91. *Second,* using the same 0.82 per cent adjustment for expected default, the expected debt risk premium falls within the range of 1.31 per cent to 1.42 per cent.

92. *Third,* multiplying the expected DRP by its lower bound elasticity estimate of 6.0, SFG's calculation indicates that the equity risk premium falls within the range of 7.86 per cent to 8.52 per cent.

93. Using the risk free rate of 3.54 per cent, the above range of the equity risk premium of 7.86 per cent to 8.52 per cent, SFG infers that the range of return on equity for DBP must be 11.4 per cent and 12.06 per cent.

94. DBP contends that its analyses indicate that the range of unbiased model outcomes of the return on equity is from 9.67 to 13.72 per cent. In addition, DBP suggests that the allowed return on debt ranges from 5.66 to 5.77 per cent (without the premium for debt issuance and hedging or the new issue premium), which translates into an expected debt risk premium of between 131 and 142 bps once the risk free rate (3.54 per cent) and default premium (82 bps) are subtracted.[74]

95. DBP concludes that this intersection, as represented below in Figure 1, represents the range of estimates of the return on equity that are both unbiased and consistent with the return on debt.[75]

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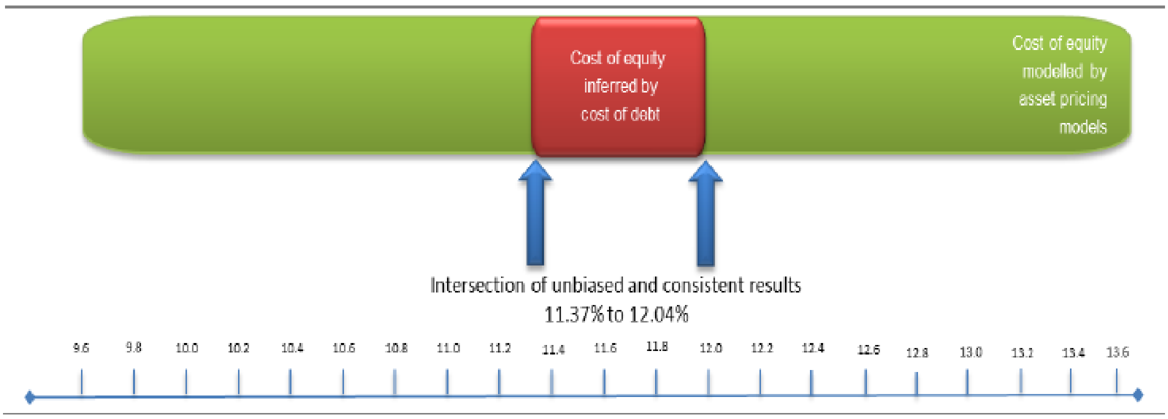
72 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 18.

73 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, Appendix L, p. 18.

74 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. 89.

75 DBNGP Transmission Pty Ltd, Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12, 31 December 2014, p. 89.

Figure 1 DBP's Return on equity from unbiased asset pricing models and inferred from return on debt



96.

Source: Figure 10, DBP's Proposed Revisions DBNGP Access Arrangement, page 89.

97. DBP then concludes that:[76]

> The true return on equity, which is unbiased and consistent with the return on debt, lies in the portion of the [range] indicated by the arrows in Figure 10 [Figure 1 above]. One could choose any point in this range and, on the strength of the data alone, reach equally valid conclusion. We choose the mean, which leads to a point estimate for the return on equity that is both unbiased and consistent of 11.71 per cent.

Return on debt

98. In relation to the return on debt, DBP adopts the Authority's revised method for estimating the annual debt risk premium (**DRP**) which was set out in the ATCO GDS Draft Decision, with:

- the benchmark sample of bonds based on non-financial domestic and international bonds with a BBB-/BBB/BBB+ credit rating;
- the 10 year DRP estimate determined as the average of three yield curve methods (the Gaussian Kernel, Nelson Siegel and Nelson Siegel Svennson methods).

99. However, DBP diverges from the Authority's Rate of Return Guidelines (and the recent ATCO GDS decision) by:[77]

- using a ten-year risk free rate instead of the five-year rate;
- utilising a ten year trailing average for both the risk free rate and the DRP, which is annually updated;
    - with the annual updating approach based on the methodology outlined by the Australian Energy Regulator in its rate of return guidelines;
    - albeit, modified slightly such that, not only is there a ten-year transition period at the outset of the switch to this new approach, but every block of capital expenditure made in an access arrangement period in

[76] DBNGP Transmission Pty Ltd, Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12, 31 December 2014, p. 89.

[77] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 20.

excess of a certain threshold (being a tenth of the capital base) itself has a ten-year transition period;

- adding 15 basis points for debt-raising and hedging costs;[78] although there is some apparent confusion here, as:
  - DBP suggest elsewhere that it does not require or include swaps costs, which are a key component in hedging, given that it is adopting a ten year term;[79]
  - DBP in its later submission on the Issues Paper then submits that it considers that 46.5 basis points is the appropriate value, based on advice from UBS:[80]

> The correct total, according to expert advice from UBS, is 60 to 63.9 basis points. If the return on debt data include conversion factors, then the true cost of debt, as distinct from the return on debt earned by investors, would be 46.5 basis points above the value determined from a yield curve model that uses Bloomberg or similar data as an input.

- adding a new issue premium of 27 basis points to the resulting annual return on debt.

100. The resulting quoted illustrative return on debt, as at the averaging period of 30 September 2014, is 6.13 per cent (nominal pre-tax – excluding the flagged change in hedging costs).[81]

Inflation

101. In relation to other matters, DBP advise that while it adopts the same approach in relation to the method for estimating inflation as set out in the Guidelines, it has used more than two bonds to undertake the linear interpolation (and adopts the same approach when it estimates the risk-free rate).[82]

102. DBP submit:[83]

> …the ERA has used an inflation rate that reflects the difference between the two bonds at the end of the period. This need not reflect inflation through the period. For example, if inflation were expected to surge for a period of time, and then return to the mean, this could be seen by applying a linear interpolation approach in each year of the access period, but would be hidden if only the final year were used. This could result in errors in inflation estimation.
>
> Our approach has therefore been to follow exactly the same approach as the ERA proposes in its Guidelines; making use of linear interpolation where the weights for each bond reflect the distance from the target date of that bond's maturity, and the Fischer equation to do the inflation calculation.

78 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. iv.

79 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020, Response to ERA Issues Paper, Submission 26*, 31 December 2014, p. 11.

80 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020, Response to ERA Issues Paper, Submission 26*, 31 December 2014, p. 11.

81 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2014, p. ii.

82 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. iii.

83 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 96.

> The only differences are that we use all government bonds and not just the two maturing closest to the end of the access period (with progressively lower weights for those expiring further from the target date), and we do an inflation calculation quarterly (using the same linear interpolation approach and Fischer equation), not once for the whole five years.

103. That gives rise to an inflation estimate that differs for each forecast year (Table 3). DBP suggest that its results are slightly smaller than those of the Authority, suggesting:[84]

> The differences arise because the market (as expressed by the difference in the relevant indexed and non-indexed bonds) clearly believes that inflation will be lower at the start of the next access period than at the end. By using only the one interpolation at the end of the access period, the ERA has slightly over-estimated the cost of inflation.

84 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 97.

Table 3 DBP's proposed annual inflation estimates

	Quarterly (annualised) rates	Annual averages
Dec-14	2.05	2.05
Mar-15	2.03	
Jun-15	2.02	
Sep-15	2.02	2.02
Dec-15	2.02	
Mar-16	2.03	
Jun-16	2.03	
Sep-16	2.04	2.04
Dec-16	2.05	
Mar-17	2.06	
Jun-17	2.08	
Sep-17	2.09	2.09
Dec-17	2.11	
Mar-18	2.13	
Jun-18	2.15	
Sep-18	2.17	2.16
Dec-18	2.19	
Mar-19	2.19	
Jun-19	2.21	
Sep-19	2.23	2.22
Dec-19	2.25	
Mar-20	2.27	
Jun-20	2.29	
Sep-20	2.30	2.30
Dec-20	2.32	

Source: DBP analysis

Proposed rate of return

104. In revisions to the Access Arrangement, DBP propose an allowed post tax nominal rate of return for the benchmark efficient entity of 8.36 per cent (as at 30 September 2014).

105. With debt gearing of 60 per cent, DBP's proposed nominal rate of return is a weighted average of:

- a return on equity of 11.71 per cent; and
- a return on debt of 6.13 per cent.

Submissions

106. The Authority received a number of submissions on DBP's proposed revisions which referenced issues related to the rate of return. These submission are available on the Authority's website.

107. In summary:

- Wesfarmers Chemicals, Energy and Fertilisers (**WESCEF**) consider that the rate of return proposed by DBP is high in comparison to other regulatory decisions.[85] Specific points include:
  - DBP has used the highest estimate of the four models for the DRP;
  - DBP has included non-energy stocks in the sample used to estimate the return on equity, which is not appropriate, as it does not reflect the risk of the asset; and
  - WESCEF does not support the use of the Black CAPM as it is contrary to the most widely used and supported Sharpe Lintner CAPM model as recommended in the ERA Rate of Return Guidelines. WESCEF is surprised that DBP is proposing using a model other than Sharpe Lintner CAPM as all information provided by DBP to WESCEF in the last 12 months during shipper contract renegotiations used the Sharpe Lintner CAPM model. WESCEF suggests that the ERA requests DBP to advise the reason for the change in the use of model in the last 12 months.
- Alinta is concerned that DBP's proposed approach of annually updating the return on debt within the access period, following the method of the AER, may result in volatility for end use customers. Alinta consider that increased volatility will ultimately flow through to end use customers via higher and potentially more volatile prices.[86]
- BHPB consider that there is no cause to depart from the Guidelines when setting the return on equity. With regard to the return on debt, BHPB supports DBP's proposal for a trailing average that includes a transition and which is based on the AER's estimation and annual updating method. BHPB's preference is for precise weighting, even at the expense of complexity.[87]
- United Energy and Multinet Gas (**UEMG**) submitted two papers it considered were relevant to the Authority's decision:[88]
  - the first by Esquant Statistical Consulting examines the properties of methods to extrapolate the Reserve Bank of Australia's Gaussian Kernel estimates of the debt risk premium; and

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85 Wesfarmers Chemicals, Energy & Fertilisers, *Re: Wesfarmers Chemicals, Energy & Fertilisers submission on the proposed Dampier to Bunbury Natural Gas Pipeline Access Arrangement (2016-2020)*, 2 June 2015.

86 Alinta Energy, *Issues Paper – Proposed Revisions to the Dampier to Bunbury Natural Gas Pipeline Access Arrangement 2016-2020: Alinta Energy Submission*, 2 June 2015.

87 BHP Billiton, *Public Submission By BHP Billiton In response to DBNGP (WA) Transmission Pty Ltd's proposed revisions to the Dampier to Bunbury Natural Gas Pipeline Access Arrangement*, 21 May 2015.

88 United Energy and Multinet Gas, *DBNGP (WA) Transmission Ptd Ltd (DBP): Response to Issues Paper on Proposed Revisions to the Dampier to Bunbury Natural Gas Pipeline Access Arrangement, 2016 – 2020*, 2 June 2015.

- the second by NERA develops econometric evidence for the capitalisation of the value of imputation credits in stock prices.

- CITIC Pacific Mining Management (**CPMM**) considers that the rate of return should be estimated consistent with the method set out in the Guidelines. CPMM does not agree with DBP's proposed approach with regard to the term of the risk free rate, the application of a new issue premium, the use of the Black CAPM, or by corollary, the estimation of beta.[89]

- DBP submitted a number of clarifications with regard to DBP positions reported in the Issues Paper.[90] DBP also submitted 'new information', relating to matters in the Issues Paper, which it considered was not available at the time it submitted its proposed revisions. That included commissioned reports by:
  - UBS on hedging costs; and
  - NERA on the cost of equity.

Considerations of the Authority

108. The Authority does not agree with DBP's approach for estimating the rate of return. This approach does not comply with the Authority's *Rate of Return Guidelines*[91] and neither is it consistent with subsequent amendments recently applied as a result of the ATCO GDS Final Decision,[92] which the Authority considers to be correctly aligned with the regulatory requirements for the rate of return as specified in the NGR.[93]

109. In its Rate of Return Guidelines released in December 2013, the Authority set out the criteria it would use to assess the appropriateness of the proposed approach/model to be utilised in estimating the inputs of the rate of return. The Authority is of the view that it is appropriate to utilise these criteria to assess the approach proposed by SFG in estimating the return on equity for DBP.

110. The Authority considers that the criteria necessarily need to be consistent with the requirements of the NGL, the NGO, the NGR and the allowed rate of return objective. The requirements of the NGL, the NGO, the NGR and the allowed rate of return objective have primacy at all times. The criteria allow the Authority to articulate its interpretation of these requirements set out in the NGL and the NGR.

111. As indicated in the Rate of Return Guidelines, the Authority was of the view that the criteria, which are reproduced below, are not intended to supplant the NGL and NGR. Rather they are subordinate to the requirements set out in the two instruments. That said, the Authority considers it desirable if the proposed rate of return methods are:

- driven by economic principles;

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89 CITIC Pacific Mining Management, *Public Submission in response to the Economic Regulation Authority's Issues Paper on Proposed Revisions to the Dampier to Bunbury Natural Gas Pipeline Access Arrangement 2016 – 2020*, 2 June 2015.

90 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Response to ERA Issues Paper Submission 26*, 2 June 2015.

91 Economic Regulation Authority, *Rate of Return Guidelines*, 16 December 2013.

92 Economic Regulatory Authority*, Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems*, as amended 10 September 2015.

93 Economic Regulatory Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems*, as amended 10 September 2015.

  - based on a strong theoretical foundation, informed by empirical analysis;

- fit for purpose;
  - able to perform well in estimating the cost of debt and the return on equity over the regulatory years of the access arrangement period;
  - implemented in accordance with best practice;
- supported by robust, transparent and replicable analysis that is derived from available, credible datasets;
  - based on quantitative modelling that is sufficiently robust as to not be unduly sensitive to small changes in the input data;
  - based on quantitative modelling which avoids arbitrary filtering or adjustment of data, which does not have a sound rationale;
- capable of reflecting changes in market conditions and able to incorporate new information as it becomes available;
- supportive of specific regulatory aims; and thereby:
  - recognise the desirability of consistent approaches to regulation across industries, so as to promote economic efficiency;
  - seek to achieve rates of return that would be consistent with the outcomes of efficient, effectively competitive markets;
  - as far as possible, ensure that the net present value of returns is sufficient to cover a service provider's efficient expenditures (the 'NPV=0' condition);
  - provide incentives to finance efficiently;
  - promote simple approaches to estimating the rate of return over complex approaches where appropriate;
  - promote reasoned, predictable and transparent decision making;
  - enhance the credibility and acceptability of a decision.

112. The Authority does not accept DBP's claim that the criteria do not account for the prediction performance of the relevant models – the second and fourth criteria clearly address this issue.

113. The following sub-sections outline the Authority's considerations with regard to DBP's approach to estimating the rate of return, with specific regard to its estimates of:

- gearing
- the risk free rate;
- the return on equity;
  - beta
  - the market risk premium; and

- the return on debt;
  - estimating the debt risk premium;
  - hedging and other transactions costs.

Gearing

114. The Authority accepts DBP's proposed gearing of 60 per cent debt, 40 per cent equity, as it is consistent with assumptions in the Guidelines.

Risk free rate

115. The key issues for the estimate of the risk free rate are:

- the term of the estimate;
- the method of estimating the risk free rate; and
- the averaging period.

The term of the risk free rate

116. The Authority considers that, in order to ensure NPV = 0 (or the **present value condition**), the appropriate term for the risk free rate in the current regulatory setting should be 5 years. This follows because the rate of return is reset every 5 years, concomitant with the term of the access arrangement.

117. The Authority's detailed consideration of this issue was set out in the Rate of Return Guidelines.[94] The Authority conclusions with regard to the term were based on the work of Lally and Davis.

118. The Authority notes that it took account, in the final draft of the Rate of Return Guidelines, of an extensive critique by DBP and others on this material and the Authority's interpretation of it.[95]

119. The Authority recently engaged Lally to undertake a review of its conclusions in the Rate of Return Guidelines. Lally noted a small number of relatively minor points with regard to the Authority's interpretation, but otherwise concurred with the Authority's analysis and conclusions. That analysis included the response by the Authority to the submitted views of DBP.[96]

120. However, DBP in its access arrangement proposal takes further issue with the same material from Lally. At the core of the DBP critique is the following:[97]

> The most important assumption in this respect is that which Lally makes about the terminal value of the asset. Like a government bond, he assumes that the value of the asset at the end of the AA period (two AA periods in his model) is known with certainty

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94 Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, Appendix 2.

95 DBNGP (WA) Transmission Pty Ltd 2013, *ERA Draft Rate of Return Guidelines: DBP Response*, 23 September, pp. 36 – 39.

96 M. Lally, *Review of arguments on the term of the risk free rate*, 20 November 2015, p. 3.

97 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 14.

at the outset.[98] If this were true, Lally's model would hold, and this would justify the use of a tenor for determining the interest rate that matches the five-year AA period as the service provider would earn a "certain" (except for demand risk) revenue through the AA period and would then receive a certain terminal payment at the end of the access period, just as occurs with government bonds. However, if this assumption does not hold, then the NPV=0 condition is not met by using interest rates reflective of the five-year regulatory term, but requires the use of a longer-term rate that reflects the uncertainty of cashflows occurring after the conclusion of the current access period which affect the terminal value of the asset at the conclusion of this access period.

121. DBP engaged SFG Consulting to consider these matters. SFG key points are as follows:[99]

- The present value principle only suggests that the term of the allowed return should be matched to the length of the regulatory period in the case where the market value of the regulated asset at the end of the regulatory period is known for sure from the outset. This is because the asset can be valued as the present value of cash flows over the regulatory period only (one of which is the known end-of-period market value of the asset).
- If the end-of-period market value of the asset is not known with certainty from the outset, the present value principle does not imply that the term of the allowed return should match the length of the regulatory period. This is because the asset cannot be valued as the present value of the cash flows over the regulatory period;
- Where the end-of-period market value of the asset is not known with certainty from the outset, the asset would be valued as the present value of the cash flows to be generated over the life of the asset. In this case a long-term discount rate would be used and therefore the allowed return should be set on the basis of a long-term rate;
- The dominant commercial practice is to use a long-term discount rate, even when valuing regulated infrastructure assets where the regulator sets allowed returns based on a shorter-term rate;
- The vast majority of regulated infrastructure assets in Australia have their allowed return set on the basis of a long-term (10-year) rate;
- The ERA argues that its (currently low) 5-year allowed return is consistent with the (currently higher) 10-year required return used by investors. The ERA argues that investors actually require a low return over the next five years (the same as what the ERA currently allows) and a much higher return on cash flows thereafter. However, there is no mechanism whereby the high future returns that the ERA says investors require can ever be delivered by the ERA's rate-setting process. The more likely outcome is that, at every determination, the ERA simply uses this term structure argument to explain why its current regulatory allowance is below the return that investors require; and
- If the ERA does adopt a 5-year risk-free rate, consistency requires that the same rate must be used in the two places it appears in the CAPM formula.

122. DBP also queries why the Authority adopts the 10 year term for its rail decisions, but not for its gas decisions.

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98 [DBP footnote] See Appendix B: for details of the numerous papers in which Lally confirms that this assumption is being made, including his original paper.

99 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, Appendix B, p. 1.

123. The Authority addresses each of these points as follows.

Value of the regulated asset

124. The Authority considers that SFG's contention – that the *market value* of the business at the end of the regulatory period must be known with certainty – is a separate issue to the certainty of the Regulated Asset Base (**RAB**). Lally summarises why such a conflation is misleading, as follows:

> …this proposition assumes that the resetting process at the end of each regulatory cycle (typically five years) must be such as to equate the market value of the firm's equity with its regulatory book value at that time, and this is not possible because share prices of regulated businesses are influenced by factors beyond the regulatory period. However the QTC seem to be conflating the share price of a regulated business with the share price of the company that carries out the regulated activities, and only the latter exists. For example, suppose a company undertakes some regulated business and this is its only existing activity but it also possesses some growth options, i.e., potential opportunities to engage in NPV positive projects outside the regulated business at some future point. Its share price will reflect the value of these opportunities and will therefore change as the market's perception of those options changes. However, this has no bearing on the appropriate risk free rate for the regulated activities that it undertakes.[100]

125. With regard to the RAB, its certainty would only be applicable in the theoretical context where the only source of risk relates to changes in the risk free rate, which is the case in the analysis by Lally in his 2007 article.[101,102] Lally had already dealt with the presence of an additional risk premium in his 2004 article, finding that even in the presence of a risk premium, it is appropriate to set the term of the risk free base equal to the regulatory period.[103] The Authority covered this ground in depth in the Guidelines.[104] Lally reiterates the relevance of the 2004 article in his recent review of the matter:[105]

> SFG (2014, section 2) argues that the Present Value Principle is only valid if the value of the regulatory assets at the end of the regulatory cycle are known with certainty. However, certainty on this matter is not a necessary assumption, as demonstrated in Lally (2004)…

126. That said, except under highly stylised circumstances, the Authority acknowledges that the value of *any* asset at the end of the investment horizon cannot be known with full certainty. Risk premia generally apply.

100 [Lally's footnote] The market value of the regulated business may also differ from the RAB if the market's perception of expected costs (inclusive of any efficiency gains) differs from the costs allowed by the regulator.

101 The examples outlined in Lally's 2007 paper set out the NPV = 0 conditions (M Lally, Regulation and the Term of the Risk Free Rate: Implications for Corporate Debt, *Accounting and Research Journal,* Vol. 20, No.1, 2007). For the Authority's consideration of this paper, see Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, Appendix 2, pp. 20 – 23.

102 That said, the Authority noted in the Guidelines that the RAB is not re-valued periodically, implying a very low risk for the full return of the value of the RAB at the end of the regulatory period – generally investors know its value for regulatory purposes with a large degree of certainty (Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 89).

103 Lally M. 2004, "Regulation and the Choice of the Risk Free Rate", *Accounting Research Journal*, Volume 17, No. 1, 2004, p. 19.

104 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, Appendix 2, pp. 18 - 26.

105 M. Lally, *Review of Arguments on the Term of the Risk Free Rate*, 20 November 2015, p. 13.

127. In the case of debt instruments, credit risk factors impact the certainty of full and timely payment of the ending market value (for example the principal).

128. Similarly, here the credit rating, and hence the debt risk premium, accounts for credit risk over the average term of finance issuance that stems from factors such as declaration of redundant assets, changing depreciation schedules, disallowance of forecast capital expenditure from being included in the asset base and disruptive technologies.

129. With regard to equity, an investor can diversify such risks away and to the extent they cannot, they are compensated through the equity risk premium via the weighting (equity beta) the premium is given.

130. From a regulated revenue perspective both debt and equity have similar characteristics to investment in a 5 year vanilla bullet bond.[106] The features of a bond such as the coupon rate, term to maturity and face value to be repaid upon maturity are captured in the bond indenture. The determination outlines the regulated cost of capital applicable to the RAB over the next 5 years, and the associated dollar value of the RAB at the outset of that period.

131. Like the coupon rate for a vanilla bond, the cost of capital factors in credit risk which in turn, captures risks that can affect the value of the RAB. Like the face value of the bond at the end of 5 years the RAB is subject to economic and financial market conditions that prevail and influence regulatory outcomes up until that time.

132. Assuming the bond is not issued at a discount or premium to the face value, the coupon rate is equivalent to the yield to maturity at issue. The yield to maturity has a risky and risk free component, which is priced as the ‘credit spread’ and base rate respectively. The credit spread in the regulatory context is represented as the debt risk premium. The calculation of this reflects a 10 year exposure to credit risk as outlined in paragraph 466.

133. Further expanding on this example, the base rate reflects the yield on the swap curve for the Australian dollar which reflects the risk free rate of return and a swap spread to Commonwealth Government Securities at a given tenor. The term for the base rate must be matched to the length of exposure to changes in the base rate.

134. For example, from a longer term perspective, the 5 year risk free rate in the regulated return for a 10 year investment in the RAB is analogous to the 3 month base rate in a 1 year floating rate debt instrument. For such an instrument a 3 month base rate, such as the 3 month bank bill swap rate, is used as a reference to reset the ‘risk free’ component or ‘base rate’ of the coupon rate every quarter.[107] The yield to maturity of the base rate reflects a 3 month tenor, *not a 1 year tenor,* due to exposure to changes in the base rate within the 1 year term being limited to 3 months at a time by virtue of quarterly resets in the base rate to match the prevailing rate.

135. By the same reasoning a 10 year debt instrument with 5 yearly resets would use an index with a 5 year yield to maturity as the interest rate risk exposure is limited to 5 years at a time, on account of the base rate being reset every 5 years to match the

[106] Vanilla is reference to a bond that is ‘plain’ from the perspective of having no optionality or other non-standard debt features. Bullet bonds receive full repayment of principal at expiry. That is the principal is not amortized over the term of the bond. This example assumes a coupon paying bond.

[107] Ignoring interest rate swap spreads to Commonwealth Government Securities for illustration sake.

prevailing market yield. Similarly, equity holders' exposure to base risk is limited to five years at a time due to the 5 yearly regulatory reset.

136. Lally previously has made exactly this point in a worked example rebutting SFG's claims:[108,109]

> The scenario examined here is conceptually identical to that of a floating rate bond, and the same recursive valuation process applies. For such bonds, the interest rate used at each reset point must be for a term matching the reset frequency (Jarrow and Turnbull, section 13.2.4).

137. The Authority therefore considers the appropriate term for the risk free rate and base rate in the current regulatory setting – where the rate of return is reset every 5 years concomitant with market conditions – is 5 years, in order to ensure NPV = 0.

Commercial practice

138. While the Authority acknowledges that equity analysts use a long dated tenor for the risk free rate in discounting, it notes that the circumstances under which equity returns are determined differ to drivers of those returns for non-regulated returns.

139. First, equity analysts generally are seeking to value the firm and therefore seek a discount rate to perpetuity, which are then applied to determine the present value of the expected cashflows over the life of the assets.

140. SFG quotes a report from Incenta as evidence that the dominant commercial practice is use the 10 year rate when valuing regulatory businesses. Importantly, reference to the Incenta report makes clear that Incenta surveyed analysts about the rate they would use in the '*valuation* of the regulated business' [our italicised emphasis].[110]

141. Second, in contrast, the Authority considers that it is undertaking a different exercise when establishing the rate of return for the benchmark efficient entity; the Authority is not establishing the value of the regulated business based on the expected cashflows to perpetuity.[111] Rather, the regulator is seeking to establish the value of cashflows over the access arrangement period, consistent with the value of the regulated asset base, which is determined first.[112]

142. Regulated equity returns are afforded a degree of protection against interest rate risk over the medium term due the 5 yearly resets of the base rate, as discussed above. Therefore, the value of the firm in perpetuity from the next access arrangement forward – using the long term risk free rate expected to prevail at the start of the next

108 M. Lally, *Response to submissions on the risk free rate and the MRP*, 22 October 2013, p. 48.

109 SFG claim that Lally in 'his most recent contribution on this issue, Lally (2012 QCA) is very clear about the assumption that serves as the foundation for all of his derivations. He assumes that the regulatory process is such that the market value of the regulated assets at the end of each regulatory period is not subject to any risk' (DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, Appendix B, p. 6). However, Lally's numerical example refers to 'assets costing $100m' (M. Lally, *Response to submissions on the risk free rate and the MRP*, 22 October 2013, p. 46). This is a RAB value, not a market value.

110 Incenta Economic Consulting, *Term of the risk free rate for the cost of equity*, June 2013, p. 26.

111 Lally endorses exactly this view when he responds to similar arguments for the QCA in the context of the risk free rate (see M. Lally, *Response to submissions on the risk free rate and the MRP*, 22 October 2013, p. 24 and also paragraph 136 above for the relevant quote).

112 The regulated asset base is the written down value of opening capital base, determined using depreciation from regulatory year to the next.

access arrangement as the discounting factor – can be discounted back to the current present value, using a discount factor incorporating the 5 year risk free rate.[113]

143. Additionally, the Authority notes that the approach to estimating the MRP has been adjusted since the Rate of Return Guidelines, such that the MRP is calculated using a 5 year risk free rate instead of a 10 year rate. The longer exposure of equity to risk is thus incorporated in the MRP, instead of the risk free rate. This is discussed in detail in paragraph 308 below.

Gas versus rail decisions

144. DBP also queries why the Authority adopts the 10 year term for its rail decisions, but not for its gas decisions.[114]

145. The Authority made clear in its rail decision that the effective term for its estimates is the 'economic life of the assets',[115] as this is the requirement under the rail Code:[116]

> The Authority notes that the longer term estimates developed for the rail WACC are not directly comparable to the five year forward looking estimate of the rate of return used for its gas decisions. The term of the gas rate of return is conditioned by the five year term of the regulatory period, which requires a five year term for the rate of return estimate in order to maintain the present value ("NPV=0") condition. In contrast, the term of the rail WACC is conditioned by the explicit requirement for a 'gross replacement value' annuity, which is paid over the 'economic life' of the rail assets. This is a different regulatory framework to that utilised for the Authority's gas pipeline regulation. As the weighted average life of typical rail infrastructure assets approaches 50 years or more, the WACC is long term.

146. The Authority therefore rejects DBP's view that the term of the risk free rate should be set at 10 years. The Authority maintains its view – clearly set out in the Rate of Return Guidelines – that the appropriate term should be commensurate with the term of the regulatory period. That term is 5 years.

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113 In this context, DBP claim (DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12, p. 15):

> The key question therefore concerns the certainty of the asset value at the conclusion of the current access period. The value of an asset reflects the NPV of expected future cashflows. As the ERA notes in the ATCO Draft Decision (see footnote 255, p146), in the regulatory sphere, this could be broken into a short term of the next access period, followed by the cashflows to perpetuity that the ERA suggests would be discounted at a different long-term rate. Clearly, if the asset is worth the NPV of a stream of discounted cashflows to perpetuity at the conclusion of the current access period, and these cashflows are discounted using a rate that is currently unknown (either because the parameters of a known model are unknown or because the future models used by regulators are currently unknown), then Lally's assumption of certain asset values at the termination of the AA period fails to hold.

However, as noted above at paragraph 125, Lally does not assume certain asset values at the termination of the access arrangement period. Furthermore, the long term rate which might be expected (now) to apply at the conclusion of the access arrangement period will be consistent with the current expectations of the 5 year rate, so it is not 'currently unknown'. Whether that long term rate is borne out in reality at the end of the access arrangement is another matter, as it would also be the expectations, now, for the 5 year rate to apply for the next access arrangement.

114 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12,* 31 December 2015, p. 16.

115 *Railways (Access) Code 2000*, Schedule 4, Division 1, Clause 2.

116 Economic Regulation Authority, *Review of the method for estimating the Weighted Average Cost of Capital for the Regulated Railway Networks – Final Decision*, 18 September 2015, p. 55.

Proxy for the risk free rate

147. DBP propose that the return on Commonwealth Government Securities (**CGS**) provides an acceptable proxy for the risk free rate.[117]

148. DBP then uses this proxy for estimating both the return on debt and the return on equity.

149. The Authority considers that the return on CGS does provide a reasonable proxy for the risk free rate. The Authority therefore agrees that CGS may be used to estimate the risk free rate for the return on equity.

150. For the return on debt, the Authority will use estimates of the prevailing interest rate swaps of appropriate terms for estimating the return on debt. The swap rates incorporate a spread to the rate on Commonwealth Government Securities. Use of the swap rate is a convenience which simplifies the calculation of the DRP (the alternative would be to use the CGS and incorporate the spread to swap in the DRP). On that basis, the Authority considers that use of the swap rate is not inconsistent with the use of the CGS as the proxy for the risk free rate.

Averaging period

151. In the Rate of Return Guidelines, the Authority determined that the averaging period should be a 40 day period, for the purposes of removing day to day variation in the estimates.[118]

152. Consistent with the Guidelines, DBP proposes a 40 day averaging period.[119]

153. In this context, the Authority notes that it recently accepted a proposal from ATCO for a 20 day averaging period.[120] In addition the Authority also notes that DBP in its response to the Authority's Discussion Paper on estimating the return on debt suggested that a longer averaging period – up to 60 days – could be adopted with little loss of predictive power.[121] The Authority acknowledges this point.

154. However, for the purposes of this Draft Decision, the Authority considers that DBP is proposing 40 days for the averaging period. As that is consistent with the Guidelines, the Authority accepts this proposal.

The estimate of the risk free rate

155. For illustrative purposes for this Draft Decision, the Authority utilises the rate of return estimates from its recent ATCO GDS Final Decision. These provide results that are indicative of the method which will apply for the DBP Final Decision. However, that ATCO GDS estimate, which is reported here, utilised a 20 day averaging period.

117 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 19.

118 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2016, p. 86.

119 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 81.

120 Economic Regulation Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems*, as amended 10 September 2015, p. 216.

121 DBNGP Transmission Pty Ltd, *Estimating the Return on Debt: Response to Authority Discussion Paper of 4 March 2015*, 25 March 2015, p. 7

Nevertheless, as it is indicative only; it does not preclude DBP retaining a 40 day averaging period.

156. With that caveat, the average of the observed 20 days of the 5-year Commonwealth Government Securities (**CGS**) risk-free rate as at 2 April 2015 was 1.96 per cent. This provides an indicative point estimate for the risk free rate for the return on equity set out in this Draft Decision.

157. The average of the observed 20 days of the 5-year swap rate (**BBSW**) as at 2 April 2015 was 2.431 per cent. This provides a point estimate for the risk free rate for the return on debt set out in this Draft Decision.

Inflation

162. The expected rate of inflation for the coming 5 year regulatory period is estimated using the procedure outlined in the Rate of Return Guidelines over the nominated averaging period.[122]

163. The expected inflation rate is estimated using the Treasury bond implied inflation approach. The approach uses the Fisher equation (shown in equation 12 below) and the observed yields of 5-year Commonwealth Government Securities (**CGS**) (which reflect a market based estimate of the nominal risk free rate) and 5-year indexed Treasury bonds (which incorporate a market based estimate of a real risk free rate). Linear interpolation is used to derive the daily point estimates of both the nominal 5-year risk free rate and the real 5-year risk free rate, for use in the Fisher equation.

$$1+i=(1+r)(1+\pi^{e}) \qquad (12)$$

164. DBP proposed that five unique inflation forecasts for each year should be used in place of a single five year estimate that remains constant over each year in the financial model. Each of these forecasts use all Treasury bonds for forecasting within the access arrangement period instead of just the two bonds that straddle the date marking the end of the access arrangement period.[123]

165. DBP is of the view that the Authority's current approach, which uses just the two bonds straddling the date marking the end of the access arrangement period, 'artificially narrows' its bond selection and that it does not reflect inflation through the period. It outlined an example which stated that a surge in inflation within the period would not be reflected in the Authority's approach if inflation returned to the mean thereafter, within the period.[124]

122 Economic Regulation Authority, *Rate of Return Guidelines*, 16 December 2013, pp. 32-33.

123 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, pp. 96-97.

124 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, pp. 96-97.

Expectations Theory

166. Expectations theory predicts that the 5 year annualised inflation rate expected to prevail from today (5 year 'spot' inflation rate) will be equal to the geometric average (compounded) forward rates.

$$\pi_{0,5} = \left[(1+\pi_{0,1})(1+\pi_{1,1})(1+\pi_{2,1})(1+\pi_{3,1})(1+\pi_{4,1})\right]^{\frac{1}{5}} - 1 \qquad (13)$$

Where:

$\pi_{0,5}$ is the 5 year annualised inflation rate expected to prevail from today (or 'spot' inflation rate);

$\pi_{0,1}$ is the 1 year annualised 'spot' inflation rate;

$\pi_{1,1}$ is the 1 year annualised inflation rate expected to prevail from 1 year later (1 year forward inflation rate);

$\pi_{2,1}$ is the 1 year annualised forward inflation rate expected to prevail from 2 years later;

$\pi_{3,1}$ is the 1 year annualised forward inflation rate expected to prevail from 3 years later; and;

$\pi_{4,1}$ is the 1 year annualised forward inflation rate expected to prevail from 4 years later.

167. If this relationship does not hold arbitrage opportunities exist where riskless profits can be made. Assuming the market for Treasury bonds and Treasury indexed bonds is efficient and no trading frictions – such as transaction costs – exist, the 5 year annualised inflation rate expected to prevail from today will be the same as the geometric average of the 1 year spot inflation rate and forward rates.

168. From this perspective the Authority disagrees with DBP's claim that the 5 year annualised inflation rate 'need not reflect inflation through the period'.[125] As shown in equation (13), a surge in expected inflation in any one of the one year periods will be reflected in the 5 year annualised inflation rate.

169. DBP has presented no evidence to demonstrate that the equality in equation (13) does not hold. The Authority is not aware of any evidence of inequality in the equation, such that the right hand side becomes a better measure of expectations than the 5 year spot rate on the left (due to factors such as transaction costs). The Authority has no reason to expect that the 5 year spot rate and component forward rates on the right hand side of the equation will not align at any point in time.

125 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 96.

170. Additionally, DBP's proposed method appears unconventional in proposing to use a weighting mechanism on bonds that gives less weight to those expiring further from the target date. The method, however, is not clearly outlined.[126]

171. In light of these arguments, the Authority is not convinced to depart from its method for estimating inflation set out in the Rate of Return Guidelines.

172. For illustrative purposes in this Draft Decision, the Authority utilises the rate of return estimates from its recent ATCO GDS Final Decision. The resulting estimate of inflation over the course of the regulatory period for this Draft Decision is 1.90 per cent.

Return on equity

158. In line with the requirements of NGR 87(5), the Authority considers that it evaluated the relevance of a broad range of material for estimating the return on equity in the Rate of Return Guidelines, covering relevant estimation methods, financial models, market data and other evidence.[127]

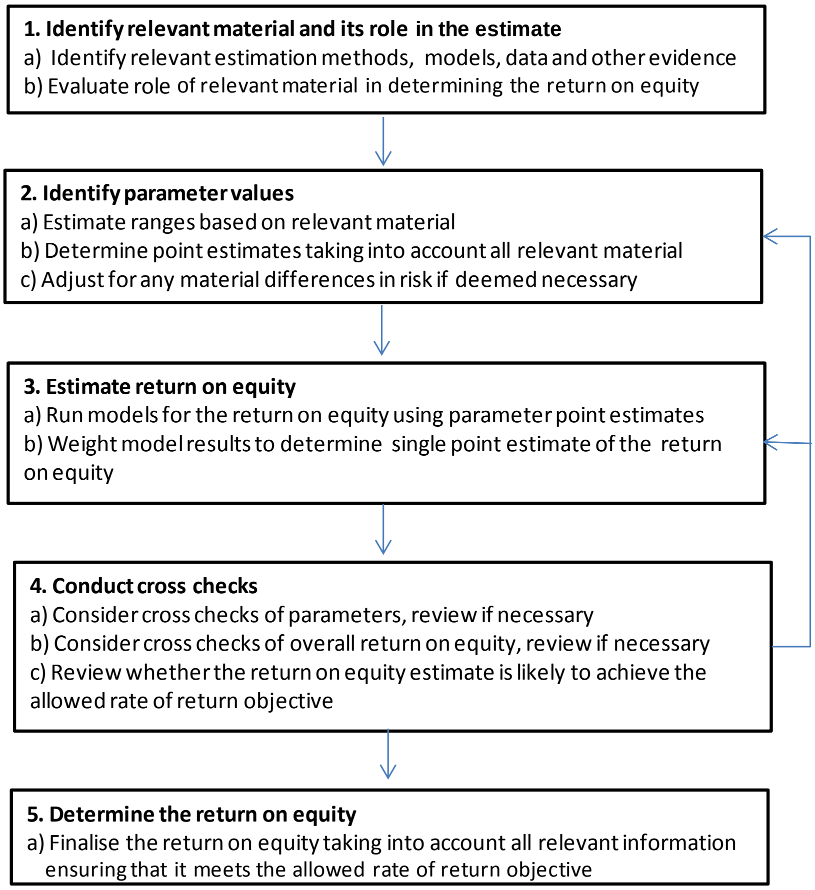
159. The Rate of Return Guidelines set out that the Authority will utilise a five step approach for estimating the return on equity.[128] The five steps are summarised in Figure 2 (below).

[126] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 96.

[127] Australian Energy Market Commission, *Rule Determination: National Gas Amendment (Price and Revenue Regulation of Gas Services) Rule 2012*, 29 November 2013, p. 36.

[128] Economic Regulation Authority, *Rate of Return Guidelines: Meeting the requirements of the National Gas Rules*, 16 December 2013, p. 22.

Figure 2 Proposed approach to estimating the return on equity [129]



Source: Economic Regulation Authority, Rate of Return Guidelines, 16 December 2013, p. 23.

160. Through this approach, the Authority has assessed a wide range of material, and identified relevant models for the return on equity, as well as a range of other relevant information. For this Draft Decision, the Authority has given weight to relevant material, according to its merits at the current time, seeking to achieve fully the requirements of the allowed rate of return objective.[130]

161. The Authority in the Rate of Return Guidelines determined that only a subset of the evaluated material could be considered relevant in the Australian context, so as to best achieve the allowed rate of return objective. The Authority is of the view that:

> Rate of return estimate materials – the estimation methods, financial models, market data and other evidence – would need to be broadly consistent with the requirements of the NGL, the NGO, the NGR and the allowed rate of return objective to be considered

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129 The Authority considers that the term:

- ‘approach’ refers to the overall framework or method for estimating the return on equity, which combines the relevant estimation methods, financial models, market data and other evidence;
- ‘estimation material’ refers to any of the relevant estimation methods, financial models, market data and other evidence that contribute the ‘approach’; and
- ‘estimation method’ relates primarily to the estimation of the parameters of financial models, or to the technique employed within that model to deliver an output.

130 The allowed rate of return objective is set out at NGR 87(3):

The allowed rate of return objective is that the rate of return for a service provider is to be commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to the service provider in respect of the provision of reference services.

relevant. Some estimation materials may perform better on some requirements and less well on others, and yet may still be considered relevant. Accordingly, the assessment is whether, on balance, estimation materials are consistent with the requirements of the NGL, the NGO, the NGR and the allowed rate of return objective.

Nevertheless, estimation materials would need to pass a threshold of adequacy to be considered relevant. To the extent that estimation materials failed the adequacy threshold, then they would be rejected. This rejection would be consistent with the AEMC's purpose for the guidelines:[131]

> In order for the guidelines to have some purpose and value at the time of the regulatory determination or access arrangement process, they must have some weight to narrow the debate.

Once over the threshold for adequacy, then, as noted, any particular estimation material may meet the requirements of the NGL, the NGO, the NGR and the allowed rate of return objective to a greater or lesser degree. With this in mind, the criteria would then be used as a means to articulate the Authority's evaluation of the estimation materials, in terms of how they performed in meeting the requirements of the NGL, the NGO, the NGR and the allowed rate of return objective. In this way, the criteria are intended to assist transparency around its exercise of judgement. [132]

162. In that context, the following analysis provides the Authority's determination for this Draft Decision of the return on equity for DBP. The Authority considers that the estimate is consistent with delivering an outcome that meets the allowed rate of return objective, as well as the NGL and NGR more broadly.[133]

Step 1: Identifying relevant material and its role in the estimate

173. The Authority evaluated the relevance of the following materials for estimating the return on equity in the Rate of Return Guidelines, in terms of their ability to contribute to the achievement of the allowed rate of return objective:[134]

- the Sharpe Lintner Capital Asset Pricing Model (**Sharpe Linter-CAPM**), as well as other asset pricing models in the CAPM 'family'; and
- an extensive range of other models and approaches which seek to estimate the return on equity.

174. The Authority concluded in the Guidelines that the Sharpe Lintner CAPM model is relevant for informing the Authority's estimation of the prevailing return on equity for the regulated firm at the current time.

131 Australian Energy Market Commission, *Rule Determination, National Gas Amendment (Price and Revenue Regulation of Gas Services) Rule 2012*, 29 November, p. 58.

132 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 12.

133 The allowed rate of return objective is set out at NGR 87(3):

The allowed rate of return objective is that the rate of return for a service provider is to be commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to the service provider in respect of the provision of reference services.

134 Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, Appendix 8.

175. However, the Authority determined that it would give weight to relevant outputs from the Dividend Growth Model (**DGM**) when estimating the market risk premium (**MRP**), which is an input to the Sharpe Lintner CAPM.[135]

176. The Authority also noted the empirical evidence provided by the Black and Empirical CAPM models, pointing to potential bias in the estimates from the Sharpe Lintner CAPM, and noted that it would take this relevant information into account when estimating the point estimate of the equity beta from within its estimated range.[136]

177. The Authority concluded that other models and approaches are not relevant within the Australian context, at the current time, without some new developments in terms of the theoretical foundations or in the empirical evidence. Generally, there are resulting shortcomings with regard to robustness in the Australian context. On this basis, the Authority considered that these other models are not 'fit for purpose' or able to be 'implemented in accordance with best practice'.

178. The Authority considered that its approach in the Rate of Return Guidelines with regard to the determination of relevance – in terms of best meeting the allowed rate of return objective – is consistent with the intent of the AEMC:[137,138]

> … In general the final rules give the regulator greater discretion than it has currently. The objectives and factors show the regulator what it must bear in mind when it exercises that discretion.
>
> The role of the objective is to indicate what the regulator should be *seeking* to achieve in the exercise of its discretion. Some stakeholders appear to have understood the objectives as imposing on the regulator a requirement and that failure to comply with this would mean the regulator is in breach of the rules. This is not the case. Although the language of an obligation is used in some objectives, it is not necessarily expected that the substance of the objective will always be fully achieved, but rather the regulator should be striving to achieve the objective as fully as possible. Where it is used in rate of return and capital expenditure incentives, the objective has primacy over other matters which the regulator is directed to consider.
>
> These other matters include factors which the regulator is directed to consider. The rules use language such as "have regard to" and "take into account" to direct the regulator to consider certain factors. Throughout this rule change process there has been discussion over the respective meanings of these phrases. The Commission's approach is that these phrases mean the same thing and nothing is implied by the use of one rather than the other. The Johnson Winter & Slattery advice attached to the Australian Pipeline Industry Association (**APIA**) submission[139] includes a useful guide to how the phrases

135 Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 78.

136 Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 67.

137 Australian Energy Market Commission, *Rule Determination, National Gas Amendment (Price and Revenue Regulation of Gas Services) Rule 2012*, 29 November 2013, p. 36.

138 The Authority notes that relevant means 'closely connected or appropriate to the matter in hand' (Oxford dictionary) or 'bearing upon or connected with the matter in hand; to the purpose; pertinent' (Macquarie dictionary).

139 APIA, *Economic Regulation of Network Service Providers: Response to AEMC*, 4 October 2012, Appendix 1, p. 11. The Authority notes that that the Johnson Winter & Slattery advice stated:

…as long as the Regulator has taken into account the specified factors, it remains in the Regulator's discretion how those factors influence its decision. The practical application of this rule could result in the Regulator considering other estimation methods, financial models, etc. but then putting all but one to the side and continuing to estimate the cost of debt and cost of equity using its already stated preferred approach (i.e. the Sharpe Lintner CAPM)…

If evidence is "irrelevant", the Regulator will not fall into error by failing to "take it into account".

should be interpreted. The regulator must actively turn its mind to the factors listed, but it is up to the regulator to determine how the factors should influence its decision. It may, indeed, consider all of them and decide none should influence its decision. It is not intended that the regulator's decision is solely dependent on how it applies any or all of those factors. The intention is that where the rules require the regulator to consider certain factors in conjunction with an overall objective, it should explain its decision including how it has had regard to those factors in making a decision that meets the objective.

Models for the return on equity

179. DBP engaged CEG to provide expert advice in relation to the Authority’s treatment of the capital asset pricing models. Based on CEG’s advice, DBP is of the view that both Black CAPM and the Fama French three factor model are relevant, in addition to the Sharpe Lintner CAPM, and as such, should be considered relevant for the purpose of estimating the return on equity for DBNGP.

180. The Authority notes that DBP presents only limited new information in its proposal – in relation to relevant estimation methods, financial models, market data and other evidence – that was not considered as part of the development of the Rate of Return Guidelines.

181. Detailed discussions of CEG’s view in relation to the Authority’s treatment of capital asset pricing models, together with the Authority’s responses to CEG’s view, are presented in Appendix 4A. In summary, the Authority agrees with DBP that the Sharpe Lintner CAPM and Black CAPM are relevant models.

182. However, the Authority does not accept the use of the Black CAPM for directly estimating the return on equity, as DBP does. This is principally because estimates of the zero-beta return are unstable and cannot be relied on in the Australian context. As a result, estimates using the Black CAPM are not fit for purpose. Further details of the Authority’s analysis of the properties of the Black CAPM are included in Appendix 4A and 4Ai.

163. Reflecting these shortcomings, the Black CAPM has not been widely adopted by academics or practitioners in Australia or overseas for estimating a return on equity directly. Consistent with this view, the Authority considers that it is impractical to utilise the Black CAPM to determine the return on equity directly.

164. In addition, the Authority does not agree that the Fama French Model (**FFM**) is relevant in the Australian context, and hence considers that it should play no role in estimating a return on equity for DBP. This decision is based on the following considerations (see Appendix 4A for the detail of the Authority’s evaluation):

- The Fama French three-factor model was not developed on a theoretical basis.
- New factors that are now included in the new Fama French five factor model raise questions about the validity of the FFM three factor model.
- The estimates from the Fama French three factor model vary significantly and produce mixed results.
- The Fama French three factor model is not used by economic regulators either in Australia or overseas to estimate the expected return on equity.

In practice, of course, this will require some form of value judgment by the Regulator about whether evidence put before it is relevant or not. This appears to be consistent with the very broad discretion envisaged by the AEMC in the Draft Rule Determinations.

183. DBP ultimately proposes an initial Step 3 estimate for the return on equity that is based on the Sharpe Lintner CAPM, albeit with the estimate of the beta term adjusted to give an estimate consistent with the Black CAPM. The Authority considers that the use of the Sharpe Lintner CAPM, adjusted to take account of the theoretical insights of the Black CAPM, is appropriate, and follows the method set out in the Guidelines.

184. However, the Authority does not agree with the adjustment for beta estimated by DBP – the so-called 'betastar' correction. DBP's adjustment means, in effect, that the estimate is derived *from* the Black CAPM, rather than using the Sharpe Linter CAPM. In line with this, DBP state explicitly:[140]

> The Black CAPM, as implemented through our betastar model, is considered relevant via our model adequacy test, and is used for calculating the permissible ranges of the return on equity in stages two and three of the ERA's process.

165. As set out above, the Authority does not accept estimates that are directly based on the Black CAPM, as these are not reliable. Accordingly, the Authority will retain the use of the Sharpe Lintner CAPM, albeit with the choice of beta adjusted within its estimated range, so as to account for the theoretical insights of the Black CAPM.

Evaluation of DBP's Model Adequacy Test and its Betastar

166. The Authority notes that DBP utilises a 'model adequacy test', which seeks to evaluate the predictive power of the models. DBP's proposed model adequacy test involves taking each of the models that it considers are relevant (i.e., Sharpe Lintner CAPM, the Black CAPM, and the Fama-French model), and using them to forecast the return on equity at different points in time in the past. Those forecasts are then compared to the actual outcomes in the historic data. DBP considers that a model which, statistically, is shown not to be reliable in predicting actual outcomes is unlikely to be appropriate as the sole relevant model going forward.[141]

167. As noted above, the Authority does not consider that the Black CAPM or FFM offer quantitatively robust estimates in the Australian context. For that reason, the Authority does not consider that these models can be compared with the Sharpe Lintner CAPM through the proposed model adequacy test.

168. However, irrespective of the validity of the model estimates, the Authority also has issues with the model adequacy method, as proposed by DBP. The Authority has considered DBP's model adequacy test in detail in Appendix 4B and Appendix 4Bi. The following two sections provide the core of the Authority's reasoning in rejecting the model adequacy test as implemented by DBP.

Conceptual elements

169. The Authority considers that testing the 'predictive power' of the alternative methods for estimating the expected return on equity in question presents a considerable challenge. That said, the Authority considers that DBP's test does not properly compare the alternative methods.

140 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12*, 31 December 2015, p. 82.

141 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020, Rate of Return - Supporting Submission: 12, 31 December 2015*, p. 49.

170. In particular, while the Authority considers that historical data may provide some information as to future returns, it is not solely used for predicting the return on equity by the Authority. The Authority's preferred approach – which utilises the Sharpe Lintner CAPM – was set out in its Final Decision for the ATCO GDS.[142] Of relevance, the Authority utilises various sources of information, in order to determine a forward looking estimate of the Market Risk Premium (**MRP**) including (i) forward looking information, such as estimates of the MRP from the DGM and a range of other indicators; and (ii) backward looking information such as historical data on risk premium. The Authority then exercises its judgment to determine the MRP. In the ATCO GDS decision, the resulting MRP significantly exceeded the estimate that was based on the historic estimates alone.

171. Therefore, relying on the historical data alone – as DBP does – for testing the relative adequacy of the Authority's approach, is erroneous. Other forward looking information needs to be taken into account, as the Authority does in its approach to estimating the return on equity. It follows that DBP's model adequacy approach does not actually test the Authority's approach in using the Sharpe Lintner CAPM for estimating the return on equity. DBP is setting up a straw man, and not actually evaluating the Authority's method at all.

172. For the same reasons, the Authority rejects DBP's views on bias in the Sharpe Lintner CAPM that were set out in later submission on the Issues Paper.[143]

173. Based on the above considerations, the Authority is of the view that DBP's model adequacy test:

- does not test the Authority's forward looking approach to estimating the return on equity using the Sharpe Lintner CAPM, but rather versions based on historic MRP outcomes;
- compares two models that are not robust in the Australian context (the Black CAPM and FFM), with another method that is not relied on either (the Sharpe Lintner CAPM, using an MRP that is based on historic data only).

174. Accordingly, the Authority rejects DBP's proposal on conceptual grounds.

Empirical elements of DBP's model adequacy test

175. In relation to the empirical elements of the DBP's model adequacy test, the following issues are considered.

- *First,* the estimates of zero beta premium from NERA (2013) study;
- *Second,* DBP's model adequacy test produces nonsensical outcomes; and
- *Third,* a range of other issues with regard to the empirical method.

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[142] Economic Regulatory Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems*, as amended 10 September 2015, p. 250.

[143] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Response to ERA Issues Paper Submission 26*, 2 June 2015, p. 15.

The estimates of zero beta premium

176. The Authority notes that empirical estimates have been conducted by consultants for network service providers in Australia. Key findings from these studies are summarised as follows:

- CEG (2008) used Australian data from 1964 to 2007 and reported estimates of the zero beta premium that range between 7.21 per cent per annum and 10.31 per cent per annum using various cross-sections of stocks traded on the ASX data formed into 10 portfolios on the basis of past estimates of beta.[144]
- NERA (2013) used Australian data from 1974 to 2012 and reports estimates of the zero beta premium that range between 8.74 per cent per annum and 13.95 per cent per annum using both individual stocks and stocks formed into portfolios on the basis of past estimates of beta.[145]
- SFG (2014) reported an estimate of the zero beta premium of 3.34 per cent per year. This study was based on 20 years of returns information from 1994 and 2013.[146]

177. The Authority notes the view from Professors McKenzie and Partington (2012) in relation to the validity of the estimates of the zero beta premia. In relation to NERA's estimates of zero beta premium, Professors McKenzie and Partington were of the view that:[147]

> There are many potential sources of error and bias in the estimation of zero beta returns and consequently such estimates should be viewed with great caution. Even if the foregoing problems were set aside, there are also question marks over the standard errors of the zero beta return estimates. This is an important unresolved issue given that the magnitude of the standard error is the basis for concluding whether estimated zero beta returns differ from zero.

178. In addition, in relation to the robustness of the estimated zero beta, McKenzie and Partington (2012) are of the view that robustness means that there is little or no variation of the estimated parameter in response to sensible alternative approaches to estimation. On this ground, McKenzie and Partington argue that NERA's estimates of the zero beta premiums are not robust. They also argued that:[148]

> We make a more general and more important point that "the empirical zero beta portfolio" is not unique. Consequently, there are many different zero beta returns that might be estimated and very large differences in the value of that return could be obtained.

179. McKenzie and Partington were of the view that estimates of zero beta premiums are problematic. They considered that:[149]

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144 Competition Economists Group, *Estimation of, and correction for, biases inherent in the Sharpe CAPM formula: a report prepared for the Energy Networks Association Grid Australia and APIA*, September 2008.

145 NERA Economic Consulting, *Estimates of the Zero-Beta Premium*, a report prepared for the Energy Networks Association, June 2013, p. 16 and p. 23.

146 SFG Consulting, *Cost of equity in the Black Capital Asset Pricing Model*, *a report prepared for Jemena Gas Networks, ActewAGL, Ergon, Transend, TransGrid, and SA PowerNetworks*, 2014, p. 27.

147 McKenzie, M and Partington, G. *Review of NERA report on the Black CAPM,* The Securities Industry Research Centre of Asia Pacific (SIRCA) Limited, 22 August 2012, p. 5.

148 McKenzie, M and Partington, G. *Review of NERA report on the Black CAPM,* The Securities Industry Research Centre of Asia Pacific (SIRCA) Limited, 22 August 2012, p. 4.

149 McKenzie, M and Partington, G. *Review of NERA report on the Black CAPM,* The Securities Industry Research Centre of Asia Pacific (SIRCA) Limited, 22 August 2012, p. 8.

> There is no generally accepted empirical measurement of the zero beta return in the Black CAPM. This is because the empirical measurement of the zero beta return is neither simple, nor transparent. There are many possible zero beta portfolios that might be used and the return on these portfolios is not directly observed, but has to be estimated. In the estimation process for the zero beta return, there are also inputs that cannot be observed and they too have to be estimated. The resulting estimate of the zero beta return is sensitive to the choices made in regard to the input variables and methods of estimation.

180. The Authority notes NERA's responses to McKenzie and Partington's view in relation to NERA's estimates of zero beta premium.[150] However, the Authority considers that none of these responses from NERA reassure as to the robustness of the zero beta premium in the Australian context. The Authority considers that fundamental issues with the Black CAPM remain unsolved (refer to Appendix 4A for more detail).

181. In their recent report prepared for the AER, Partington and Satchell also concluded that:[151]

> Beaulieu, Dufour and Khalaf have been working on this problem [of estimating zero beta return] for over a decade and have developed improved estimation procedures. Applying these procedures they conclude that the estimate of the zero beta return is unstable over time. Although these improved procedures are a valuable contribution to the research literature, they involve complex econometrics and are not yet widely accepted. Consequently, we would not currently recommend them for regulatory use.

182. Partington and Satchell noted that:[152]

> Given that an inefficient portfolio is used as the proxy for the market portfolio there is an infinite possible set of zero beta returns and even when you constrain the estimate by using a regression model, what you get is very much determined by what you do. Hence the wide range of estimates previously submitted by regulated business.

and that:[153]

> First, the estimate of the return on the zero beta portfolio is sensitive to the choice of the portfolio used to represent the market and it can be very sensitive to this choice. Second the sensitivity depends on the curvature of the efficient frontier lying between alternative portfolios used to represent the market.
>
> At a theoretical level the choice of portfolio to represent the market leads to a multiplicity of possible values for the zero beta return and what you get in empirical work depends very much on what you do. The very substantial variation in the estimates provided by the regulated businesses, and the theoretical and empirical work showing the unreliable nature of zero beta return estimates, clearly suggests that estimates of zero beta returns are not appropriate for use in determining regulated returns.

183. The Authority has confirmed the lack of robustness of the zero beta portfolio in its own estimates (Appendix 4Ai). The Authority has also confirmed the inefficiency of the zero beta portfolio utilising the NERA method of estimation (to the extent that it lies inside the return mean-variance efficient frontier)

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[150] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Response to ERA Issues Paper Submission 26*, 2 June 2015, Appendix C.

[151] Partington, G. and Satchell, S. "*Report to the AER: Analysis of Criticism of 2015 Determinations", a report prepared for the Australian Energy Regulator*, October 2015, p. 19.

[152] Partington, G. and Satchell, S. *"Report to the AER: Analysis of Criticism of 2015 Determinations", a report prepared for the Australian Energy Regulator*, October 2015, p. 20.

[153] Partington, G. and Satchell, S. *"Report to the AER: Analysis of Criticism of 2015 Determinations", a report prepared for the Australian Energy Regulator*, October 2015, p. 26.

184. On balance, the Authority considers that there are still many unsolved issues in relation to the estimates of the zero beta premiums. As such, the Authority considers that DBP's estimates – which use a single estimate of zero beta premium – disguises the significant instability in the model. Therefore, the Authority does not consider that DBP's model adequacy test is empirically true to the Black CAPM model.

185. The Authority is convinced that the unsolved issues in relation to the estimates of the zero beta premium may well explain the Black CAPM has never been adopted by practitioners.

DBP's model adequacy test produces nonsensical outcomes

186. The Authority notes that based on the findings from its model adequacy test, DBP is of the view that the bias in its Sharpe Lintner CAPM analysis is not only statistically significant, but economically significant as well, with a mean forecast error of around four percentage points per annum. DBP considers that this means that a regulator using the Authority's approach to setting prices would provide investors with returns that are four percentage points lower than they could be earning by facing similar levels of systematic risk elsewhere in the economy.[154]

187. The Authority considers that the implication of DBP's finding is that the expected return on equity for low beta assets, such as the ATCO GDS, the GGP and the DBNGP, needs to be increased by 4 percentage points, based on DBP's analysis and conclusion. For example, DBP argue that the expected return for DBP or ATCO (a low asset beta) using historical data on DBP's model adequacy test should be 11.28 per cent.

188. The Authority notes that the market return on equity for a long period is approximately 10.83 per cent,[155] which is lower than DBP's estimated return for low asset betas such as DBP and ATCO. DBP is therefore suggesting that its return on equity is more risky than the market as a whole. The Authority does not consider that this view is sound.

189. There is conceptual support for the equity beta of an infrastructure network benchmark efficient entity being less than 1:

- business risk – which may be disaggregated into intrinsic (economic) risk and operational risk – is the primary driver of systematic risk, and this risk is low for the benchmark efficient entity relative to the market average;
- despite relatively high financial leverage, the benchmark efficient entity does not have high financial risk – rather it is the intrinsic risk of the firm which is the key driver of systematic risk.

190. McKenzie and Partington endorse the view that the equity beta is likely to be below 1, concluding that there is:[156]

> …evidence to suggest that the theoretical beta of the benchmark firm is very low. While it is difficult to provide a point estimate of beta, based on these considerations, it is hard to think of an industry that is more insulated from the business cycle due to inelastic

[154] DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020, Rate of Return, Supporting Submission: 12*, 31 December 2014, p. 60.

[155] Economic Regulatory Authority, *Final Decision on Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems*, as amended 10 September 2015, p. 255.

[156] McKenzie, Partington, *Report to the AER: Estimation of the Equity Beta (Conceptual and Regulatory Issues) for a Gas Regulatory Process in 2012*, April 2012, p. 15.

demand and a fixed component to their pricing structure. In this case, one would expect the beta to be among the lowest possible and this conclusion would apply equally irrespective as to whether the benchmark firm is a regulated energy network or a regulated gas transmission pipeline.

191. The Authority notes these views and considers that the reasoning is relevant.

192. These pieces of evidence provide further support for the Authority's view that DBP's model adequacy test produces nonsensical results.

193. As a further illustration of this lack of credibility, DBP's analysis suggests that the estimates for Portfolio 9 – high beta stocks – are statistically significant under both Method A and Method B, a (positive) bias is 8.15 per cent (for Method A) and 6.37 per cent (for Method B). Given the risk free rate of 1.96 per cent and the MRP of 7.6 per cent, together with equity beta of 1.43, the return on equity for this portfolio is 12.93 per cent. Taking into account a positive bias suggested by DBP (i.e. the Sharpe Lintner CAPM overestimates the high beta assets), then the return on equity for this particular business would need to be reduced to approximately 4.78 per cent (for Method A) and 6.56 per cent (for Method B). Both estimates of return on equity in these two cases are lower than the cost of debt for this portfolio.

194. On balance, the Authority is of the view that the findings of DBP's analysis are not robust and the approach produces nonsensical outcomes.

Other issues

195. Several other immediate issues in relation to DBP's model adequacy test are also discussed in Appendix 4Bi. These issues, associated with DBP's model adequacy test, are summarised as follows.

- The test does not evaluate prediction bias as claimed by DBP, only overall prediction accuracy which is comprised of irreducible bias and variance components.
- The test does not include the uncertainty of prediction estimates within the test.
- The testing of each portfolio through the use of a t-test will suffer from the multiple comparison problem, which will increase with the number of portfolios.
- The method of generating predictions potentially suffers from pseudo-replication.
- The t-test is not specified: for discussion purposes – it is assumed to be a two-sample t-test. In contrast, a paired t-test is a uniformly more powerful test in discriminating differences between two dependent samples of data.
- The model adequacy test described is not state of the art in the statistical literature for assessing model performance. There are no references in the literature in defence of the method cited by DBP.

196. The Authority is of the view that a more appropriate framework for assessing prediction accuracy, and hence model adequacy, is to utilise the cross-validation measure of prediction error. This framework can be extended to explicitly decompose prediction error into its irreducible bias and variance components by employing jack-knife methods (Efron 1979). Moreover, cross-validation is a widely applied framework within the statistical literature (Hastie et al. 2009), and its strengths and failings have been well researched. Further details of this framework can be found in Appendix 2A.

Overall conclusions

197. The Authority has considered both the conceptual and empirical elements of DBP's model adequacy test. Based on its considerations, the Authority is of the view that DBP's model adequacy test does not properly compare the prediction performance of the Authority's method. The Authority considers that DBP's analysis is fundamentally flawed and its approach is unable to produce any sensible estimates.

198. In conclusion, based on these considerations, the Authority is of the view that DBP's model adequacy test fails both conceptually and in empirical application. As such, the Authority deems that the analysis is not fit for the purpose of estimating equity beta.

Conclusions with regard to relevant models

199. The following conclusions have been reached in relation to the approach for estimating the return on equity in this Draft Decision for DBP:

- The Sharpe Lintner CAPM will be utilised to estimate the return on equity.
- The Fama French three factor model is not relevant and as such, this model is not used for the purpose of estimating a return on equity.
- The Black CAPM is relevant for the purpose of estimating a return on equity. However, given it is not reliable and practical to estimate a robust return on equity using this model, the model will not be used directly, but only to inform the point estimate of the equity beta from within its range for input to the Sharpe Lintner CAPM.
- The DGM is a relevant model for informing the market return on equity and also the forward looking MRP.
- Other information such as historical data on equity risk premium; surveys of market risk and other equity analysts' estimates are also relevant for the purpose of estimating the MRP and the market return on equity. This other material will be used as a cross check for the return on equity.

185. Given that the only robust model for estimating the return on equity in the Australian context is the Sharpe Lintner CAPM, the Authority does not see any current need for data sourced from the SIRCA SPPR database, as suggested by DBP.[157] The SPPR database was required by DBP to form long time series of predictions for the model adequacy test.[158] As need for the model adequacy test has been rejected, then so too has the need for the SPPR database.

186. The Authority remains of the view that its reasons for adopting the Sharpe Lintner CAPM are sound. The Authority considers that its application of the Sharpe Lintner CAPM meets the requirements of the NGR, and the allowed rate of return objective.

- The Authority does not agree with DBP's submission that it has not taken all of the relevant information into consideration with respect to its estimate of the return on equity. The Authority is of the view that all of the issues raised by DBP and its consultants have been considered in this Draft Decision.

157 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020, Rate of Return, Supporting Submission: 12*, 31 December 2014, p. 55.

158 This need for a long time series was considered one of the weaknesses of the model adequacy test (Appendix 4B), one which can be circumnavigated by various approaches to cross-validation (Appendix 4Bi).

- The Authority also disagrees with DBP's estimates of the rate of return on equity. The Authority has conducted significant research into the rate of return and has cross checked its estimate across various sources. The Authority's estimate for the rate of return is in line with other industry estimates.
- The Authority considers that the estimated return on equity adopted in this Draft Decision is commensurate with the equity costs incurred by a benchmark efficient entity with a similar degree of risk as DBP with respect to the provision of reference services. The Authority therefore considers that the estimated rate of return meets the allowed rate of return objectives and the requirements of the NGR and NGL.

Step 2 – Estimate parameters for the relevant models

Estimate of the risk free rate

187. The risk free rate will be based on a 5 year term to maturity, determined as the average of the observed yields of the 5-year Commonwealth Government Securities over the nominated 40 business day averaging period that is just prior to start of the regulatory period.

188. The *indicative* risk free rate for this Draft Decision is 1.96 per cent as at 2 April 2015.

Estimate of the equity beta

DBP's Betastar

200. The Authority notes that DBP does not put forward an estimate of the equity beta that is consistent with the Sharpe Lintner CAPM.

201. Instead, DBP introduces the concept of Betastar, which reflects estimates based on the Black CAPM. In doing so, DBP submits that it is correcting for the bias in the Sharpe Lintner CAPM, by adjusting beta in the betastar model. Because DBP load all of the corrections onto a single parameter, the adjustment is very large.

202. To form a range for Betastar, DBP selects the 20th percentile and the 99th percentile which produces the range of Betastar from 0.94 to 1.11.[159]

203. However, as noted above at paragraphs 184 to 198, the Authority is not convinced that the estimates derived from the Black CAPM, or DBP's concept of Betastar for use in the Sharpe Lintner CAPM, are relevant and appropriate for the purpose of estimating a return on equity.

Beta in the Sharpe Lintner CAPM

204. Under the CAPM, the total risk of an asset is divided into systematic and non-systematic risk. Systematic risk is a function of broad macroeconomic factors (such as economic growth rates) that affect all assets and cannot be eliminated by diversification of the investor's asset portfolio.

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159 DBNGP Transmission Pty Ltd, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020, Rate of Return, Supporting Submission: 12*, 31 December 2014, p. 77.

205. The key insight of the CAPM is that the contribution of an asset to the systematic risk of a portfolio of assets is the correct measure of the asset's risk (known as beta risk), over and above the return on a risk free asset.

206. In contrast, non-systematic risk relates to the attributes of a particular asset. The CAPM recognises this risk can be managed by portfolio diversification. Therefore, the investor in an asset does not require compensation for this risk.

207. In the CAPM, the equity beta value is a scaling factor applied to the market risk premium, to reflect the relative systematic risk for the return to equity of the firm in question, as compared to the systematic risk for all assets. Two types of risks are generally considered to determine a value of equity beta for a particular firm: (i) the type of business, and associated capital assets, that the firm operates; and (ii) the amount of financial leverage (gearing) employed by the firm.

208. In the Rate of Return Guidelines, the Authority considered that empirical evidence provides the best means to inform its judgment for equity beta.[160]

209. However, as noted at paragraph 189 and 190 above there is conceptual support for the equity beta of an infrastructure network benchmark efficient entity being less than 1.[161] The Authority has notes these views and considers that the reasoning is relevant.[162] Nonetheless, the conceptual analysis does not provide sufficient grounds to establish the point value of the equity beta. To inform its decision on the point value, the Authority conducted a detailed empirical estimation of the required equity beta as part of the development of the Rate of Return Guidelines.[163]

210. The Authority has also considered the following issues in relation to the estimates of equity beta in the Draft Decision for DBP.

160 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines: Meeting the Requirements of the National Gas Rules,* December 2013, p. 161.

161 See for example Australian Energy Regulator, Draft Decision Jemena (NSW), Attachment 3: Rate of return, November 2014, p. 3-235.

162 The Authority notes DBP's view – reported above – that model adequacy tests suggest that application of the Sharpe Lintner CAPM is not estimating what low beta firms 'actually earn for their equity investors' (Dampier Bunbury Pipeline, DBP Submission to ATCO Draft Decision, 7 January 2015, p. 3). However, the Authority considers that the evidence provided by DBP does not accord with the well accepted theoretical underpinnings of the CAPM, in that it suggests that as beta (systematic risk) declines, the equity risk premium increases. This raises significant issues for the DBP empirical analysis, and the underlying quality of the data that is used for that analysis. The Authority is in the process of investigating these matters for the DBP access arrangement review.

Similarly, the Authority considers that the points made by the ENA also refer to the same matters (Energy Networks Association, WA ERA Draft Decision for ATCO Gas ENA Response, 12 January 2015, p. 4). In particular, the evidence on the performance of Sharpe Lintner CAPM for low beta stocks evaluated by the ENA's consultant NERA utilises the same SIRCA database which is used by DBP (see NERA Economic Consulting, Estimates of the zero-beta premium, June 2013, p. 15). Furthermore, as a related point, the Authority does not consider that the four estimates cited by ENA are robust in the Australian context.

At the current time, the Authority remains of the view that the conceptual foundation of the CAPM supports the estimates of the return on equity set out in this Draft Decision.

163 Econometric analysis of beta was conducted in: Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, December 2013, Chapter 12. Justification and explanation for econometric techniques was provided in Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, December 2013, Appendix 17, 22 and 23.

211. *First*, the Authority acknowledged in the Guidelines that a high level of imprecision existed for any empirically estimated value of the equity beta.[164] The Authority considered that issues of imprecision are best addressed via the use of statistical techniques to inform a possible range for any equity beta estimate. These issues and statistical techniques were explored at length in the Rate of Return Guidelines.[165]

212. *Second*, a range of other issues were considered by the Authority, including those relating to sampling and instability.

213. *Third*, the Authority considered that it was inappropriate to include overseas businesses in the comparator sample which was used to estimate the required equity beta of the benchmark efficient entity.[166] This was based on the consideration that while a larger sample may improve the comparator sample size, such an inclusion will be outweighed by the distortions caused due to the dissimilarity with the benchmark efficient entity.

214. *Fourth*, the Authority acknowledged there was some evidence of the potential for downward bias in the estimate of the equity beta. The Authority therefore determined to adopt a point estimate of equity beta towards the upper end of its estimated range.[167]

215. These issues are further considered in what follows.

Imprecision of the estimates

216. The Authority drew on its own studies of the equity beta of Australian utilities, together with other relevant studies, to estimate an appropriate range for the equity beta of the benchmark efficient entity.[168]

217. In recent times, the number of comparable businesses in the sample for the benchmark efficient entity has reduced. However, the Authority is of the view that the robustness of the estimates continues to be supported, given the overall stability of the beta estimates.

218. The Authority considers that the empirical studies of the Australian sample, including the Authority's studies in 2011 and 2013, and Henry's studies for the AER in 2014, 2009 and 2004, have produced similar outcomes, despite variation in the econometric techniques, portfolios of firms and time periods. The Authority notes that all possible scenarios have been explored in these studies. The studies used various econometric techniques including a standard Ordinary Least Squares (**OLS**)

164 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, December 2013, p. 162.

165 Econometric analysis of beta was conducted in: Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines: Meeting the Requirements of the National Gas Rules,* December 2013, Chapter 12. Justification and explanation for econometric techniques was provided in Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines: Meeting the Requirements of the National Gas Rules,* December 2013, Appendix 17, 22 and 23.

166 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, December 2013, p. 188.

167 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, December 2013, p. 197.

168 In particular, Henry's (2014) study for the AER provided a recent update of estimates (see O. Henry, *Estimating β: An update*, April 2014).

approach and other robustness approaches such as the Least Absolute Deviations (**LAD**); maximum likelihood robust methodology (**MM**); and Theil Sen approaches.

219. The majority of the evidence presented across all estimators, firms and portfolios, and all sample periods considered, suggests that the point estimate for equity beta for a sample of the Australian utilities lies in the range of 0.3 and 0.8.

220. In addition, the Authority has recently conducted an analysis in 2015 in relation to the estimates of equity beta for regulated energy businesses in Australia. Findings from this recent analysis indicates that 0.8 is an upper bound of the equity beta across various samples and econometric techniques. Full details of the Authority's 2015 analysis are included in the Appendix 4B.

221. With regard to the Authority's 2013 estimates, the 95 per cent confidence interval for the estimates based on the average of the recent data for six firms is 0.31 to 0.76.[169] The Authority considers that the confidence intervals developed for the Rate of Return Guidelines for individual firms support a 95 per cent confidence interval range from a (rounded) 0.3 to 0.8.[170]

222. This is the same confidence interval as that determined by Henry in 2014:[171]

> …the majority of the evidence presented in this report, across all estimators, firms and portfolios, and all sample periods considered, suggests that the point estimate for β lies in the range 0.3 to 0.8. Given the differences in sample periods and sizes underlying the various individual estimates provided in Tables 2, 14 and 16 using individual assets and fixed weight portfolios it is difficult to pin down a value for the beta of a typical firm, however within the range 0.3 to 0.8 the average of the OLS estimates for the individual firms reported in Table 2 is 0.5223 while the median estimate is 0.3285.

169 ATCO Gas Australia, *ATCO Gas Australia's Response to the ERA's Draft Decision*, 22 December 2014, Appendix 9.1, p. 8.

170 The Authority remains of the view that confidence intervals calculated using this bootstrap approach are more accurate than the traditional approach, which assume a parametric form regarding the regression coefficients. Confidence intervals calculated using the bootstrap approach are directly comparable across regression estimators, whereas they are not under the traditional approach (see Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, December 2013, p. 190).

171 O. Henry, Estimating β: An update, April 2014, p. 63.

Table 4 Australian estimates of equity beta

Study	Period	Average of individual firms	Fixed portfolios	Varying portfolios
ERA 2015	2000 - 2015	0.41 – 0.81		
Henry 2014	1992-2013	0.37-0.56	0.38 – 0.71	0.39-0.53
Grant Samuel 2014	2009-2014	0.42-0.64		
ERA 2013	2002-2013	0.48-0.52	0.39-0.59	
SFG2 2013	2002-2013	0.60		0.55
ERA 2012	2002-2011	0.44-0.60		
Henry 2009	2002-2008	0.45-0.71	0.35-0.94	0.41-0.78
ACG 2009	1990-2008	0.50-0.58		0.69-0.91
Henry 2008	2002-2008	0.35-0.67	0.31-0.77	
ACG 2002	2000-2002	0.61-0.69		

*Source: The AER's Draft Decision for ActweAGL Distribution Determ*ination, Table 3-55, page 3-262 and the ERA's 2015 study

223. Based on its 2015 study, the Authority notes that, when all econometric techniques (including the OLS, LAD, MM, and Theil-Sen methods used in the Guidelines, and now also ARIMAX and GARCH) are applied to various portfolios (including equally weighted and value weighted portfolios), equity beta falls within the range of 0.41 (lower bound at 2.5 per cent) and 0.81 (upper bound at 97.5 per cent). The Authority also notes that the median estimates of equity beta fall within the range of 0.60 and 0.65.

224. The Authority notes the view from NERA, DBP's advisor on the issue, that LAD estimators can be biased while OLS estimators are simultaneously unbiased when the distribution of the disturbance from a regression is skewed. NERA is also of the view that if the benefits of using robust regression techniques exceed the costs and the market for academic research is efficient, then one should expect to find evidence of the frequent use of these techniques in published work. NERA concludes that there are relatively few references to robust regression techniques whereas the OLS techniques are used frequently.[172]

225. In response, the Authority notes that the OLS technique plays a key role in Henry's studies for the AER. However, the Authority is of the view that robust regression methods, such as LAD, also can provide useful information about the properties of the sample. The Authority considers that each of the various econometric techniques – whether OLS or robust regression methods – have strengths and weaknesses. It follows that evaluation of the beta estimates based on information from the diverse econometric techniques is appropriate.

226. The Authority is of the view that the range of 0.3 to 0.8 for equity beta for Australian network service providers is appropriate. This range is based on the Authority's judgment, drawing on the estimates derived using the OLS and various robust regression techniques. The Authority notes that the various estimation methods deliver outcomes that are broadly consistent with this range.

172 O. Henry, *Estimating β: An update*, April 2014, p. 63.

227. On the basis of the above empirical studies, including the Authority's most recent analysis in 2015, the Authority in this Draft Decision considers that a range of equity beta of 0.3 to 0.8, which was adopted in the Final Decision for ATCO, is still appropriate for an Australian pipeline service provider. This accounts for:

- the Authority's recent study using the most updated data until 2015, which provides the range of 0.41 and 0.81;
- the evidence for the 95 per cent confidence interval from the 2013 ERA study, which is 0.3 to 0.8; and
- Henry's view – based on his 2014 work – that equity beta is likely to be in the range of 0.3 to 0.8.

228. The Authority remains of the view that the available Australian studies are fit for the purpose for estimating an equity beta range for the benchmark efficient entity.

Stability of the estimates

229. The Authority rejects SFG's criticism regarding the sensitivity of individual equity beta estimates to the methodological choices of regression technique and sampling period. The Authority previously addressed these issues at length in the Rate of Return Guidelines.[173] SFG has ignored this in its analysis, simply restating its previous evidence with regard to Hastings Diversified Utilities Fund (**HDF**) (drawn from the Authority's old 2011 study), with the implication that this refutes the Authority's determined equity beta range.[174]

230. SFG also considers it 'implausible' that equity beta estimates could change over a two year period.[175] However, the rolling beta estimates produced by the Authority in the Guidelines demonstrate that, for individual firms, the relative sensitivity to systematic risk can vary quite dramatically.[176] The Authority has no reason to believe that this does not reflect a re-rating by the market of the respective firms, in terms of risk relative to the market. The Authority notes that the significant variation occurs during the Global Financial Crisis, a period where excessive leverage was marked down, followed by a period in which firms significantly reduced leverage and investors chose to chase the 'safe yields' offered by infrastructure firms.

231. The Authority also rejects SFG's contentions with regard to sampling interval stability. The Authority considered the validity of weekly (Friday) versus monthly estimates in the Guidelines, noting:[177]

> The Authority is of the view that weekly data is preferred to monthly data. It is noted that estimates of equity beta using monthly data create a smaller sample which is likely to result in a reduced statistical efficiency of the estimates. In addition, the Authority notes that estimates using monthly data are also vulnerable to the "day-of the- week effect". This means that if prices are dependent on the day-of-the-week, then this effect is required to be controlled to ensure that returns are observed on the same weekday (Monday, Tuesday, Wednesday, Thursday, Friday). This effect cannot be controlled

[173] Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guideline*, December 2013, Section 12.2.5, Section 12.2.8.

[174] NERA Economic Consulting, *Robust Regression Techniques,* a Report for DBP, December 2014, pp. ii-iii.

[175] ATCO Gas Australia, *ATCO Gas Australia's Response to the ERA's Draft Decision*, 22 December 2014, Appendix 9.1, p. 9.

[176] Only HDF falls outside the estimated range.

[177] Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guideline*, December 2013, p. 189.

> when the monthly data is used because a calendar month can end on any day of the week.
>
> In his advice to the AER in 2008, Henry discussed the issue of daily versus monthly estimates.[178] He then concluded that weekly data is an appropriate trade-off between noisy daily data and lack of degrees of freedom (due to smaller samples) using monthly data. In addition, the Authority notes that the average of the estimates based on daily data that CEG has presented appears to be comparable to the average of the estimates based on weekly data closing Friday.[179] The Authority therefore concludes that weekly intervals are appropriate for equity beta estimation.

232. The Authority rejects the view that these issues undermine the validity of the estimates. However, the Authority has estimated day of the week beta estimates in its most recent 2015 study (see Appendix 2B).

Use of international comparators

233. The Authority has considered the proposal to include US energy firms in the sample of Australian energy firms to estimate equity beta for an Australian benchmark efficient entity is not appropriate. The Authority considers statistical estimates of equity beta using a sample of comparable exchange listed Australian firms (as was done in the Rate of Return Guidelines) to be the preferred method of estimating systematic risk for the benchmark firm.[180]

234. The Authority is of the view that the US based firms do not operate within Australia, so they do not match the Authority's definition of a benchmark efficient entity, which is based on:[181]

> An efficient 'pure-play' regulated gas network business operating within Australia without parental ownership, with a similar degree of risk as that which applies to the service provider in respect of the provision of reference services.

235. The Authority notes that the Sharpe Lintner CAPM adopted in the Authority's decision is a domestic version of CAPM, in which other inputs such as the risk free rate, MRP and market return on equity are derived from the Australian domestic environment. The Authority is of the view that it is desirable that any estimate of equity beta be based on Australian data, if at all possible. As noted above, the Authority considers that robust domestic estimates are available and fit for purpose for this Draft Decision.[182]

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178 O. Henry, *Econometric advice and beta estimation*, November 2008.

179 Competition Economists Group, *Regression estimates of equity beta*, September 2013, Figure 3.

180 Where exchange listed Australian comparators cannot be found, the next most preferred method is to estimate asset and equity beta using comparable international firms (as was done in the 2015 Weighted Average Cost of Capital for Railway Networks). Where neither of these approaches are possible, then alternative approaches can be considered.

181 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 36.

182 The Authority notes that it has adopted overseas comparators for its rail decision. However, the Authority considers its relaxation of its approach in that instance is justified, as there was only *one* domestic rail comparator (Aurizon) (see Economic Regulation Authority, *Review of the method for estimating the Weighted Average Cost of Capital for the Regulated Railway Networks – Revised Draft Decision*, 28 November 2014, p. 107). The Authority therefore sought other comparators both domestically (ports, logistics) and internationally. As noted in that Decision, 'Authority does not consider that this should create a general precedent for other determinations, where adequate domestic data is available' (Economic Regulation Authority, *Review of the method for estimating the Weighted Average Cost of Capital for the Regulated Railway Networks – Revised Draft Decision*, 28 November 2014, p. 133). The Authority considers that adequate domestic data is available for this Final Decision, given the span of studies and results.

236. While the Authority agrees that an increase in the number of firms in the sample may increase the reliability of the estimates of equity beta in an econometric sense, the Authority is not convinced that including the US network providers in the Australian sample will improve the accuracy of the estimates.

237. Specifically, the estimates of equity beta in the SFG (2014) study are measured with respect to the market portfolio of the US, which is the S&P1500. These estimates are not a measurement of the firm's systematic risk relative to the Australian domestic market portfolio, which is required under the definition of the Sharpe Lintner CAPM used by the Authority. The Authority agrees that a beta for any market portfolio is always equal to 1 regardless of the country. However, this does not change the Authority's view that including US energy firms in the Australian sample for the purpose of estimating an equity beta as in the SFG 2014 study is a second best solution. The Authority remains of the view that the Australian sample is a more reasonable comparator set than that provided by US energy firms.

238. The Authority notes that Handley also agrees with this view.[183]

> The difficulty here is that domestic betas and international betas are not strictly comparable and so we have a classic case of comparing apples and oranges. In general, domestic betas and international betas measure different things and are not comparable due to potential differences in the covariance structure and level of systematic risk in the respective markets. This is purely a definitional difference.

239. The Authority does not believe that SFG has satisfactorily demonstrated or provided evidence that the suggested sample of 56 US energy firms included in the sample together with Australian firms are sufficiently comparable to an Australian benchmark efficient entity.

240. The Authority notes that a sample of Australian comparators was carefully selected by Professor Henry for the AER in 2008. The Authority considers that these comparators are all Australian firms and as such these comparators have operated in the same the domestic economy with similar geography, business cycles, regulatory environment and various other factors. The Authority does not suggest that these nine comparators included in the sample have exactly had the same level of systematic risk in comparison with an Australian benchmark efficient firm for regulatory purposes. However, the Authority considers that these selected firms can reasonably be used as the comparators.

241. The Authority notes that a number of US comparator businesses are vertically integrated. Some US firms used in the SFG sample also operate in energy generation, wholesale and retail of energy, as well as other activities distinct from the energy distribution and transmission such as telecommunications, real estate development and manufacturing activities.[184] The Authority considers that these activities are very different from the benchmark efficient entity, which is a pure play regulated energy network business (operating within Australia). The Authority notes that SFG itself recognised that international energy network firms are less comparable to the benchmark efficient entity than Australian energy network firms. However, it also considered the comparator set of Australian energy network firms was too small and produced unreliable equity beta estimates. The Authority is of the view that SFG's concern is not substantiated as previously discussed.

183 Handley, J. "*Advice on the Return on Equity", a report prepared for the Australian Energy Regulator*, October 2014, p. 23.

184 The Australian Energy Regulator, *Draft Decision – ActewAGL distribution determination 2015-16 to 2018-19*, Attachment 3: Rate of Return, Table 3-38, p. 246, November 2014.

Bias of the estimates

242. The Authority also noted in the Rate of Return Guidelines that relevant empirical evidence supports a view that there is some downward bias in equity beta estimates that are less than 1, and upward bias in equity beta estimates that are greater than 1. Therefore, the Authority was inclined to assume a point estimate for the equity beta that is towards the top end of the estimated range, at 0.7, so as to account for potential bias in the estimate. With respect to the Black CAPM, the Authority rejects SFG's assertion that this implies an equity beta of 1, based on the analysis conducted by NERA.[185]

243. *First*, the Authority rejected the use of the Black CAPM in the Rate of Return Guidelines, on the basis that its empirical performance was unreliable.[186] Second, the Authority noted in the Rate of Return Guidelines that:[187]

> … the Authority intends to account for empirical evidence relating to potential bias in the estimates of the equity beta that are used in applying the Sharpe Linter CAPM. The Authority considers that such an approach would account for much of the evidence supporting the use of the Empirical and Black CAPM models.

244. *Second*, the Authority recognises the theoretical principles underpinning the Black CAPM, and the implications for firms with an equity beta below 1.0. Various studies have argued that the Black CAPM may predict a higher return on equity than the Sharpe Lintner CAPM, implying a low asset beta bias.

245. However, following an extensive literature review, the Authority's view is that this bias is not well established in either the theoretical and empirical studies. In addition, the applications of the Sharpe Lintner CAPM and Black CAPM are two different processes in which any input for each model is required to be estimated in its own right. For example, in order to estimate a return on equity using the Sharpe Lintner CAPM, the estimates of its inputs including a risk free rate, the MRP and equity beta, are required. Similarly, the estimates of the zero beta (excess) return and beta for the zero-beta portfolio are required under the Black CAPM.

246. The implication is that estimates of a return on equity either using Sharpe Lintner CAPM or Black CAPM are best implemented in their own right. However, the Black CAPM outcomes are not robust in the Australian context.

247. The Authority considers therefore that the Black CAPM is only useful to the extent that it suggests a downward bias in the return on equity generated by the Sharp Linter CAPM for firms with an equity beta less than 1. The Authority is of the view that it is difficult to quantify the extent of any downward bias. Nevertheless, to acknowledge the potential bias inherent in the theory of the Sharpe Lintner CAPM, the Authority considers it may be appropriate to adopt an equity beta in the Sharpe Lintner CAPM which is somewhat higher than the best estimate of 0.5, toward the upper end of the estimated range of 0.3 and 0.8.[188]

185 NERA, *Estimates of the Zero-Beta Premium*, June 2013.

186 Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, December 2013, Appendix 8.

187 Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, December 2013, Appendix 8, p. 67.

188 The Authority considers that the bias does not arise in the theory of the CAPM, but rather is an empirical claim.

248. With respect to the previous access arrangement for the ATCO distribution network adopting an equity beta of 0.8, the Authority considers that this was primarily a consequence of a number of empirical studies available and the statistical properties of the equity beta estimates that existed at the time of the previous access arrangement. For example, Henry's study in 2009 was the most relevant study on the estimate of equity beta at that time. In addition, only two econometric techniques – OLS and the LAD techniques – were used at the time.

249. The Authority considers that the majority of the most recent empirical evidence considered in the Rate of Return Guidelines demonstrates that the equity beta range of between 0.3 and 0.8 is appropriate. The Authority's study suggest that this is consistent with a 95 per cent confidence interval.

250. The Authority now considers that a value of 0.8, which is at the top end of this estimated range, would be excessive for a gas distribution network such as the DBP, with its highly diversified demand base.

251. Furthermore, the Authority notes that SFG considers only the individual firm estimates, ignoring the fact the Authority has consistently utilised averages across all of the benchmark sample of firms to inform individual firm beta estimates. In particular, the Authority's 2011 analysis determined an individual firm average range of 0.44-0.60, while the updated 2013 analysis determined an individual average range of 0.49-0.52.[189]

252. Moreover, the Authority has consistently reiterated that as a consequence of the statistical imprecision inherent in equity beta estimation, a range of values and regression techniques are necessary in order to inform the permissible range of equity beta values. This acts to mitigate the impact an individual firm's equity beta estimate can have on the determined equity beta estimate. The Authority considers that issues of statistical imprecision are best addressed via the use of multiple models and regression techniques to inform the possible range of equity beta estimates.

Conclusions with regard to equity beta

253. Based on the above considerations, the Authority is of the view that available Australian estimates of equity beta are reliable and that the estimates from these studies should be used to determine an appropriate equity beta for a network service provider.

254. The Authority considers that including US energy firms in the Australian sample for the purpose of estimating equity beta is inappropriate, given that the SFG (2014) study on a larger comparator set of US and Australian energy network firms is unlikely to increase the reliability of the equity beta estimates. The Authority considers that increasing the sample size may not be helpful if that larger comparator set is less representative of a true value of equity beta for a network service provider.

255. The Authority considers that available estimates of equity beta in Australia including Henry's studies and the Authority's own analyses, as presented in Table 4 above, indicate a best empirical equity beta estimate of approximately 0.5. The Authority also widened its estimated range to 0.6 and 0.8, to be consistent with its 95 per cent confidence interval, and also the opinion of Henry.

[189] Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines: Meeting the Requirements of the National Gas Rules,* December 2013, Table 22, p. 171.

256. The Authority remains of the view that it is appropriate to account for all considerations in its determination of the equity beta point estimate. In particular, it will continue to account for the theoretical implications from the Black CAPM, and the potential for the use of the Sharpe Lintner CAPM to underestimate returns. The exact uplift to address this issue is difficult to determine.

257. Based on its considerations outlined above, the Authority has determined to adopt the estimate of equity beta of 0.7 for this Draft Decision for the DBNGP.

Estimate of the Market Risk Premium

258. The Authority's views on the best means to estimate the forward looking MRP have evolved in recent decisions.

259. In the Final Decision for the third Western Power Access Arrangement the Authority applied an MRP of 6 per cent in the Sharpe Lintner CAPM, based on regulatory precedent and analysis by Handley with regard to the historic average MRP.[190] The view implicit in this approach was that the MRP is mean reverting, such that the historic average provided a robust estimator for future outcomes (on average).

260. Handley's analysis was based on Brailsford, Handley and Maheswaran (**BHM**) data.[191] At the time, the Authority did not have access to the underlying BHM data.

261. The Authority gained access to the BHM data during the development of the Rate of Return Guidelines, enabling it to undertake statistical testing on the long run average market return on equity and MRP, in order to ascertain whether each series was stationary (in the sense of being mean reverting). Stationarity is an important property of a data set if historic averages are to be used as a predictor for outcomes likely to prevail over future periods.

262. The results indicated the market *return on equity* was stationary.[192]

263. However, the results produced mixed evidence on the stationarity of the MRP, with the analysis supporting a conclusion that the MRP is non-stationary.[193,194] This finding led the Authority to the important conclusion that the long run historical estimate of 6 per cent could be a poor predictor of the MRP prevailing in future regulatory periods. The Authority therefore dropped the fixed estimate of 6 per cent, instead establishing a range of possible future outcomes for the MRP, informed by information that a rational market participant would use in making investment decisions. The resultant range for the MRP was 5 to 7.5 per cent.[195]

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190 J. Handley, *An Estimate of the Historical Equity Risk Premium for the Period 1883 to 2010*, 25 January 2011.

191 T.J. Brailsford, J.C. Handley and K. Maheswaran, The Historical Equity Risk Premium in Australia: Post-GFC and 128 Years of Data, *Accounting and Finance*, 52, 2012, pp. 237-247.

192 Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, Appendix 8, p. 63 and Appendix 16.

193 Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, Appendix 8, p. 63 and Appendix 16.

194 Further support for the non-stationarity of the MRP is given by the finding that the risk free rate is non-stationary (Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, Appendix 16). As the market return on equity is comprised of the risk free rate and the MRP, if follows that then that MRP must be non-stationary, by construction.

195 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 137.

264. With respect to this range, the Authority acknowledges the contention in its response to the Draft Decision that the range of 5 to 7.5 per cent established in the Rate of Return Guidelines may lead to outcomes that are too low.[196] In particular, it is clear that using a range with an inappropriately constrained upper bound could result in downward bias in the Authority's forward looking MRP estimates. The Authority therefore has reviewed the approach to establishing a range for the forward looking MRP for this Draft Decision.

265. Most significantly, the Authority has now concluded that it is not reasonable to constrain the MRP to a fixed range over time. The erratic behaviour of the risk free rate in Australia to date, and more particularly, its pronounced decline in the current economic environment, leads to a situation where the combination of a fixed range for the MRP and prevailing risk free rate may not result in an outcome which is consistent with the achievement of the average market return on equity over the long run.

266. Specifically, the estimate of the upper bound for the forward looking MRP of 7.5 per cent that was based on the DGM will fluctuate in line with the risk free rate. So for example, at times when the risk free rate is low, as it currently is, the upper bound for the MRP should be higher. There will be times – such as during the GFC – when the Authority would be more likely to select a point estimate of the MRP which is close to the upper bound. The resulting required return on the market in that type of situation could possibly exceed the long run average return on equity indicated by the historical data.

267. For this reason the Authority considers it appropriate to determine a range for the MRP at the time of each decision.

Interpreting the historic evidence

268. The Ibbotson approach is consistent with the view that *MRP* is stationary and therefore will return to some constant long run average that is a good predictor for the MRP in future. If the stationarity of the MRP is borne out in reality, then the Ibbotson approach, despite being based on historical data, could be used as a reasonable 'on-the-day' prediction of the MRP over a future period. It can be combined with the on-the-day estimate of the risk free rate, which is considered the best predictor of future rates in light of the efficient market hypothesis.

269. On the other hand, the Wright approach concludes that the MRP is not mean reverting, rather it is the long run real historical *market return on equity* that is mean reverting. With the Wright interpretation – at any point in time – the real average market return on equity may be combined with the estimate of the long run *expected* inflation rate, using the Fisher equation, to provide a best estimate of the expected nominal future average value of the return on the market. It follows then that deducting the on the day estimate of the risk free rate from that nominal estimate will provide the contemporaneous on the day forward looking estimate of the MRP. This approach implies that the MRP and risk free rate are perfectly correlated one for one.

270. For this Draft Decision, the Authority accounts for the Ibbotson approach in its process for establishing the lower bound of a range for the forward looking MRP.

196 ATCO Gas Australia, *ATCO Gas Australia's Response to the ERA's Draft Decision*, 22 December 2014, p. 190.

271. The use of the Ibbotson approach to inform the lower bound of the MRP does not mean the Authority ascribes to the view that the MRP in Australia is stationary.[197] The Authority remains of the view that evidence on mean reversion of the MRP in Australia is inconclusive as outlined in the Guidelines which conducted empirical tests on the Australian data.

272. The Authority also notes that any empirical testing may be subject to shortcomings such as those relating to the data itself, its span or in the methods applied. Empirical evidence may provide information that assists in understanding economic and financial relationships, but should be grounded in theory. For this reason the Authority considers it reasonable that investors may give credence to historical averages of the MRP in forming their views for the future.[198] Therefore, the Authority considers that the two opposing theoretical interpretations for estimating the MRP (Ibbotson and Wright) cannot be dismissed.[199]

273. Turning now to the estimates themselves, the Authority first evaluated the long run average market return observed from the Brailsford, Handley and Maheswaran (**BHM**) series in Rate of Return Guidelines. The BHM (2012) series spanned 128 years and so was considered the most appropriate data set for determining the long run average market return on equity and the related MRP.

274. However, concerns have been raised relating to the quality of the BHM data. Additionally, the series covers a pre- and post-imputation credit regime and so requires adjustment from 1987 onward to ensure returns are estimated on a consistent basis over the whole series. With regard to data quality, the BHM historic series are claimed to be downwardly biased on account of an inadequate adjustment made to the dividend yields employed in the data. To address this perceived issue, in 2013 NERA produced an Australian stock market total return series that readjusted the dividend yields prior to 1957.[200]

275. In the Final Decision for ATCO, the Authority extended the BHM and NERA series through to 2014, based on the most recent data.[201] The difference between the long run average (nominal) market return on equity based on the BHM and NERA series is 36 basis points (Table 5).

[197] Equally, the Authority does not accept the Wright approach as being the sole guide for the estimate. The 'Wright' view on the stationarity of the market return on equity was considered in the Guidelines. However, the Guidelines rejected the view that the MRP and risk free rate are perfectly correlated one for one. The Authority remains of the view that while being an acceptable theoretical foundation, sole reliance on the one for one correlation over anything but the very long run is not likely to be helpful in practice.

[198] For example, many private sector equity analysts, such as Grant Samuel, utilise a historic estimate of the MRP when undertaking valuations.

[199] For the risk free rate, the efficient market hypothesis provides a theoretical foundation, which is therefore supported by empirics.

[200] NERA Economic Consulting, *The Market Risk Premium: Analysis in Response to the AER's Draft Rate of Return Guideline*, A Report for the Energy Networks Association, October 2013.

[201] Daily ASX All Ordinaries (AS30) and Accumulation (ASA3) indices were sourced from Bloomberg. Annual outcomes were calculated consistent with the method set out by BHM in their 2012 study (see T.J. Brailsford, J.C. Handley and K. Maheswaran, The Historical Equity Risk Premium in Australia: Post-GFC and 128 Years of Data, *Accounting and Finance*, 52, 2012, section 2, p. 238). Bond and bill yields were extended based on the Reserve Bank of Australia statistics (90 day Bank Accepted Bills were used for 2013 and 2014 as there is no 3 month Treasury bills data for those years). Gamma was assumed at 0.4 consistent with the Authority's estimate for ATCO Final Decision.

Table 5 BHM and NERA long run historic nominal and real annual average market returns for 1883 to 2014 (excluding imputation credits)

	NERA approach	BHM approach	Difference
Nominal return	12.00%	11.64%	0.36%
Real return	8.76%	8.40%	0.36%

Source: NERA (2013), Brailsford, Handley and Maheswaran (2012) and ERA Analysis

276. Handley's advice to the AER prepared in October 2014 raised a number of concerns regarding the analysis underlying the NERA (2013) data. In particular, he highlighted a lack of consistency between NERA's source of dividend yields and those employed by Lamberton on which the BHM series was based.[202] Additionally, he highlighted that NERA had not reconciled their adjusted yields with those of Lamberton. The Authority therefore is of the view that the analysis underlying the NERA (2013) data is insufficient grounds to justify the full upward adjustment to the BHM series performed by NERA.

277. Given the uncertainty surrounding the most appropriate adjustment to the market return series, the Authority will use an average of the two series to minimise any potential error with use of either series alone. The real returns of both series are used (Table 5), removing inflation on a consistent basis (informed by the estimates of historic inflation set out in the BHM data).[203]

Imputation Gross-Up Adjustment

278. The real long term average market return of the BHM and NERA series is estimated as the 'gross return' investors in equity would expect to receive on the market. That is, it is reported inclusive of yields from capital gains and dividends. The series do not account for the introduction of imputation after 1987, so need to be adjusted up from that point on to account for the imputation credit yields.[204]

279. The post-tax financial model which is a requirement under NGR 87 compensates for required returns lost to taxation by providing an explicit allowance in the model cash flows for the taxes payable, which are then recovered in regulated tariffs.[205] At the same time, the reduction for the value of imputation credits is also explicitly accounted for in the cash flows, following the requirements of NGR 87A.

280. Therefore, applying a return on equity in the post–tax model which was not 'grossed up' for imputation credits would result in under compensation for the investor. This would result because the value of imputation credits would be removed twice, first from the rate of return, and second from the revenue cash flows.

202 J. Handley, *Advice on the Return on Equity*, A Report prepared for the Australian Energy Regulatory, 16 October 2014, p. 19.

203 T.J. Brailsford, J.C. Handley and K. Maheswaran, , The Historical Equity Risk Premium in Australia: Post-GFC and 128 Years of Data, *Accounting and Finance*, 52, 2012, p. 241; NERA Economic Consulting, *The Market Risk Premium: Analysis in Response to the AER's Draft Rate of Return Guideline*, A Report for the Energy Networks Association, October 2013, Table 2.7, p. 28.

204 T.J. Brailsford, J.C. Handley and K. Maheswaran, The Historical Equity Risk Premium in Australia: Post-GFC and 128 Years of Data, *Accounting and Finance*, 52, 2012, Table 2, pp. 237-247.

205 Gamma in the post-tax approach is factored in through a reduction in the compensation for company tax, reflecting the estimated cash flows received by investors from imputation credits through their personal tax.

281. It follows that the Authority needs to 'gross up' the observed post 1987 market returns in the BHM data for the estimated value of imputation credits. Applying this in the post-tax revenue model will then ensure that the investor receives an 'after company tax, after some personal tax' return.[206] The final component of the required return on equity is then received through the investor's tax return.

282. To calculate the value of imputation credit yields in each year from 1988 (inclusive) onwards, equation (14) based on that set out by Handley (2008), accounting for theta directly, is used (see paragraphs 808 and 809 in Appendix 4A for the derivation of this equation):[207,208]

$$c_t = F \ x \ d_t \left(\frac{T_t}{1 - T_t} \right) x \ \theta \qquad (14)$$

Where:

- θ is the value of distributed imputation credits consistent with the Authority's estimate of gamma;
- d_t is the dividend yield in year t ;
- F is the proportion of dividends which are franked; and
- T_t is the corporate tax prevailing in that year.

283. The yield is then added on to the total return in each year 1988 through to 2014. The results for both series for the period following the introduction of imputation are the same, as the NERA and BHM total return series do not differ over this period. The average yield value of imputation credits to investors from 1988 to 2014 based on these assumptions and the real return data is an estimated 0.88 per cent.

284. The imputation credit yields for each year are then added to the real total returns for both the BHM and NERA series from 1988 on and the two series are then averaged (Table 6).

206 J.C. Handley, *Further comments on the historical equity risk premium*, 14 April 2009, pp. 16-17.

207 T.Brailsford, J.Handley and K.Maheswaran, *Re-examination of the Historical Equity Risk Premium in Australia*, Accounting and Finance, vol. 48, 2008, p. 85. The F in equation 4 is taken to be 0.75, hence a value for theta of 0.53 corresponds to an estimate of gamma of 0.4.

208 The imputation credit regime commenced from 1 July 1987.

Table 6 Average annual imputation credit yields and grossed up arithmetic average returns (nominal, consistent with the estimate of gamma of 0.4)

	NERA	BHM	Average
Nominal returns excluding imputation yield (1883-2014)	12.00%	11.64%	11.82%
Nominal imputation credit yield (**1988**-2014)	0.88%	0.88%	0.88%
Grossed up nominal returns (1883-2014)	12.19%	11.83%	12.01%
Grossed up real returns (1883-2014)	8.94%	8.58%	8.76%
Expected inflation for AA4	1.90%	1.90%	1.90%
Grossed up nominal return commensurate with current inflation expectations	11.01%	10.64%	10.83%

Source: ERA Analysis, NERA (2013), Brailsford, Handley and Maheswaran (2012)

285. As a final step, the grossed up expected return on equity for the market may be developed consistent with the inflation outlook for the next 5 years. The estimate of inflation for the next 5 years used in this Draft Decision is 1.90 per cent. This estimate is used to inflate the resulting average real return geometrically (based on the Fisher equation). This produces a nominal estimate for the average return on the market of 11.01 per cent for the NERA based data and 10.64 per cent for the BHM based data. The average of the two series is 10.83 per cent. The Authority considers that this estimate provides the estimate for the nominal average market return on equity that is consistent with Wright's interpretation of the historic data and the current inflation outlook.

286. This is an important marker for the market return on equity. As the available evidence supports the hypothesis that the market return on equity is mean reverting, this historic outcome from a long span of data may be used as a cross check for the long run average of the forward looking market return on equity from each regulatory period.

287. The Authority also notes that with the current risk free rate at 1.96 per cent, the MRP that is consistent with the Wright interpretation of the data is (10.83 – 1.96 =) 8.87 per cent.

Upper bound of the MRP range

288. The upper bound of the MRP range in the Rate of Return Guidelines in 2013 was set at 7.5 per cent, based on the range for the return on the market from a range of Dividend Growth Models (**DGM**) evaluated for the Rate of Return Guidelines.

289. As noted above, the Authority considers that this bound is not high enough given prevailing market conditions. There are two potential issues with the range for the market return on equity estimates derived from the DGM:

- first, there is a need to ensure that returns from all estimates grossed up, as to be on a consistent basis for input to the Authority's estimate; and
- second, the Authority should account for the range of outcomes based on the credible DGM estimates.

290. The Authority has revisited the DGM estimates, gathering a range of grossed up market return on equity estimates from the more recent DGM models (Table 7).

Table 7 Recent estimates of the MRP using the DGM

Study/Author	Date	Dividend yield source	Theta	Risk free rate (%)	Implied MRP (%)
Capital Research	Feb 2012	Factset	0.5	3.8	9.7
NERA	Sep 2012	Bloomberg	0.35	3.13	8.03
CEG	Nov 2012	RBA	0.35	3.05	8.89
Lally	Mar 2013	Bloomberg	0.35	3.26	5.90 – 8.39
ERA	Aug 2013	Bloomberg	0.35 – 0.7	3.31	5.34 – 7.57
SFG	Dec 2014	Thomson Reuters I/B/E/S	0.35 - 0.7	2.95 – 3.58	7.84 – 9.58
AER	Sep 2014	Bloomberg	0.7	3.48	6.6 – 7.8
ERA	Mar 2015	Bloomberg	0.53	1.96	8.24
Estimated range of the MRP consistent with gamma of 0.4			0.55		5.6 – 9.7

Source: *Capital Research,* Forward Estimate of the Market Risk:Premium: Update*, A response to the draft distribution determination by the AER for Aurora Energy Pty Ltd, February 2012, p. 20;*
NERA Economic Consulting, The Market, Size and Value Premiums*, June 2013, p. 49;*
Competition Economists Group, Update to March 2012 Report*, November 2012, p. 31.,*
M. Lally, The Dividend Growth Model*, 4 March 2013, p. 16.*
Economic Regulation Authority, Appendices to the Explanatory Statement for the Rate of Return Guidelines, 16 December 2013, pp. 125 – 127.
ATCO Gas Australia, ATCO Gas Australia's Response to the ERA's Draft Decision, 22 December 2014*, Appendix 9.1 (SFG), p. 32; and*

Australian Energy Regulator, Draft decision: Jemena Gas Networks (NSW) Ltd: Access arrangement 2015–20, Attachment 3: Rate of return, November 2014 p. 3-200; and Authority estimates.

291. The majority of studies in Table 7 use a franking proportion of 0.75 to gross up returns. The commensurate estimate of theta for that franking proportion, which delivers a gamma of 0.4, is just under 0.55. Based on these results, the Authority judges that a range for the MRP commensurate with a gamma of 0.4 is 5.6 to 9.7 per cent. The lower bound is established by the Authority's August 2013 lower bound estimate for a theta of 0.55, while the upper bound is given by Capital Research's February 2012 estimate.

292. In addition, the Authority updated its two stage DGM estimate (Box 1), to be current as at March 2015 (which is the date of the *indicative* estimates for this Draft Decision). The model was used to develop the range for the MRP in the Rate of Return Guidelines.[209]

Box 1 The two stage DGM

The return implied by the Gordon DGM is based on a forecast dividend based on a forecast dividend growth rate to calculate a forecast dividend yield and then augments this yield with the growth forecast itself. This is shown in equation (15).

$$r_e = \left(\frac{E(D_1)}{P_0}\right) + g \qquad (15)$$

Where $E(D_1) = D_0(1+g)$ and is the last dividend per share paid.

The Authority's current estimate of the DGM is based on a simple two stage approach as outlined in equation (16).

$$P_0 = \frac{m \text{ x } E(D_0)}{(1+k)^{m/2}} + \sum_{t=1}^{N} \frac{E(D_t)}{(1+k)^{m+t-0.5}} + \frac{\frac{E(D_N)(1+g)}{k-g}}{(1+k)^{m+N-0.5}} \qquad (16)$$

Where:

- D_t is current price the of the equity index;
- m is the fraction of the current year remaining;
- t is the dividend per share expected in the current year;
- $E(D_t)$ is the dividend per share expected years into the future;
- k is the return on equity implied by the model;
- N is the year of the furthest out dividend forecast; and
- g is the long run dividend growth rate.

Monthly net dividend per share forecasts for the All Ordinaries Index were sourced from Bloomberg for the current year, the next year and the year after. The monthly closing price for the All Ordinaries index was also sourced from Bloomberg.

Source: Australian Energy Regulator and ERA Analysis

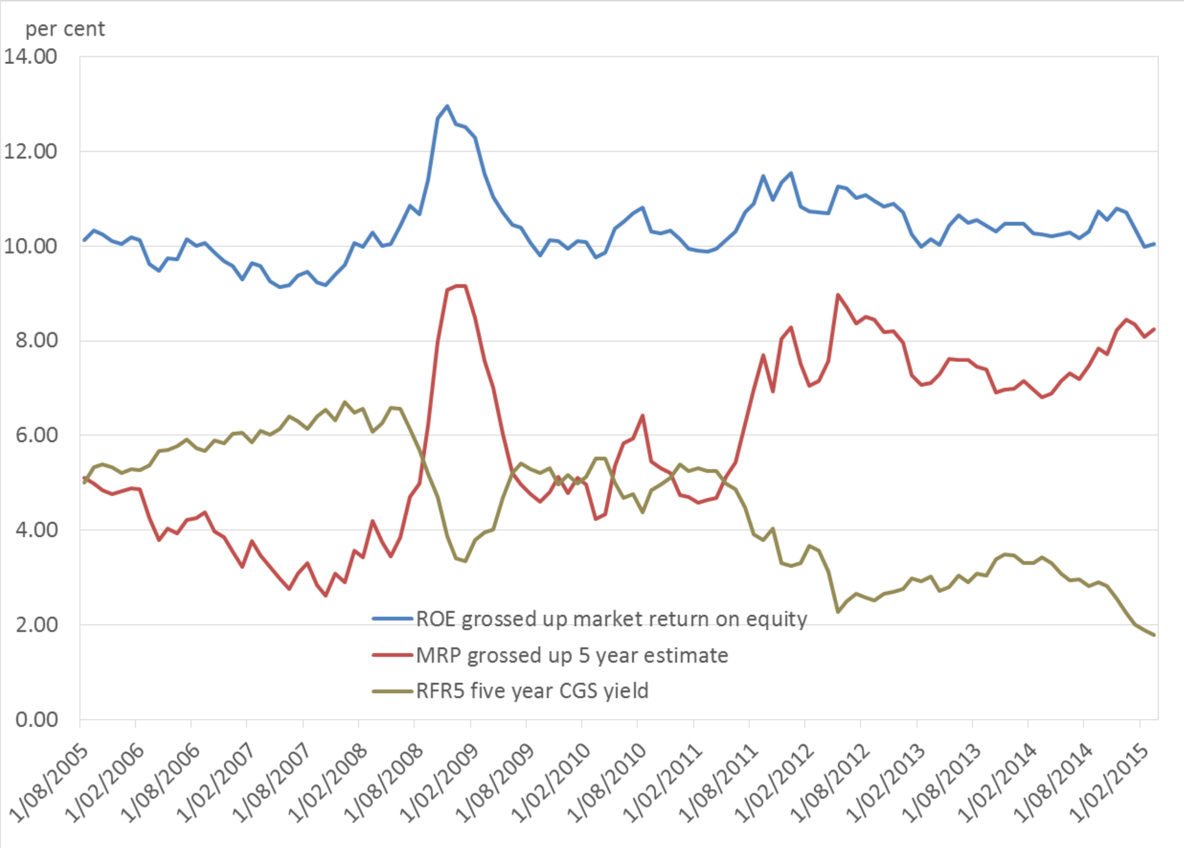
293. The assumption for the long run dividend growth rate in the updated DGM model, *g*, at 4.6 per cent, is consistent with the analysis in Lally's 2013 study.[210] This equates *g* to the estimated long run nominal GDP growth, of 5.6 per cent, less 1.0 per cent to account for new share issues and new companies. The resulting grossed up DGM estimate of the required return on the market is 10.04 per cent as at 31 March 2015.

209 Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 122.

210 M. Lally, *The Dividend Growth Model*, 4 March, 2013, p. 17.

294. The corresponding results for g of 4.6 per cent – when combined with the historic consensus dividend forecasts and share prices from Bloomberg going back to 2005 – are shown in Figure 3.

Figure 3 Dividend Growth Model implied return on equity: All Ordinaries Index (monthly, grossed up)



Source: Bloomberg and ERA analysis

295. The implied expected market return on equity (grossed up for imputation credit yields) typically fluctuates, in this case between 9 and 11 per cent, only breaking higher in periods of perceived heightened risk, such as 2008 to 2009 and 2011 to 2012. The model indicates that, from the end of 2014 through March 2015, expected returns declined somewhat.

296. The most recent available monthly observation for 31 March 2015 at 10.04 per cent is below the middle of the 'more typical' range for the return on equity (that is, excluding the GFC type periods). It is at the 30th percentile of the observations reported in Figure 3.

297. Deducting the Authority's on-the-day estimate of the 5 year risk free rate, of 1.96 per cent, from the return on the market for the end of March 2015, gives a forward looking 5 year MRP of 8.24 per cent, which also may be observed in Figure 3.

298. The MRP series suggests that the current forward looking estimate is near the top end of its typical range, exceeded only by estimates at the height of the GFC.

299. The estimates from the DGM are sensitive to input assumptions, particularly the long run growth rate. Varying the long run growth rate, *g*, from 4.0 to 5.1 per cent leads to a range for the MRP estimate at an *indicative* March 2015 of 7.67 to 8.70 per cent.

300. The Authority notes that DGM estimates are recognised to have shortcomings, including that:[211]

- analyst forecasts (which underpin some of the studies reported in Table 7 and which will be incorporated in the 'consensus' estimates from Bloomberg) have a tendency to be upwardly biased, as they are based on over-optimistic expectations for target prices and earnings;
- DGMs proxy the free cash flow to equity through the estimated dividends, however, dividends may not react to changes in market conditions, for example in downturns where companies may maintain their dividend policy, which will upwardly bias returns;
- DGMs do not capture non-dividend cash flows, such as share repurchases or dividend re-investment plans.

301. Furthermore, the DGM estimates reported here provide a single discount rate, which equates the present value of the future infinite dividend stream with the observed share price. The estimate therefore looks out beyond the 5 year period for which the Authority is seeking to estimate the MRP. If a lower nominal GDP estimate is expected than assumed – say for the two years beyond the three actual dividend growth rate forecasts incorporated in the model – then the estimates of the DGM should be lower than that reported here. The implication would be that the 5 year forward looking MRP would also be lower.

302. The Authority notes that there is no clear agreement among experts as to the best form for the DGM, or its input assumptions. For that reason, the Authority adopts a wide range, informed by a spectrum of recent studies.

303. Ideally, DGM return on equity estimates should be based on the most current on-the-day dividend forecasts. However, the Authority notes that the number of studies estimating return on equity using the DGM in Australia is limited and that it is not possible to update all of the various estimates available. Therefore, to allow for a broad range of information, DGM return on equity estimates since 2012 have been accounted for. The Authority is of the view that it is appropriate that the most recent estimates (since mid-2014) provide the more relevant and up-to-date information as presented in Table 7.

304. Overall, the Authority infers from the DGM MRP information before it that the market expectation is that the MRP has moved upwards in recent times due to declines in the risk free rate.

305. Figure 3 suggests that a representative *indicative* range for the estimate of the grossed up MRP from the DGM, consistent with the estimate of gamma of 0.4 adopted for this Draft Decision, is 5.6 to 9.7 per cent.[212]

306. The Authority adopts this range for the DGM estimate for this Draft Decision. The upper bound of the DGM range – 9.7 per cent – provides the upper bound of the Authority's overall range for the MRP. However, as indicated, the Authority considers

[211] See for example M. McKenzie and G. Partington, *Report to the AER, Part A: Return on equity*, October 2014, pp. 26-31.

[212] The lower bound of 5.6 per cent is the Authority's 2013 estimate for a gamma of 0.4. The upper bound of 9.7 per cent is the Capital Research's estimate, which is based on a 'net theta' of 0.5, which aligns with a gamma of 0.4.

that this estimate of 9.7 per cent is a less relevant estimate in comparison with all other estimates as presented in Table 7.

Lower bound of the MRP range

307. As noted above, for this Draft Decision, the Authority will utilise the 'Ibbotson' approach to inform its estimate for the lower bound for the range of the forward looking MRP. The Ibbotson approach uses the concept of a long run average MRP as today's best estimate of the MRP in future and combines this with an on the day risk free rate to arrive at an on the day estimate of the market return on equity.

308. For consistency, the estimate of the long run average MRP must reflect the term of the risk free rate used in the Sharpe Lintner CAPM, which is 5 years for this Draft Decision. For this purpose the Authority has made an estimate of the historic average MRP with reference to 5 year bonds, by taking an average of the historic MRP annual estimates referenced to bonds and bills.[213]

309. The nominal 5 year MRP estimates (grossed up for imputation credit yields) were calculated on both the NERA and BHM data by subtracting relevant bond and bill yields from the nominal NERA and BHM annual grossed up returns. The average arithmetic and geometric means of the resulting four series were then calculated (Table 8). Averaging the bill and bond MRPs for both NERA and BHM produces 5 year MRP estimates that range between 5.8 and 6.6 per cent for the arithmetic means and 3.8 and 5.1 per cent for the geometric means.

310. The Authority notes that there are mixed views as to the best estimator of historic returns. Arithmetic average returns will tend to overstate returns, whereas geometric average returns will tend to understate returns.[214] An unbiased estimator is likely to lie somewhere between the two estimates. The Authority's view is that arithmetic means are preferred in most circumstances.

Table 8 Estimates of bill and bond-based 5 year grossed up nominal average Market Risk Premiums

Period	BHM	NERA	Average	BHM	NERA	Average
	Arithmetic mean			Geometric mean		
1883-2014	6.6%	6.4%	6.5%	5.2%	5.0%	5.1%
1937-2014	6.2%	6.2%	6.2%	4.2%	4.3%	4.2%
1958 - 2014	6.6%	6.6%	6.6%	4.2%	4.2%	4.2%
1980 - 2014	6.3%	6.3%	6.3%	3.8%	3.8%	3.8%
1988 - 2014	5.8%	5.8%	5.8%	4.0%	4.0%	4.0%

Source: Brailsford, Handley, Maheswaran (2012) and ERA Analysis

311. That said, the Authority in this instance is looking for a reasonable lower bound for its range. On this basis, the Authority is inclined to the arithmetic mean as a preferred estimator. A lower bound informed by the lowest arithmetic mean estimate from

213 In the BHM data, bills are around 3 months and bonds are around 10 years, thus the average term of the two estimates is approximately 5 years (see T.Brailsford, J.Handley and K.Maheswaran, *Re-examination of the Historical Equity Risk Premium in Australia*, Accounting and Finance,vol.48, 2008, pp. 81 to 83). Taking the average of the historic annual MRPs with respect to bonds and bills will give an estimate of the annual MRP that is close to a 5 year term.

214 M. McKenzie and G. Partington, *Supplementary report on the equity MRP*, 22 February 2012, p. 5.

Table 8 would be 5.8 per cent. However, the Authority considers that this lower bound may be too high, given potential upward bias in the arithmetic estimate.

312. The Authority therefore exercises its judgment to adjust this bound down, informed by the lower estimates of the average MRP that are provided by the geometric means (Table 8). The Authority considers that 5.5 per cent provides a reasonable lower bound, being the average of the lowest arithmetic mean of 5.8 per cent and the highest geometric mean of 5.2 per cent.

313. The resultant estimate of 5.5 per cent implies an upward adjustment of the original lower bound for the MRP range set out in the Guidelines, which was 5 per cent. The Authority will apply the revised lower bound of 5.5 per cent to establish the overall range for the forward looking MRP for this Draft Decision.

314. For completeness, the Authority notes that the upper bound for the range of the MRP, informed by the historic estimates, would be given by the Wright estimate, which is the 10.83 per cent nominal return, as presented in Table 6, minus the current estimate of the risk free rate, which is 1.96 per cent. The resulting upper bound for the historic estimates given the inflation outlook at the current time would be 8.87 per cent, or 8.9 per cent rounded.

Range for the MRP

315. The Authority will adopt an *indicative* range for the 5 year forward looking MRP for this Draft Decision of 5.5 to 9.7 per cent. The:

- lower bound of the range is informed by the Ibbotson average excess premium; and
- upper bound of the range is informed by the upper bound of recent DGM estimates.

316. This range is wider than that informed by the historic estimates (5.5 to 8.9 per cent based on Ibbotson and Wright respectively), given that the upper bound of 9.7 per cent reflects Capital Research's 2012 DGM estimate shown in Table 7.

317. The Authority uses forward looking indicators and its judgment to assist in determining a point estimate for the MRP from within this historic range for input to the Sharpe Lintner CAPM.

Forward looking indicators (conditioning variables)

318. The Guidelines set out that forward looking indicators approach would be used to condition the point estimate of the MRP within the estimated range, for the five years of the access arrangement:[215]

> The Authority considers that a range of other information is relevant for determining the point estimate of the MRP… this additional information will be considered as to whether it implies a revision, upwards or downwards, to the midpoint of the MRP range.

319. In light of this the Authority now considers it preferable to take a non-parametric approach, estimating an upper and lower bound at each determination and

[215] Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 216. The Authority undertook that step in the indicative example in the Guidelines in Step 4, but now considers that it is better placed in Step 2. However, the use of forward looking indicators is not a 'new development' (ATCO Gas Australia, *ATCO Gas Australia's Response to the ERA's Draft Decision*, 22 December 2014, Appendix 9.1, p. 22).

considering the position of the MRP relative to the mid-point. Mechanistic calculation and application of distributions may not be robust due to issues associated with non-stationary and unrepresentative data series. There are also qualitative issues as to how forward looking data is viewed and interpreted by market participants.

320. The mid-point of the *indicative* 5.5 to 8.9 per cent (informed by the Ibbotson and Wright approaches) is 7.2 per cent.

321. For this Draft Decision, four forward looking indicators of market conditions for the next 5 years that are readily available and consistent with the date of the *indicative* estimate for the rate of return are adopted to inform the point estimate. These are:

- dividend yields on the All Ordinaries, a financial metric;
- interest rate swap spreads on 5 year bonds, which can be viewed as a type of term structure variable;
- default spreads, another term structure variable that makes forward looking expected returns explicit; and [216]
- the Australian Stock Exchange (ASX) 200 volatility index (**VIX**) which measures investors' perceptions of equity market risk.

Dividend yields

322. Bloomberg's dividend yield series provide one forward looking indicator. The dividend yields are the 'consensus' of analysts' expectations for dividends for the ASX All Ordinaries.[217]

323. The dividend yields referred to above are expressed as equation (17) below.

$$Dividend\ Yields_0 = \left(\frac{D_0}{P_0}\right) \qquad (17)$$

where:

- D_0 is the latest net dividend paid; and
- P_0 is the latest price of the equity in question.

324. Recent expectations for dividend yields at the end of March 2015 were 4.1 per cent, just above the longer term average of 4.1 per cent (since 1 January 2000 – see Figure 4 below).

216 The default spread was calculated as the difference between the 5 year AA Australian corporate Bloomberg fair value curve and 5 year Commonwealth Government Bond index. These series are the most liquid, complete and up to date default spread measures available to the Authority and so are considered the most efficient reflection of market price movements.

217 The Authority notes that dividend yields contribute to the DGM estimates for the expected return on the market. Their use here is intended to provide an indication of forward earnings relative to the past, and hence provide an indication of the forward looking MRP relative to the range derived from the historic estimates.

325. The Authority considers that dividend yields support an estimate for the forward looking 5 year MRP that is somewhat above the mid-point of its historic range.[218]

Figure 4 ASX All Ordinaries analyst consensus dividend yields

Source Bloomberg EQY_DVD_YLD_12M

Default and Interest Rate Swap Spreads

326. The 5 year interest rate swap spreads capture, among other things, the credit risk of financial institutions. The interest rate swap (**IRS**) rate is the index rate at which financial institutions borrow and lend from each other. This rate is higher than the Commonwealth Government bond (**CGS**) yield of an equivalent term with the 'spread' over the CGS capturing the credit risk of financial institutions.

327. Figure 5 below shows that the 5 year AA default and IRS spread move in a very similar fashion which tends to confirm that they are subject to similar market risk.[219]

[218] The current dividend yields are at the 60th percentile of the historic observations in Figure 4 ASX All Ordinaries analyst consensus dividend yields

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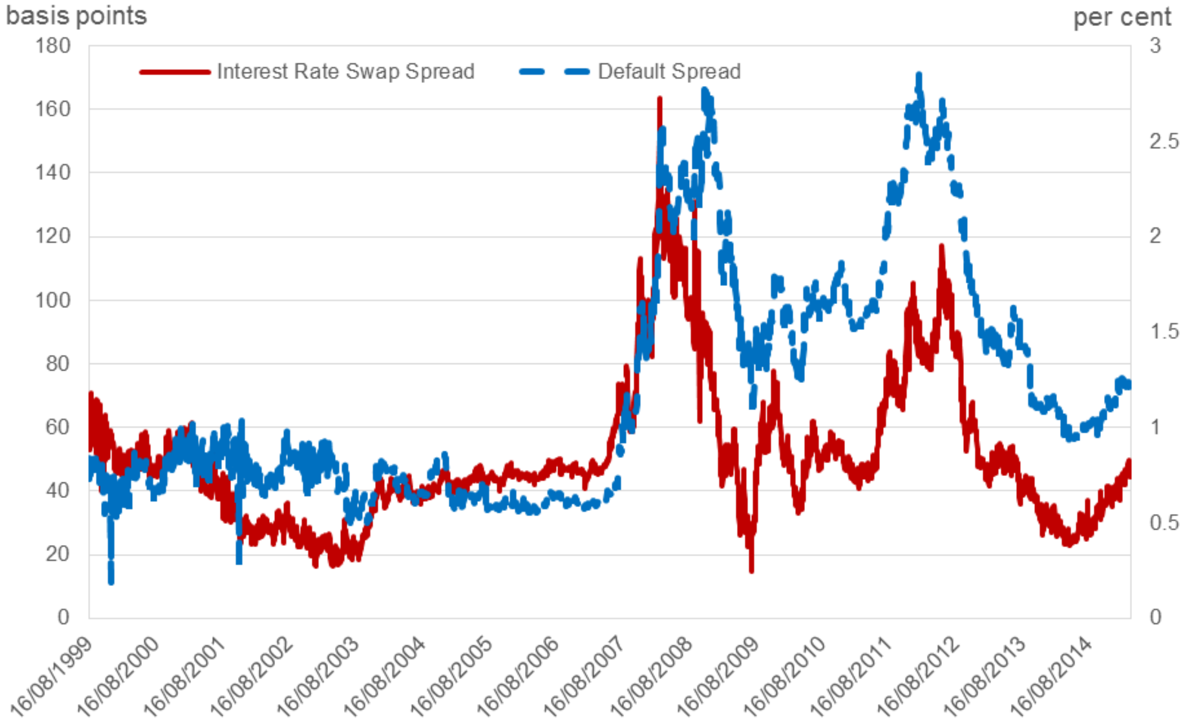
[219] The Authority notes that the majority of bonds that constitute the Bloomberg AA fair value curve are those issued by financial institutions. As at 18 March 2015, 89 per cent of the constituent bonds are issued by issuers classified as financials.

Figure 5 5 Year interest rate swap spread versus 5 year default spread



Source: Bloomberg and ERA Analysis

328. The 5 year interest rate swap spread (Figure 5) appears to have returned to pre-2007 levels, but has recently begun to trend upward. The current spread, however, does not suggest that levels of risk in the financial sector are unusually high.

329. The default spread (Figure 5 5 Year interest rate swap spread versus 5 year default spread

330. , RHS, basis points) has not returned to pre-crisis levels and also has been trending upward in line with the swap spread. This suggests that in the broader corporate sector (other than financials) levels of credit risk are still perceived to be relatively high, although still below the levels associated with 2008 to 2009 and 2011 to 2012. The current estimate – at 1.22 per cent – is above the mid-point of the range of more typical' observations, which is 0.5 to 1.7 per cent.[220]

331. The Authority considers that default spreads therefore support an MRP estimate somewhat above the mid-point of the historic range.

Stock Market Volatility Index

332. The benefit of using stock market volatility indices is that it represents a different class of index to those discussed already. As outlined above, the IRS spreads and default spreads convey similar information while the DGM is an extension of dividend yields. Using different versions of similar indicators introduces the risk of double counting, or over-weighting measures that contain the same information. A volatility index of some variety provides a differentiated measure of risk as it is concerned with variance

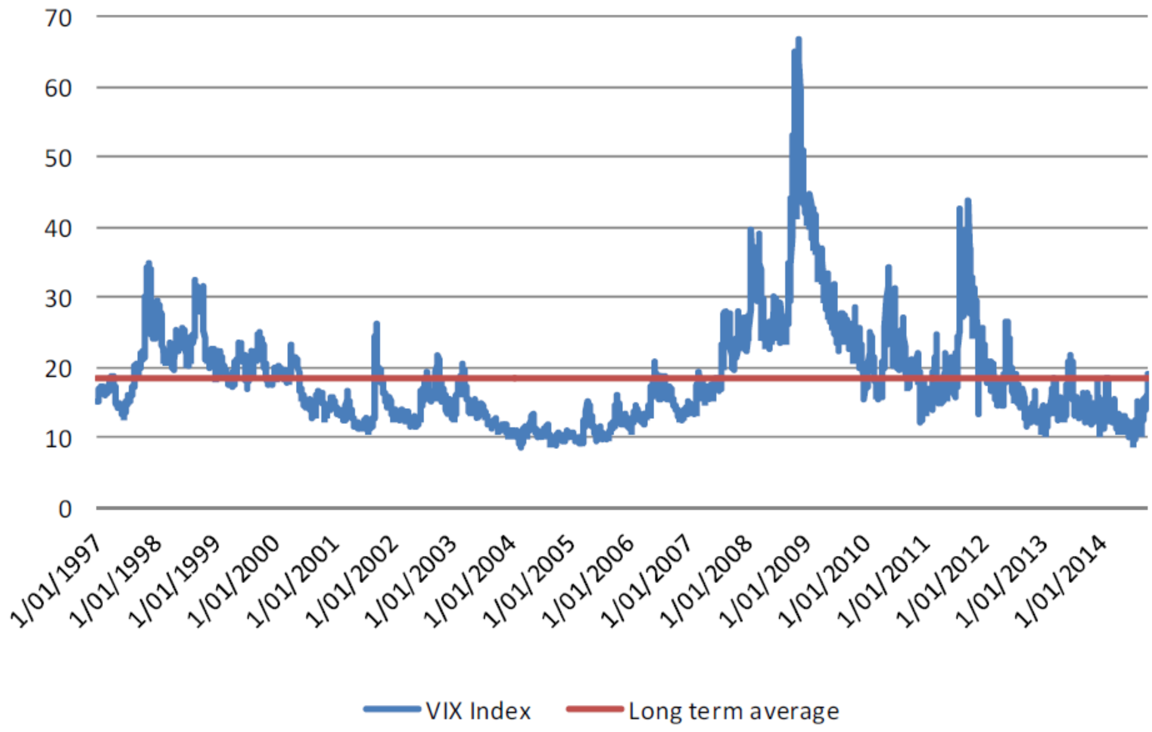
220 The most recent estimate is at the 62nd percentile of all the observations in Figure 5 5 Year interest rate swap spread versus 5 year default spread

(uncertainty around return outcomes) as opposed to levels of return or yields. The VIX was therefore used as measure of forward looking risk for the Draft Decision.

333. Although useful for gauging future perceptions of risk stemming from forecast variability in returns, the VIX was given very little weight. This is mainly because the series the Authority had access to had a limited history, dating back only to 2008. The latest observations of the VIX were therefore limited to being compared with the high levels of risk in 2008 and may have incorrectly indicated that volatility and risk are at historical lows.

334. The Authority notes that the AER has sourced a longer term series of the ASX 200 VIX index which allows for more meaningful historical comparison between the most recent level of the VIX and previous levels. This series is reproduced in Figure 6. [221]

Figure 6 Implied Volatility (ASX200 VIX) Over Time



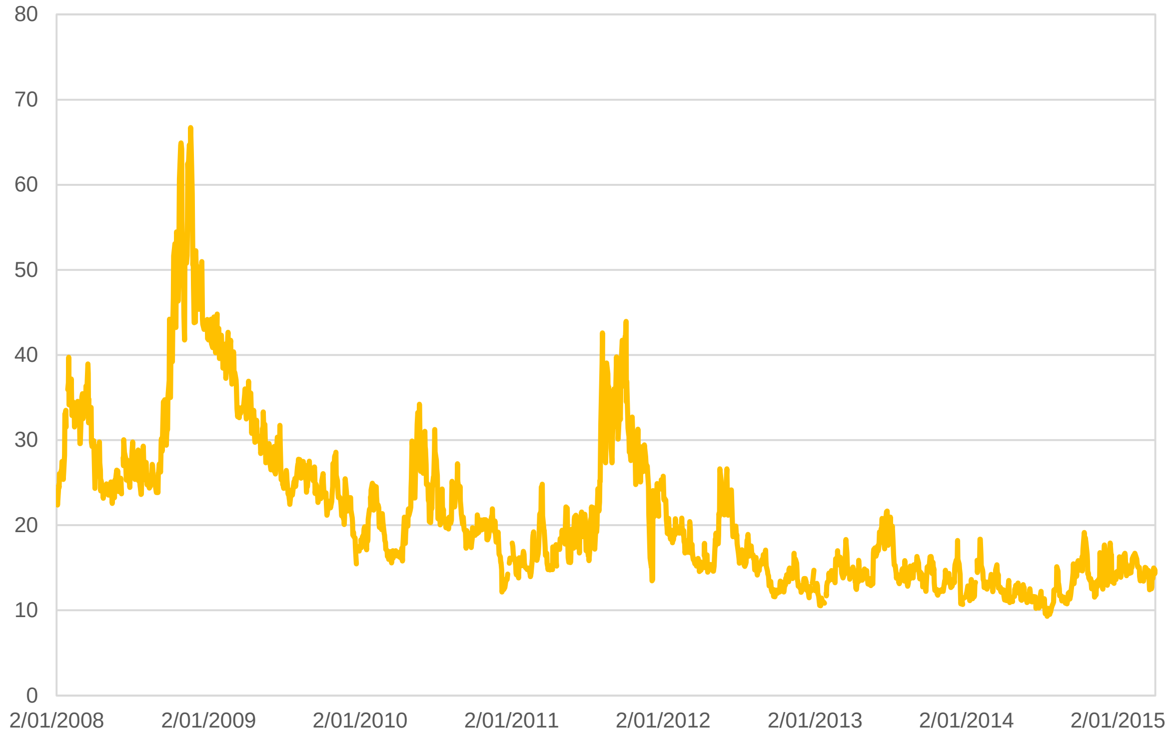
Source: Australian Energy Regulator[222]

335. The series around 2014 reaches a level which is approximately on par with the low points observed over 2004 to 2005. More recently the series has begun to revert toward the long term average level observed. The series has been updated to 2 April 2015 in Figure 6 with data that is accessible to the Authority.

221 Australian Energy Regulator, *Jemena Gas Networks (NSW) Ltd Access Arrangement 2015-2020: Draft Decision*, Attachment 3: Rate of Return, November 2014, p. 205. The Authority is not able to access this proprietary data as it is no longer available. The Authority has been advised by the Australian Energy Regulator that the series prior to 2008 was sourced from Bloomberg as the CITJAVIX Index, which is no longer provided by Bloomberg. The AER's chart of this data is therefore reproduced here.

222 The Authority has been advised by the Australian Energy Regulator that the series prior to 2008 was sourced from Bloomberg as the CITJAVIX Index, which is no longer provided by Bloomberg.

Figure 7 Implied Volatility (ASX200 VIX): 2 January 2008 to 2 April 2015



Source: Bloomberg and ERA Analysis

336. This series suggest that the VIX is below the long term median value in the observed data in Figure 6 and Figure 7. This supports the choice of an MRP that is below the mid-point of the historic MRP range.

337. DBP submit that the Authority proposed to use an 'index' composed of the forward looking indicators outlined above. It engaged Esquant to determine whether this index is related to the MRP and market returns firstly, in the way the Authority asserts and secondly if there is any relationship at all. Esquant's terms of reference set out by DBP were as follows:

- Regress the four driver variables on the market risk premium (market returns minus the five and ten year CGS; two separate regressions), taking all due care in respect of statistical issues such as stationarity, serial correlation, multicollinearity and heteroscedasticity, and provide a report on the robustness of these statistical estimates.

- Examine the regression for any structural breaks, and also examine Granger Causality between the dependent and independent variables (we are interested in understanding what drives what; if the MRP drives these variables rather than the other way around, then clearly they cannot be leading indicators of it).

- Use the coefficients to re-weight the weighted average the ERA has constructed; with the understanding that some (or indeed all) of the weights may be zero.[223]

[223] N.Diamond, *Estimating the Market Risk Premium: A Report for DBP*, Esquant Statistical Consulting, 24 December 2014, p.4.

338. DBP's view of the Authority's approach to using the four forward looking indicators appears to be that an index, consisting of the four variables, is mechanistically applied at each determination. Esquant's analysis proceeds on this view. This mechanistic approach is outlined in equation (18).

$$Index_t = w_{VIX}(\text{Volatility Index}_t) + w_{DY}(\text{Dividend Yield}_t) + w_{IRS}(\text{5 Year IRS Spread}_t) + w_{DS}(\text{Default Spread}_t) \quad (18)$$

339. The variables w_{VIX} , w_{DY} , w_{IRS} , and w_{DS} are the weights assigned to each variable.

340. A key point to note is that the weights have no t subscript attached, which reflects DBP's view that the weights *do not vary through time*. DBP and Esquant assumed various combinations of *time invariant* weighting for their analysis shown in Table 9.

Table 9 DBP/Esquant Time Invariant Weighting Assumed

Weight	w_{VIX}	w_{DY}	w_{IRS}	w_{DS}
Assumed ERA weights	0.1	0.3	0.3	0.3
Esquant's cointegrating weighting	1	-0.27	2.37	-1.34

341. The weightings in the first row of Table 9 are the initial weights proposed by the Authority in the Draft Decision for ATCO.[224] The weightings in the second row are those based on the results of Esquant's cointegration analysis, the output of which is a set of weights that create a stationary, or mean reverting index composed of the four variables.[225]

342. While the Authority believes the methodology in the analysis undertaken by Esquant is both rigorous and conventional, the assumption of time invariant weighting means the approach (represented by equation 18) analysed by Esquant does not represent either the approach that the Authority proposed in the Draft Decision for ATCO or the approach implemented in the Final Decision for ATCO.[226] This is because the Authority applies its discretion at the date of *each determination* when applying the forward looking indicator variables.

343. The Authority does not propose to fix the weights or even explicitly apply weights to the forward looking indicators. This is because the Authority believes the circumstances driving changes in the forward looking indicators must be considered before determining whether the variable is useful in quantifying changes in the MRP. In addition, other factors outside the forward looking indicators may also be taken in to consideration when determining the MRP on a particular date.

224 Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System*, 14 October 2014, p. 167.

225 N.Diamond, *Estimating the Market Risk Premium: A Report for DBP*, Esquant Statistical Consulting, 24 December 2014, p. 21.

226 Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System*, 14 October 2014, p.167. For the approach in the Final Decision for ATCO see Economic Regulation Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems 30 June 2015*, 10 September 2015, pp. 262-267.

344. Therefore, in order to correctly assess the Authority's approach, Esquant (theoretically) should supplant the indices they have used in their analysis based on equation (18) with a series of the Authority's MRP determinations based on the forward looking indicator variables. From a practical point of view this is not possible because there are too few determinations to provide a sample of estimates across time that can be used to produce robust statistical results. The inability to perform this analysis, however, does not automatically validate the results of DBP and Esquant's analysis. This is because their methodology is not testing the actual approach the Authority uses in estimating the MRP, but rather tests some other approach which assumes time-invariant weighting of the indicator variables.

345. On this basis the Authority is not convinced to depart from its 'non-mechanistic' application of the forward looking indicator variables in its determination of the MRP.

The point estimate of the MRP

346. The forward looking MRP for input to the Sharpe Lintner CAPM is unobservable. The Authority has therefore accounted for a range of information in order to estimate the MRP. That information includes:

- a range for the MRP that reflects historic excess returns;
  - which is combined with conditioning variables which indicate expectations for relative risk over the regulatory period – interest rate spreads, market volatility, as well as current expectations for dividend yields; and
- a range for the forward looking MRP that reflects the DGM model.

347. In considering that information for this Draft Decision, the Authority has concluded that the MRP can exhibit marked variation, depending on circumstances. Given that marked variation, the Authority considers that it should not unduly constrain the range for the MRP. The Authority therefore has re-estimated the range, widening the estimates to account for all recent relevant information. The lower bound has increased in recognition that the MRP needs to be estimated with regard to the five year risk free rate. The upper bound has increased consistent with the five year risk free rate, and also to account for the broad range from recent DGM estimates.

348. The resulting *indicative* estimated range for this Draft Decision is 5.5 per cent to 9.7 per cent, which spans:

- the range of the MRP implied by the historic data, which is 5.5 per cent to 8.9 per cent;
- the range for the MRP implied by recent estimates from the DGM, which is 5.6 per cent to 9.7 per cent.

349. With the range established, the Authority then exercises its judgment, to determine an *indicative* point estimate that is consistent with prevailing conditions in equity markets as at 2 April 2015 (which is the end of the *indicative* averaging period for this Draft Decision).

350. With regard to the historic estimates, the Authority draws on a range of forward looking indicators to assist its determination of the most reasonable point estimate of the MRP from within the estimated range:

- The VIX data indicate that the 5 year post-tax nominal MRP is somewhat below the mid-point of the historic MRP range:

- The spread data supports a forward looking estimate that is somewhat above the mid-point of the historic range.
- Dividend growth data also suggest an MRP point estimate that is somewhat above the mid-point of the range.

351. The Authority notes that, under its approach, a forward looking MRP of 7.2 per cent (a mid-point of the historic range) is not a final estimate. The conditioning data, taken together, suggest that the forward looking MRP should be somewhat above the mid-point estimate using historical data. The Authority therefore considers that a final estimate of the forward looking MRP based on the historic range should be higher than 7.2 per cent.

352. In addition, the Authority notes that a forward looking MRP estimated using the DGM falls within a range of 5.6 per cent and 9.7 per cent, with the mid-point estimate of approximately 7.7 per cent. The Authority considers that it is widely accepted that a market return on equity (or the MRP) using the DGM tends to be over-estimated. In addition, at the same time, the Authority recognises that the DGM estimates need to be tempered to account for a range of issues which imply upward bias, as indicated, in the resulting estimates of the MRP.

353. On balance, taking all the above mentioned information into account, the Authority exercises its judgment to determine an *indicative* estimate of the forward looking post-tax nominal MRP for this Draft Decision of 7.6 per cent, as reflecting the expectations of the market as at 2 April 2015.

354. With this estimate, the Authority has accounted for:

- the information provided by the forward looking indicators relative to their history, which suggest an MRP that is around the mid-point of the historic range;
- the implied MRP from a range of recent DGM estimates, which suggest that expected returns are between the mid-point and the upper bound of the overall range, noting that:
  - the DGM outcomes do not exactly match the 5 year outlook adopted for this Draft Decision;
  - the recognised shortcomings of the DGM approaches which lead to upward bias in the estimates; and
  - differences in approach and vintage, which render some estimates more relevant than others.

355. The Authority is satisfied that the resulting estimate meets the requirements of the NGL and NGR. In particular, the Authority is satisfied that the estimate for the MRP of 7.6 per cent reflects prevailing conditions in the market for equity funds and that it contributes to the achievement of the allowed rate of return objective, as required under NGR 87.

Step 3: Estimation of the return on equity using the Sharpe Lintner CAPM

356. Following its review of DBP's proposal, the Authority is not convinced that the empirical estimate of the return on equity adopted by DBP is either theoretically supported, or empirically robust (see Appendix 4A for consideration of relevant models, Step 4 below and Appendix 4C for the evaluation of the relationship between the return on equity and the return on debt). The Authority considers that the DBP proposed return on equity does not meet the requirements of the NGR. The Authority

is therefore not persuaded to move away from the method for estimating the return on equity that was set out in the Guidelines, and amended in the recent ATCO GDS Final Decision.

357. Utilising the Sharpe Lintner CAPM, informed by the point estimates for the parameters identified above, the Authority calculates that the indicative estimate of return on equity for this Draft Decision, consistent with the 2 April 2015 averaging period date is:

Estimated return on equity = 1.96 per cent + 0.7*(7.6 per cent) = 7.28 per cent

358. The implied return on the market for the average firm with a beta of 1 is 9.56 per cent. The resulting equity risk premium for the benchmark efficient entity is 5.32 per cent.

Step 4: Cross checking the estimate of return on equity

359. The Authority set out in the Rate of Return Guidelines that it would consider a range of other material as a test for reasonableness of the estimate derived in Step 3.[227]

360. The Authority is not convinced that DBP's proposed crosscheck material provides the best set of information for validating the final estimate of the return on equity:[228]

- DBP provides a range of estimates proposed by other service providers, but these have not been accepted by either the Australian Energy Regulator or the Authority.
- The Authority does not accept that its interpretation of the recent Grant Samuel report or other evidence of independent analysts is flawed, as submitted by DBP.
- The Authority does not accept that the proposed relationship between the return on debt and the return on equity, adopted by DBP for informing its return on equity, is robust (see Appendix 4C for further detail).

361. The Authority considers relevant cross-check material in what follows.

Other evidence on the risk free rate

362. The estimate of the risk free rate is the *indicative* 20 day average of the 5 year yield on Commonwealth Government Securities (**CGS**). Similarly, the base rate for the return on debt is estimated from the *indicative* 20 day average of the 5 year interest rate swap. As these estimates are observed from the market, the Authority considers that they are robust.

363. The Authority notes that at 1.96 per cent at 2 April 2015, the *indicative* CGS estimate is lower than the average of 5 year rates over recent decades, reflecting a concerted downward trend. However, the Authority has no evidence as to the prospect for significantly higher rates over the next five years. The Authority considers that the prevailing 5 year CGS estimate is the best predictor for the next five years. On this basis, the Authority considers that 1.96 per cent as at 2 April 2015 is the best estimate for use in the Sharpe Lintner CAPM.

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227 Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, Appendix 29 – Other relevant material.

228 DBP, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12*, 31 December 2014, pp. 82 – 89.

Cross checks of parameters in the Sharpe Lintner CAPM

Other evidence on the market risk premium and the implied market return on equity

364. For this Draft Decision, the Authority has taken account of forward looking information to inform its estimate of the point MRP, including:

- a range for the MRP that reflects historic excess returns;
- forward looking conditioning variables – measures of risk based on interest rate spreads and market volatility, as well as current expectations for dividend yields; and
- a range for the forward looking MRP that reflects the DGM model.

365. The Guidelines noted that a range of other material is considered relevant which may provide a cross check for the estimate of the MRP and the resulting estimate of the return on equity:

- views of valuation experts and surveys;
- decisions of other regulators; and
- the relationship between the return on equity and the return on debt.

366. A threshold issue in any comparison involves ensuring that estimates are on a consistent 'apples with apples' basis. Key issues in this context involve:

- the term of the estimates; and
- the treatment of imputation.

Term of the estimates

367. As noted above, the Authority is of the view that the term over which the rate of return expectations should be assessed is 5 years, so as to match the regulatory period. This is consistent with the Authority's intention to account for the 'present value' principle.

368. The 5 year forward looking horizon contrasts with that of independent analysts. Independent analysts tend to adopt a longer horizon for their discount rates because they are typically valuing assets on the basis of the cash flows to perpetuity. In Australian financial markets, 10 year government bonds are among the most common 'long maturity' bonds, and thus traditionally have been used as a proxy for the long term return on debt to perpetuity. Similarly, analysts estimate the equity premia component over a longer term horizon, involving 10 years or more.[229]

369. A 10 year view tends to 'smooth' out the large, but infrequent spikes in expected risk premia that are more evident in shorter investment horizons. The implication is that risk premia under a 5 year approach are generally lower than the 10 year average, for much of the time. However, the 5 year estimates are more volatile than the 10 year estimates, as they are more sensitive to fluctuations in prevailing market conditions. Over time, the average of the many 5 year observations should converge toward the average risk premium observed under a longer perpetuity approach.

229 The DGM, for example, estimates the discount rate that equates the future stream of cash flows to the current share price.

370. The Authority's 5 year estimates therefore are not directly comparable to the long run estimates commonly developed by independent analysts.

371. Lally endorses exactly this view when he responds to similar arguments for the QCA in the context of the risk free rate:[230]

> This line of argument presumes that the QCA is engaged in the same exercise as the valuers and therefore ought to be using the same parameter values. However the two exercises are fundamentally different, and this readily explains the difference in rates. The QCA resets the risk-free rate every few years (typically five years) and therefore need only be concerned with the prevailing risk-free rate for the next five years. By contrast these valuers are conducting DCFs for businesses with infinite-life cash flows and therefore would be interested in the prevailing term structure of risk-free rates for terms out to infinity. Since observed rates exist only out to ten years, these valuers would have to speculate upon the rest of the term structure, and then invoke an average rate if they used only one rate (as they do). Since the term structure is currently markedly upward sloping, the term structure beyond the five year term invoked by the QCA will be in excess of this regulatory rate and therefore the average rate invoked by the valuers over the entire term structure would be in excess of the five-year rate invoked by the QCA.

372. Seeking comparability, the Authority in the ATCO Gas Distribution System Draft Decision developed a rolling forward looking estimate of the 5 year return on equity for the market, derived using the sum of the 40 day averages of the 5 year government bond rate and the contemporaneous 5 year forward looking estimate of the MRP following an (indicative) fixed weights approach with the forward indicators.[231] It then took an average of this forward looking 5 year return on equity series for the 1993 – 2014 period, which was 10.9 per cent. This average estimate was then used for the purpose of comparing the Authority's estimates for the return on the market with that of independent analyst estimates.

373. The Authority notes that the 10.9 per cent estimate developed in the ATCO Draft Decision is similar in concept to the Wright estimate of the return on the market to perpetuity. To estimate the return on equity for the market to perpetuity, the Authority would apply an estimate of inflation consistent with the mid-point of the Reserve Bank of Australia's target range, which is 2.5 per cent, to its estimate of the long run real market return on equity, grossed up, which is 8.76 per cent.[232] The resulting nominal estimate of the return on equity for the market is 11.48 per cent (grossed up –Table 10).[233]

230 M. Lally, Response to submissions on the risk free rate and the MRP, 22 October 2013, p. 24.

231 The rolling forward looking five year estimate of the MRP was derived by applying a weighted average from four 'normalised' forward looking indicators to the Authority's range in the Draft Decision for the MRP (5 – 7.5 per cent) (see Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System*, 14 October 2014, pp. 174 – 176).

232 This is exactly the approach adopted by the Authority in its rail WACC decisions, where the estimate has a term to perpetuity (see Economic Regulation Authority, *Review of the method for estimating the Weighted Average Cost of Capital for the Regulated Railway Networks: Revised Draft Decision*, 28 November 2014, p. 93).

233 T.J. Brailsford, J.C. Handley and K. Maheswaran, , The Historical Equity Risk Premium in Australia: Post-GFC and 128 Years of Data, *Accounting and Finance*, 52, 2012, p. 241; NERA Economic Consulting, *The Market Risk Premium: Analysis in Response to the AER's Draft Rate of Return Guideline*, A Report for the Energy Networks Association, October 2013, Table 2.7, p. 28.

Table 10 Average annual imputation credit yields and grossed up arithmetic average returns (nominal, consistent with the estimate of gamma of 0.4)

	NERA	BHM	Average
Nominal returns excluding imputation yield (1883-2014)	12.00%	11.64%	11.82%
Nominal imputation credit yield (1988-2014)	0.91%	0.91%	0.90%
Grossed up nominal returns (1883-2014)	12.19%	11.83%	12.01%
Grossed up real returns (1883-2014)	8.94%	8.58%	8.76%
Expected inflation to perpetuity	2.50%	2.50%	2.50%
Grossed up forward looking return on the market to perpetuity	11.67%	11.30%	11.48%

Source: ERA Analysis, NERA (2013), Brailsford, Handley and Maheswaran (2012)

374. Therefore, the Authority is of the view that its 5 year forward looking estimate is not directly comparable to the perpetuity estimates developed by independent analysts for valuing firms. It is more appropriate to compare an estimate based on the long term average of the return on equity – such as the Wright estimate – with those of independent analysts.

Adjustments for imputation credits

375. A further consideration when comparing estimates relates to the treatment of imputation credits.

376. Longer term average return on equity estimates which include data before 1987 – such as the long term 128 year average historic estimates of Brailsford et al will tend to overstate the average observed 'market' return on equity under the current imputation credit regime (that is, the return observed in the market arising from dividends and capital gains).

377. This is because many investors in the post 1987 period receive a proportion of their required return on equity through imputation credits; yet this return is not observed in the market. The return through imputation credits therefore accounts for a proportion of the overall return on equity, all other things being equal. Hence the pre 1987 observed return on equity is not comparable to the post 1987 observed return; the latter will be lower due to part of the required return coming from imputation credits which cannot be observed in the market.

378. It is therefore important to 'gross up' any post 1987 observed market return to account for the impact of imputation credits, if the full return on equity is to be accounted for.

379. The amount of the gross up will depend on the assumptions relating to the impact of imputation credits in the Australian capital market. The assumptions adopted in grossing up the historic estimates for this Draft Decision are consistent with those used when estimating the gamma term.

380. As noted by Handley:[234]

> The Officer model typically used to inform returns on equity in Australia under the CAPM has one before company tax and four after company tax WACCs. The four after tax company tax WACCs each differ, based on whether the interest tax shield and the value

[234] J.C. Handley, *Further comments on the historical equity risk premium*, Report for the Australian Energy Regulator, 14 April 2009, pp. 16-17.

of imputation credits are included or otherwise in the definition of the corresponding after tax cash flows.

381. Officer assumes the CAPM holds when returns are expressed on an 'after company but before personal tax basis'. As shown in (19):

$$X_E = X_E' + \gamma T(X_O - X_D) \qquad (19)$$

Where:

- X_0 is the firm's operating income (free cash flow) that is ultimately distributed to X_D (that is, to debt claimants), X_E (equity claimants) and X_G (government claimant through the tax rate T);
- $X_E' = (1-T)(X_O - X_D)$ is the cash dividend distributed to equity investors;
- $T(X_O - X_D)$ is the amount of franking credits distributed to investors;
- $\gamma T(X_O - X_D)$ is the proportion of the franking credits distributed to investors.

382. X_E is the 'grossed up' value of the returns to investors which includes the value of franking credits. It is consistent with the value on an 'after company before personal tax basis'. On the other hand, XE' is consistent with the value on an 'after company after some personal tax' basis.

383. The conventional approach to describing a return as 'after company tax' is somewhat misleading in an imputation setting, as company tax paid $T(X_O - X_D)$ consists of a mixture of personal tax $\gamma T(X_O - X_D)$ – being the part rebated against personal taxes – and the effective company tax $T(X_O - X_D)(1-\gamma)$ being the part that is not rebated against personal taxes.

384. The Officer CAPM for the Australian imputation tax system is as shown in (20):

$$E(R_E) = R_F + \beta\,[\mathrm{E}(\mathrm{R}_M) - R_F] \qquad (20)$$

Where:

- $E(R_E)$ is the expected grossed up return on equity;
- R_F is the risk free rate of return;
- β is the equity beta of the firm; and
- $E(R_M)$ is the expected grossed up return on the market portfolio.

385. Officer assumes the CAPM holds when expected returns are expressed on an 'after company before personal tax basis' that is consistent with X_E.

386. The Authority's starting estimate of the return on equity is the vanilla $E(R_E)$, which can be derived using Officer's after tax case (iii).[235] The $E(R_E)$ is consistent with X_E, being the return observed in the market inclusive of imputation credits. As noted above, the Authority's longer term average of the estimates of $E(R_E)$ may be higher or lower than its current 5 year forward looking estimate, inclusive of imputation credits.

387. In the post-tax revenue model building block approach adopted by the Authority, the return on equity included in the rate of return weighted average cost of capital will be kE. The PTRM then explicitly accounts for the return to investors $\gamma T\left(X_O - X_D\right)$ as an adjustment to the cash flow allowance for tax within the model.

Views of valuation experts

388. Evidence of market analysts' views suggest that their expectations for the forward average market returns on equity are consistent with the longer term average of the forward looking return on equity underpinning the Authority's estimates.

389. An example is the recent WACC estimate by Grant Samuel used in discounting Envestra's cash flows, which was cited by SFG Consulting.[236]

390. Grant Samuel's estimate of the return on equity is informed by the Sharpe Lintner CAPM, with the risk premium and risk free rate then adjusted to have regard to a range of other evidence, including that from the Gordon Dividend Growth Model (**DGM**).[237]

391. Grant Samuel's initial estimate for the *market* return on equity derived using the Sharpe Lintner CAPM is 10.2 per cent. Grant Samuel states that:[238]

> The CAPM is probably the most widely accepted and used methodology for determining the cost of equity capital. There are more sophisticated multivariate models which utilise additional risk factors but these models have not achieved any significant degree of usage or acceptance in practice. However, while the theory underlying the CAPM is rigorous the practical application is subject to shortcomings and limitations and the results of applying the CAPM model should only be regarded as providing a general guide.

392. The Grant Samuel estimate is based on a long run historic MRP of 6 per cent, which is added to the prevailing 10 year risk free rate (at the time) of 4.2 per cent. Grant Samuel notes that it:[239]

235 J.C. Handley, *Further comments on the historical equity risk premium*, Report for the Australian Energy Regulator, 14 April 2009, pp. 16-17.

236 ATCO Gas Australia, *Access Arrangement Information: 1 July 2014 – 31 December 2019*, 3 April 2014, Appendix 19, p. 84.

237 Grant Samuel, *Envestra: Financial Services Guide and Independent Expert's Report*, 3 March 2014, Appendix 3.

238 Grant Samuel, *Envestra: Financial Services Guide and Independent Expert's Report*, 3 March 2014, Appendix 3, p. 1.

239 Grant Samuel, *Envestra: Financial Services Guide and Independent Expert's Report*, 3 March 2014, Appendix 3, p. 6.

> …has consistently adopted a market risk premium of 6% and believes that this continues to be a reasonable estimate. It:
>
> - is not statistically significantly different to the premium suggested by long term historical data;
> - is similar to that used by a wide variety of analysts and practitioners (typically in the range 5-7%); and
> - makes no explicit allowance for the impact of Australia's dividend imputation system.

393. The Grant Samuel estimate is defined as a 'classical', after tax rate that is based on the estimated nominal ungeared after tax cash flows.[240] On this basis, it is defined consistent with Officer's after tax case (iv).[241] In this case, the k_E is identical to the k_E in case (iii), being the total return on equity from all sources. The Grant Samuel WACC CAPM estimate of 10.2 per cent ignores the impact of imputation credits.[242]

394. The Authority notes that the resulting estimate should be grossed up. Appropriately configured – assuming that dividends provide around 4.5 per cent of the total 10.2 per cent yield – the grossed up return would be 10.97 per cent (utilising the Authority's estimate of gamma of 0.4).

395. The Grant Samuel estimate was made at a time when the 10 year risk free rate was 4.2 per cent. The prevailing (indicative 2 April 2015) rate is closer to 2.6 per cent. Adjusting the grossed up Grant Samuel estimate for this change would yield an estimate of the grossed up market return on equity using the Sharpe Lintner CAPM of 9.4 per cent.

396. Grant Samuel ultimately assess' an overall equity *market* return to be in the range of 10.7 to 15.2 per cent, an estimate that is higher than its CAPM-based estimate, which is 10.2 per cent, as noted above. The higher range accounts for:

- first, estimates from other return on equity models, such as the Gordon DGM;
- second, for Grant Samuel's view that equity investors have re-priced risk since the global financial crisis (lifting the MRP above 6 per cent); and
- third, that bond rates are at unsustainably low levels (which Grant Samuel therefore 'normalise' by increasing the risk free rate from the observed current value around 4 per cent to 5 per cent).[243]

397. The resulting grossed up range is 11.47 to 15.97 per cent, using the Authority's assumptions on the dividend yield and on gamma, set out above.

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240 The Authority notes that Grant Samuel's 'classical WACC' differs from the 'nominal vanilla WACC' estimate. The classical WACC reduces the cost of debt to account for the impact of the tax shield (that is, the cost of debt component is D/V*(1-T)*Rd), whereas the nominal vanilla WACC ignores the impact of the tax shield as this is accounted for in the cash flows. However, both approaches adopt the same estimate for the return on equity component (that is, E/V*k_E using Handley's terminology).

241 J.C. Handley, *Further comments on the historical equity risk premium*, Report for the Australian Energy Regulator, 14 April 2009, pp. 16-17.

242. Grant Samuel, Envestra: Financial Services Guide and Independent Expert's Report, 3 March 2014, Appendix 3, p. 9:

> In Grant Samuel's view, however, the evidence gathered to date as to the value the market attributes to franking credits is insufficient to rely on for valuation purposes. More importantly, Grant Samuel does not believe that such adjustments are widely used by acquirers of assets at present… Accordingly, it is Grant Samuel's opinion, that it is not appropriate to make any adjustment.

243 Authority estimate based on Grant Samuel data, assuming a nominal risk free rate of 5.0 per cent.

398. The Authority considers that a comparison estimate for the return on the market to perpetuity, such as that undertaken by Grant Samuel, is that based on a long run average of the grossed up historic return on equity estimates, which is around 11.48 per cent (paragraph 373 above

399. The Authority does not consider it appropriate to adjust up the risk free rate to a higher rate, as is done by Grant Samuel. Therefore, a more relevant lower bound for the Grant Samuel estimates is the Sharpe Lintner CAPM adjusted estimate of 9.4 per cent, with the range then 9.4 to 16.0 per cent (grossed up). The Authority notes that the perpetuity estimate outlined in the previous paragraph is within the Grant Samuel range. To the extent that the average of the Authority's sequential estimates of the return on equity, for each 5 year regulatory period, converge – over the long term – to the perpetuity estimate, then they would also be consistent with the Grant Samuel estimate. However, this cross-check would take a number of regulatory periods before it could be implemented.

400. The Grant Samuel estimates therefore give the Authority no cause to revise its estimate of the return on equity, or its current estimates for the MRP.

401. The survey by Ernst & Young of other analysts' estimates gives results that are broadly consistent with the Grant Samuel view. Ernst & Young note that in 2012, independent market experts' market cost of equity estimates averaged 10.7 per cent. Ernst & Young also notes that independent experts typically do not assign a value to imputation credits, and that adjustment for this outcome would raise the estimate of independent brokers. [244, 245] Grossed up using the Authority's assumptions, the estimate would equate to 11.47 per cent, which is close to the Grant Samuel estimate. Again, this outcome would give the Authority no cause to revise its estimate of the return on equity, or its current estimates for the MRP.

402. On this basis, the Authority is satisfied that its current estimate, albeit based on a different term, is reasonable.

Views of other regulators

403. As noted in the Rate of Return Guidelines, the Authority will consider other regulators' estimates to check outcomes of its own decisions.

Australian Energy Regulator

404. The AER's return on the market is derived using the Sharpe Lintner CAPM, with point estimates informed by a range of relevant information and models.

405. The AER has the view that a longer term 10 year perspective is appropriate, based on the view that equity investors have long term investment horizons.[246]

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244 ATCO Gas Australia, *Access Arrangement Information: 1 July 2014 – 31 December 2019*, 3 April 2014, Appendix 35, pp. 14-15.

245 ATCO Gas Australia, *Access Arrangement Information: 1 July 2014 – 31 December 2019*, 3 April 2014, Appendix 35, p. 23.

246 S. Pratt and R. Grabowski, *Cost of Capital: Applications and Examples*, 4th edition, 2010, pp. 118–120; A. Damodaran, 'What is the risk free rate? A search for the basic building block', December 2008, pp. 9-10. Lally, M., The risk free rate and the present value principle, 22 August 2012. cited in Australian Energy Regulator, *Rate of Return Guidelines, Explanatory Statemen*t, December 2013, p. 49.

406. In line with this view, the AER adopts a different term for the risk free rate in the Sharpe Lintner CAPM. Specifically, in its recent draft Jemena decision, the AER adopted:[247]

- a term for the return on debt of 10 years, with:
- the risk free rate based on the estimated Commonwealth Government Securities (**CGS**) yield, of 3.55 per cent;
- a point estimate for the MRP of 6.5 per cent, from within an estimated range of 5.1 to 7.8 per cent;
- an equity beta of 0.7;
- giving a 8.1 per cent return on equity for the benchmark efficient entity; which is consistent with
- a resulting overall estimate of the return on the market of 10.1 per cent.

407. The range estimate of the AER for the MRP is lower than the Authority's. This reflects the AER's judgment based on a range of information, including:

- historical excess returns – which the AER determines are in the range of 5.1 to 7.8 per cent based on the BHM data;
- the AER's DGM estimates range from 6.6 (two stage DGM) to 7.8 per cent (three stage DGM).

408. The lower range for the MRP also incorporates the AER's estimate of gamma (which was 0.5, which will make the MRP higher) and the use of the 10 year risk free rate (which will tend to make the MRP lower than the Authority's).

IPART

409. IPART uses an average of a current 40 day and 10 year term for the risk free rate.

410. IPART proposes to adopt an estimate of the MRP which is informed by a range that is based on a range for historic estimates (estimated at 5.5 per cent to 6.5 per cent) and a range based on other current market data approaches – including using DGMs – which fall in the range 7.4 per cent to 8.8 per cent, giving an overall range for the MRP of 6.0 per cent to 8.7 per cent (as at February 2015). The mid-point of the assessed range – 7.2 per cent (as at February 2015) – may then be adjusted to account for strong contrary evidence. Given an estimated mid-point risk free rate as at February 2015 of 3.8 per cent, IPART's return on the market is estimated to be around 12.0 per cent.[248]

411. The Authority considers that the IPART estimate is comparable to its own estimate, albeit based on a somewhat different method and judgements.

Other regulators decisions

412. Other recent decisions by regulators for the MRP range from 6.0 to 6.5 per cent (Table 11).

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247 Australian Energy Regulator, *Draft decision: Jemena Gas Networks (NSW) Ltd: Access arrangement 2015–20,* Attachment 3: Rate of return, November 2014.

248 Authority analysis, based on IPART, *Fact sheet – WACC update*, August 2014.

Table 11 Other regulators' recent decisions

Regulator	Decision date	Sector	MRP (%)
QCA	August 2014	General	6.5
ESCV	June 2014	Water	6.0
NTUC	April 2014	Electricity	6.0

Source *Australian Energy Regulator*, *Draft decision: Jemena Gas Networks (NSW) Ltd: Access arrangement 2015–20, Attachment 3: Rate of return*, p. 3-205.

Conclusions with regard to other regulators' estimates

413. In accounting for this evidence relating to the views of other regulators, the Authority considers, first, that its estimate of the risk free rate is appropriate. It is consistent with the term of DBP's regulatory period, which is five years. This issue was discussed extensively in the Rate of Return Guidelines. It is also consistent with the use of the Australian domestic CAPM, set out in the Rate of Return Guidelines. No material presented by DBP, nor the views presented in the approaches of other regulators, has changed the Authority's view.

414. Second, with regard to the MRP, the Authority considers that its estimated range – of 5.5 per cent to 9.7 per cent – is comparable to other regulators, including the AER. The Authority considers that the evidence shows that the Authority has similar metrics relating to the MRP and the return on equity as compared to other regulators, albeit when compared on a consistent longer term basis.

Beta

415. The Authority considers that its range for beta derived from the Australian benchmark comparator sample is reasonable, and allows selection of a point estimate that is comparable to that for the benchmark efficient entity operating in Australia. Taking account of all relevant information relating to the Australian market, the Authority considers that the resulting point estimate will provide a better estimate than one that is informed by information from overseas markets.

416. However, the Authority notes that the Australian Energy Regulator assembled a range of international empirical estimates for energy networks.[249] The evidence points to a wide range of empirical estimates, with estimates both below and above the Authority's point estimate. The reported estimates span a range of 0.45 to 1.3. The Authority notes there are issues with regard to re-levering international estimates, which may render them unreliable, given the underlying differences in conditions in the countries of origin.[250]

417. In conclusion, the Authority has considered the information on equity betas for utilities operating in overseas jurisdictions. The Authority has determined that these estimates are likely to provide a less reliable estimate of beta than that derived from the domestic comparator sample. The Authority does not rely on them either for establishing the range, or for determining the point estimate of beta. Nevertheless, the Authority considers that its domestic range and point estimate of beta is not inconsistent with the reported range. The Authority therefore is satisfied that the beta

249 Australian Energy Regulator, *Draft Decision: Jemena Gas Networks (NSW) 2015-20,* November 2014, p. 3-263.

250 G. Partington, *Report to the AER: Return on equity (updated),* April 2015, p. 74.

estimate it has determined is robust and fit for purpose, and will therefore contribute to the achievement of the allowed rate of return objective.

Consistency of the return on equity with the return on debt

418. The Authority notes DBP's argument that the return on debt can be used as a quantitative cross check for the return on equity, while giving form to the consistency requirements of NGR 87(5) and NGR 87(11).[251] DBP bases its position on advice from SFG with regard to the relationship between the cost of debt and the return on equity.

419. In particular, SFG argues that Merton (1974) concluded that equity and debt are contingent claims over the assets of the same firm. Both become less valuable as the assets of the firm decline in value and both become more valuable as the assets of the firm rise in value. Both are linked to the value of the assets of the firm. Thus, if there are certain factors that drive changes in the value of the assets of the firm, those same factors will drive the returns to debt and equity in that firm. SFG argues that this means that there is a positive relationship between the return on debt and the return on equity in the same firm.[252]

420. Based on its analysis, SFG concludes that, given the debt risk premium, internal consistency requires that the equity risk premium must be at least 6.0 per cent.[253] The Authority's detailed consideration of the SFG material is presented in Appendix 4C.

421. The Authority notes that SFG's proposed approach does not follow any standard finance theory. The approach is not well established and is untested. In addition, based on the Authority's sensitivity analyses, there are fundamental issues attached to the SFG's proposed approach, setting aside its failure on theoretical grounds.

422. In summary, the Authority is of the view that evidence presented in SFG's analysis to support the relationship between the cost of debt and the return on equity is inconclusive and that the link between the two markets is not robustly established. As a result, this approach should not be adopted.

423. Therefore, SFG's proposed approach, which states that the return on equity can be directly derived from the observed cost of debt, is not relevant for the purpose of a cross check for the return on equity.

Cross-check that the return on equity exceeds the return on debt

424. The estimated debt risk premium for the 2015 calendar year in this Draft Decision is 2.51 per cent above swap. The margin of the 5 year swap rate to the 5 year Commonwealth Government Security (**CGS**) rate used for the return on equity is 0.467 per cent, implying a total risk premium for the return on debt above the CGS rate of 2.98 per cent.

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251 DBP, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12*, 31 December 2014, p. 84.

252 DBP, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12*, 31 December 2014, Appendix L, p. 2.

253 DBP, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12*, 31 December 2014, Appendix L, p. 18.

425. The Authority's estimate of the MRP is 7.6 per cent. With a beta of 0.7, together with the risk free rate of 1.96 per cent as at 2 April 2015, the equity risk premium for the benchmark efficient entity in this Draft Decision is therefore 7.28 per cent. The Authority considers that the resulting difference in the premiums, of around 2.11 percentage points – being the difference between the return on equity of 7.28 per cent and the cost of debt of 5.172 per cent – is reasonable.

426. The Authority notes that DBP narrows the range of its return on equity estimate in Steps 4 and 5, drawing principally on a mooted relationship between the return on equity and the return on debt, attributed to Merton (this method is evaluated in detail under the section on cross-checks below, and in Appendix 4C). The resulting range for the return on equity is narrowed to 11.37 to 12.04 per cent, from which DBP chooses the mean of 11.71 per cent as its final estimate of the return on equity. At its core then, DBP's estimate is based on the mooted relationship between the return on equity and the return on debt.

Step 5 – Determine the return on equity

427. Taking into account all of the relevant information, the Authority is of the view that an indicative expected return on equity of 7.28 per cent is appropriate as an estimate for the forward looking 5 year return on equity for the benchmark efficient entity, as at 2 April 2015:

Estimated return on equity = 1.96 per cent + 0.7*(7.6 per cent) = 7.28 per cent

428. This is based on the forward looking 5 year estimate from the Sharpe Lintner CAPM. The cross checks set out in Step 4 confirm that this estimate is reasonable.

429. The Authority considers that the estimate is commensurate with the efficient equity financing costs of the benchmark efficient entity with a similar degree of risk as that which applies to the Service Provider in respect of the provision of Reference Services prevailing at this time. On this basis, the Authority considers that the estimate meets the allowed rate of return objective and the requirements of the NGR and NGL more broadly.

Return on debt

430. DBP submitted that it:[254]

- was in broad agreement with the Authority's approach to the calculation of the return on debt at the outset of the access arrangement period, as articulated in the ATCO Draft Decision, being the sum of the risk free rate, debt risk premium and debt-raising and hedging costs;
- nonetheless, considered that a number of key departures were warranted:
  - the appropriate risk free rate ought to be the 10 year risk free rate, not the 5 year rate;
  - the addition of a premium to cover the cost of raising debt in primary markets.

[254] DBP, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12*, p. 19.

431. DBP also propose to annually update the return on debt by means of a 10 year trailing average which follows the Australian Energy Regulator's (**AER**) Guidelines method:[255]

- there is a ten year transition period, following the AER method;
- one tenth of the return on debt is rolled over each year of the access arrangement;
- but with one variation on the AER approach:[256]
    - new investment is subject to exactly the same transition period as is proposed by the AER for the existing asset base, which, according to DBP:[257]

> …removes the perverse incentives associated with an update which automatically changes the asset value and develops a new set of backwards-looking tranches of debt discussed above, and ensures that large investments, as well as those that are marginal, face the current cost of investing at all times.

- but only for new capital investment that exceeds the annual one tenth rollover amount, as according to DBP:[258]

> Obviously such a transition period for every small addition to the capital base would quickly result in a very complex set of weights and prove unworkable. However, since the AER's approach updates the return on debt for one-tenth of the asset base every year, this forms a sensible cut-off for consideration, with additions smaller than this not treated as new stand-alone assets, and those above this level so treated. This is something that would be appropriate for discussion with the ERA, and indeed DBP would envisage that the investment plan, and how it would transition into the trailing average approach, would be discussed with the regulator at the start of each access arrangement period. As the system matures, it may be appropriate to simplify the weighting for some older assets and amalgamate them where doing so would not adversely affect efficient pricing.

432. In its recent ATCO GDS Final Decision, the Authority amended the approach for estimating the return on debt that it had set out in the Rate of Return Guidelines. The Authority in the GDS Final Decision:[259]

- revised its position with regard to the term for the DRP, accepting 10 years;
- adopted an 'extended bond yield' approach for estimating the DRP, incorporating bonds issued internationally, among other changes;
- adopted a 'hybrid trailing average', which utilises an 'on the day' estimate of the risk free rate in combination with a simple 10 year trailing average of the DRP, without any transition; and
- rejected capex weights.

255 DBP, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12*, p. 39.

256 DBP, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12*, p. 40.

257 Ibid.

258 Ibid.

259 Economic Regulation Authority, Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems, as amended 10 September 2015, p. 289.

433. The Authority considers that this position is preferred. It followed an Issues Paper and workshop on the approach to estimating the return on debt in early 2015.[260] DBP was among the entities which made submissions on the topic.

434. The Authority does not consider that DBP's proposal gives reason for it to depart from its revised approach set out in the ATCO Final Decision. Accordingly, the Authority therefore takes issue with the following aspects of DBP's proposal for estimating the return on debt:

- the 10 year term used for estimating the risk free rate;
- the use of a 10 year trailing average for estimating the annual allowance for the risk free rate;
- the requirement for a transition;
- the use of capex weights;
- the use of Commonwealth Government Securities as the proxy for estimating the risk free rate;
- the allowance for hedging costs;
- the inclusion of a New Issue Premium.

435. Each of these issues is addressed in what follows.

The term of the risk free rate

436. As noted in the detailed discussion on the risk free rate commencing at paragraph 115 above, the Authority does not accept the proposed 10 year term for the estimate of the risk free rate.

437. The Authority therefore requires that the term of the risk free rate be 5 years.

The proposed 10 year trailing average of the risk free rate

438. DBP proposes a *full* trailing average for estimating the return on debt. A full trailing average means here that it utilises a trailing average for both the risk free rate and the DRP (as opposed to a *hybrid*, which incorporates a trailing average for just the DRP component). DBP's principal reason for this position appears to be that:[261]

> The ERA's approach to updating the return on debt through the regulatory period is fundamentally unsound, and likely to result in substantial practical implementation issues. We therefore follow the AER's trailing average approach, with a slight modification whereby a transition mechanism for major new capital spending is introduced to avoid the potential for perverse investment incentives.

Acceptance of the trailing average approach for the DRP

439. As noted above, the Authority accepted the *hybrid* trailing average variant of the trailing average approach in its most recent decision on the ATCO GDS Final Decision. The hybrid trailing average approach fixes the risk free rate at the start of

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260 Economic Regulation Authority, *Estimating the return on debt: Discussion paper*, 4 March 2015.

261 DBP, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12*, p. 41.

the access arrangement period ('on the day'), while incorporating a trailing average for annual estimate of the DRP.

440. In reaching that decision, the Authority concluded that the hybrid trailing average and the previous 'on the day' approach have strengths and weaknesses.[262] Broadly speaking, both approaches:[263]

- allow for hedging of the risk free rate at the start of the regulatory period, so are not distinguished in this regard; and
- are not distinguished in terms of debt raising costs and hedging costs.

441. The Authority determined that the key differences between the hybrid trailing average and the previous on the day approaches relate to the outcomes for the DRP. In particular:[264]

- With regard to efficiency, the Authority is not aware of a data series sufficient to determine the statistical properties of the DRP – whether it exhibits a random walk or is mean reverting – hence it is not possible to be definitive about prediction performance:
  - however, there is some evidence from the available data that the 'on the day' approach for the DRP performs at least as well as the trailing average for the DRP in prediction terms for the year ahead, and may be superior;[265]
  - the on the day approach appears to deliver a DRP that is closer to the prevailing rate over the next 12 months much of the time, thereby providing for superior signals for investment by the benchmark efficient entity when it is annually updated;
  - trailing average approaches can be weighted for new capex, overcoming this shortcoming, albeit at the cost of some complexity.
- In terms of signalling efficient use by upstream and downstream users, there is some evidence that the on the day approach performs at least as well as, and potentially better than, the hybrid trailing average DRP.
- With regard to 'minimising differences', the trailing average approach to estimating the DRP can be replicated exactly by the firm, whereas the 'on the day' approach to the DRP cannot.[266] Under the Authority's current approach, the firm is required to manage the ups and downs of prevailing rates, with its

262 The 'previous' on the day approach encompassed the approach set out in the Guidelines, which was for an 'on the day' risk free rate, set once at the start of the regulatory period, combined with an annually updated 'on the day' DRP. The previous approach was further amended in the ATCO Draft Decision, whereby the annually updated DRP was only carried through to tariffs at each regulatory reset, as a net 'unders and overs' adjustment to the total revenue in the subsequent access arrangement period.

263 Economic Regulation Authority, Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems, as amended 10 September 2015, p. 321.

264 Ibid.

265 DBP questioned the Authority's implementation, in the Guidelines, of the Diebold Mariano test (DBP, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12*, p. 36 and Appendix N). However, the Authority in its ATCO Draft Decision accepted some of the points made by DBP, modifying its analytical approach (Economic Regulation Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems*, as amended 10 September 2015, p. 298). The Authority therefore considers that these points by DBP are no longer salient to its decision.

266 Performance in terms of 'minimising differences' is relevant, given that that NGR 87(11)(a) requires the Authority to have regard to 'the desirability of minimising any difference between the return on debt and the return on debt of a benchmark efficient entity'.

cost of debt sometimes exceeding the regulated return on debt, and sometimes undercutting it. On that basis, the hybrid trailing average approach is superior.

- To the extent that the trailing average may be matched by the regulated firm, it potentially may lower credit risk, and hence cost, as compared to the on the day approach. However, over time, on average, there are likely to be limited differences between the various approaches with regard to this consideration. Nevertheless, this consideration adds further support for the hybrid trailing average approach.
- Trailing average approaches can achieve the present value condition exactly at any point in time, whereas the Authority's current approach only approximates the condition, on average, over the longer term. Again, this provides support for the hybrid trailing average approaches.

442. The Authority considered that the hybrid trailing average approach may perform slightly less well on efficiency grounds than the on the day approach, although there was not strong evidence for this. On the other hand, the hybrid trailing average approach performs better in terms of 'minimising differences' and the present value condition. The simple hybrid trailing average approach also performs best with regard to regulatory costs.[267]

443. Overall, weighing up the strengths and weaknesses, the Authority concluded that the hybrid trailing average approach is slightly preferable in terms of meeting the requirements of the NGL and NGR, including the allowed rate of return objective and the requirements of NGR 87 more generally. In coming to that conclusion, the Authority was mindful of the very limited evidence separating the approaches in terms of their outcomes for economic efficiency.

444. The Authority therefore determined to adopt a hybrid trailing average approach, annually updated, for estimating the return on debt.

445. The key question with regard to this decision then becomes whether to accept DBP's proposal for a full trailing average (which incorporates a trailing average for the risk free rate) or to require DBP to adopt a hybrid trailing average, consistent with the Authority's approach set out in the ATCO GDS Final Decision.

Hybrid or full trailing average?

446. The key difference between the hybrid and full trailing average relates to the treatment of the risk free rate:

- under the hybrid trailing average, the risk free rate is set once, based on the rate prevailing at the start of the regulatory period;
- under the full trailing average, an n-year trailing average of past estimates of the risk free rate is applied (with n generally taken to be 10, consistent with the observed average term of debt issuance of typical infrastructure businesses);
- under the transitional approach to the full trailing average, as applied by the Australian Energy Regulator, a 10-year trailing average is phased in over 10 years, with the on the day risk free rate applying in the first year, with 1/10 of that rate replaced with the prevailing rate in each subsequent year, such that the full 10-year trailing average is only achieved after 10 years.

[267] Economic Regulation Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems*, as amended 10 September 2015, p. 321.

447. The Authority considers that the hybrid trailing average offers advantages over the full trailing average, in that it:

- aligns with the potential for businesses to hedge the risk free at the start of the regulatory period, thereby achieving in the 5 year rate incorporated in the total revenue;
- does not require the benchmark efficient entity to unwind previous hedging arrangements relating to the risk free rates, and hence avoids the need for the transitional approach; and
- does not require estimation of the risk free rate at each annual anniversary of the averaging period, for inclusion in the annual update of the trailing average.

448. With regard to the need to unwind previous hedging arrangements the Authority considers the evidence is that it has been common practice for regulated entities to hedge the risk free rate component of the return on debt at the start of each regulatory period. While not a universal practice, the majority of regulated entities hedge the risk free rate. The exceptions are those who appear to have been taking positions seeking to lower their cost of debt below the regulated rate:[268]

> While many NSPs fully or largely hedge the base rate to the regulatory period, some carry partial trailing average fixed rate exposure, floating rates or a mixture of the two…
>
> Some companies reflect an almost identical base rate profile to that assumed in AER's Basic Approach to EFP [efficient financing practice], i.e. fixed base rates only matching the regulatory period. However, other companies display a partial trailing fixed rate component mixed with a large portion to match the regulatory period. These do not use a smoothly staggered fixed base rate approach.
>
> A small number of companies keep some floating base rate exposure, and there is evidence of this being combined with a partial trailing fixed rate component…
>
> Some firms have taken what appear to be inefficient or speculative decisions, or a combination of both by introducing base rate risk. This is a natural part of a competitive industry and is a positive sign that benchmark regulation allows room for individual enterprises to manoeuvre. A competitive industry should expect to see winners and losers amongst participants.

449. Similarly, Lally has concluded that:[269]

> In conclusion, under the previous regime, it seems to have been the general practice of private-sector firms to use interest rate swaps to hedge the base rate component of the cost of debt and this creates a strong presumption that this was efficient behavior *[sic]*. Furthermore, this conclusion is strengthened by the fact that using these swaps seemed to reduce expected interest costs and also reduced risk (in the sense of reducing mismatches between the allowed base rate for the cost of debt and that incurred).

450. To the extent that regulated entities have hedged the risk free rate over past regulatory periods, it would not be appropriate to provide a full trailing average of the risk free rate, as this would not match the return for the regulated entity on its debt portfolio. Specifically, there would likely be significant over- or under-recompense, depending on the differences between actual risk free rates over time and those applying at the start of each past regulatory decision (to which the hedged rate would be fixed). This violates the present value condition.

[268] Chairmont Consulting, *Financing Practices Under Regulation: Past and Transitional*, 13 October 2015, pp. 42 to 44.

[269] M. Lally, Review of Submissions on Transition Issues for the Cost of Debt, p. 26.

451. On that basis, if the full trailing average approach was accepted, there would need to be time for the regulated entity to unwind previous hedging positions. Concurrently, the regulated cost of debt would need to move away gradually from the on the day approach, so as to avoid under or over-recompense. In that case, the appropriate approach would be to provide for the phased transitional approach to the full trailing average. This is the method adopted by the Australian Energy Regulator, who account for the following reasons:[270]

> We are not satisfied that adopting a backwards looking trailing average (Option 4) is reasonable or would contribute to the achievement of the allowed rate of return objective. This is because it:
>
> - It has the potential to create a bias in regulatory decision making that can arise from the selection of historical data after the results of that data is already known.
> - would exaggerate a mismatch between the allowed return on debt and the efficient financing costs of a benchmark efficient entity over the life of its assets. This means that over the life of the assets a benchmark efficient entity is likely to materially either over- or under-recover its efficient financing costs.
> - does not approximately match the allowed return on debt with the efficient financing costs of a benchmark efficient entity over the 2016–20 period as it transitions its financing practices to the trailing average approach. Given a benchmark efficient entity will already have financing practices in place it entered into in the past, it needs time to unwind these practices and gradually adopt practices that match the trailing average approach. This transformation cannot occur instantly and does not avoid practical difficulties with the use of historical data. However, we are satisfied that this is a relatively minor issue compared to the above points.

452. The Authority notes that DBP has proposed such a transition, albeit conditional on regulatory developments on the east coast. DBP leaves the exact method open to review, stating:[271]

> Several service providers have included in their recently revised pricing proposals submitted to the AER (under the NGR and the National Electricity Rules) a trailing average approach to varying the cost of debt during an AA period that varies from that version of the trailing average approach outlined by the AER in its Guidelines. At this stage, it is not apparent to DBP which of these variations of the trailing average approach best contributes to the achievement of the ARORO. To the extent that further guidance is given on which variation does best contribute towards the achievement of the ARORO during the ERA's assessment of DBP's proposed revised access arrangement, DBP would encourage the ERA to consider this guidance and, before the ERA issues its final decision:
>
> • provide stakeholders with an opportunity to comment on this further guidance; and
>
> • provide DBP with the opportunity to submit revisions on this aspect of the proposed revised access arrangement.

453. The Authority does not accept such an indeterminate proposal.

454. More importantly, the Authority considers that a full trailing average for the risk free rate will over-recompense the benchmark efficient entity.

455. In particular, the Authority's requirement for the 5 year term for the risk free rate is predicated on the understanding that the benchmark efficient entity will be able to

[270] Australian Energy Regulator, *Preliminary Decision: Jemena distribution determination: 2016 to 2020: Attachment 3 − Rate of return*, October 2015, p. 3-165.

[271] DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12, p. 39.

hedge the risk free rate of any debt it raises. With hedging, a 5 year term for the risk free rate, commensurate with the regulatory period, is appropriate as – given the typical term structure of interest rates – allowing a 10 year term for the risk free rate would over-compensate the benchmark efficient entity which undertook hedging (see risk free rate section above).

456. The Authority considers that the hybrid trailing average approach aligns with the 5 year term for the risk free rate. Provided that the benchmark efficient entity is able to hedge its debt to the 5 year regulated rate, then the present value condition is met under the hybrid trailing average, and differences between the return on debt and the cost of debt of the benchmark efficient entity are minimised.

457. However, the Authority recognises that the benchmark efficient entity may be of a size where it was unable to hedge the whole debt portfolio efficiently within a specified averaging period, as the swaps requirement might 'move the market'. In that case, the Authority considers that a proportion of the regulated asset base (**RAB**) debt may not be able to be hedged efficiently.

458. In response, the Authority would consider allocating a proportion of the debt to the hybrid approach, and a proportion to the full trailing average:

- the hybrid proportion would be based on the on the day 5 year risk free rate;
- the full trailing average proportion would be based on the 10 year risk free rate, and would be phased in over a 10 year transition period.

459. At the next access arrangement, the proportion would be reviewed. However, irrespective, the existing trailing average tranche assigned to the full trailing average, from the prior access arrangement, would continue to be phased in, with five years remaining for the transition for that component. A new trailing average component *may* commence at the start of the next access arrangement, with a 10 year transition for that tranche, if there was evidence that the proportion of debt requiring hedging, for that next access arrangement, could not be accommodated without moving the market.

460. The proportions to be applied would require evidence as to what part of the debt portfolio reasonably could not be hedged, without driving up the cost of debt. The Authority considered this issue in the Rate of Return Guidelines, concluding that it had not been presented with concrete evidence of impediments to hedging the risk free rate for typical gas pipeline debt portfolios.[272] The Authority therefore would require evidence on this aspect from any service provider that was proposing the full trailing average.

461. Otherwise, the Authority considers that it should require the hybrid trailing average, as it meets the requirements of the NGL and NGR, consistent with the conclusions summarised at paragraphs 440 to 443 above.

462. In this context, the Authority's notes that the DBP RAB, at around $3.6 billion, has an associated debt portfolio of around $2.2 billion. This debt portfolio is not of a size that should create any issues for hedging within the 40 day averaging period. The Authority notes that advice from Chairmont indicated that transacting $2 billion of swaps in 20 days, in normal circumstances would not move the market price of

272 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 68.

swaps.[273] The Authority would be open to extending the length of the averaging period, to as much as 60 days, as one means to ensure that the ability to hedge the DBP portfolio was retained. On that basis, the Authority considers that DBP would be able to hedge its full portfolio of debt.

463. Therefore, the threshold requirement indicating a proportion of the return on debt to be based on the full trailing average is not met. Accordingly, the Authority considers that basing return on debt on the hybrid trailing average approach would meet the requirements of the NGL and the NGR, neither under- nor over-compensating the benchmark efficient entity.

464. For the above reasons, the Authority requires that DBP change its proposed approach to estimating the cost of debt to be consistent with the hybrid trailing average approach.

465. This required hybrid trailing average approach is outlined in what follows. The approach to the return on debt is identical to that adopted for the recent ATCO Gas Distribution System. Therefore, the Authority *illustrates* the numerics of the return on debt outcomes by using the ATCO estimates. (It may be noted that the ATCO Gas Distribution System estimates are for the 20 day averaging period ending 2 April 2015. The same *approach* as outlined below will be applied for the Final Decision, albeit updated using DBP's nominated averaging period for 2016, and with the updates for 2017 to 2020 based on the averaging periods proposed by DBP.)

The hybrid trailing average approach

Key features of the hybrid trailing average approach

466. An estimate of the return on debt based on a hybrid trailing average will:

- be comprised of the sum of a debt risk premium and a base risk free rate, combined with a margin for administrative and hedging costs:

  Return on Debt = Risk Free Rate + Debt Risk Premium + Debt raising costs + Hedging costs

- estimate the risk free rate once, based on an averaging period at the start of the regulatory period (implying the 'on the day' approach for the risk free rate);
- adopt a 10 year term for the DRP – following Lally's recommendations with regard to achieving the present value principle (or NPV=0 condition), estimate the DRP consistent with the average term at issuance, which the Authority in the Draft Decision determined was 10 years;
- annually update the estimate of the DRP, just prior to the start of each regulatory year, based on the updated hybrid trailing average estimate of the DRP;
- the annually updated hybrid trailing average will feed through into each annual tariff variation.

467. Having determined to adopt the hybrid trailing average approach for this Draft Decision, the remaining key details of the approach are now considered:

- the averaging periods for the DRP estimates;

273 Chairmont Consulting, *Comparative Hedging Analysis*, 12 June 2013, p. 19.

- the method for estimating the base rate and the resulting point estimate for this Draft Decision;
- the term of the DRP;
- the number of years in the trailing average for the DRP;
- the method for weighting for the trailing average;
- the need for a transition;
- the credit rating for the benchmark efficient entity;
- the method for estimating the DRP and the resulting point estimate for this Draft Decision;
- the method for estimating the other debt raising and hedging costs and the resulting point estimates for this Draft Decision;
- the method for annually updating the return on debt in tariffs, so as to account for the annual update of the DRP component.

The averaging period of the estimates

468. The averaging period for the base *risk free rate* estimate contributing the *indicative* calendar year 2016 estimate of the return on debt for this Draft Decision is the 20 days ending 2 April 2015 (on the issue of 20 versus 40 days for the averaging period, see paragraph 465 above).

469. For the indicative calendar year 2016 *DRP* estimate used for this Draft Decision, the Authority also draws on the (calendar year 2015) estimate developed in its recent ATCO GDS decision. For that estimate, the Authority developed a forward looking indicative estimate for the DRP – for the period in calendar year 2015 that falls after 2 April 2015 – based on an estimate over the 20 day averaging period ending 2 April 2015. Prior to that date, the Authority used RBA monthly data in the trailing average DRP estimates stretching back to 2005.[274]

470. The Authority will update these calendar year 2016 estimates for the Final Decision, following a similar method to that utilised in the ATCO GDS Final Decision. That will require DBP to nominate an averaging period for 2016, for the purpose of the Final Decision estimate.

471. For the annual *updating* of the DRP trailing average, it is necessary to adopt a different averaging period for the DRP.[275] The annual update process requires additional averaging periods for the forward looking estimates of the DRP for 2017, 2018, 2019 and 2020.

472. For the DRP update estimates for 2017, 2018, 2019 and 2020, the averaging period for the forward looking DRP would be based on a reasonably short period that is as close as practicable to the start of each of the calendar years to which it will apply, while still allowing sufficient flexibility to conduct debt operations without moving the market. The period also needs to give sufficient time for the Authority to consider

274 Ultimately, for the Final Decision – which is expected to occur in the middle of 2016 – a similar composite estimate for the DRP for 2016 will be developed. That estimate will be based on the RBA historic monthly data up to the nominated averaging period

275 The risk free rate will remain unchanged, as in the hybrid trailing average approach it is the 'on the day' estimate made once at the start of the regulatory period. It will therefore be based on the 2016 calendar year estimate for the whole of the access arrangement.

and approve the annually updated tariffs prior to their subsequent application date on 1 January in each of the specified years.

473. For those reasons, the Authority considers that choosing the averaging period in the window between two months and seven months prior to the regulatory period is preferred. The five month period is considered sufficient to ensure that the 40 day averaging period cannot be inferred by other market participants. In the event that DBP elected a 60 day averaging period, the window would be extended to six months (ending two months prior to 1 January).

474. Accordingly, for the 40 day averaging period, the Authority will require that the nominated averaging period occur in the period 1 June to 31 October in each year, which is reasonably close to the following 1 January update. Hence the averaging period for 2017 would be in the window 1 June 2016 to 31 October 2016, providing the updated DRP for inclusion in the 1 January 2017 tariff variation.

475. The Authority considers that adopting a consistent length for the averaging period – therefore of the same length as that used for the risk free rate – has clear advantages for internal consistency. This will be important when the averaging period for the two estimates coincide, for example when setting the rate of return prior to the next access arrangement.

476. The averaging periods for the future annual updates should be nominated in advance, with the dates then remaining confidential. This is to ensure that the resulting estimates are not biased by opportunistic behaviour. The Authority will require DBP to nominate the averaging periods for 2017 to 2020 as soon as practicable around the time of release of the Final Decision (which is expected to occur in the second half of 2016). The Authority does not require that the nominated averaging period for each of the four years be identical periods, only that they occur in the period 1 June to 31 October.

477. In summary, averaging periods are required for each year of the regulatory period, in order to facilitate the annual update of the DRP for the tariff variations to occur on 1 January in 2017, 2018, 2019 and 2020. The Authority requires DBP to nominate all three averaging periods, as well as the 2016 period, as soon as possible, and consistent with the following averaging period criteria. Each of the three averaging periods;

- is required to be consecutive business days (DBP have proposed 40 days, although as noted the *indicative* estimate for this Draft Decision is based on 20 days);
- needs to fall in the period between 1 June and 31 October – in the year prior to the year which the resulting forward looking estimate of the DRP first contributes to the hybrid trailing average estimate of the return on debt;
- does not need to be over the same dates as that in other years.

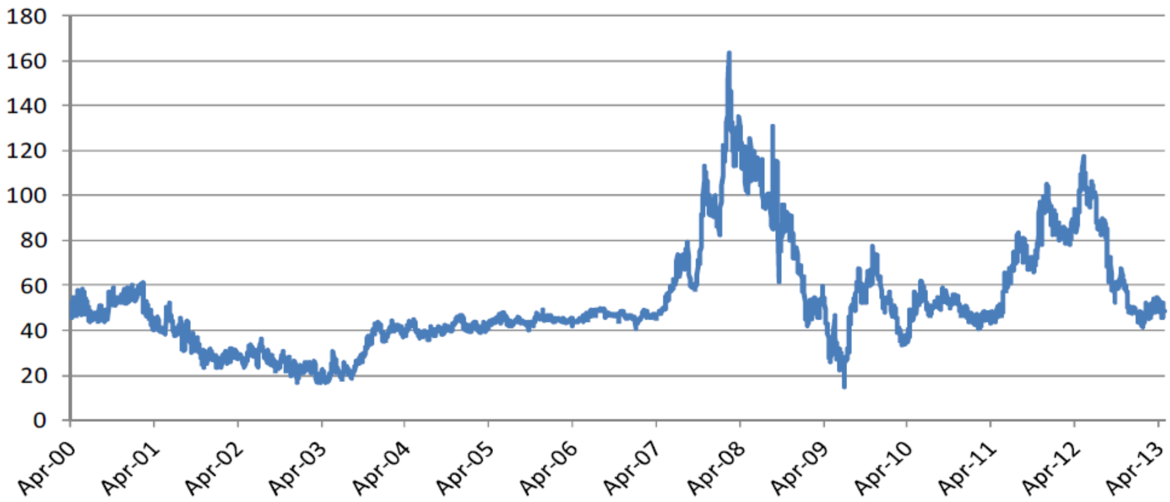
The method for estimating the base rate and the resulting point estimate

478. DBP has proposed use of Commonwealth Government Securities (**CGS**) as the proxy for the risk free rate. However, the Authority has recently moved to consider the swaps rate as being the appropriate proxy rate for the estimate of the return on debt.

479. Interest rate swaps are derivative contracts, which typically exchange – or swap – fixed-rate interest payments for floating-rate interest payments. They provide a means to hedge and manage risk. Investment and commercial banks with strong credit ratings are swap market-makers.

480. A swap has two 'legs', one floating and one fixed. The floating rate is generally referenced to either the Bank Bill Swap Rate (**BBSW**) or the Bank Bill Bid Rate (**BBSY**).[276] There is usually a difference or spread between the rate on CGS and that of swaps (for example, the 5 year swap spread to CGS is shown in Figure 8. The difference reflects the higher risk associated with the counterparty involved in a floating swap transaction, for a particular credit rating, as compared to the lower risk of the government-backed CGS.

Figure 8 5 year swap spread 2000-2013



Source Chairmont Consulting, Comparative Hedging Analysis, 12 June 2013, p. 17.

481. The Authority considered this issue in the Guidelines:[277]

> As set out by Chairmont Consulting in its June 2013 report to the Authority, the difference between a CGS risk free rate and a swap rate of similar term is called the spread of swap (**SS**). However, it should not matter which rate is used for determining the overall return on debt. If debt risk premiums are estimated consistent with the chosen base – whether that base be the CGS risk free rate or BBSW – there should be no difference in the resulting build up of the overall return on debt. The two approaches just represent 'two different ways of splitting up the total interest rate', with:[278]

$$Yield = R_F + SS + DRP_s \qquad (21)$$

276 BBSW is the average mid rate for Australian Dollar bills of exchange having various tenors which appear on the Reuters Screen BBSW Page at approximately 10.10am Sydney time on the relevant Payment Date. BBSY is the Australian Bank Bill Swap Bid Rate, being the average bid rate for Australian Dollar bills of exchange having various tenors which appear on the Reuters Screen BBSY Page at approximately 10.10am Sydney time on the relevant Payment Date (Westpac, *Interest Rate Swap*, accessed 17 March 2015, pp. 6 and 15).

277 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 83.

278 Chairmont Consulting, *Comparative Hedging Analysis*, www.erawa.com.au, 12 June 2013, p. 14.

Where

R_F is the CGS risk free rate;

SS is the spread of swaps to the CGS rate; and

DRP_s is the debt risk premium to the underlying swaps rate base.

482. The Authority considered a move to using swap rates for the risk free rate when estimating the return on debt at the time of the Guidelines. Such an approach would align with typical hedging practices. However, the Authority had concerns that available IRS market data on swap rates for longer maturities – such as beyond 6 months – are less reliable than short term swaps rate.

483. The Authority noted that using observed market transactions of swap rates will result in estimates of the risk free rate that are biased upward. This is a consequence of the possible counter-party credit risk present in IRS, and the implicit premium paid by those hedging when entering into a swap.[279] This approach also relies on the assumption that longer maturity swap markets are sufficiently liquid.

484. Therefore, the Authority considered that it was more appropriate to retain the use of CGS as the proxy for the risk free rate, as the longer dated rates may be more robustly estimated from CGS data. The Authority noted that such an approach would ensure that firms have ‘reasonable opportunity’ to recover their cost of debt.

485. The Authority considered that firms base their hedging on the swap rates and that the risk-free rate is generally lower than the relevant swap rate. On this basis, the Authority was of the view that using a risk-free rate as a base rate would allow regulated businesses to hedge a small part of the Authority’s estimate of the DRP, together with the risk-free rate.[280]

486. The Authority however is now of the view that – as it is moving to the hybrid trailing average approach – the benefits associated with using CGS are less important, given that the benchmark efficient entity may exactly replicate a hybrid trailing average based on the swaps rate.

487. Therefore, for the purposes of estimating the return on debt, the Authority will use the 5 year swap mid-rate, as published on Bloomberg (Last Price), over the relevant averaging period for each regulatory year. The Authority considers that this will simplify the understanding of the estimate, but remain entirely consistent with the underlying CGS rate that is used more broadly for this decision. The difference will be the spread between the two.

The term of the DRP

488. The Authority in the ATCO Gas Distribution System Draft Decision accepted a 10 year term for its estimate of the DRP, following clarifying advice from Lally, and

279 Hull J.C (2009), *Options, Futures and other Derivatives*, Seventh Edition, Pearson Prentice Hall, p. 169.

280 This arises because the debt risk premium estimated by the Authority, against a CGS base, will be larger than the debt risk premium over and above the swap rate. Then, to the extent that firms use the swaps market to hedge movements in the base, some of the Authority’s estimate of the debt risk premium will also be hedged. The additional amount hedged will be the spread of swaps.

evidence that the average term at issuance of debt by the benchmark efficient entity is 10 years.[281] This is consistent with DBP's proposal.

The credit rating for the benchmark efficient entity

489. The Guidelines proposed a credit rating in the BBB/BBB/BBB+ band for the benchmark efficient entity.

490. DBP has accepted this rating for the purposes of estimating the return on debt.[282] Therefore, the BBB/BBB/BBB+ band will be retained for this Draft Decision.

The method for developing the estimator of the DRP

491. The Authority evaluated two approaches for estimating the 10 year DRP:

- the RBA credit spread estimates; and
- the Authority's revised bond yield approach, which was augmented to allow estimation of a yield curve.

The RBA's corporate credit spread

492. The RBA's estimates of corporate credit spreads, at the targeted tenor of 10 years, are available for the A-rated and BBB credit rating bands.[283]

493. The RBA credit spreads are estimated with respect to both contemporaneous estimates of the return on Commonwealth Government Securities and Bank Bill Swap rates, at various target tenors.[284] They provide one potential approach to estimating the debt risk premium for the BBB band, at 10 year target tenor.

494. A starting point for the RBA's estimation approach is the development of the samples of Australian corporate bonds that are used to estimate the spreads for the A and BBB credit rating bands respectively. The RBA adopts the following selection criteria to filter the corporate bonds for each of the respective benchmark samples:[285]

- a credit rating of A-rated band or BBB-rated band;
- a remaining term to maturity of 1 year or longer;
- an amount at issuance of A$1 million or greater;
- inclusion of bonds denominated both in Australian dollars and foreign currencies; including US dollars and Euros;
- inclusion of bullet bonds and bonds with embedded options, such as callable bonds; and

281 Economic Regulation Authority, *Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System*, 14 October 2014, p. 189.

282 Goldfields Gas Transmission, Goldfields Gas Pipeline: Access Arrangement Revision Proposal Supporting Information, 15 August 2014, p. 135.

283 Reserve Bank of Australia, Interest rates: aggregate measures of Australian corporate bond spreads and yields, Table F3, www.rba.gov.au/statistics/tables/index.html.

284 Reserve Bank of Australia, 'New Measures of Australian Corporate Credit Spreads', Bulletin, December quarter 2013.

285 Reserve Bank of Australia, 'New Measures of Australian Corporate Credit Spreads', Bulletin, December quarter 2013.

- all bonds identified by Bloomberg that were outstanding after 1 January 1990 and were issued by non-financial corporates (**NFCs**) incorporated in Australia.[286]

495. Once the benchmark sample is developed, the RBA estimates the aggregate credit spreads for A-rated and BBB-rated Australian NFCs given the desired target tenor, based on the weighted average of the Australian dollar equivalent credit spreads over the swap rate. The method is applied to the cross-section of bonds in the sample that have the desired credit rating.

496. The RBA estimates are determined by the Gaussian Kernel method. This approach assigns a weight to every observation in the bond sample – informed by the distance of the observation's residual maturity from the target tenor – according to a Gaussian (normal) distribution centred at the target tenor.[287] The RBA notes that this method recognises that the observed spreads on bonds with residual maturities close to the target tenor contain more information about the underlying spread at that tenor than spreads on bonds with residual maturities further away. The RBA also argues that:[288]

> The advantage of the Gaussian Kernel over parametric methods that have been popularised in the literature on the estimation of government yield curves, is its simplicity. Also, it does not impose a particular functional form on the credit spread curve but allows the observed data to determine its shape.[289]

497. Formally, the Gaussian Kernel average credit spread estimator $S(T)$ at target tenor T (say, 5 years) for a given broad rating (say, BBB-rated bonds) and date is given by (22):

$$S(T) = \sum_{i=1}^{N} w_i(T;\sigma) \times S_i \qquad (22)$$

Where

$w_i(T;\sigma)$ is the weight for the target tenor T of the i^{th} bond in the sub-sample of bonds with the given broad rating; and

S_i is the observed spread on the i^{th} bond in the sub-sample of N bonds with the given broad rating.

286 Non-financial corporations are identified based on their classification by Bloomberg in a group other than banking, commercial finance, consumer finance, financial services, life insurance, property and casualty insurance, real estate, government agencies, government development banks, governments regional or local, sovereigns, supranationals and winding-up agencies.

287 Reserve Bank of Australia, *'New Measures of Australian Corporate Credit Spreads'*, *Bulletin*, December quarter 2013, p. 20.

288 Reserve Bank of Australia, '*New Measures of Australian Corporate Credit Spreads*', *Bulletin*, December quarter 2013, p. 20.

289 A number of estimation methods were investigated. These methods produced very similar estimates of credit spreads across tenors and broad credit ratings. These methods included a range of parametric models estimated by least squares regressions applied to the cross-section in each period. In particular, the Nelson and Siegel (1987) method was examined in detail owing to its wide use in practice for estimating government yield curves (BIS 2005); this method has also been adapted for the estimation of corporate bond yield and spread curves (Xiao 2010). However, the RBA notes that in its sample these models displayed spurious statistical properties, producing very high model fit but largely statistically insignificant coefficients. Other studies have also found evidence of possible over-fitting of the data using parametric methods, particularly in the case of the Nelson and Siegel model.

σ (sigma), which is measured in years, controls the weight assigned to the spread of each observation based on the distance between that bond's residual maturity and the target tenor. Sigma is the standard deviation of the normal distribution used to assign the weights. It determines the effective width of the window of residual maturities used in the estimator, with a larger effective window producing smoother estimates.

498. The weighting function is as follows in (23).

$$w_i(T;\sigma) = \frac{K(T_i - T;\sigma) \times F_i}{\sum_{j=1}^{N} K(T_j - T;\sigma) \times F_j} \quad (23)$$

Where

$K(T;\sigma)$ is the Gaussian Kernel function giving weight to the i^{th} bond based on the distance of its residual maturity from the target tenor $(|T_i - T|)$.

F_i is the face value of the i^{th} bond.

499. The Gaussian Kernel may then be defined as below in (24).

$$K(T_i - T;\sigma) = \frac{1}{\sqrt{2\pi}\,\sigma} \exp\left[-\frac{(T_i - T)^2}{2\sigma^2}\right] \quad (24)$$

500. The Gaussian Kernel method provides for a degree of flexibility in weighting the observations around the target tenor through the choice of the value of the smoothing parameter, σ.

501. The RBA then selects a smoothing parameter of 1.5 years for both A-rated bonds and BBB-rated bonds.

502. The RBA concluded that the Gaussian Kernel method produces effective weighted average tenors that are very close to each of the target tenors. The exception is the 10 year tenor, where the effective tenor is currently 8.6 years. The RBA argues that this difference reflects the dearth of issuance of bonds with tenors of 10 years or more.

503. The Authority considers that the estimates developed by the RBA are not the best means to deliver on the allowed rate of return objective.

504. First, the Authority is of the view that there is a need for consistency in the term estimates (that is, the estimates for the target tenors). The Authority notes that the RBA approach does not necessarily achieve this outcome, particularly at the 10 year target tenor. As noted above, the RBA method produces an estimate that is 8.6 years. The Authority recognises that methods are available to adjust the target tenor, which while less than ideal, are able to circumvent this problem.

505. Second, the Authority notes that the RBA estimates are only available for the BBB and A bands. However, Australian economic regulators, including the Authority, have adopted various other combinations of credit ratings for their regulatory decisions. The Authority considers it should not be constrained in its credit rating evaluation by a limited set of estimates of the related debt risk premia, as this may not be consistent with the requirements of the NGR, or the allowed rate of return. If the Authority determined to use a different credit rating it would use a different bond sample (as indeed it does for its rail decisions). The Authority considers that this flexibility is important.

506. Third, the RBA estimates are reported as the month-end estimates of the debt risk premium using relevant swap rates or Commonwealth Government Security (**CGS**) rates. The resulting estimates are less than ideal because Australian regulatory practice is to adopt an average over a period between 20 or 40 trading days, so as to avoid significant fluctuation of the estimates on any particular day. The Authority recognises that interpolation may be used to approximate daily rates, but considers that its own estimation will not require approximation, which has statistical advantages (see paragraph 509 below).

507. On this basis, the Authority remains of the view that it is more appropriate to develop its own yield estimates. To this end, the Authority revised its bond yield approach with two additions: (i) the benchmark sample was extended to recognise the importance of Australian bonds denominated in foreign currencies; and (ii) various curve fitting techniques are adopted to allow the estimation of the debt risk premium at various tenors.

Revised bond yield approach

508. The revised bond yield approach allows for the specification of bond selection criteria for a given credit rating band. A regulator or Network Service Provider (**NSP**) employing the approach therefore has the flexibility to assess the impact of employing criteria that differ to (or are the same as) that used by the RBA. In a scenario where few bonds are available under a given set of criteria, less restrictive criteria can be specified to produce yield estimates that can serve as a robustness check.

509. The Authority views the interpolation of a point estimate between two 1 day estimates to approximate 20 or 40 day averages to be less representative of yields prevailing in the averaging period in question and subject to a higher degree of statistical noise. Two observations represent a very small sample and it is entirely possible that the two observations could differ substantially to those prevailing throughout the averaging period.

510. Additionally, the Authority considers its approach to be more transparent than using RBA corporate credit spreads because the sample of bonds underlying the bond yield approach estimates are published.

511. The Authority is of the view that the revised bond yield approach:

- provides flexibility in sampling bonds within a particular credit rating bands;
- directly addresses the issue of the effective tenor of the Reserve Bank of Australia (**RBA**) corporate credit spread estimates being less than 10 years; and
- is more robust to anomalous market yields by virtue of using 20 to 40 days of yield observations than using methods based on one day of observations;

Extending the benchmark sample for the bond yield approach

512. In its bond yield approach discussion paper in December 2010, the Authority considered the trade-off between the 'market relevance' and the 'accuracy' of the approach to be adopted in estimating the proxy for the cost of debt/the debt risk premium for a benchmark sample of Australian corporate bonds.[290] The Authority considered that a bond price (or its observed yield) is determined by the markets, not by the companies or the regulators. As a result, the Authority was of the view that relying on market data will provide the best means of estimating the proxy for the cost of debt. This means that observed bond yields play a fundamental role in the method of estimation.

513. In addition, the Authority places emphasis on market relevance. This takes account of the fact that new bond issuers consider the prevailing market conditions prior to the issuance of the bonds. In particular, issuers will consider issuing longer term bonds in a 'normal' market situation, whereas shorter term bonds may be more appropriately issued during very unstable market conditions. As a result, the observed yields of bonds currently traded in the market will reflect the nature of the prevailing market conditions prior to the issuance of the bonds.

514. The Authority notes that firms are increasingly choosing to issue Australian bonds denominated in offshore markets and currencies.[291] As long as the majority of bond issuances of the various markets and currencies can be captured, then the associated outcomes are 'market relevant', and ideally should be included in the benchmark sample.

515. The decision to issue bonds in the Australian or overseas financial markets lies with businesses. There may be a cost advantage in issuing bonds overseas taking into account all possible risks associated with the process such as exchange rate risk. Alternatively, it may be more convenient to issue longer term bonds and/or bonds with larger amounts at issuance in overseas markets given the Australian financial market is generally considered a smaller market in comparison with the US, European, and UK markets.

516. An initial search on the Bloomberg terminal, as at 18 June 2014, indicated that Australian corporate bonds are largely denominated either in Australian dollars, US dollars (**USD**), Euros, or British pounds (**GBP**).

[290] Economic Regulation Authority, *Measuring the debt risk premium: bond-yield approach*, 30 November 2010.

[291] Reserve Bank of Australia, *'New Measures of Australian Corporate Credit Spreads'*, *Bulletin*, December quarter 2013, p. 16.

Table 12 Australian corporate bonds denominated in various currencies

Currency	No of bonds	Percentage	Amount (in relevant currency)	Exchange rate as at 18 June 2014	Amount (in A$)	Percentage
AUD	74	39%	20,531,775,500	1.0000	20,531,775,500	21%
CAD	2	1%	521,370,000	1.0148	513,766,259	0.52%
CHF	3	2%	492,910,000	0.8399	413,995,109	0.42%
EUR	14	7%	10,805,920,000	0.6893	15,676,657,479	15.81%
GBP	12	6%	6,196,342,000	0.5504	11,257,888,808	11.36%
JPY	2	1%	109,813,500	95.4700	1,150,241	0.0012%
NZD	3	2%	771,090,000	1.0778	715,429,579	0.72%
SGD	1	1%	217,903,000	1.1704	186,178,230	0.19%
USD	78	41%	46,539,000,000	0.9337	49,843,632,859	50.28%
		100%	86,186,124,000		99,140,474,063	100%

Source: Authority analysis based on data obtained from Bloomberg and the RBA (for exchange rate), June 2014

517. The above table indicates that if only Australian corporate bonds denominated in Australian dollars are included in the benchmark sample, then only 39 per cent (in terms of number issued) and 21 per cent (in terms of value at issuance) of bonds are covered. However, when foreign currencies such as USD; Euros; and GBP are included, the benchmark sample captures relevant information relating to 93 per cent of all debt (in terms of the number of bonds issued) and 98 per cent of all debt (in terms of the amount at issuance).

518. It is clear then that the majority of Australian corporate bonds are denominated in foreign currencies.[292] Furthermore, overseas markets have assumed greater importance for the longer end of the yield curve.

519. In conclusion, the Authority considers that Australian corporate bonds denominated in selected foreign currencies should be included in the benchmark sample, given the changing nature of debt markets, and the clear trend to foreign issuance. Doing so will increase the sample size of the benchmark sample, which leads to a more robust estimate of the DRP.

520. The Authority notes that DBP considers that the criteria filtering bonds of less than two year remaining term is less relevant given that yield curve estimation is used.[293] However, the Authority considers that bonds of less than two years can introduce bias due to thin trading as bonds approach maturity. However, DBP have not taken issue with this criteria and follow it, so the Authority does not consider this matter further.

521. The Authority will include Australian bonds denominated in USD; Euros; and GBP in the benchmark sample under its revised bond yield approach. The Authority notes

292 Reserve Bank of Australia, *'New Measures of Australian Corporate Credit Spreads'*, *Bulletin*, December quarter 2013, p. 17.

293 DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12, p. 21.

that as at August 2014, bonds denominated in AUD; USD; Euros and GBP covered the majority of debt issued by Australian corporates. Should the debt market evolve in the future and other currencies play a more significant role, the choice of currencies may need to change. The Authority considers that provided the bond sample covers at least 90 per cent of both the number of bonds and the amount at issuance, then its estimates are likely to be sufficiently representative of actual debt issuing practices.

522. As a further consideration, the Authority notes that it is standard practice to exclude firms operating in the financial sector, because these firms have a different capital structure.[294] Exclusion of bonds issued by firms in the financial sector may reduce the sample size. However, given the approach to include bonds denominated in foreign currencies, this reduction in the sample size does not have an effect on the robustness of the estimates.

523. In summary, the Authority considers that it is appropriate to include Australian corporate bonds denominated in key foreign currencies in the benchmark sample, as well as domestic issuance in Australian dollars. The Authority also considers it appropriate to exclude bonds issued by financial entities.

524. The revised bond yield approach criteria are outlined in Table 13.

Table 13 Bonds in Draft Decision Sample with Country of Risk other than Australia

Criteria	Authority's approach
Remaining term	>= 2 years
Amount at issuance	N/A
Denominated currency	AUD, USD, EUR and GBP
Industry of issuers	Non-financial corporates only
Country of Risk	Australia
Maturity Type	Bullet, Callable and Putable
Exclude	Perpetual, inflation linked, called instruments
Consolidate	Duplicate issues

Source Bloomberg and ERA Analysis

525. The country of risk criteria ensures that yields and credit spreads estimated on the bonds issued are reflective of risks primarily linked to economic and financial market conditions in Australia. Perpetual, inflation linked and called instruments are excluded. This is because these instruments appear infrequently in sampling and require additional complexity in calculating yields that are comparable to those of the other instruments. The additional benefit of including such instruments does not justify the additional complexity of including them. Duplicate issues such as those that are reported by Bloomberg as both privately placed and publically issued are excluded to avoid double counting their yields in the sample.

526. The sample of bonds as at 2 April 2015 includes 92 instruments which are outlined in Table 45 in Appendix 4E. These bonds are used for the purpose of developing the indicative DRP estimate.

[294] The Authority notes that the RBA estimates exclude financial sector bonds.

Techniques to estimate the debt risk premium

527. The Authority in the Draft Decision investigated methods for the purpose of estimating the cost of debt at tenors beyond 5 years.

528. The Authority notes that there are different curve fitting techniques that could be used for this purpose. However, the following three techniques are widely used:

- the Gaussian Kernel;
- the Nelson-Siegel methodology; and
- the Nelson-Siegel-Svennson methodology.

529. Each of these techniques is discussed in turn below.

Gaussian Kernel

530. This methodology was discussed in detail above under the discussion of the RBA's approach.

531. For the Authority's Gaussian Kernel estimates, bond issue amounts expressed in foreign currencies are converted to Australian dollar amounts before being applied as weights in the Gaussian Kernel estimates.[295] Consequently, where a bond is issued in a foreign currency the weighting in the Gaussian Kernel estimates uses the principal amount converted into an Australian dollar amount. The currency conversion uses the closing exchange rate on the date of the bond's issue.

The Nelson-Siegel methodology

532. The Nelson-Siegel methodology assumes that the term structure of the yield curve has the parametric form shown in (25):

$$y_t(\tau) = \beta_{0t} + \beta_{1t}\frac{1-e^{-\lambda\tau}}{\lambda\tau} + \beta_{2t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right) \qquad (25)$$

Where

$\hat{y}(\tau)$ is the credit spread (debt risk premium) at time t for maturity τ ; and

$\beta_{0t}, \beta_{1t}, \beta_{2t}, \lambda$ are the parameters of the model to be estimated from the data.

533. The Nelson-Siegel methodology uses observed data from the bond market to estimate the parameters $\beta_{0t}, \beta_{1t}, \beta_{2t}, \lambda$ by using the observed yields and maturities for bonds. With the estimated parameters $\beta_{0t}, \beta_{1t}, \beta_{2t}, \lambda$, a yield curve is produced by substituting these estimates into the above equation and plotting the resulting estimated yield $\hat{y}(\tau)$ by varying the maturity τ . $\hat{y}(\tau)$ has the interpretation of being the *estimated* yield for a benchmark bond with a maturity of τ for a given credit rating.

[295] ATCO Gas Australia, *Response to the Authority's Draft Decision on required amendments to the Access Arrangement for the Mid-West and South-West Gas Distribution System*, 27 November 2014, Appendix 9.2, p. 72.

The Nelson-Siegel-Svennson methodology

534. The parametric from of the Nelson-Siegel-Svennson curve used by the Authority is that specified in Svennson's 1994 paper.[296] The notation for this parametric form is shown in equation (26).

$$\hat{y}_t(\tau) = \beta_{0t} + \beta_{1t}\frac{1-e^{-\tau/\lambda_1}}{\tau/\lambda_1} + \beta_{2t}\left[\frac{1-e^{-\tau/\lambda_1}}{\tau/\lambda_1} - e^{-\tau/\lambda_1}\right] + \beta_{3t}\left[\frac{1-e^{-\tau/\lambda_2}}{\tau/\lambda_2} - e^{-\tau/\lambda_2}\right] \quad (26)$$

Where

$y_t(\tau)$ is the credit spread (debt risk premium) at time t for maturity τ ; and

$\beta_{0t}, \beta_{1t}, \beta_{2t}, \beta_{3t}, \lambda_{1,} \lambda_2$ are the parameters of the model to be estimated from the data.

535. The Nelson-Siegel-Svennson methodology is estimated in the same way as the Nelson-Siegel method, except uses a different parametric form.

Using the Authority's revised bond yield approach to estimate the regulated debt risk premium

536. On the basis of the above considerations, the Authority will use its revised bond yield approach for the purpose of estimating the regulated DRP.

537. To estimate the regulated DRP, the Authority:

- extends the benchmark sample under the bond yield approach to: (i) include Australian corporate bonds denominated in domestic currency (**AUD**) and foreign currencies including USD; Euros; and British pounds; and (ii) exclude bonds issued by financial sectors including banks, duplicates, inflation linked, called and perpetual instruments;
- converts the yields into hedged Australian Dollar equivalent yields inclusive of Australian Swap rates;
- averages AUD equivalent bond yields across the averaging period for each bond (for example, where a 20 trading day averaging period applies, each bond will have a single 20 day average yield calculated for it);
- estimates yield curves on this data – applying the Gaussian Kernel, Nelson-Siegel and Nelson-Siegel-Svennson techniques;
- uses the simple average of these 3 yield curve's 10 year cost of debt estimate to arrive at the market estimate of the 10 year cost of debt;[297]
- estimates the regulated debt risk premium for the purposes of estimating the regulated cost of debt.

296 L. Svennson, *Estimating and Interpreting Forward Interest Rates: Sweden 1992-1994*, Institute for International Economic Studies, University of Stockholm, Seminar Paper No 579, p. 6.

297 The Authority intends to adopt the average, because there is no strong evidence to suggest that one approach outperforms the others. It is likely that the average will show less variability under a range of prevailing conditions.

538. The following sections summarise these steps in more detail.

Step 1: Determining the benchmark sample

539. The criteria set out in the Rate of Return Guidelines to determine the benchmark sample in the Authority's bond yield approach have been revised. The following characteristics will be applied to select corporate bonds to be included in the benchmark sample:[298]

- credit rating of each bond must match that of the benchmark efficient entity, as rated by Standard & Poors;
- time to maturity of 2 years or longer;
- bonds issued where the country of risk is Australia (except by the financial sector[299]) and denominated in AUD; USD; Euros; and GBP;[300]
- inclusion of both fixed bonds[301] and floating bonds;[302]
- inclusion of both bullet and callable/ puttable redemptions;[303]
- at least 50 per cent of observations for the averaging period is required (that is, 20 yield observations over the required averaging period of 40 trading days are required);[304] and
- are not called, perpetual, a duplicate or inflation linked.

540. The inclusion of the last criteria in paragraph 539 above ensures the exclusion of duplicates, called, perpetual and inflation linked instruments. Employing these criteria in the Bloomberg search function ensures a consistent sample with that employed by the Authority.

541. The sample of bonds as at 2 April 2015 – used for the 2015 estimate – included the 92 international instruments which are outlined in Appendix 4E.

[298] Economic Regulation Authority, *Discussion Paper – Measuring the Debt Risk Premium: A Bond Yield Approach*, December 2010, p. 11.

[299] As classified by Bloomberg Industry Classification System level 1.

[300] Country of risk is based on Bloomberg's methodology using four factors listed in order of importance; management location, country of primary listing, country of revenue and reporting currency of issuer. This criteria allows for the largest sample of bonds that reflect an Australian risk premium.

[301] This is a long term bond that pays a fixed rate of interest (a coupon rate) over its life.

[302] This is a bond whose interest payment fluctuates in step with the market interest rates, or some other external measure. Price of floating rate bonds remains relatively stable because neither a capital gain nor capital loss occurs as market interest rates go up or down. Technically, the coupons are linked to the bank bill swap rate (it could also be linked to another index, such as LIBOR), but this is highly correlated with the RBA's cash rate. As such, as interest rates rise, the bondholders in floaters will be compensated with a higher coupon rate.

[303] A callable (putable) bond includes a provision in a bond contract that give the issuer (the bondholder) the right to redeem the bonds under specified terms prior to the normal maturity date. This is in contrast to a standard bond that is not able to be redeemed prior to maturity. A callable (putable) bond therefore has a higher (lower) yield relative to a standard bond, since there is a possibility that the bond will be redeemed by the issuer (bondholder) if market interest rates fall (rise).

[304] The Authority notes that there is a tendency for fewer bonds to be available on the long end of the yield curve. If circumstances arise where this criteria results in a paucity of bonds such that curve fitting is impractical the Authority may exercise judgement to determine whether exclusion of bonds based on this criteria is appropriate.

Step 2: Conversion of yields into AUD equivalents

542. Under the finalised approach for conversion of yields into Australian dollar equivalents only hedged Australian dollar equivalents yields (as opposed to spreads) are reported. The spread to an Australian dollar swap is calculated as a single estimate based on the observed cost of debt on the entire sample of bonds, as opposed to downloading individual swap spreads.

543. The Authority's finalised approach for conversion into Australian dollar equivalents does not require estimates of a conversion factor as it utilises Bloomberg Swap Manager facilities directly. The Authority believes this approach is transparent and replicable - anyone with access to a Bloomberg terminal can enable the functionality will get the same hedged Australian dollar equivalent yield for any given bond, provided they use the same date, currency, payment frequency and deal type. Further details of the approach are outlined in Appendix 4D.

Step 3: Averaging yields over the averaging period

544. Under the finalised approach for conversion of yields into Australian dollar equivalents only hedged Australian dollar equivalent yields (as opposed to spreads) are reported. The averaging period (in the *indicative example* used for this Draft Decision being 20 days) results in 20 hedged Australian dollar equivalent yields for each bond. The days are based on Australian eastern states trading days and are counted back from and include the determination date for the DRP calculation.

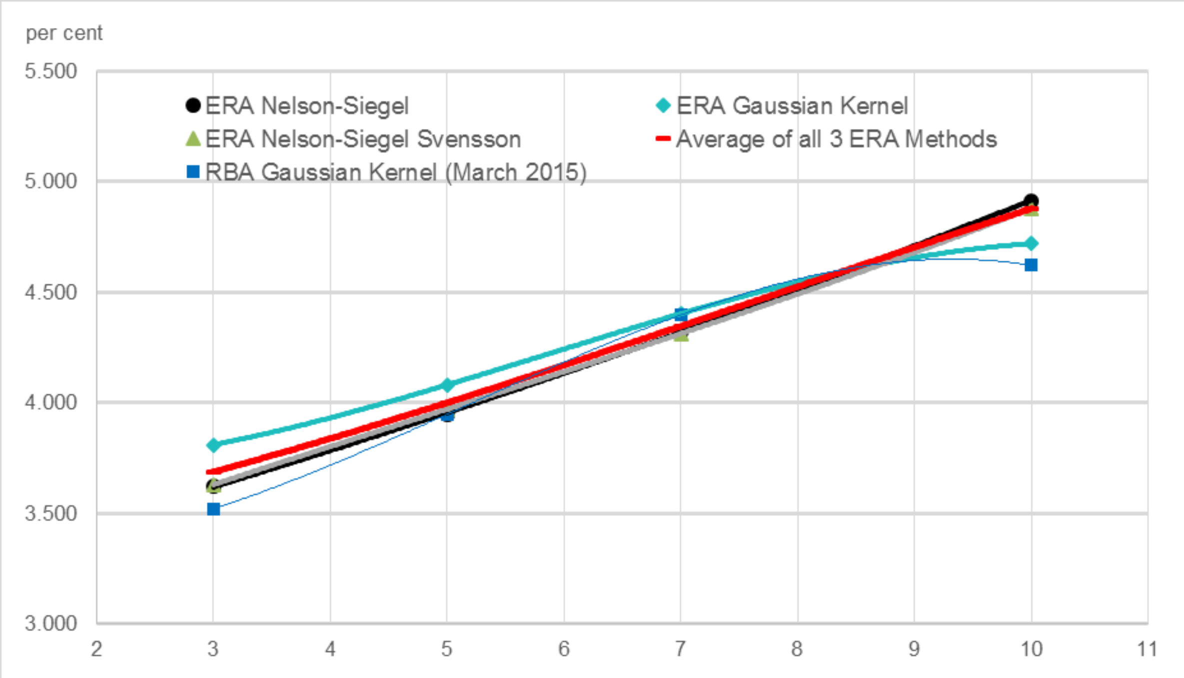
545. The observations on these days are then averaged to create one 20 day average observation for each bond. The spread to an Australian dollar swap is calculated as a single estimate based on the observed cost of debt estimated using all three techniques on the entire sample of bonds.[305]

Step 4: Apply curve fitting techniques

546. The results of the three curve fitting techniques applied to the sample of bonds listed in Appendix 4E are plotted in Figure 9.

[305] As opposed to downloading individual swap spreads.

Figure 9 Estimated Effective Annual Spot Yield Curves for the Cost of Debt for the Averaging Period up to 2 April 2015



Source: Bloomberg, Reserve Bank of Australia and Authority Analysis

547. The parameters and constraints for the fitted curves are reproduced in Table 14 and Table 15.

Table 14 Nelson-Siegel-Curve Fitted Parameters and Constraints

Parameter	Value	Constraints
β_{0t}	10.43797	> 0
β_{1t}	-7.13218	
β_{2t}	-6.70704	
$\beta_{0t} + \beta_{1t}$	3.30579	> 0
λ_1	0.15734	> 0

Source: Authority Analysis

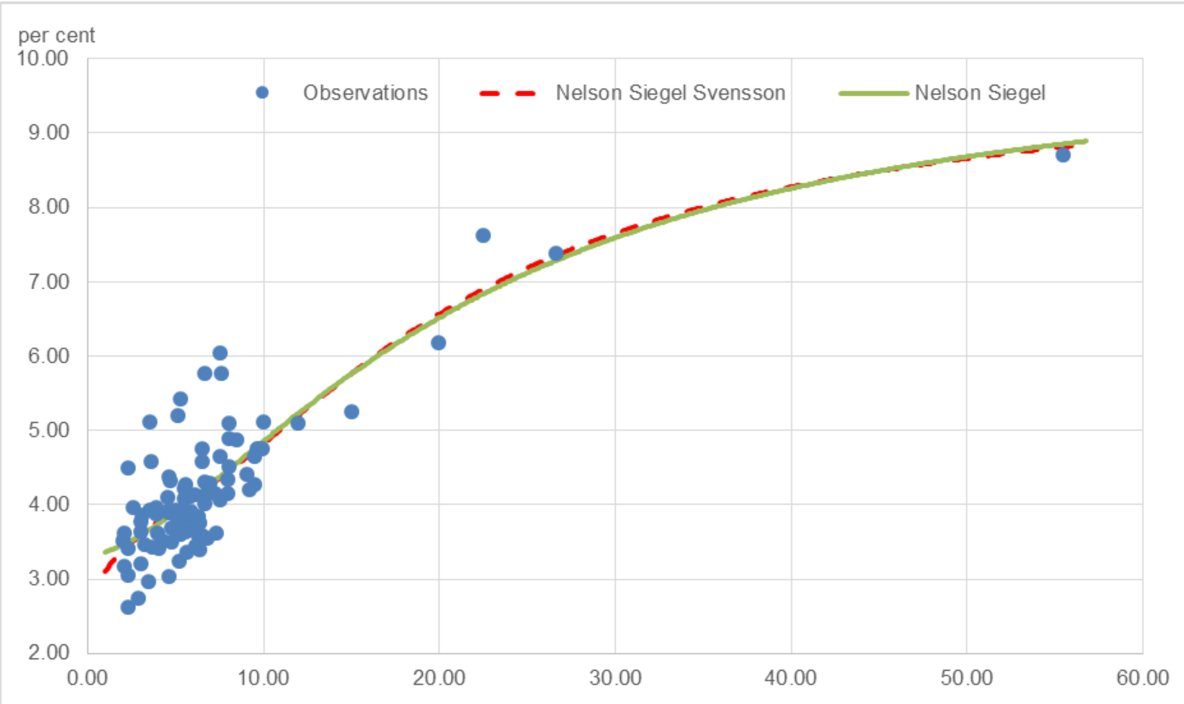
Table 15 Nelson-Siegel-Svennson Curve Fitted Parameters and Constraints

Parameter	Value	Constraints	
β_{0t}	10.20747	0 =<	=< 15
β_{1t}	-7.53168	-15 =<	=< 30
β_{2t}	2.94275	-30 =<	=< 30
β_{3t}	-14.29823	-30 =<	=< 30
λ_1	2.50000	0 =<	=< 2.5
λ_2	4.61199	2.5 =<	=< 5.5

Source: Authority Analysis

548. A graphical representation of the curves and the data points they were fitted on is shown in Figure 10.

Figure 10 Fitted Nelson-Siegel and Nelson-Siegel-Svennson, Curves



Source: Bloomberg and Authority Analysis

549. The curve in Figure 9 representing the average of all three estimates employs a different Authority 10 year Gaussian Kernel estimate to that depicted on the Authority Gaussian Kernel estimate curve. The 10 year Gaussian Kernel estimate employed in the average of all three methods has been calculated setting the target tenor such that the *effective tenor* equals 10 years. This changes the 10 year Gaussian Kernel estimate from 4.720 to 4.841 per cent; an increase of 16.1 basis points. The specific yields at each tenor for the various methods are shown in Table 16.

Table 16 Estimated effective annual spot yields at each tenor for the cost of debt as at 2 April 2015

Years	3	5	7	10
RBA Gaussian Kernel (March 2015)	3.520	3.948	4.397	4.622
Authority Gaussian Kernel	3.811	4.082	4.404	4.720
Authority Gaussian Kernel with 10 Year Weighted Tenor Correction				4.841
Authority Nelson-Siegel	3.622	3.949	4.325	4.915
Authority Nelson-Siegel Svennson	3.630	3.971	4.313	4.881
Average of all 3 Authority Methods	3.688	4.001	4.347	4.879

Source: Bloomberg, Reserve Bank of Australia and Authority Analysis

Step 5: Estimate the regulatory debt risk premium

550. For the purposes of calculating the 10 year DRP for the calendar year 2015, which is used as the *indicative* cost of debt for calendar 2016 in this Draft Decision, the Authority will use the 10 year cost of debt estimate of 4.879 per cent based on the average of all three methods, estimated as at 2 April 2015.

551. The 20 day average of the 10 year Australian dollar swap rate as at 2 April 2015 expressed as an annual effective yield was 2.838 per cent.[306]

552. Subtracting the 10 year swap rate of 2.838 per cent from the 10 year cost of debt gives a spread to swap of 2.041 per cent. The Authority will therefore apply a DRP of 2.041 per cent as the spot estimate for the 2016 year for the purposes of the Draft Decision.

553. The foregoing method will be used to annually update the forward looking DRP, consistent with the ‘automatic formula’ requirement of NGR 87(12). The automatic formula is set out at Appendix 4G. The Authority notes that DBP has expressed a preference for estimation using the R package.[307] However, the Authority has elected to use Excel for transparency; for example, it is amenable to the write up in Appendix 4G. The Authority therefore requires estimation in Excel.

306 The 20 day average coupon for ‘ADSWAP10 Curncy’ was 2.818 per cent which is paid semi-annually.

307 DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12, p. 22.

Method of applying weights

554. The trailing average estimate of the DRP weights the past 10 years of estimates of the annual DRP, consistent with the average term of debt issued by the benchmark efficient entity and its staggered debt portfolio.[308]

555. The resulting 10 year trailing average is proposed to be updated annually, adding in the most recent estimate of the DRP, according to its weight, and dropping the estimate from 10 years ago. This replicates the cost of debt for the benchmark efficient entity under a strategy whereby it rolls over 10 per cent of its debt each year.

556. The weights for a simple hybrid trailing average DRP estimate would be 10 per cent for each year's estimated of the DRP over the most recent relevant 10 years.

557. The benchmark efficient entity could then replicate a simple 10 year trailing average by issuing one tenth of its debt each year. While a simplification of likely practice in reality, this would closely proxy the cost of debt under the observed financing strategies of benchmark efficient entities.

558. DBP however proposes to apply capex weights, albeit above a certain threshold.[309] In its subsequent submission on the Authority's 2015 return on debt Discussion Paper,[310] DBP stated:[311]

> DBP considers it necessary to discuss aspects of the model like the cut-off points with the ERA prior to implementation. The Discussion Paper could be considered as part of this discussion, and if the ERA would prefer no cut-off, and for there to be a forward and backward looking component to the model, then this would actually be closer to DBP's original idea for the weighting mechanism than its own proposal, and would thus be supported by DBP.

559. As a result, the Authority considered whether to overlay capital expenditure weights on the simple trailing average. The Authority's consideration of this additional weighting component is discussed in the section on 'Capex Weights, at paragraph 565 below.

The simple equally weighted trailing average

560. A first step in developing weights is to establish the formula for the equally weighted trailing average. This develops the weights to each of the DRP annual estimates for the nine past regulatory years, plus the 'current' estimate, that would contribute to the hybrid trailing average DRP estimate for each current regulatory year.

561. The following equation in (27) specifies the formula for estimating the simple equally weighted 10 year trailing average of the DRP to apply in any regulatory year:

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[308] Analysis in the Rate of Return Guidelines supported a term at issuance for the benchmark efficient entity of around 10 years. (Economic Regulation Authority, *Appendices to the Explanatory Statement for the Rate of Return Guidelines: Meeting the Requirements of the National Gas Rules*, December 2013, p. 39).

[309] DBP, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12*, p. 40.

[310] Economic Regulation Authority, *Estimating the return on debt: Discussion paper*, 4 March 2015.

[311] DBP, *Estimating the Return on Debt: Response to ERA Discussion Paper of 4 March 2015*, 25 March 2015, p. 10.

$$TA\ DRP_0 = \frac{\sum_{t=0}^{-9} DRP_t}{10} \tag{27}$$

Where

$TA\ DRP_0$ is the equally weighted trailing average of the DRP to apply in the following year as the annual update of the estimate used in the current year; and

DRP_t is the DRP estimated for each of the 10 regulatory years t = *0, -1, -2…. , -9*.

562. All years are in the same year convention as year *0*. For example, if year *0* is the next regulatory year 2016 for which the $TA\ DRP_0$ is being calculated, t = *-9* is the calendar year 2007 because 2016 is a calendar year in this Access Arrangement. Using the same logic if year *0* is regulatory year 2014-15, t = *-9* is the financial year 2005/2006.

563. So for example, in (28) the DRP trailing average estimate for the calendar 2016 regulatory year will be:

$$\begin{aligned} TA\ DRP_{2016} = {} & 0.1 \times DRP_{2016} + 0.1 \times DRP_{2015} + 0.1 \times DRP_{2014} \\ & + 0.1 \times DRP_{2013} + 0.1 \times DRP_{2012} + 0.1 \times DRP_{2011} \\ & + 0.1 \times DRP_{2010} + 0.1 \times DRP_{2009} + 0.1 \times DRP_{2008} \\ & + 0.1 \times DRP_{2007} \end{aligned} \tag{28}$$

564. In terms of the notation used by the Australian Energy Regulator (but in the Authority's case applying just to the DRP trailing average), the foregoing TA DRP for the 2016 calendar year may be written as follows in (29):[312]

$$\begin{aligned} {}_{2015}kd_{2016} = {} & 0.1 \times {}_{2006}R_{2007} + 0.1 \times {}_{2007}R_{2008} + 0.1 \times {}_{2008}R_{2009} \\ & + 0.1 \times {}_{2009}R_{2010} + 0.1 \times {}_{2010}R_{2011} + 0.1 \times {}_{2011}R_{2012} \\ & + 0.1 \times {}_{2012}R_{2013} + 0.1 \times {}_{2013}R_{2014} + 0.1 \times {}_{2014}R_{2015} \\ & + 0.1 \times {}_{2015}R_{2016} \end{aligned} \tag{29}$$

Capex weights

565. Weighting the trailing average to account for new capex can ensure that the marginal cost of investment for new capex reflects the Authority's most recent forward looking estimate of the prevailing DRP. This efficiency consideration is a key concern of the Authority, given the requirements of the NGL and NGR.

312 Australian Energy Regulator, *Draft Decision: Jemena Gas Networks (NSW) 2015-20*, November 2014, Attachment 3, p. 3-288.

566. However, the approach adds complexity. That said, the Authority notes that QTC and DBP have demonstrated how a spreadsheet calculation relating to weights could be implemented for a Post Tax Revenue Model (**PTRM**) capex weights approach.[313]

567. The Discussion Paper released by the Authority earlier in 2015 incorporated PTRM capex weights as part of the 'alternative' hybrid trailing average option set out by the Authority.[314] Submissions on the Discussion Paper provided mixed support for the mooted capex weights approach:

- ATCO made no comment on the capex weights;[315]
- GGT in its submission on the Discussion Paper stated that 'in advance of a draft decision on the GGP Access Arrangement revisions proposal, GGT maintains the position set out in the Supporting Information, that it is appropriate to use a simple trailing average to estimate the return on debt';[316]
- DBP on the other hand supported the capex weights approach, with caveats.[317]

568. The Authority considered a potential approach for including a PTRM capex weights overlay for the ATCO Final Decision (see Appendix 4F).

569. In its evaluation of whether to accept the simple hybrid trailing average approach, the Authority has determined that there are costs and benefits associated with the capex weighting overlay.

570. First, the Authority notes the potential benefits of capex weights in aligning the marginal cost of investment for the benchmark efficient entity with the forward looking estimate of the prevailing rate. However, in deciding to adopt the trailing average approach for this Draft Decision, the Authority has recognised the difficulty of distinguishing between the on the day and the trailing average approaches with regard to prediction performance.[318] While there is some evidence for the on the day approach in the available data, it is very limited. This outcome is relevant; if the annually updated trailing average performs as well as the annually updated 'on the day' approach in predicting the forward looking DRP, then there would be no gain in adopting capex weights.

571. Second, the Authority notes the potential for actual capex undertaken by the service provider to diverge from forecast capex. This might be in response to changing financial conditions, and therefore may be an efficient response. For example, the DRP might rise sharply for a period, causing the service provider to delay a capital expenditure program.

313 DBP, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12*, 31 December 2015, Appendix J.

314 Economic Regulation Authority, *Estimating the return on debt: Discussion paper*, 4 March 2015.

315 ATCO, Re: Estimating the return on debt: ATCO Gas Australia's response to the Authority's Discussion Paper, 25 March 2015, Attachment.

316 Goldfields Gas Transmission, *GGT submission on Authority return on debt discussion paper*, 25 March 2015, p. 1.

317 Dampier Bunbury Pipeline, *Estimating the Return on Debt: Response to Authority Discussion Paper of 4 March 2015*, 25 March 2015, p. 10.

318 As noted above at paragraphs 441 - 442 this recognition has led the Authority to accept the hybrid trailing average approach over the on the day approach, both annually updated.

572. However, the capex weights method would lock in a sharply higher return on debt into the trailing average for the remainder of the regulatory period, which did not reflect actual costs.

573. PTRM weightings also could feasibly add incentives to game the capex estimates and their timing under some circumstances. For example:

- if the DRP was expected to rise over the initial part of the access arrangement period, then there would be an incentive to shift scheduled capex to that period in the forecasts, all other things equal;
- where the expected increase in the DRP did not eventuate as expected, but instead was delayed, it could pay the service provider to defer some of the scheduled initial period capex to the end of the access arrangement, knowing that the weighting would be 'trued up' for actual capital expenditure at the next access arrangement reset through the capex weights adjustment (see Appendix 4F).

574. Third, the Authority notes the significant complexity involved in developing a capex weights overlay within the PTRM. It creates the need for a complex series of adjustments at each access arrangement revision, which increases the potential for error (see Appendix 4F).

575. In conclusion, the Authority has carefully considered the PTRM weights approach, given its potential ability to improve the efficiency of the incentives for new capex. On balance, however, the Authority is not convinced that limited evidence for the benefits of the capex weighted approach outweigh the clear regulatory costs in terms of the additional complexity.

576. Therefore, the Authority has determined not to include capex weights in the DRP trailing average. The Authority does not accept DBP's capex weighting approach for the above reasons.

The need for a transition

577. A transition would gradually phase in the hybrid trailing average approach. A transition consistent with the 'QTC method' would, for the DRP component:

- provide for 100 per cent weight to the prevailing estimate of the DRP in year 1;
- in year 2, provide for 90 per cent weight to the prevailing estimate of the DRP in year 1, and 10 per cent weight to the annually updated (prevailing) estimate of the DRP in year 2;
- in year 3, provide for 80 per cent weight to the prevailing estimate of the DRP in year 1, and 10 per cent weight to each of the annually updated (prevailing) estimates of the DRP in years 2 and 3 respectively;
- and so on;
- until at year 10, the trailing average is estimated with equal 10 per cent weights for each of the 10 annual updates of the DRP;
- at year 11, the year 1 estimate of the DRP drops off, and is replaced by the year 11 annual update;
- at year 12, the year 2 estimate of the DRP drops off, and is replaced by the year 12 annual update;
- and so on ad infinitum.

578. DBP did propose a transition as part of its trailing average approach, for both the DRP and the risk free rate components of its full trailing average proposal.

579. In its 2015 return on debt Discussion Paper, the Authority proposed a 10 year transition period phasing in the full trailing average would:[319]

- enhance confidence in the predictability of the regulatory regime;
- facilitate data collection for implementing the trailing average, as historic data would not be required;
- remove the potential for gaming of the regulatory regime by service providers (with the specified trailing average approach established through a fixed principle and to apply for 10 years).

580. The Authority also noted that a transition could allow firms time to adjust arrangements from the previous regulatory regime (on the day), where firms would have undertaken hedging arrangements to align the cost of debt closely to the regulated rate, consistent with the approach adopted by the AER:[320]

> As discussed in chapter seven, we consider that an efficient financing practice of the benchmark efficient entity would be to minimise the expected present value of its financing costs over the life of its assets subject to managing the associated financial risks (and subject to the regulatory regime). On this basis we have concluded that the benchmark efficient entity would have likely entered into hedging contracts to manage its interest rate risk in the current regulatory control period (that is, under the 'on the day' approach). Further, we consider that holding a (fixed rate) debt portfolio with staggered maturity dates to align its return on debt with the regulatory allowance is likely to be an efficient financing practice of the benchmark efficient entity under the trailing average portfolio approach. To achieve this the benchmark efficient entity would need to unwind its existing hedging contracts and issue new (fixed rate) debt over a transition period to gradually accumulate a portfolio that matches the trailing average regulatory return on debt allowance. Consistent with this, we consider that post transition the benchmark efficient entity is not likely to engage in an active debt management strategy using swaps.

581. ATCO's consultant CEG submitted that adopting a transition would 'fail to compensate the benchmark efficient entity for its estimated future costs consistent with its trailing average debt risk premium (DRP) costs incurred over the last 10 years'.[321]

582. CEG further argued that:[322,323]

- if the benchmark efficient debt management strategy in the past was the hybrid (as accepted by the AER); and
- if the Authority is proposing to adopt the hybrid as the benchmark efficient strategy in the future; then
- there is no need to transition to the hybrid – it should be implemented immediately because it simply reflects benchmark efficient costs.

319 Economic Regulation Authority, *Estimating the return on debt: Discussion paper*, 4 March 2015.

320 Australian Energy Regulator, *Explanatory Statement Rate of Return Guideline*, December 2013, p. 141.

321 ATCO Gas Australia, Re: Estimating the return on debt: ATCO Gas Australia's response to the Authority's Discussion Paper, 25 March 2015, Attachment, p. 11.

322 ATCO Gas Australia, Re: Estimating the return on debt: ATCO Gas Australia's response to the Authority's Discussion Paper, 25 March 2015, Attachment, p. 12.

323 DBP make similar points (Dampier Bunbury Pipeline, *Response to Authority Discussion Paper of 4 March 2015*, 25 March 2015, pp. 16-18).

583. The Authority recognises that a key reason for a transition would be to allow firms time to unwind hedging positions in the event that, like the AER, a full trailing average was being adopted. That is, the transition would be important for the risk free rate component of the return on debt. However, with the hybrid trailing average, there is no need to transition for the risk free rate, as the same hedging strategy could continue.

584. With regard to the DRP, the concern would be if the previous on the day arrangement had resulted in the regulated firm receiving a regulated return on debt that significantly exceeded the actual DRP financing costs of the firm. Network users could reasonably expect to have a period of 'unders' to compensate for such a period of 'overs' – as this is the nature of the on the day approach. The concern in moving to a trailing average approach would be that users would be denied such an opportunity to recover over payments. Further, reintroducing historic estimates might have the effect of consumers overpaying twice (for example, if the spike in the DRP that occurred in late 2008 during the GFC was incorporated in the trailing average), particularly as it is possible that an efficient debt financing strategy would have been forced to raise debt on the market at that time.

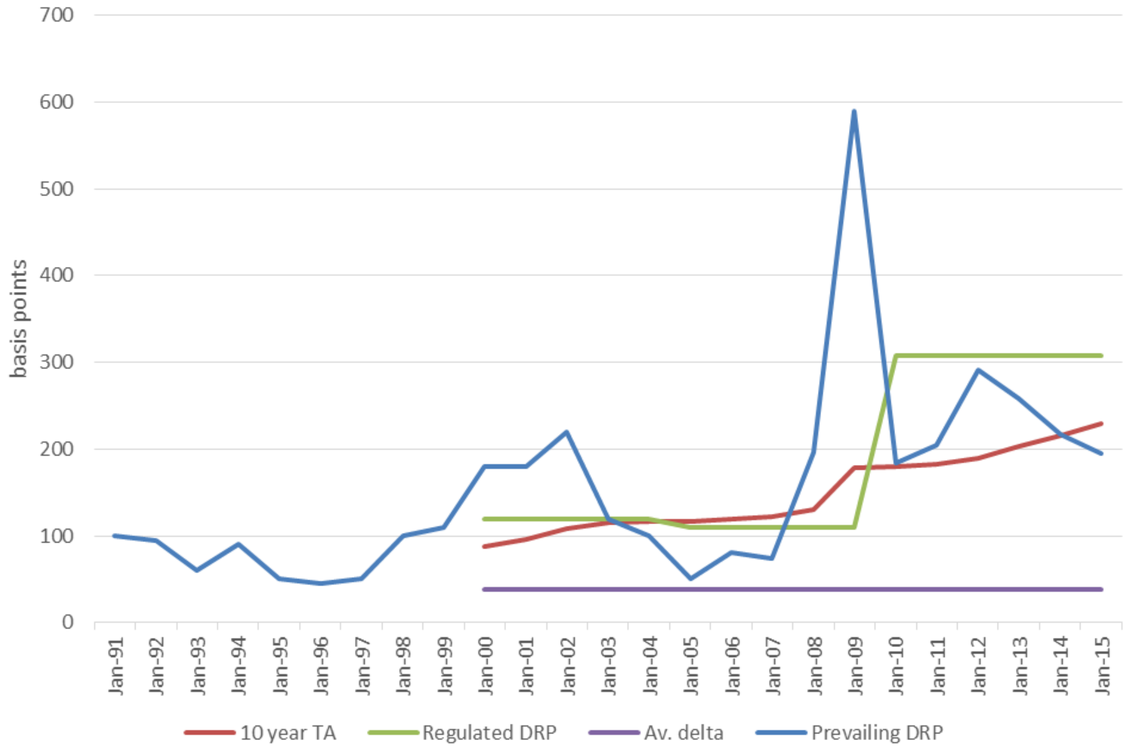
585. To examine this issue, the Authority constructed a 10 year trailing average series for each of the DBP's access arrangement periods, and compared the resulting 10 year trailing average DRP with the actual regulated DRP (Figure 11).[324] The benchmark efficient entity's assumed actual DRP costs is based on the RBA's credit spread on 10 year BBB bonds to the 10 year spread to swap back to 2005, and then a range of *indicative* estimates for the period prior to that, back to 1991.[325] This is compared to the regulated DRP that was granted – on the day – for each of the two access arrangements AA1 and AA2.[326]

[324] This assumes that the benchmark efficient entity would have hedged the risk free rate component.

[325] The Authority notes that Chairmont Consulting have concluded that the 'history of Australian BBB bond data is inadequate to measure over and under compensation over the life of energy assets' (see Chairmont Consulting, *Financing Practices Under Regulation: Past and Transitional*, 13 October 2015, p. 12). However, the Authority considers that its estimates presented here offer some indicative information, which is better than none.

[326] The averaging period is assumed to be the month of April in each year, as this is closest to the averaging period used for estimating the return on debt for each of the access arrangement periods.

Figure 11 Comparison of BBB trailing average DRP and the GGP regulated rate



Source *Reserve Bank of Australia, Aggregate measures of Australian corporate bond spreads and yields: non-financial bonds, September 2015 (accessed 3 November 2015); Macquarie Investment Management, The changed nature of credit investment, December 2012, p. 15; Authority analysis.*

586. The results, while only indicative, suggest that there was possibly a small over-payment up to the start of AA3, of around 38 basis points per annum on average for the whole period from 2000 through 2014. However, the Authority does not consider that this amount is significant, particularly given the indicative nature of the estimates. Furthermore, other factors, such as the spread of the BBSW to the risk free rate and hedging costs, have not been taken into account. Overall, the Authority concludes that this (limited) evidence does not support the occurrence of a significant under or over payment on the DRP or the return on debt.

587. For these reasons, the Authority is prepared to accept that it is more appropriate to move directly to the hybrid trailing average approach, without any phasing in transition.

588. In doing so, the Authority recognises that there is no change required in hedging arrangements between the previous approach and the hybrid trailing average approach, as both involve a single estimate of the risk free rate, set once at the start of the regulatory period. For the DRP, however, it is likely that the benchmark efficient firm would have adopted a portfolio of debt with a ten year average term, and that the firm would have been reasonably recompensed over the past three access arrangements, without being excessively compensated.

Estimates of the DRP prior to the current on the day estimate

589. The Authority has determined to adopt the simple hybrid trailing average of the DRP. The calendar year 2015 trailing average, that is used as an *indicative* estimate for

calendar year 2016 in this Draft Decision, requires annual estimates of the DRP for past years – back to 2005 – to combine with the Authority's forward looking annual estimates of the DRP (the first of which – as at 2 April 2015 – is set out above).[327]

590. The Authority endeavoured to obtain historic bond data to estimate the historic annual DRP estimates through its revised bond yield approach. However, while the Authority was able to access historic BBB credit band bond yields from Bloomberg back to 2005, the resulting bonds did not provide a large enough sample to estimate the return on debt in all years.[328]

591. The Authority therefore determined to adopt a third party source for the DRP estimates in past years, for incorporation in the trailing average to be used in this Draft Decision. A number of potential options are available which could provide historic estimates of the DRP:

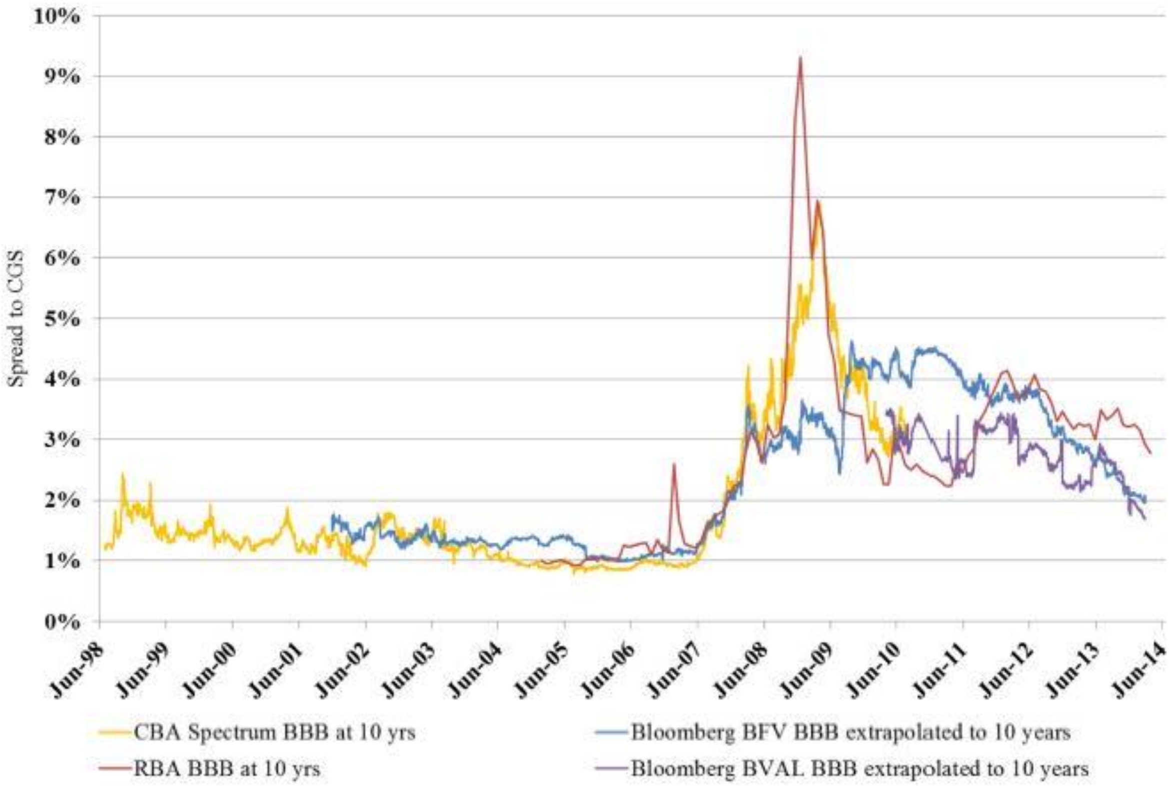
- the RBA's credit spread estimates;
- Bloomberg's FVC estimates; and
- Bloomberg's BVAL estimates.

592. The Authority notes that these sources give different estimates for the period in question (Figure 12).

[327] The calendar year 2015 *indicative* estimate set out here will be updated for calendar year 2016 for the Final Decision, based on DBP's nominated averaging period in early 2016. The overall method for determining that revised calendar year 2016 estimate will follow that set out here.

[328] The RBA have been able to acquire larger sample sizes by combining UBS historic bond data with the Bloomberg historic bond data.

Figure 12 Estimates from alternative historical DRP data series (spread to CGS)



Source: Competition Economists Group, *Memorandum to ActewAGL*, 24 May 2014, p. 5.

593. The Bloomberg BVAL data does not go back past 2010 so does not provide a consistent series over the entire period. The Authority considers that it should overlook this series for this reason.

594. It is clear from the relative performance of the two remaining series – the RBA and Bloomberg BFC series – that there is considerable variation in the estimates post June 2008, leading to uncertainty as to the best data series to adopt. An option to overcome this issue could be to average the two series. However, given the Authority's intention to use an annual average of the available data for the whole year of each of the past nine years (see below), and also to adopt a simple weighting scheme for each of those nine years (see below), there are limited differences between adopting one or the other series, or an average of the two.[329]

595. The Bloomberg BFC also does not include foreign bonds, which raises a clear point of departure from consistency with the Authority's preferred approach. The RBA data does not suffer from this omission.

[329] This may be confirmed by simple inspection of the areas between the RBA series and the FVC series – unders tend to offset overs. CEG confirm this, noting 'that even though the RBA and Bloomberg estimates differ materially through some periods in the last 10 years these differences tend to cancel each other out – with the RBA estimates being higher in some periods and the Bloomberg estimates higher in other periods. The net difference over the period January 2005 to October 2014 is only 6 basis points – with the Bloomberg average being higher' (ATCO Gas Australia, *Response to the Authority's Draft Decision on required amendments to the Access Arrangement for the Mid-West and South-West Gas Distribution System*, 27 November 2014, Appendix 9.2, p. 63).

596. A further advantage of the RBA data is the smaller extrapolation that is generally required (commonly between 1 and 2 years) as opposed to the three or more for the BFC (which only goes to tenors of 7 years in more recent times).

597. The Authority therefore considers that adopting the RBA series is fit for purpose for estimating past DRP returns, particularly given the uncertainties, and that averaging the two series is unlikely to deliver any material improvement to the historic estimates.

598. Over time, the historic RBA estimates will be progressively replaced in the trailing average by the Authority's own forward looking estimates.

Use of the RBA estimates

599. The RBA data provides an available source of historic credit spreads for 10 year non-financial corporate bonds.

600. Issues that arise in using the RBA estimates are:

- the averaging period to apply – whether to align with that adopted for the current 2015 estimate or some other averaging period;
- whether to apply capex weighting to the historic estimates; and
- the extrapolation issue – estimating the DRP to match the 10 year term assumed for this Draft Decision.

601. These issues are discussed in what follows.

Aligning with the averaging period dates

602. DBP's proposed revised access arrangement covers the period 1 January 2016 to 31 December 2020 (the AA4 period).

603. The *indicative* averaging period dates for the Authority's current forward looking return on debt estimate, made prior to the release of this Draft Decision, were the 20 business days from 6 March to 2 April 2015. The resulting 'current' ('t=0') estimate will be included in the trailing average estimate to apply for the 2016 calendar year.

604. An issue arises whether the historic DRP estimates for inclusion in the hybrid trailing average should be based on the same averaging period in each of the historic years, that is for example, aligning with the 6 March to 2 April period. This would require interpolation of the RBA monthly estimates to allow a corresponding annual estimate to be made in each previous year. However, those dates may not relate to business days in past years. It may also result in changing estimates for the historic years in the trailing average, depending on whether the averaging period changes.

605. A better alternative is to average the 12 available months of RBA data, such that the estimated DRP reflects the average DRP in whole of each past year. The Authority prefers the latter approach for the following reasons.

606. First, the Authority in this instance is not trying to develop an estimator for the year ahead. Rather, it is trying to develop an estimate for the past, which can be actual outcomes. That points to use of the whole year average.

607. Second, it is not clear when the benchmark efficient entity raised its capital in the past. For the future, the benchmark efficient entity could align its debt issuance with the averaging periods for issuing new debt. However, in the past, it may have issued

debt at any time of the year. Accordingly, the best estimate of the DRP relating to debt raised at an unknown point in a past year will be the annual average.

608. The Authority therefore intends to adopt the annual average of the DRP estimate from the RBA data. Each annual DRP estimate will be derived as the RBA 10 year BBB spread to swap, extrapolated to 10 years (see below for a summary of the method for extrapolating the RBA data), for the year which ends concurrent with the final year in the trailing average.[330]

Composition of the hybrid trailing average estimates of the DRP

609. The Authority's has determined to adopt the simple equally weighted ten year trailing average for this Draft Decision, which may be recalled has the following automatic formula (refer to paragraph 561):

$$TA\ DRP_0 = \frac{\sum_{t=0}^{-9} DRP_t}{10} \qquad (30)$$

Where

$TA\ DRP_0$ is the equally weighted trailing average of the DRP to apply in the following year as the annual update of the estimate used in the current year; and

DRP_t is the DRP estimated for each of the 10 regulatory years t = *0, -1, -2…. , -9*.

610. For the 2015 calendar year estimate (which is used as the indicative return on debt for calendar year 2016 this Draft Decision), the following estimates are included in the trailing average:

- t=-9: January to December 2006 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-8: January to December 2007 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-7: January to December 2008 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-6: January to December 2009 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-5: January to December 2010 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-4: January to December 2011 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-3: January to December 2012 : simple average of (interpolated daily) RBA DRP estimates for the period;

330 So for example, for the 2015 calendar year, the 9 historic averages to be included in the trailing average estimate would be for the 2014, 2013 and so on back to 2006 calendar years.

- t=-2: January to December 2013 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-1: January to December 2014 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=0: January to December 2015 : weighted average comprising 25% (interpolated daily) RBA DRP estimates for the period January to March 2015 and 75% the Authority's current (t=0) DRP estimate (interpolated daily to the prior RBA 31 March 2015 estimate).

611. The Authority's 2 March 2015 estimate contributes to the t=0 estimate in the 2015 DRP hybrid trailing average estimate, for that period that falls after March 2015 (prior to that date, RBA actual data is available).

612. This estimate is used to estimate the return on debt for the Draft Decision rate of return for calendar years 2016, 2017, 2018, 2019 and 2020.

613. Ultimately, in the Final Decision, to occur in 2016, the 1 January 2016 to 31 December 2016 estimate will be based on the RBA actual data reported for 2015, with estimates for 2016 forward being superseded by the 2016 Final Decision estimate. The Final Decision 2016 estimate will have a similar format to that outlined above for calendar year 2015. That is, it will be a weighted average composite of actual RBA data and the Authority's 'on the day' estimates of the DRP made using the extended bond yield approach.

614. For 2017, the Authority will estimate the t=0 DRP estimate, based on the nominated 40 trading days in the five month window 1 June to 31 October 2016, as per the averaging period requirement. For the 2017 calendar year, the Authority will adopt the following estimators:

- t=-9: January to December 2008 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-8: January to December 2009 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-7: January to December 2010 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-6: January to December 2011 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-5: January to December 2012 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-4: January to December 2013 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-3: January to December 2014 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-2: January to December 2015 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-1: January to December 2016 : weighted average of:
    - the monthly RBA DRP estimates for the period up to the nominated averaging period; and

  - the Authority's 2016 (t=0) DRP estimate (interpolated daily to the prior RBA); with
  - the averaging weights determined by the proportion of the calendar year contributed by each monthly estimate (for example, 3/12 RBA : 9/12 the Authority's 2016 DRP estimate);
- t=0: January to December 2017: 100% the automatic formula (t=0) DRP estimate.

615. For 2018, the Authority will estimate the t=0 DRP estimate, based on the nominated 40 trading days in the five month window 1 June to 31 October 2017, as per the averaging period requirement. For the 2018 calendar year, the Authority will adopt the following estimators:

- t=-9: January to December 2009 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-8: January to December 2010 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-7: January to December 2011 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-6: January to December 2012 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-5: January to December 2013 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-4: January to December 2014 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-3: January to December 2015 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-2: January to December 2016 : weighted average of:
  - the monthly RBA DRP estimates for the period up to the nominated averaging period; and
  - the Authority's 2016 (t=0) DRP estimate (interpolated daily to the prior RBA); with
  - the averaging weights determined by the proportion of the calendar year contributed by each monthly estimate (for example, 3/12 RBA : 9/12 the Authority's 2016 DRP estimate);
- t=-1: January to December 2017 : 100% the automatic formula (t=-1) DRP estimate;
- t=0: January to December 2018 : 100% the automatic formula (t=0) DRP estimate.

616. For 2019, the Authority will estimate the t=0 DRP estimate, based on the nominated 40 trading days in the five month window 1 June to 31 October 2018, as per the averaging period requirement. For the 2019 calendar year, the Authority will adopt the following estimators:

- t=-9: January to December 2010 : simple average of (interpolated daily) RBA DRP estimates for the period;

- t=-8: January to December 2011 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-7: January to December 2012 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-6: January to December 2013 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-5: January to December 2014 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-4: January to December 2015 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-3: January to December 2016 : weighted average of:
    - the monthly RBA DRP estimates for the period up to the nominated averaging period; and
    - the Authority's 2016 (t=0) DRP estimate (interpolated daily to the prior RBA); with
    - the averaging weights determined by the proportion of the calendar year contributed by each monthly estimate (for example, 3/12 RBA : 9/12 the Authority's 2016 DRP estimate);
- t=-2: January to December 2017 : 100% the automatic formula (t=-2) DRP estimate;
- t=-1: January to December 2018 : 100% the automatic formula (t=-1) DRP estimate;
- t=0: January to December 2019 : 100% the automatic formula (t=0) DRP estimate.

617. The last annual update for the AA4 period will occur as part of the 1 January 2020 tariff variation. For 2020, the Authority will estimate the t=0 DRP estimate, based on the nominated 40 trading days in the five month window 1 June to 31 October 2019, as per the averaging period requirement. For the 2020 calendar year, the Authority will adopt the following estimators:

- t=-9: January to December 2011 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-8: January to December 2012 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-7: January to December 2013 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-6: January to December 2014 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-5: January to December 2015 : simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-4: January to December 2016 : weighted average of:
    - the monthly RBA DRP estimates for the period up to the nominated averaging period; and
    - the Authority's 2016 (t=0) DRP estimate (interpolated daily to the prior RBA); with

- the averaging weights determined by the proportion of the calendar year contributed by each monthly estimate (for example, 3/12 RBA : 9/12 the Authority's 2016 DRP estimate);

- t=-3: January to December 2017 : 100% the automatic formula (t=-3) DRP estimate;
- t=-2: January to December 2018 : 100% the automatic formula (t=-2) DRP estimate;
- t=-1: January to December 2019 : 100% the automatic formula (t=-1) DRP estimate;
- t=0: January to December 2020 : 100% the automatic formula (t=0) DRP estimate.

618. A summary of the automatic formulas for the trailing average calculations, and the actual (calendar year 2015) indicative estimate of the DRP for 2016, are set out in Appendix 4G.

Method for estimating the 10 year term DRP from the RBA data

619. The Gaussian Kernel method used by the RBA for estimating the return on debt results in the effective tenor of the DRP estimates varying between years, depending on the sample of bands and their relative weighting in the estimate. In recent times, the actual effective tenor of the estimates has been less than the specified tenor of ten years.

620. The Authority has overcome this problem in its own estimates by targeting the effective Gaussian Kernel estimate to be a true 10 year term (see paragraph 549 above).

621. To be as consistent as possible, the Authority has adjusted the RBA estimates from their effective tenors to be the targeted 10 year tenor. The method follows the simple extension technique laid out by Lally.[331] It utilises the slope of the yield curve between the two observed tenors (say the effective 7 and 10 year tenor spread to swap estimates, or '7e' and '10e' tenors respectively), to linearly extrapolate the spread to swap at an exact 10 year tenor. The formula used by the Authority is analogous to that set out by Lally as follows:[332]

$$RBA(10) = RBA(10e) + Base(10) - Base(10e) + \left[\frac{DRP(10e) - DRP(7e)}{10e - 7e}\right](10 - 10e) \tag{31}$$

Where

$$RBA(10) = Base(10) + DRP(10)$$

$$DRP(10) = RBA(10e) - Base(10e) + \left[\frac{DRP(10e) - DRP(7e)}{10e - 7e}\right](10 - 10e)$$

331 M. Lally, *Implementation Issues for the Cost of Debt*, 20 November 2014, p. 38. The Authority notes that DBP proposed a comparable method (DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12, p. 23).

332 M. Lally, Implementation Issues for the Cost of Debt, 20 November 2014, p. 39.

$$DRP(10) = DRP(10e) + (10-10e)/(10-7e) \times [DRP(10e) - DRP(7e)]$$

622. The Authority also interpolates the monthly RBA estimates to daily estimates. The formula for achieving this step shown in (26):

$$y_t = yield_{start} + \left(\frac{yield_{end} - yield_{start}}{Date_{end} - Date_{start}} \right) x \ (t - Date_{start}) \qquad (32)$$

Where

y_t is the interpolated yield for any given date t ;

$yield_{start}$ is the first available yield in any given month;

$yield_{start}$ is the last available yield in any given month;

$Date_{start}$ is the date when first yield was available;

$Date_{end}$ is the date when the last available yield is available; and

t is the date for which the yield is being interpolated.

623. The Authority notes that DBP has presented evidence on alternative adjustment approaches:[333]

> If one is to consider different estimators, it is worthwhile to consider the relative efficiency of and any bias associated with each estimator. ESQUANT (2015) for the recent UED proposal, has presented evidence on how this might be done and shows that the SAPN method is more precise than the Lally method, but that the Lally method, under certain circumstances, exhibit less bias.

624. However, the Authority considers that the Lally method set out above is easily implemented within its spreadsheet based approach. The Authority notes that under certain circumstances the method exhibits less bias, which is desirable. The Authority also notes that any lack of precision is likely to be diluted, as the Gaussian Kernel approach contributes only one third of its final estimate.

625. The Authority also annualises the RBA resulting annual data, as the RBA estimates may be generally interpreted as semi-annual rates. To do this, RBA basis point estimates are converted to percentage point numbers and then annualised:

Effective annual rate = 100* (1 + yield in basis points/100/200)^2 – 100

The estimate of the DRP for 2016

626. Utilising the RBA monthly data and the Authority's t=0 (2 April 2015) estimates of the DRP delivers the following results for the annual estimates of.

- The *indicative* estimate of the simple trailing average DRP for calendar year 2016 is 2.502 per cent (Appendix 4G, paragraph 1249).

[333] DBP, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Response to ERA Issues Paper Submission 26*, 2 June 2015, p. 14.

627. More detail on the automatic formulas and contributing DRP estimates to these trailing averages are set out in Appendix 4G.

Debt raising and hedging costs

628. In the Guidelines, the Authority provided an allowance for debt raising costs of 0.125 per cent and hedging costs of 0.025 per cent. DBP proposed these costs in its initial proposal.

629. In its March 2015 Discussion Paper, the Authority noted that the debt raising cost estimate of 0.125 per cent was generally accepted.

630. With regard to hedging costs, the Discussion Paper stated:[334]

> The current spread cost of the 10 year swap is around 10 bps, half of which would be incurred by the service provider – therefore the total cost of the two swaps required at the current time could approach 2 by 5 bps, or 10 bps. Two swaps would also be required subsequent to cover the amount of any increase in debt associated with capital expenditure over the course of the regulatory period.
>
> To calculate this amount for inclusion in revenue, it would be simplest to provide a single allowance for swaps in the operating expenditure cash flows. The swaps allowance could be based on the swap spread, as outlined above, multiplied by the closing debt balance in the final year of the forecast regulatory period.

631. In response to the Discussion Paper, ATCO's consultant CEG took issue with these statements. CEG suggests that banks will price interest rate swap contracts based on the prevailing swap bid spread plus execution spread and risk spread costs. CEG considers a hedging allowance of 23 bppa is appropriate, at the upper end of the following range, given that many issues are in foreign currency:[335]

> Based on the evidence surveyed above, swap transaction costs have been estimated to be in the order of 15.5bppa to 23bppa – consistent with the QCA's stated range of 15bppa to 20bppa. The lower/upper end of this range is based on the swap costs estimated by Evans & Peck/UBS and are themselves based on domestic/foreign debt issues.

Debt raising costs

632. The Guidelines considered the estimate of debt raising costs of 0.125 per cent per annum in depth. The Guidelines noted that the debt raising cost estimate covered:[336]

- gross underwriting fee: including management fees, selling fees, arrangement fees and the cost of an underwriter for the debt;
- legal and road show fee: this includes fees for legal documentation and fees involved in creating and marketing a prospectus;
- company credit rating fee: a credit rating is generally required for the issue of a debt raising instruments, a company is charged annually by the credit rating agency for the services of providing a credit rating;
- issue credit rating fee: a separate credit rating is obtained for each debt issue;

334 Economic Regulation Authority, *Estimating the return on debt: Discussion paper*, 4 March 2015, p. 23.

335 ATCO Gas Australia, Re: Estimating the return on debt: ATCO Gas Australia's response to the Authority's Discussion Paper, 25 March 2015, Attachment, p. 9.

336 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, p. 199.

- registry fee: the maintenance of the bond register; and
- paying fee: payment of a coupon and principal to the security holder on behalf of the issuer.

633. DBP initially proposed this estimate, however subsequently submitted a revised value of 20 basis points, based on an estimate provided by UBS, who quote Incenta.[337]

634. The Incenta estimate updates the Allen Consulting Group estimate from 2004, using the same method. Incenta identify three components:[338]

- debt raising transactions costs of 9.9 basis points per annum, informed by a study by PwC with updated data for the period 2008-13;
- an allowance for Standard & Poor's liquidity requirement, of 4.9 basis points per annum; and
- an allowance for Standard & Poor's requirement to finance three months ahead, of 5.0 basis points per annum.

635. First, the Authority considers that its 2013 estimate of 12.5 basis points for debt raising costs is reasonable. The estimate was reported by the Authority in its Guidelines, based on up to date information as at December 2013. The Authority observed that the estimate was consistent with or exceeded those from a range of other studies, including by the ACCC, the Allen Consulting Group in 2004 and PwC in 2011.[339]

636. Second, the Authority does not accept the estimates for liquidity or deferral costs. The Authority's discussions with finance providers suggest the costs associated with these aspects are small, approaching as little as 1 basis point under normal liquidity conditions – provided that debt requirements are packaged efficiently. On that basis, the Authority is not convinced Incenta's bottom up analysis would be borne out in reality.

637. Overall, the Authority considers that its estimate of 12.5 basis points established in the Guidelines is reasonable. The Authority therefore retains its Guidelines estimate for this Draft Decision.

Hedging costs

638. Interest rate swaps are derivative contracts, which typically exchange – or swap – fixed-rate interest payments for floating-rate interest payments. They provide a means to hedge and manage risk. Investment and commercial banks with strong credit ratings are swap market-makers.

639. Hedging costs involved in converting from typical 10 year fixed debt to the regulated 5 year fixed rate will involve four legs:

- swapping 10 year fixed for a base floating rate at the time of issuance – paying floating and receiving 10 year fixed;

337 DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Response to ERA Issues Paper Submission 26, 2 June 2015, p. 10.

338 Incenta Economic Consulting, Debt raising transaction costs–Ergon Energy, April 2015, p. 2.

339 Economic Regulation Authority, Explanatory Statement for the Rate of Return Guidelines, 16 December 2013, p. 199 – 205.

- swapping the base floating rate at the time of the regulatory reset for 5 year fixed – receiving floating and paying 5 year fixed.

640. For each set of two legs, the following costs may be incurred:

- a credit and capital charge – relates to the risk of the counterparty, and will depend on the credit rating and the potential default loss;
- an execution charge – compensates the swap intermediary for the costs associated with transacting the swap.

641. The benchmark efficient entity would potentially engage in four different transactions in hedging the base of its portfolio of debt:[340]

- 5-year floating to fixed AUD swaps at start of AA for full amount of debt portfolio;
- bond issuance potentially made up of three different issue types and hence requiring three different swap considerations:
- foreign currency bonds – requiring a cross-currency swap into floating AUD;
- fixed-rate AUD bonds – requiring a fixed-float AUD swap;
- floating rate AUD notes – no swap will be required.

642. The QCA has been awarding swaps costs for swapping from 10 year fixed debt to shorter term (typically, although not always) 5 year fixed debt, since 2010, utilising estimates made by Evans & Peck. The most recent cost estimate is 13 basis points per annum (**bppa**) (Table 17).

Table 17 Hedging transactions costs for four legs, BBB credit rating

Estimate	10 year fixed to floating (basis points per annum)	Floating to 5 year fixed (basis points per annum)	Total (basis points per annum)
Evans & Peck[a] (12 January 2015)	8.0	5.0	13.0
UBS[b] (November 2014)			23
Jemena[c] (June 2013)			7.9 – 9.4

Source a) Evans & Peck, reported in Incenta, WACC parameters for GAWB Price Monitoring Investigation 2015-20 – Draft Report, February 2015, p. 32 (swapping 10 for 5; $250 m debt; BBB; to mid-rate; as at 12 January 2015);

b) UBS, reported in Transgrid, Revised revenue proposal, 13 January 2015, Appendix R, p. 6 (BBB+ credit rating).

c) Jemena, Rate of Return Guidelines – Consultation Paper: Submission, 21 June 2013, p. 22 (BBB+ credit rating).

643. Other recent estimates include those reported by Jemena and UBS (Table 17):

[340] Chairmont Consulting, *ERA Hedging Costs in the Cost of Debt*, 13 May 2015.

- The Jemena range is based on quotes from two separate banks for BBB+ swaps for 10 year fixed to 5 year fixed.[341]
- The UBS estimate is comprised of the AUD interest rate swap credit, capital and execution costs for a BBB+ rated entity (quoted at 5 basis points) and cross-currency interest rate swap credit, capital and execution costs for a BBB+ rated entity (quoted at 18 basis points).[342] A similar report by UBS was submitted by DBP in its response to the Issues Paper.[343]

644. The Authority notes that DBP provided the Authority with updated estimates from UBS, which are consistent with the estimates set out above.[344]

645. CEG, using evidence from Table 17, estimated a range for hedging costs of 15.5 to 23 bppa, based on an Evans & Peck estimate from 4 February 2013 and the UBS estimate (in Table 17):[345]

> Based on the evidence surveyed above, swap transaction costs have been estimated to be in the order of 15.5bppa to 23bppa – consistent with the QCA's stated range of 15bppa to 20bppa. The lower/upper end of this range is based on the swap costs estimated by Evans & Peck/UBS and are themselves based on domestic/foreign debt issues. To the extent that foreign issued debt is relied on then somewhere towards the upper end of this range is appropriate.

646. However, in its ATCO Final Decision, the Authority did not agree with this estimate. The Authority engaged Chairmont to advise on the costs of undertaking swaps. Chairmont estimates the following costs for each of the components, based on the data in Table 17 and its own enquiries:[346]

> - 5-year swaps at the start of the AA. The different submissions provide a range of estimated costs, i.e. Evans and Peck (2015) 5bp; UBS <5bp; Jemena <5bp (i.e. less than half of the total 8-10bp, as a 5-year swap costs less for capital and credit charges). This suggests approximately 4bppa is appropriate. This is also supported by informal discussions held by Chairmont with two banks in late 2014.
> - Cross-currency swaps. There was only one estimate provided and that was by UBS which reported 18bp. Chairmont's discussions with the banks suggest that this estimate is at the high end of costs and is likely to overstate a swap in relation to a new issuance. It is important to understand that banks tend to be more aggressive on swap pricing when linked to other business. A lower level of 10bp appears to be reasonable, so for further calculation a mid-point of 14bp is used.

341 As part of its investigation of this issue, the Authority approached a local bank, which confirmed estimates similar to Jemena's, as at March 2015, for a swap of 10 year fixed for 5 year fixed debt.

342 The Authority does not include other swaps costs estimated by UBS. The tracking risk and deferral cost estimates are 'a quantification of risks associated with an inability to fully hedge to the regulatory allowance even when using swaps' (ATCO, *Re: Estimating the return on debt: ATCO Gas Australia's response to the Authority's Discussion Paper*, 25 March 2015, Attachment, p. 8.).

343 The Authority does not accept DBP's contention that it has ignored conversion costs (DBP, *Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Response to ERA Issues Paper Submission 26*, 2 June 2015, p. 10). See Appendix 5.

344 DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Response to ERA Issues Paper Submission 26, 2 June 2015, Appendix B.

345 ATCO, Re: Estimating the return on debt: ATCO Gas Australia's response to the Authority's Discussion Paper, 25 March 2015, Attachment, p. 9.

346 Chairmont Consulting, Authority Hedging Costs in the Cost of Debt, 13 May 2015.

- 10-year AUD fixed-floating swaps. The submissions are Evans and Peck (2015) 8bp; UBS 5bp; Jemena and Authority (implied) 5-7bp. Taking a mid-point such as 6bp appears reasonable for this component.

647. Only a proportion of debt is raised overseas, thereby requiring overseas credit and executions costs. For example, CEG present evidence that regulated energy companies had around 65 per cent of debt issued in AUD in 2013, with the remainder in foreign currencies.[347,348] Further, CEG identifies that 24 per cent of debt amounts outstanding is already floating, typically bank loans.[349]

648. On the basis that CEG's estimates remain valid, the Authority calculates the weighted cost of hedging, using Chairmont's estimates set out above, as the sum of:

- 5 year swap floating for fixed for the full amount of debt = 4 bppa x 100 per cent = 4.0 bppa; plus
- 10 year cross currency swaps for (100 – 65 =) 35 per cent of debt issuance = 14 bppa x 35 per cent = 4.9 bppa;
- 10-year fixed-float AUD swaps for (65 – 24=) 41 per cent of debt issuance = 6 bppa x 41 per cent = 2.5 bppa.

649. That sum gives a total cost of hedging of 11.4 bppa (rounded to the nearest bppa).

650. Accordingly, the Authority will allow 11.4 bppa as the costs of hedging for this Draft Decision.

New issue premium

651. DBP propose that a 'new issue premium' be added to the return of debt. Based on a report by CEG, DBP argue that the new issue premium measures the difference between the price at which a network business can roll over its debt portfolio and prices from secondary markets where the debt is resold. DBP submitted that the current estimate of the new issue premium is 0.27 per cent.[350]

652. The Authority is not satisfied that DBP have provided convincing evidence to support its view in relation to the new issue premium. The Authority is of the view that CEG's estimate of the new issue premium is not robust and as such, it is not appropriate to use in the estimate of the total cost of debt for DBP in this Draft Decision. The Authority's reasoning is provided below.

Theoretical considerations

653. The Authority notes that there is no theory to guide the existence of new issue premium (or the under-pricing of corporate bonds) in the literature. The price of newly issued bonds (or their yields) is a function of some key characteristics such as the issuer' credit rating; the industry; the term to maturity of the bond; the face value; the coupon rate; and the current yields on comparable investment options. The Authority is not aware of any theory which provides a reasonable explanation of under-pricing

347 Competition Economists Group, *Debt strategies of utility businesses*, June 2013, p. 23.

348 This proportion exceeds that of issuance of corporate bonds by Australian corporates, more generally (see Table 12 at p. 274, which reports that only 20 per cent of corporate bonds were issued in AUD as at June 2014).

349 Competition Economists Group, *Debt strategies of utility businesses*, June 2013, p. 22.

350 DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12, p. 21.

of corporate bonds (i.e. higher yields at issuance on a primary market in comparison with yields of currently traded bonds with similar characteristics in a secondary market).

654. The Authority is of the view that bonds are generally very sensitive to changes in interest rates because interest rates mainly and fundamentally determine the price of the bonds more than anything else. As such, any change in interest rates will lead to a change in the price of the bonds (or their yields) for both newly issued bonds and secondary market bonds.

655. The Authority notes that the existence of "imperfect information" and "transaction costs" in financial markets is generally used by CEG as a theory to support the view that a new issue premium does exist. CEG argued that this literature is not inconsistent with the simple observation that there are essentially two mechanisms as alternatives or in combination by which the seller of a new issue can convince the requisite number of buyers to participate in the sale process for a new issue (of debt or equity). The first mechanism is to conduct marketing of the issue in an attempt to provide information to potential buyers that raises the price those buyers are willing to pay for the issue. The second mechanism is to lower the price of the issue in order to make the investment value of the issue attractive to the requisite number of buyers.[351]

656. The Authority disagrees with CEG's view in relation to a theoretical framework. The Authority considers that "imperfect information" and "transaction costs" are simply two characteristics of any market which may incur costs for market participants. The Authority notes that debt raising cost of 12.5 bp has already been provided for efficient benchmark entities to cover their legitimate cost of raising debts. The Authority is not satisfied that underpricing (higher yields) is consistent with an efficient practice of financing debts by an efficient benchmark entity. The Authority considers that if underpricing of newly issued corporate bonds represents a common practice of financing debts, then this practice is clearly inefficient and as a result, underpricing should not be compensated.

Empirical considerations

657. In order to support its view that the new issue premium exists, CEG has provided a list of eight different empirical papers. A brief summary of these academic papers is presented in Table 18 below.

658. Based on the evidence presented in Table 18, the Authority notes the following: (i) all of the above studies were conducted for the US financial market; (ii) there is mixed evidence in relation to whether or not a new issue premium does exist; and (iii) where studies found the presence of a new issue premium, the estimates vary significantly among studies.

659. The Authority also notes that evidence presented in Table 18 does not warrant a solid conclusion on the presence of the new issue premium for newly issued bonds even in the US financial markets. The Authority notes that some studies did confirm a presence of a new issue discount (overpricing) of newly issued bonds or failed to confirm the presence of a new issue premium.

[351] DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Rate of Return Supporting Submission: 12, Appendix H, p. 22.

660. The Authority concludes that the presence of the new issue premium is not supported by any economic theory or by empirical evidence.

The CEG's study in 2014

661. The Authority is not aware of any Australian studies in relation to the presence of the new issue premium. As such, CEG's estimate (2014) appears to be the first study of this kind for the Australian financial market. Table 19 below presents a summary of the estimates by the CEG under various scenarios.

662. CEG considered that estimates of the new issue premium at longer measurement periods, where they are statistically significant, are likely to be more robust than estimates at shorter measurement periods. However, the Authority is not satisfied that the estimates using the period from 8 weeks to 16 weeks represent the best estimates as concluded by the CEG.

Table 18 Estimates of the new issue premium

Authors (Year)	Data	Key findings
Ronn and Goldberg (2013)	• A sample of 1,494 non-finance investment grade bonds newly issued from 2008 to January 2012.	• The average new issue premium is 22.5 bp.
Cai, Helwege and Warga (2007)	• 439 IPOs and 2,536 SBOs for the period from 1995 and 1999.	• IPO (37bp) and SBO (2.7 bp) • Investment grade (as a group) is not statistically significantly different to zero.
Datta, Iskandar-Datta and Patel (1997)	• Corporate straight bond initial public offerings made between January 1976 and 1988.	• Underwriters do not, on average, under-price IPOs of straight debt.
Carayannopoulos (1996)	• The pricing of new 3-, 5-, 10-, and 30-year Treasury notes and bonds which were issued during the United States Treasury's regular refunding operation.	• The mean difference at the end of the issue month is -62 bp.
Weinstein (1978)	• Random samples of 412 outstanding bonds and 179 newly issued bonds during any period from June 1962 to July 1974.	• The new issue premium for the first month after issue is 38 basis points, which is not statistically significant. • While bonds are issued at prices below equilibrium, prices reach equilibrium by the end of the month.
Lindvall (1977)	• Bonds issued by electric, gas and water companies which were rated Moody's Aa or Standard and Poors Aa, had maturities of between 25 and 35 years and were at least $10 million in size.	• A range of new issue premiums from 45.3 bp (in periods of rising yields) to -8.0 bp (in periods of falling yields).
Ederington (1974)	• A sample of 611 nonconvertible public utility issues offered through competitive bidding between January 1, 1964 and March 1, 1971.	• The average new issue premium for 1964-1961 was 30.9 basis points, with a spread from -91 to +139 bp.
Connard and Frankena (1969)	• Aa corporate bonds from 1952-1962.	• An average of 16.7 bp using Moody's series and 9 bp using Moody and Homer series. • It took two to three months, on average, for the new issue premium to be eliminated.

Source: *The Authority's analysis, December 2015.*

663. Based on the CEG estimates of the new issue premium as presented in Table 19, the Authority notes the following:

- *First*, CEG's estimates vary significantly across 8 scenarios, ranging from 0 to 36 basis points.
- *Second*, once a different proxy is used to control for the general movement in interest rates, the estimates vary significantly. This view is supported by the estimates presented under Scenarios 1 and 2; and Scenarios 3 and 4. For example, a difference of 10 basis points or more when Bloomberg's fair value or swaps is adopted to control for the general movement in interest rates.
- *Third*, assuming that all estimates presented in Table 19 are robust, which is highly unlikely, then the possible range of the estimates varies between 4 basis points and 25 basis points.

Table 19 CEG (2014) estimates of the new issue premium

No.	Sample	Control for general movements in interest rates	Key findings	Mid point of the range
1	Full sample (A & BBB credit rating)	Bloomberg's Fair value	0 – 8 bp.	4 bp
2	Full sample (A & BBB credit rating)	Bloomberg's interest rate swaps	10 – 17 bp.	14 bp
3	Core sample (BBB-/BBB/BBB+ credit rating)	Bloomberg's Fair value	13 – 21 bp.	17 bp
4	Core sample (BBB-/BBB/BBB+ credit rating)	Bloomberg's interest rate swaps	16 – 36 bp.	21 bp
5	Exclusions of firms in finance and banking		1 – 16 bp	8 bp
6	Inclusions of only fixed bonds		3 – 24 bp	14 bp
7	Combination of Scenarios 6 and 7		2 – 25 bp	14 bp
8	Weighting of bonds by issue size			25 bp

Source: The Authority's analysis.

664. The Authority notes that interpolation and/or extrapolation has been adopted in the CEG's analysis to ensure that a term of a particular bond matches that of the fair value or the swaps, which is used as a proxy to control for a general movement in interest rates, this process results in a significant approximation in the CEG study.

665. On balance, the Authority is of the view that any positive new issue premium of newly issued bonds in the CEG's study may well fall within a margin of error of these estimates. This view is supported on the following key bases.

- *First*, CEG's study provides a wide range of estimates for the new issue premium and there is no clear guidance from both theoretical and empirical bases to select a superior estimate from all these available estimates.
- *Second,* a sample of bonds utilised in the CEG study may not be consistent with the benchmark sample used under the Authority's bond yield approach to determine the cost of debt. As such, the Authority is not satisfied that the CEG

estimates of new issue premium is relevant for the purpose of estimating the cost of debt for a benchmark efficient entity. The Authority also notes that the AER has rejected the relevance of the CEG estimates of the new issue premium to the Bloomberg BVAL curves and RBA curves.

- *Third,* interpolation and extrapolation of the raw data will generally provide an approximation of the estimates. Unless the estimates under interpolation and extrapolation are consistently significant, the estimates may just simply be an error in this approximation.

Other issues

666. The Authority notes that the new issue premium may be in existence in particular financial markets at a particular point in time. However, this existence does not imply that the Australian benchmark efficient entity should be compensated by incorporating a new issue premium into its allowed cost of debt. The Authority is of the view that this inclusion may only be possible if, and only if, it is proved that an efficient benchmark entity has been undercompensated in relation to its allowed cost of debt.

667. In this Draft Decision, the allowed cost of debt for the 2016 regulatory year is 5.172 per cent. The Authority is of the view that the allowed cost of debt is not underestimated. As a result, a new issue premium should not be included to compensate. This view is supported on the following two bases:

- *First*, the Authority notes that the Productivity Commission was of the view that the average regulatory cost of debt is 1.25 per cent higher than the estimated costs incurred by services providers.[352]
- *Second,* the term of debt of 10 years is used in the estimate of the allowed cost of debt even though the observed term of debt of an efficient benchmark entity is generally less than 10 years. The Authority notes that the longer term debt is generally more expensive than the shorter term debts in normal market conditions.

668. On balance, on the basis of the above assessment, the Authority is of the view that there is insufficient evidence that a new issue premium exists. The proposed new issue premium of newly issued corporate bonds, if any, is not considered to be relevant to an efficient benchmark entity. In addition, there is no robust evidence to confirm that the allowed cost of debt is underestimated. As a result, the Authority is of the view that a new issue premium should not be included in the cost of debt for regulated businesses.

The estimate of the return on debt for this Draft Decision

669. The Authority's *indicative* estimate for the return on debt for the 2016 calendar year (which is applied from 1 January 2016 to 31 December 2016 and also utilised for the other years of the tariff model) is 5.172 per cent (*indicative*, given that it is based on the 2015 calendar year estimate). The resulting estimate is the sum of:

- the on the day 5 year swap rate of 2.431 per cent;
- a hybrid trailing average debt risk premium of 2.502 per cent;
- debt issuing costs of 0.125 per cent; and

352 Productivity Commission, *Electricity network regulatory framework*, No. 62, Vol. 1, 9 April 2013, p. 207.

- hedging costs of 0.114 per cent.

670. The Authority's estimate of the DRP for 2015 and for 2016 will be revised for Final Decision.[353]

671. The automatic formula for updating the estimate of the DRP – which will then occur for 2017, 2018 and 2019 consistent with the requirements of NGR 87(12) – is set out at Appendix 4G.

[353] The calendar year 2015 *indicative* estimate of the return on debt, set out here, will be updated in the Final Decision to account for the latest 2015 RBA data, while the estimate for calendar year 2016 for the Final Decision also will be developed, based on DBP's nominated averaging period for the 2016 estimate. The overall method for determining that revised calendar year 2016 estimate will follow that set out here for calendar year 2015.

Appendix 4A CEG'S critique of the ERA treatment of asset pricing models

CEG's critique

672. In its report, CEG provides its critique to the Authority's decision in relation to the Black CAPM and the Fama French model. The critique of each of these two models from CEG is summarised in turn below.

The Black CAPM

673. In its report prepared for DBP, CEG's critique focused on two models: (i) the empirical CAPM; and (ii) the Fama French three-factor model. CEG noted that:[354]

> When I use the term Empirical CAPM, I am referring to an implementation of the CAPM where the return on a zero beta asset is set at a value that is above the risk free rate and where the magnitude of this 'zero beta premium' is determined by reference to empirical studies of the relationship between returns and beta. This is consistent with the terminology used by the ERA in its explanatory statement to the rate of return guideline.

674. CEG's argument in relation to the Authority's treatment of asset pricing models is based on the following four points.

675. *First*, CEG considers that there is an abundance of evidence on the performance of the Empirical CAPM. CEG concluded that:[355]

> In summary, the empirical literature that is relevant to low beta bias is very extensive and there is nothing preventing the ERA from surveying this literature and arriving at its own estimate of the zero beta premium (and, hence, the zero beta bias). Absent the ERA performing this study a conservative estimate would be that the zero beta premium is half of the market risk premium. This is conservative because it is based on the results reported in articles selected by the AER and used by it to support the reasonableness of the Sharpe Lintner CAPM (i.e., these articles can be expected to have a bias in favour of a low zero beta bias given the purpose to which the AER put them). It is also consistent with the lowest estimate of the zero beta premium using Australian data (SFG's estimate) – with the other two estimates (CEG and NERA) implying a higher zero beta premium.

676. *Second*, CEG argues that the Empirical CAPM cannot be empirically unreliable.[356] CEG considered that, purely as a matter of logic, the Empirical CAPM cannot be less empirically reliable than the Sharpe Lintner CAPM. CEG is of the view that the Empirical CAPM estimates the sensitivity of stock returns to equity beta based on the empirical data. As such, it gives the best estimate, based on the available data, of the role of beta in determining market returns.

677. CEG concludes that the available data is imperfect and, therefore, the estimates derived from that data are imperfect. On this basis, CEG argued that this helps

354 Competition Economists Group, "*ERA treatment of asset pricing models", a report prepared for DBP,* December 2014, pp. 4-5.

355 Competition Economists Group, "*ERA treatment of asset pricing models*", *a report prepared for DBP,* December 2014, p. 12.

356 Competition Economists Group, "*ERA treatment of asset pricing models*", *a report prepared for DBP,* December 2014, p. 12.

explain why not all studies arrive at the same estimate of the zero beta premium. CEG consider that the important point to note is that all studies with an estimate of the zero beta premium that is materially above zero.[357]

678. *Third*, in relation to the estimate of zero beta premium from Australian versus foreign studies, CEG argues that:[358]

> The first point to note in response to this is that international evidence is compelling. Wherever this has been tested, a zero beta premium has been found to exist. This is a settled conclusion in the finance literature. Even if there were no evidence specific to Australia the only reasonable a priori conclusion should be that the same result that has been found internationally will also be true in Australia.

679. CEG notes that, in any event, there are now at least three studies of the zero beta premium that have been undertaken in the Australian context – CEG (2008), NERA (2012), and SFG (2014). These studies find a zero beta premium of between 50 per cent and 100 per cent of the market risk premium.[359]

680. *Fourth*, CEG notes the Authority's view that the Australian studies are not published in a quality journal and therefore the results cannot be relied on. CEG argues that this position fails to come to terms with the fact that the issue has been settled in the finance literature, such that it is not a matter of current academic study.[360]

681. *Fifth*, CEG argues that the Authority's view on credibility of results from empirical studies on the estimate of zero beta premiums is inappropriate.[361] CEG was also of the view that the Authority's prior assumption that - beta must be an important determinant of risk and that, therefore, any study that finds it is not must be wrong – is inappropriate.[362]

> Rejecting an empirical finding because it does not accord with a prior belief is, as a general matter of principle, unsound. It is especially unreasonable when that empirical finding is consistent with other studies and your prior belief is not consistent with any empirical studies.

The Fama French Model

682. CEG submitted that, in essence, the Authority gives no weight to the FFM on the grounds that: (i) there is no strong theoretical basis to support the inclusion of the non-beta risk factors; and (ii) the Authority's analysis using Australian data is not consistent with the FFM.[363] CEG was not convinced that the Authority's view is appropriate.

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357 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 13.

358 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 13.

359 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 14.

360 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 14.

361 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 15.

362 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 15.

363 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 16.

683. *First*, CEG argued that:[364]

> It is unreasonable to prefer the Sharpe Lintner CAPM to the FFM on the grounds that the Sharpe Lintner CAPM is solidly based in theory and the others are based on empirical relationship. This approach is not scientific. Theory must be informed by fact and when a theory is falsified by the facts it must be adapted in a manner that is more consistent with the facts.

684. CEG submitted that the Authority relied on its own analysis to conclude that the FFM does not explain Australian stock market returns. CEG argued that the Authority should test the Sharpe Lintner CAPM and, if the Sharpe Lintner CAPM does not explain Australian stock market returns, it should also be rejected in favour of the Empirical CAPM.[365]

685. CEG considered that the Authority has acted in an internally inconsistent and unreasonable manner in relying on an empirical test of the FFM while simultaneously failing to apply a similar test to the Sharpe Lintner CAPM and rejecting the relevance of such tests performed by other parties.[366]

686. *Second*, CEG concluded that the Authority's own analysis on the application of the FFM in Australia has serious flaws. This is mainly because there is insufficient data to do any useful analysis and that this study is not published in a peer review journal whereas other studies such as the 2012 Brailsford; Gaunt & O'Brien study was and this study uses 24 years of data.[367]

CEG's argument in relation to precision versus accuracy

687. CEG considered that the Authority's decision to solely rely on the Sharpe Lintner CAPM to estimate a return on equity for regulated businesses as "precise but inaccurate".[368] CEG argued that the Empirical CAPM produces the return on equity which is "more accurate but less precise".

688. CEG argued that the weight that should be given to any individual estimate depends on a trade-off between the bias and the precision of the estimate. In statistical terms, the weights should be chosen to minimise the mean squared error (MSE) of the ultimate estimate.[369] CEG then considered that the estimates with the smallest MSE should be given the most weight and that all estimates should be given some weight unless one of them has a zero MSE. That is, it is an extreme approach to give one estimator 100 per cent weight – even if it is regarded as having the lowest MSE.

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364 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 16.

365 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 17.

366 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 17.

367 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 18.

368 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 19.

369 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 20.

689. Based on the above argument, CEG concluded that:[370]

> The a priori best estimate would be that the Sharpe Lintner CAPM has the highest MSE – and therefore should be given the least weight. This reflects the fact that ERA has acknowledged that the Sharpe Lintner CAPM is biased for low beta stocks. By contrast, the potential for bias in the Empirical CAPM is smaller precisely because it is calibrated to remove the bias present in the Sharpe Lintner CAPM. On this basis the Empirical CAPM will have a lower MSE than the Sharpe Lintner CAPM.

690. And that:[371]

> Similarly, the FFM is also an empirical model and, as such, the potential for bias is smaller. However, unlike the Empirical CAPM, it has regard to more evidence when estimating returns (the size and book to market factors as well as beta). Whether the MSE of the FFM will be higher or lower than the Empirical CAPM depends on whether the additional accuracy associated with introducing the two new factors is offset by any additional imprecision associated with the estimation of those factors.

The Authority's considerations

691. The Authority notes that CEG's so-called 'Empirical CAPM' is the Black CAPM using the Authority's terminology. The Authority also notes that CEG refers to the Empirical CAPM rather than the Black CAPM in order to be clear that not only the theoretical conclusions of Black (1972), but also the empirical work in Black Jensen Scholes (1972) and many other similar studies, are referred to. CEG considered that the Authority's terminology tends to use the term 'Black CAPM' to encompass what CEG referred to as the Empirical CAPM.[372]

692. The Authority evaluated the relevance of the following materials for estimating the return on equity in the Rate of Return Guidelines, in terms of their ability to contribute to the achievement of the allowed rate of return objective:[373]

- the Sharpe Lintner Capital Asset Pricing Model (**CAPM**), as well as other asset pricing models in the CAPM 'family'; and
- an extensive range of other models and approaches which seek to estimate the return on equity.

693. The Authority concluded in the Guidelines that only the Sharpe Lintner CAPM model is relevant for informing the Authority's estimation of the prevailing return on equity for the regulated firm at the current time. The Authority considered that incorporating returns from other models would detract from the ability of the Authority to meet the allowed rate of return objective.

[370] Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 21.

[371] Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 21.

[372] Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 5.

[373] Economic Regulation Authority, Appendices to the Explanatory Statement for the Rate of Return Guidelines, 16 December 2013, Appendix 8.

694. However, the Authority determined that it would give weight to relevant outputs from the Dividend Growth Model (**DGM**) when estimating the market risk premium (**MRP**), which is an input to the Sharpe Lintner CAPM.[374]

695. The Authority also noted the empirical evidence provided by the Black and Empirical CAPM models, pointing to potential bias in the estimates from the Sharpe Lintner CAPM, and noted that it would take this information into account when estimating the point estimate of the equity beta from within its estimated range.[375]

696. The Authority concluded that other models and approaches are not relevant within the Australian context, at the current time, without some new developments in terms of the theoretical foundations or in the empirical evidence. Generally, there are resulting shortcomings with regard to robustness in the Australian context. On this basis, the Authority considered that these other models are not 'fit for purpose' or able to be 'implemented in accordance with best practice'.

697. The Authority considered that its approach in the Rate of Return Guidelines with regard to the determination of relevance – in terms of best meeting the allowed rate of return objective – is consistent with the intent of the AEMC:[376,377]

> … In general the final rules give the regulator greater discretion than it has currently. The objectives and factors show the regulator what it must bear in mind when it exercises that discretion.
>
> The role of the objective is to indicate what the regulator should be *seeking* to achieve in the exercise of its discretion. Some stakeholders appear to have understood the objectives as imposing on the regulator a requirement and that failure to comply with this would mean the regulator is in breach of the rules. This is not the case. Although the language of an obligation is used in some objectives, it is not necessarily expected that the substance of the objective will always be fully achieved, but rather the regulator should be striving to achieve the objective as fully as possible. Where it is used in rate of return and capital expenditure incentives, the objective has primacy over other matters which the regulator is directed to consider.
>
> These other matters include factors which the regulator is directed to consider. The rules use language such as "have regard to" and "take into account" to direct the regulator to consider certain factors. Throughout this rule change process there has been discussion over the respective meanings of these phrases. The Commission's approach is that these phrases mean the same thing and nothing is implied by the use of one rather than the other. The Johnson Winter & Slattery advice attached to the Australian Pipeline Industry Association (**APIA**) submission[378] includes a useful guide to how the phrases

[374] Economic Regulation Authority, Appendices to the Explanatory Statement for the Rate of Return Guidelines, 16 December 2013, p. 78.

[375] Economic Regulation Authority, Appendices to the Explanatory Statement for the Rate of Return Guidelines, 16 December 2013, p. 67.

[376] Australian Energy Market Commission, *Rule Determination, National Gas Amendment (Price and Revenue Regulation of Gas Services) Rule 2012*, 29 November 2013, p. 36.

[377] The Authority notes that relevant means 'closely connected or appropriate to the matter in hand' (Oxford dictionary) or 'bearing upon or connected with the matter in hand; to the purpose; pertinent' (Macquarie dictionary).

[378] APIA, *Economic Regulation of Network Service Providers: Response to AEMC*, 4 October 2012, Appendix 1, p. 11. The Authority notes that that the Johnson Winter & Slattery advice stated:

…as long as the Regulator has taken into account the specified factors, it remains in the Regulator's discretion how those factors influence its decision. The practical application of this rule could result in the Regulator considering other estimation methods, financial models, etc. but then putting all but one to the side and continuing to estimate the cost of debt and cost of equity using its already stated preferred approach (i.e. the Sharpe Lintner CAPM)…

If evidence is "irrelevant", the Regulator will not fall into error by failing to "take it into account".

should be interpreted. The regulator must actively turn its mind to the factors listed, but it is up to the regulator to determine how the factors should influence its decision. It may, indeed, consider all of them and decide none should influence its decision. It is not intended that the regulator's decision is solely dependent on how it applies any or all of those factors. The intention is that where the rules require the regulator to consider certain factors in conjunction with an overall objective, it should explain its decision including how it has had regard to those factors in making a decision that meets the objective.

698. The Authority noted that DBP and its consultant CEG had presented only limited new information in its proposal – in relation to relevant estimation methods, financial models, market data and other evidence – that was not considered as part of the development of the Rate of Return Guidelines. Nonetheless, the Authority further considered the models for estimating the return on equity, including the Sharpe Lintner CAPM, the Fama-French Model (**FFM**), and the DGM.

699. Following review of DBP's proposal, the Authority remains of the view that its reasons for adopting the Sharpe Lintner CAPM, with the parameters informed by outcomes from the DGM and the Black CAPM, were sound for the purpose of estimating the return on equity. The Authority considered that the resulting application of the Sharpe Lintner CAPM met the requirements of the NGR and the allowed rate of return objective.[379]

The Sharpe Lintner CAPM

700. This section considers the ability of estimates of the return on equity derived from the Sharpe Lintner CAPM to meet the requirements of the NGL and NGR. Each of the three inputs to the Sharpe Lintner CAPM – the estimates of the risk free rate, equity beta, and the MRP – are considered in the following sections.

701. Based on CEG's advice, DBP is of the view that the application of the Sharpe Lintner CAPM by the Authority is inappropriate and as such, this model should not be used.

702. However, the Authority notes that there is no new information presented by DBP in its proposal with regard to the use of the Sharpe Lintner CAPM. The Authority considers that the information submitted by DBP has been previously considered in the Rate of Return Guidelines. However, for completeness, key criticisms in relation to the adoption of the Sharpe Lintner CAPM are considered in turn below.

Empirical evidence of the Sharpe Lintner CAPM

703. As discussed in detail in its Rate of Return Guidelines and ATCO Final Decision, the Authority is of the view that the Sharpe Lintner CAPM was developed from theory, the results are robust and the model is widely adopted by practitioners and academics for determining the return on equity.

704. The Authority also addresses criticisms in relation to the poor empirical performance of the Sharpe Lintner CAPM. The Authority remains of the view that these criticisms remain contentious, with no clear agreement among the experts (for example, with regard to the estimate of beta, exemplified in the consideration of the Black CAPM

In practice, of course, this will require some form of value judgment by the Regulator about whether evidence put before it is relevant or not. This appears to be consistent with the very broad discretion envisaged by the AEMC in the Draft Rule Determinations.

379 Economic Regulation Authority, Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System, 14 October 2014, p. 160.

above). However, the Authority notes that an adoption of equity beta from an upper bound of the estimated range of equity beta from empirical studies represents an upward revision of the return on equity estimated from the Sharpe Lintner CAPM.

705. The Authority notes that, in their report prepared for the AER in October 2014, Professors McKenzie and Partington concluded that:[380]

> With regard to the CAPM, its efficacy comes from the test of time. This model has been around for in excess of half a century and has become the standard workhorse model of modern finance both in theory and practice. The CAPM's place as the foundation model is justifiable in terms of its simple theoretical underpinnings and relative ease of application. The competing alternatives, which build upon the CAPM, serve to add a level of complexity to the analysis.

706. The Authority notes that other criticisms of the Sharpe Lintner CAPM include those relating to the risk factors proposed by Fama and French. Fama and French, and some others, have argued that beta alone cannot explain the cross section of average returns of the stocks. However, the Authority notes that the cross section of stocks' average returns is only one dimension of interest when modelling the risk-return relationship.

707. In addition, as discussed in McKenzie and Partington's report, the evidence against the CAPM may not be as robust as previously thought.[381]

- *First*, Ray, Savin and Tiwari (2009) conclude that the statistical evidence for rejecting the CAPM is weaker than previously thought when more appropriate statistical tests are used.
- *Second*, more importantly, Da, Guo and Jagannathan (2012) argue that the empirical evidence against the CAPM based on stock returns does not invalidate its use for estimating the cost of capital for projects in making capital budgeting decisions. Their findings support the continued use of the CAPM irrespective of one's interpretation of the empirical literature on asset pricing.

708. The Authority also notes DBP's recent argument in its response to the Authority's Issues Paper in relation to the relevance of the Sharpe Lintner CAPM and the Black CAPM for the purpose of estimating the return on equity. DBP concludes that:[382]

> In our AA Proposal, DBP presented a "model adequacy test" which suggests that the SL-CAPM is both statistically and economically biased downwards as a model of the required return on equity. A similar analysis was undertaken by NERA (2015c) and presented to the AER by various electricity utilities. NERA's work included both in-sample and out-of-sample tests of bias, whilst DBP's test was a purely out-of-sample test of bias.

709. In its report prepared for DBP, NERA concludes that:[383]

> The central empirical result that NERA provides in its February 2015 report is that models like the SL CAPM and AER CAPM that use beta as a measure of risk and a restriction that a zero-beta portfolio earn either the risk-free rate or, as in the AER

380 McKenzie, M. and Partington, G. "A Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 9.

381 McKenzie, M. and Partington, G. "A Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 9.

382 DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period, Response to ERA Issues Paper, Submission: 26, 2 June 2015, p. 15.

383 NERA Economic Consulting, The Cost of Equity: A Critical Review of the Analysis of the AER and its Advisors, a report for DBP, June 2015, p. ii.

> CAPM, a rate that sits only a small distance above the risk-free rate provide poor estimates of the return required on equity. In particular, the models tend to underestimate the returns required on low-beta equity portfolios and overestimate the returns required on high-beta equity portfolios. In other words, models that use beta as a measure of risk and a restriction that a zero-beta portfolio earn either the risk-free rate or a rate that sits only a small distance above the risk-free rate produce estimates of required returns that are biased – especially for low-beta and high-beta equity portfolios. Thus estimates of the return required on equity that use the SL CAPM and the AER CAPM will not satisfy Rule 74 (2) of the National Gas Rules. Estimates of the return required on equity that use the SL CAPM or the AER CAPM do not represent the best forecasts possible in the circumstances.

And that:[384]

> The SL CAPM and the AER CAPM perform so badly that even a naïve model that states that the mean returns to all equities are identical performs better. One cannot reject the hypothesis that the naïve model generates estimates of the return required on an equity portfolio that are unbiased. Similarly, one cannot reject the hypothesis that the Black CAPM generates estimates of the return required on an equity portfolio that are unbiased. Thus estimates of the return required on equity that use the naïve model or the Black CAPM will satisfy Rule 74 (2) of the National Gas Rules.

710. The Authority is not convinced that these inferences by NERA should give cause to alter its conclusions, which are based on the findings from a range of studies. The Authority maintains its view in relation to the empirical evidence for the Sharpe Lintner CAPM, as previously discussed.

711. In addition, based on its recent analysis in relation to the estimate of zero beta portfolio premiums, the Authority is strongly of the view that the estimates of zero beta premiums are not robust, as previously considered. Further details are presented in Appendix 4C.

Ability to reflect changes in market conditions

712. The Authority is not satisfied that a return on equity estimated by the Sharpe Lintner CAPM is unable to reflect changes in market conditions. The Authority notes that estimates of risk free rate, equity beta and the MRP consider relevant data available at the time the decision is made. As such, any changes in market conditions should be reflected in the data which are used in the estimates.

713. For example, estimates of the risk free rate use recently observed yields on the Commonwealth Government bonds over the period of 40 trading days at a point prior to the decision. Similarly, estimates of equity beta generally use a sample of stock and market returns over the most recent period of five years.

714. Estimates of the MRP also account for prevailing conditions.

Achieving rates of return that would be consistent with the outcomes of efficient, effectively competitive markets

715. The Authority is satisfied that an equity rate of return derived from the Sharpe Lintner CAPM is consistent with the outcomes of efficient, effectively competitive markets. As noted above, the model is widely accepted, has stood the test of time, and as a

384 NERA Economic Consulting, The Cost of Equity: A Critical Review of the Analysis of the AER and its Advisors, a report for DBP, June 2015, p. ii.

result continues to be the standard asset pricing model of modern finance, in theory and practice.

716. The Authority's process for determining the return on equity cross checks the outputs of the model against available evidence from the market (see Step 4 below). On the basis of that analysis, the Authority is satisfied that the rate of return on equity determined using the Sharpe Lintner is consistent with prevailing market outcomes and for the benchmark efficient entity.

The Authority's decision on the Sharpe Lintner CAPM

717. The Authority does recognise that recent market conditions since the Global Financial Crisis have raised important issues with regard to the application of the Sharpe Lintner CAPM. The Authority considers that its revised approach to estimating the Sharpe Lintner CAPM – as set out in the Rate of Return Guidelines and implemented for this Draft Decision – allows for much greater flexibility in the estimates of the return on equity, thereby improving the overall estimates of that return. That approach, among other things, involves establishing a range for the forward looking MRP and then determining a point estimate at the time of each decision, based on the prevailing conditions in the market.

718. The Authority notes that its decision in relation to a continuous use of the Sharpe Lintner CAPM to estimating the return on equity for DBP is fully supported by the most recent report prepared by Professors Partington and Satchell:[385]

> "Our first observation is that the CAPM is ubiquitous in relation to the estimation of the cost of equity. The same cannot be said for the alternative models proposed by the regulated businesses. Whilst much of the criticism of the CAPM has some validity, the good points of the CAPM need repeating, it is parsimonious, it is widely used and understood, and, importantly, it is an equilibrium model. Equilibrium theories for the Fama and French models are much less well-founded and the model itself is in the process of revision by Fama and French. The zero-beta CAPM is an equilibrium model, but we have made the case, that was not refuted by the submission of the regulated businesses, that there are troublesome problems in estimating the zero beta return".

719. Partington and Satchell also concluded that:[386]

> The CAPM has not performed well in terms of empirical attempts to fit the model to realised returns, but the CAPM has passed an important test. That test is the test of time. While academics are still debating the merits of the different asset pricing models, how they should be tested and what the appropriate test statistics are, the users of models have made up their mind about which model to use when estimating the cost of capital. The CAPM has had several decades of widespread practical use in estimating the cost of capital. None of the other models have passed the same test.

Black CAPM

189. The Authority notes the information presented by DBP in its proposal with regard to the approach using the Black CAPM.

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385 Partington, G. and Satchell, S. "Report to the AER: Analysis of Criticism of 2015 Determinations", a report prepared for the Australian Energy Regulator, October 2015, p. 17.

386 Partington, G. and Satchell, S. "Report to the AER: Analysis of Criticism of 2015 Determinations", a report prepared for the Australian Energy Regulator, October 2015, p. 21.

720. In addition, the Authority notes the material submitted by DBP in response to the Issues Paper.[387] In that submission, DBP confirms its position that the rate of return on equity should be determined using an approach which: (i) does not rely on the use of only one financial model; (ii) considers the use of models which not only have a theoretical grounding, but also are capable of being shown to be empirically relevant; (iii) assesses whether the predictions of theoretically grounded models deliver outcomes which are comparable with actual subsequent returns on equity earned by benchmark businesses; (iv) considers ranges, rather than point estimates, in the application of each of the relevant models; (v) examines the results from models used with a series of cross checks – one such cross check being the consistency between calculated debt and equity premia.

721. The Authority is of the view that DBP's approach in relation to the estimate of a return on equity is similar to the Authority's five-step approach presented in the Final Decision on Rate of Return Guidelines in 2013. The following section is devoted to the analysis in relation to the Black CAPM which is considered relevant by DBP, and as such, adopted by DBP in estimating the return on equity for DBNGP.

Assumptions under the Black CAPM

722. The Authority notes that the assumptions underlying the Black CAPM are the same as those of the Sharpe Lintner CAPM, with one exception. One assumption underpinning the Sharpe Lintner CAPM is that investors are assumed to be able to borrow or lend freely at the risk free rate of a risk free asset. Black (1972) questioned this assumption by arguing that an investor may take unlimited long or short positions in any security, including the risk free security.

723. In his paper, Black (1972) considered two separate scenarios:

- *First*; there is no risk free security and, as such, no borrowing or lending at the risk free rate. However investors may take long or short positions of any size in any risky asset. This version of the Black CAPM is also known as the fully restricted version.
- *Second*; investors are assumed to be able to lend but not borrow at the risk free rate, known as the partially restricted version.

724. McKenzie and Partington (2014) considered that in the absence of the riskless asset, there is a role for the zero beta portfolio. The expected return on any asset is a linear function of the beta of the asset. In the second scenario the resulting market equilibrium is more complex, but equilibrium asset returns again depend linearly on the beta of the asset as well.[388]

725. The Black CAPM requires that investors can short sell. SFG (2014) argued that while in reality investors do not have an unlimited ability to sell short, short-selling is a feature of the equity market. It is possible that the more realistic assumptions underlying the Black CAPM provide a better data fit.

726. In the Rate of Return Guidelines, the Authority was of the view that the Black CAPM substituted one assumption of the Sharpe Lintner CAPM with another assumption

387 DBP, "Proposed Revisions DBNGP Access Arrangement: 2016 – 2020 Regulatory Period", Response to ERA Issues Paper, June 2015, p. 4.

388 McKenzie, M. and Partington, G. "A Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, pp. 21-22.

that was arguably, unrealistic. The Authority notes that this view is consistent with both Black (1972) and Fama French (2004).

> This assumption is not realistic, since restrictions on short selling are at least as stringent as restrictions on borrowing.[389]

and that:

> The assumption that short selling is unrestricted is as unrealistic as unrestricted risk-free borrowing and lending.[390]

190. In their report prepared for the AER in October 2014, Professors McKenzie and Partington concluded that:[391]

> In theory, theory and practice are the same. In practice, however, theory and practice are different. It is important to understand that the conditions under which investors can short sell in the real world are very different to the conditions assumed in the Black model. As SFG point out, investors in the real world do not have an unlimited ability to short sell. The differences go far beyond that however, and short selling is actually a very risky and expensive exercise. In order to short sell, an investor must typically borrow the stock and most stock loan agreements require the investor to post in excess of 100% of the value of the loan in cash or equivalent, they must pay a fee for lending the stock (termed the rebate rate), loans are typically on 24-hour recall, investors face the constant risk of a short squeeze, etc.. For details on the process of stock lending for short selling see Faulkner (2002) and for academic research on the costs and impact of short selling see Henry and McKenzie (2006), McKenzie, (2012), Berkman and McKenzie (2012), McKenzie and Henry (2012) Jain, Jain, McInish and McKenzie (2013).

727. In conclusion, the Authority is of the view that it is incorrect to suggest that the Black model is based on more realistic assumptions than the Sharpe Lintner CAPM. The Authority considers that the Black model simply replaces one of the underlying assumptions of the Sharpe Lintner CAPM with another, and the validity of this new assumption has not been substantiated in either theory or practice. This view is supported by McKenzie & Partington and also by Handley.[392]

Estimates of the return on zero beta portfolio under the Black CAPM

728. Network service providers and their consultants have argued that empirical results obtained from the Black CAPM are better at explaining historical stock returns for low beta assets than those obtained by the Sharpe Lintner CAPM. This is generally known as a “low beta bias”. This bias has led to the argument that the Black CAPM is better for estimating the return on equity than the Sharpe Lintner CAPM.

729. However in a report prepared for the AER in October 2014, Professors McKenzie and Partington disagreed with that view:[393]

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389 Black, F., 1972, Capital Market Equilibrium with Restricted Borrowing, *Journal of Business*, 45, pp. 444-454, p. 446.

390 Fama, E.F. and K.R. French, 2004. The Capital Asset Pricing Model: Theory and Evidence, *Journal of Economic Perspectives*, Vol. 18, pp. 25-46, p. 30.

391 McKenzie, M. and Partington, G. “A Return on Equity”, a report prepared for the Australian Energy Regulator, October 2014, p. 22.

392 Handley, J. “Advice on the Return on Equity”, a report prepared for the Australian Energy Regulator, October 2014, p. 10.

393 McKenzie, M. and Partington, G. “A Return on Equity”, a report prepared for the Australian Energy Regulator, October 2014, p. 23.

> To be clear on this point, empirical results for the Black and S-L CAPM are not directly comparable as they each involve very different investment strategies. In the S-L CAPM, the investor may hold the risk free asset. In the Black CAPM however, the investor may hold the zero beta portfolio, which consists of long and short positions. It is entirely reasonable to expect that these two strategies will have different payoffs, given their different risks and costs.
>
> The fact that the S-L CAPM produces a relationship between beta and average return that is too flat (as exemplified in Figures 2, 5 and 6 in SFG, 2014e), cannot be interpreted as evidence in support of the Black CAPM, or indeed as evidence against the S-L CAPM. It does remain an outstanding issue as to why these empirical predictions differ to the theoretical predictions of the CAPM. As noted earlier, Ray, Savin and Tiwari (2009) shows that the statistical evidence for rejecting the CAPM is weaker than previously thought when more appropriate statistical tests are used.

730. Handley (2014) has also concluded that:[394]

> The difficulty here lay in knowing how to interpret this empirical evidence. It is important to be clear that the results of Black, Jensen and Scholes (1972) and the updated results in Fama and French (2004) are said to be consistent with rather than being a direct test of the Black-CAPM. In other words, the Black-CAPM and the low beta bias are not equivalent concepts.

731. And that:

> In particular there are a number of competing (but not necessarily mutually exclusive) explanations for the low beta bias. It may reflect restrictions on riskless borrowing consistent with the Black CAPM. It may reflect the impact of barriers to international investment consistent with the international CAPM of Black (1974). Black identifies a variety of types of such barriers including the possibility of expropriation of foreign holdings, direct controls on the import or export of capital, reserve requirements on bank deposits and other assets held by foreigners, restrictions on the fraction of a business that can be foreign owned and even the barriers created by the unfamiliarity that residents of one country have with other countries. It may reflect a specification error in the proxy for the market portfolio consistent with the suggestion by Roll (1977). It may reflect model misspecification consistent with the value and/or size effects of the Fama-French model. It was also initially thought that it may reflect the impact of differential personal taxes consistent with the after-tax CAPM of Brennan (1970) but this idea has since been dismissed by subsequent research. It may reflect price pressure exerted by leverage-constrained investors who tilt their portfolios towards high-beta stocks relative to low-beta stocks in seeking higher expected returns, consistent with Frazzini and Pederson (2014). It may reflect price pressure exerted by investors who seek lottery-like stocks consistent with Bali, Brown, Murray and Tang (2014).

732. The Authority notes that estimated returns on a zero beta portfolio by NERA in 2012 were evaluated by Professors McKenzie and Partington for the AER in 2012, where they concluded that:[395]

> With regard to the robustness of the estimated zero beta return we take this to mean robustness in the sense that there is little or no variation of the estimated parameter in response to sensible alternative approaches to estimation. We conclude that, with respect **to the magnitude of the zero beta return, the estimate is not robust**. The NERA (2012) report, for example, shows estimates ranging from 6.985 percent to 10.309 percent. However, we make a more general and more important point that “the empirical zero beta portfolio” is not unique. Consequently, **there are many different**

[394] Handley, J. “Advice on the Return on Equity”, a report prepared for the Australian Energy Regulator, October 2014, p. 10.

[395] McKenzie, M. and Partington, G. “Review of NERS report on the Black CAPM”, a report prepared for the Australian Energy Regulator, August 2012.

zero beta returns that might be estimated and very large differences in the value of that return could be obtained [emphasis added].

733. The Authority notes that empirical estimates have been conducted by consultants for network service providers in Australia. Key findings from these studies are summarised as follows:

- CEG (2008) used Australian data from 1964 to 2007 and reported estimates of the zero beta premium that range between 7.21 per cent per annum and 10.31 per cent per annum using various cross-sections of stocks traded on the ASX data formed into 10 portfolios on the basis of past estimates of beta.[396]
- NERA (2013) used Australian data from 1974 to 2012 and reports estimates of the zero beta premium that range between 8.74 per cent per annum and 13.95 per cent per annum using both individual stocks and stocks formed into portfolios on the basis of past estimates of beta.[397]
- SFG (2014) reported an estimate of the zero beta premium of 3.34 per cent per year. This study was based on 20 years of returns information from 1994 and 2013.[398]

734. In their recent report prepared for the AER, Partington and Satchell also concluded that:[399]

> Beaulieu, Dufour and Khalaf have been working on this problem [of estimating zero beta return] for over a decade and have developed improved estimation procedures. Applying these procedures they conclude that the estimate of the zero beta return is unstable over time. Although these improved procedures are a valuable contribution to the research literature, they involve complex econometrics and are not yet widely accepted. Consequently, we would not currently recommend them for regulatory use.

735. Partington and Satchell noted that:[400]

> Given that an inefficient portfolio is used as the proxy for the market portfolio there is an infinite possible set of zero beta returns and even when you constrain the estimate by using a regression model, what you get is very much determined by what you do. Hence the wide range of estimates previously submitted by regulated business.

736. And that:[401]

> First, the estimate of the return on the zero beta portfolio is sensitive to the choice of the portfolio used to represent the market and it can be very sensitive to this choice. Second the sensitivity depends on the curvature of the efficient frontier lying between alternative portfolios used to represent the market.
>
> At a theoretical level the choice of portfolio to represent the market leads to a multiplicity of possible values for the zero beta return and what you get in empirical work depends very much on what you do. The very substantial variation in the estimates provided by

396 CEG (September 2008) *Estimation of, and correction for, biases inherent in the Sharpe CAPM formula,* a report prepared for the Energy Networks Association Grid Australia and APIA.

397 NERA Economic Consulting (June 2013) *Estimates of the Zero-Beta Premium,* a report prepared for the Energy Networks Association, p. 16 and p. 23.

398 SFG Consulting (2014) *Cost of equity in the Black Capital Asset Pricing Model,* a report prepared for Jemena Gas Networks, ActewAGL, Ergon, Transend, TransGrid, and SA PowerNetworks, p. 27.

399 Partington, G. and Satchell, S. "Report to the AER: Analysis of Criticism of 2015 Determinations", a report prepared for the Australian Energy Regulator, October 2015, p. 19.

400 Partington, G. and Satchell, S. "Report to the AER: Analysis of Criticism of 2015 Determinations", a report prepared for the Australian Energy Regulator, October 2015, p. 20.

401 Partington, G. and Satchell, S. "Report to the AER: Analysis of Criticism of 2015 Determinations", a report prepared for the Australian Energy Regulator, October 2015, p. 26.

> the regulated businesses, and the theoretical and empirical work showing the unreliable nature of zero beta return estimates, clearly suggests that estimates of zero beta returns are not appropriate for use in determining regulated returns.

737. Based on its recent analysis, the Authority notes that various approaches have been attempted to estimate the zero-beta portfolio returns. The Authority is of the view that the differences in method illustrate that there are a significant number of decision variables involved in determining how a zero-beta return may be calculated. These different methods can influence the estimates of the zero-beta return. Moreover, the different methods seem to have undue influence on the calculation of the ratio of the zero-beta premium over the market-ratio premium, which from the Authority's estimates range from 0.52 to 1.27 between methods. This ratio is key to the beta star calculation proposed by DBP in its model adequacy test. Further details of the Authority's analysis are included in Appendix 2A.

738. In conclusion, the Authority is of the view that the estimates of the zero beta premium are not robust and that there are many different zero beta returns which could be estimated. Therefore, the differences in the value of the estimates may vary significantly from study to study as previously presented. The issue of wide estimates of the zero beta premium is closely linked with the argument that the Black CAPM is not widely used by academics and practitioners, as discussed in detail below.

The Black CAPM is not widely used by academics or practitioners

739. The Authority is of the view that the Black CAPM is not widely used by academics as an approach to estimating a return on equity, either in Australia or overseas. Neither is the Authority aware of any regulator in Australia or overseas who has utilised the Black CAPM to provide a direct estimate of the return on equity in its decisions. This view is supported McKenzie & Partington and Handley.

740. In addition, Handley argued that:[402]

> The Black CAPM is not widely adopted in practice – there is one very good reason for this. The theoretical prediction which distinguishes the Black-CAPM from the Sharpe-CAPM is that the (shadow) risk free interest rate – more commonly called the zero beta rate – is unspecified except to say that it must be less than the expected return on the market portfolio. In the partially-restricted version of the model, the zero beta rate must also be above the risk free rate. From a practical point of view, this is not very useful due to the wide range of possible values that the zero beta rate may take on. The Black-CAPM therefore presents the non-trivial task of having to estimate the expected zero beta rate which the theory says could be anywhere in a very wide range as well as having to estimate an expected market risk premium relative to the expected zero beta rate.

CEG's review

741. CEG considered a range of studies which estimate the zero beta premium and concluded that all estimates are materially above zero.[403] In particular, CEG noted that, in any event, there are now at least three studies of the zero beta premium that have been undertaken in the Australian context – CEG (2008), NERA (2012), and

402 Handley, J. *"Advice on the Return on Equity", a report prepared for the Australian Energy Regulator*, October 2014, p. 12.

403 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 13.

SFG (2014). These studies find a zero beta premium of between 50 per cent and 100 per cent of the market risk premium.[404]

742. CEG considered that the Authority's view on credibility of results from empirical studies on the estimate of zero beta premiums is inappropriate.[405] CEG was also of the view that the Authority's prior assumption that - beta must be an important determinant of risk and that, therefore, any study that finds it is not must be wrong – is inappropriate.[406]

743. The Authority is of the view that the estimates of zero beta portfolio premiums are not settled. As previously discussed, the Authority maintains its view that it is incorrect to suggest that the Black model is based on more realistic assumptions than the Sharpe Lintner CAPM. The Authority considers that the Black model simply replaces one of the underlying assumptions of the Sharpe Lintner CAPM with another, and the validity of this new assumption has not been substantiated in either theory or practice.

744. In addition, the Authority is also of the view that the Black CAPM has not gained support to be implemented in the Australian regulatory environment. This view is based on the following two strong grounds: (i) estimates of zero beta premiums, a key input to the Black CAPM, vary significantly across studies; and (ii) the model has not been widely used by practitioners and academics.

The Authority's decision on the Black CAPM

745. The Authority has come to the view that the Black CAPM is relevant for the purpose of estimating a return on equity for regulatory decisions in Australia. All of its underlying assumptions except for one are the same as those underlying the Sharpe Lintner CAPM. The Black model therefore satisfies the criterion of having a theoretical foundation.

746. The concept of zero beta portfolio, however, is not well established. Estimates of the zero beta premium are both unstable and unreliable, particularly in the Australian context. Neither is the Black CAPM widely adopted by academics or practitioners in Australia or overseas for estimating a return on equity directly. None of the estimates of a return on equity that are made using the Black CAPM are sufficiently robust. The Authority considers that it is therefore impractical to utilise the Black CAPM to determine the return on equity directly.

747. However, the Authority will recognise the theoretical insight from the Black CAPM when estimating a return on equity with the Sharpe Lintner CAPM. The Authority will have regard to these outcomes when estimating the equity beta from within the estimated range.

The Fama French three-factor model

748. The Authority in the Final Decision for ATCO noted that the FFM has consistently been put forward by regulated businesses as a means to estimate the return on equity. However, in its previous regulatory decisions, the Authority concluded that

[404] Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 14.

[405] Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 15.

[406] Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 15.

there is no strong theoretical basis to support the inclusion of the two additional risk factors to estimate the rate of return on equity, as occurs in the FFM. This is because the FFM is dependent on empirical justification – that is, the systematic observance of the FFM risk premia. Given that the FFM risk premia are not systematically observed in the Australian market, there is no reasonable basis for the FFM to be applied in Australia.

749. The Authority notes that the most recent analysis of the FFM in the context of the Australian market for equity showed that observed empirical evidence is not consistent with the FFM.[407] The Authority notes that the findings from this recent analysis are consistent with other Australian empirical studies: factors from the FFM are not consistently observed in the Australian context.

750. The Authority does not agree with SFG's comments that 'no reasonable person could possibly give any weight to the ERA "study" of the Fama- French model over the published study of Brailsford, Gaunt and O'Brien, which concludes that "the three-factor model is found to be consistently superior to the CAPM":[408] The Authority is of the view that there is no accepted good practice in relation to implementation of the FFM because there is no widely accepted correct method of applying the FFM. For example, in its own study in relation to the application of the FFM in Australia, using the same dataset, the Authority has demonstrated that outcomes obtained from the FFM will be significantly different when the approach to portfolio formation is different. However, the Authority notes that the above conclusion has been drawn from a sample of various empirical studies, as presented in Table 20. The Authority is of the view that given the inherent instability of the findings obtained from the Fama French model for the Australian context, findings from various studies should be considered.

751. Together with other evidence, presented in Table 20 below, the Authority is of the view the FFM is empirically unstable due to the fact that the model is not developed on a robust theory. The Authority does not agree that one study is superior to the other.

752. The Authority's analysis considered the robustness of the estimates of the two additional risk premia (size factor and value factor) from the FFM in the Australian context. The study was conducted using a consistent dataset under various scenarios in which different proxies are used and under different approaches in which portfolios are formed.

753. The Authority's analysis points to conflicting, variable FFM risk premia and inconsistent FFM factor coefficients, depending on the proxies and/or different portfolios adopted. It is noted that while the size factor is relatively well explained, the value factor is not. These findings are in line with other empirical studies in Australia.

754. Overall, the Authority remains of the view that the FFM cannot contribute to the rate of return objective. A wide range of evidence, together with its own empirical analysis, suggests that the FFM is not fit for the purpose of estimating the return on equity, as:

407 Vo, D. (2015), 'Which factors are priced: An application of the Fama French three factor model in Australia", *Economic Papers: A Journal of Applied Economics and Policy*, 2015, Vol. 34, No.4, December 2015, pp.290-301.

408 ATCO Gas Australia, Response to the ERA's Draft Decision on required amendments to the Access Arrangement for the Mid-West and South-West Gas Distribution System, 27 November 2014, Appendix 9.1, p. 66.

- applications of the FFM in Australia fail to produce consistent outcomes;
- the key contribution from the FFM is that the additional factors – the size (**SMB**) and value (**HML**) factors – are priced in explaining the return on equity;
- however, studies in the Australian context do not consistently report this pricing – some studies price the size factor, while others price the value factor;
- different proxies are adopted in different empirical studies, with the result that the estimates from the FFM vary significantly from study to study;
- the Authority found – in its own empirical work – that adopting different portfolio formation on the same dataset will provide different outcomes, yet portfolio formation is a key characteristics of the FFM;
- more than 300 different factors have been examined in empirical studies to date, but there is no body of theory to support which factors should be considered; and
- Fama himself now recognises that the Fama French three factor model is an empirical test, and is not based on theory, confirming the oft stated view of Australian regulators.[409]

755. These points are further considered in what follows.

The Fama French three factor model was not developed on a theoretical foundation

756. Network service providers have argued that the FFM was developed on the basis of the Arbitrage Pricing Theory (**APT**) (Ross, 1976) as an alternative to the CAPM. The APT predicts that the return to any risky asset is linearly related to a set of k factors. This is in contrast with the CAPM's prediction that all returns of any risk security are linearly related to a single factor; the return on the market portfolio. Under the APT, the relationship between risk and return can be expressed as (33).

$$E(R_i) = R_F + \beta_{i,1}\left(E(R_{i,1}) - R_F\right) + \beta_{i,2}\left(E(R_{i,2}) - R_F\right) + ... + \beta_{i,k}\left(E(R_{i,k}) - R_F\right) \qquad (33)$$

where:

- $E(R_i)$ is the expected return on asset;
- $\beta_{i,k}$ is the security's beta with respect to the k^{th} factor;
- $E(R_{i,k})$ is the expected return on the k^{th} factor; and
- R_F is the risk free rate of return.

757. It is noted that the APT model does not specify any factors which may be included in the estimate of a return on equity. As a result, it may be argued that the APT model fails in terms of fully specifying a model. That leaves the relevant model factors open to interpretation, of which there have been many.

409 E. Fama and K. French, *A Five-Factor Asset Pricing Model*, 2014, Working Paper available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2287202

758. Fama and French (1993) presented a three factor model of asset returns. Their model incorporates the predictions of the CAPM by including the return on the market portfolio as a factor. In addition to this factor, Fama and French (1993) also included two additional factors that had been found to be statistically significant in explaining the cross section of average returns. These two factors are: (i) firm size, which is measured by market capitalisation (the **SMB** factor), and (ii) the ratio of the book value of equity to the market value of equity (the **HML** factor). The Authority considers that these two factors were selected on the basis of data exploration. The selection was not guided by any economic theory.

759. Four years after the initial publication of the FFM, Carhart incorporated another factor, making it a four-factor model. The fourth factor is intended to capture the momentum in returns. The Authority is of the view that the selection of this factor was also not supported by any economic theory.

760. The Authority disagrees with SFG's view that the FFM was developed on the foundations of the inter-temporal CAPM and the APT. The Authority notes that in these two theories, no specific factors or attributes are presented. As further discussed in detail in the following sections, the Authority considers that neither of the two factors (the SMB and the HML) are appropriate for use in estimating the rate of return. *Firstly*, Brailsford, Gaunt and O'Brien (2012), which in SFG's view is the most recent and comprehensive estimates of the FFM using Australian data, concluded that only the HML factor is priced in Australia. This means that the size factor (SMB) is not priced in Australia. *Secondly*, in their most recent five factor model, Fama and French concluded that the HML has become redundant in explaining average returns.

761. The Authority notes that while Brailsford, Gaunt and O'Brien concluded that only a *value factor* (HML) is priced in the Fama French three-factor model, Fama and French concluded that this factor (HML) is becoming redundant in their multi factor model. On the balance of the above evidence, the Authority remains of the view that the FFM was not developed on a theoretical foundation.

New factors included in the Fama French three factor model are found through data exploration

762. Most multi-factor models including the FFM can be classified as parametric or empirical models. These models are not developed on the foundation of any robust economic theory. The term *empirical* refers to their development on the evidence of interrogating historical financial data for regularities and relationships. It is argued that in creating these empirical models, their authors examine the historical data directly in order to extrapolate relationships between the attributes of the data and expected returns. If the resulting relationships are found to be statistically significant within a given data set, then these attributes (or factors) are used to explain an expected return.[410]

763. Professor Fama, a Nobel Prize winner in 2013 and one of the two authors of the FFM acknowledged that:[411]

> The three-factor model is an **empirical** asset pricing model. Standard asset pricing models work forward from assumptions about investor tastes and portfolio opportunities

410 Fama, E. (2014). "Two Pillars of Asset Pricing", *American Economic Review,* Vol. 104 (6), 1467-1485, p. 1480.

411 Fama, E. (2014). "Two Pillars of Asset Pricing", *American Economic Review,* Vol. 104 (6), 1467-1485, p. 1480.

to predictions about how risk should be measured and the relation between risk and expected return. Empirical asset pricing models work backward. They take as given the patterns in average returns, and propose models to capture them. The three-factor model is designed to capture the relation between average return and size (market capitalization) and the relation between average return and price ratios like the book-to-market ratio, which were the two well-known patterns in average returns at the time of our 1993 paper. [emphasis added]

764. Since the introduction of the FFM in 1992, Fama and French have stood for the view that their two new factors of:

- firm size, which is measured by market capitalisation; and
- the ratio of the book value of equity to the market value of equity;

\- can be used to explain a cross section of an expected return for a particular asset. In the years subsequent to the publication of the Fama French model, academic researchers have presented various new factors with the claim that they are also able to explain a cross section of an expected return.

765. The Authority notes that Fama and French have also moved away from the three-factor model. In 2014, Fama and French developed a five-factor model in which portfolios are formed on the basis of:

- market portfolio;
- firm's size (Small Minus Big – **SMB**);
- the ratio of the book value of equity to the market value of equity (High Minus Low – **HML**);
- profitability (Robust Minus Weak profitability – RMW); and
- investment (Conservative Minus Aggressive investment – **CMA**).

766. Fama and French concluded that their new five-factor model provides better descriptions of average returns than their three-factor model. They also found that a market to book factor is no longer "priced" when it is included in the five factor model, although this effect may be sample specific:[412]

> The five-factor model **outperforms** the original three-factor model on all metrics and it generally outperforms other models, with one major exception. Specifically, the five-factor model and the four-factor model that excludes *HML* are similar on all measures of performance, including the *GRS* statistic. [emphasis added]

and that:

> We note above that the five-factor model never improves the description of average returns from the four-factor model that drops HML. The explanation is interesting. The average HML return is captured by the exposures of HML to other factors. Thus, in the five-factor model, **HML seems to be redundant for explaining average returns**. [emphasis added]

767. The introduction of the Fama French five-factor model has placed the validity of the book-to-market value factor in doubt. Fama and French have argued the validity of this HML factor in explaining cross section of equity returns in the last two decades. However, they argued that the findings in their five-factor model in relation to the HML factor happen due to a sample specific issue.

412 E. Fama and K. French, *A Five-Factor Asset Pricing Model*, 2014, Working Paper available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2287202, p. 19.

768. In their report prepared for the AER in October 2014, Professors McKenzie and Partington concluded that:[413]

> Following the work of Roll and Ross (1980), Chen (1983), Chen, Roll and Ross (1986), Burmeister, and Wall (1986), Burmeister and McElroy (1988) and McElroy and Burmeister (1988) inter alia, an alternative strand of the literature explains equilibrium returns using macroeconomic factors. These include factors such as unanticipated shock to industrial production or inflation, movements in the default premium or shifts to the slope of the term structure of interest rates.

769. McKenzie and Partington note that there is no real overlap between the factors used in this literature and those used in Fama and French (1993, 2014 inter alia) type studies.

770. More recently, Harvey et al (2014) presented a useful review of the available literature seeking to explain asset returns. Papers focussing on small groups of stocks, or employing data collected over short periods of time were omitted from the study. This review found 312 papers suggesting a total of 315 different factors that might be used to explain asset returns. It is important to note that Harvey et al (2014) are quick to acknowledge that this list of factors is not exhaustive:[414]

> Our collection of 315 factors likely under-represents the factor population. First, we generally only consider top journals. Second, we are very selective in choosing only a handful of working papers. Third, and perhaps most importantly, we should be measuring the number of factors tested (which is unobservable) — that is, we do not observe the factors that were tested but failed to pass the usual significance levels and were never published.

771. Harvey et al (2014) also stated that:[415]

> Our goal is not to catalogue every asset pricing paper ever published. We narrow the focus to papers that propose and test new factors.
>
> Since our focus is on factors that can broadly explain asset market return patterns, we omit papers that focus on a small group of stocks or for a short period of time. This will, for example, exclude a substantial amount of empirical corporate finance research that studies event-driven return movements.
>
> To include the most recent research, we search for working papers on SSRN. Working papers pose a challenge because there are thousands of them and they are not refereed. We choose a subset of papers that we suspect are in review at top journals or have been presented at top conferences or are due to be presented at top conferences. We end up using 63 working papers. In total, we focus on 312 published works and selected working papers. We catalogue 315 different factors.

772. The key conclusion from this paper is that:[416]

> Hundreds of papers and hundreds of factors attempt to explain the cross-section of expected returns. Given **this extensive data mining**, it does not make any economic or statistical sense to use the usual significance criteria for a newly discovered factor, e.g., a t-ratio greater than 2.0. However, what hurdle should be used for current research? Our paper introduces a multiple testing framework and provides a time series

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413 McKenzie, M. and Partington, G. "A Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 16.

414 Harvey, C; Liu, Y. and Zhu, H. (2014), *… and the Cross-Section of Expected Returns*, Working Paper available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2249314, p. 3.

415 Harvey, C; Liu, Y. and Zhu, H. (2014), *… and the Cross-Section of Expected Returns*, Working Paper available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2249314, pp. 2-4.

416 Harvey, C; Liu, Y. and Zhu, H. (2014), *… and the Cross-Section of Expected Returns*, Working Paper available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2249314, the first page (Abstract).

> of historical significance cut-offs from the first empirical tests in 1967 to today. We develop a new framework that allows for correlation among the tests as well as missing data. We also project forward 20 years assuming the rate of factor production remains similar to the experience of the last few years. The estimation of our model suggests that today a newly discovered factor needs to clear a much higher hurdle, with a t-ratio greater than 3.0. Echoing a recent disturbing conclusion in the medical literature, we argue that most claimed research findings in financial economics are likely false. [emphasis added]

191. In addition, McKenzie and Partington (2014), Subrahmanyam (2010) documents over 50 variables that have been used to predict stock returns and concluded that:[417]

> The research at this point presents a rather unsatisfying picture of a morass of variables, and an inability of us finance researchers to understand which effects are robust and which do not survive simple variations in methodology and use of alternative controls (p. 35)

and that:

> As a central theme, I maintain that our learning about the cross-section is hampered when so many predictive variables accumulate without any understanding of the correlation structure between the variables, and our collective inability or unwillingness to adequately control for a comprehensive set of variables (p. 28).

773. Green et al (2014) documented over 330 predictive return signals and concluded that:[418]

> given the large number of Return Predictive Signals (RPS) that have already been reported in the literature and the high degree of multidimensionality we empirically find to be present in returns, we propose that an important avenue for future research is to understand why returns are so highly dimensional, and why the most important multidimensioned RPS are priced the way they are (p. 26).

774. On the basis of the findings from the study by Green et al (2014), McKenzie and Partington concluded that:[419]

> Green et al (2014) find that 24 of 100 readily programmed signals are multidimensionally priced (i.e. the mean coefficient estimates produced t-statics in excess of 3). The authors suggest that increasing the dimensionality of the cross-section is important **as the size and book-to-market factors are not the most statistically significant predictive signals**. This is an interesting point in the current context as recall from our earlier discussion that in order to operationalise the APT, the number of assets, *n*, must exceed the number of factors, *k*. Given that we have so few assets in the Australian context, **this presents a serious problem for operationalising a model with many factors** [emphasis added].

775. In response to the extensive data mining in empirical studies on asset pricings, Harvey et al (2104) considered that it is appropriate to change the way in which we think about factors as being important. One possible solution is to introduce additional testable assumptions that a systematic risk factor has to satisfy before it can claim to be significant. In addition, as presented in Pukthuanthong and Roll (2014), a seven-stage protocol could be followed to identify and measure important

417 McKenzie, M. and Partington, G. "A Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 16.

418 McKenzie, M. and Partington, G. "A Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 16.

419 McKenzie, M. and Partington, G. "A Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 17.

factors. Harvey and Liu (2014) on the other hand argue that an evaluation of the economic contribution of a risk factor should be used to determine its importance.

776. Whatever the case, it appears clear that any number of factors can be found to have explanatory power, but that these cannot be relied upon for estimating the return on equity in any meaningfully robust sense.

The estimates from the Fama French three-factor model vary significantly and produce mixed results

777. There have been various attempts to apply the Fama French three factor model in Australia using Australian data. It is noted that the results from these studies are mixed, as presented in Table 20 below.

Table 20 Applications of the Fama French three-factor model in Australia

Authors	Year	Studied period	Risk premia		FFM parameter analysis		
			HML (%)	SMB (%)	Intercept not significant	HML coefficients significant	SMB coefficients
Fama & French[420]	1998	1975-1995	12.3	N/A	N/A	N/A	N/A
Halliwell et al.[421]	1999	1980-1991	14.6	6.0	23 of 25	6 of 25	18 of 25
Faff[422]	2001	1991-1999	14.0	-9.0	20 of 24	7 of 24	11 of 24
Faff[423]	2004	1996-1999	6.0	-6.5	19 of 24	14 of 24	18 of 24
Gaunt[424]	2004	1993-2001	8.5	10.0	19 of 25	21 of 25	13 of 28
Ghargori, Chan & Faff[425]	2007	1996-2004	10.4	17.2	24 of 27	20 of 27	14 of 27
O'Brien et al.[426]	2008	1982-2006	9.4	4.3	14 of 25	22 of 25	16 of 25
Kassimatis[427]	2008	1993-2005	12.6	11.5	11 of 25	20 of 25	11 of 25
Ghargori, Lee & Veeraghavan[428]	2009	1993-2005	N/A	N/A	2 of 12	10 of 12	5 of 12
Brailsford; Gaunt & O'Brien, 2012[429]	2012	1982-2006	9.1	-2.6	24 of 25	15 of 25	22 of 25
Brailsford; Gaunt & O'Brien[430]	2012	1982-2006	12	N/A	Varies depending on the approach of portfolio formation		
Vo, Duc[431]	2015	2009 - 2014	N/A	N/A	Significant different outcomes across various scenarios and depending on the formation of different portfolios		

Source: Economic Regulation Authority's analysis

420 Fama, E. and French, K., "Value versus Growth: The International Evidence", *The Journal of Finance,* Vol. 53, No. 6 (Dec., 1998), pp. 1975-1999.

421 Halliwell, J. Heaney, R. and Sawicki, J., 'Size and book to market effects in Australian share markets: a time series analysis', *Accounting Research Journal*, 1999, vol. 12, pp. 122–137.

422 Faff, R. 'An examination of the Fama and French three-factor model using commercially available factors', *Australian Journal of Management*, 2001, vol. 26, pp. 1–17.

423 Faff, R., 'A simple test of the Fama and French model using daily data: Australian evidence', *Applied Financial Economics*, 2004, vol. 14, pp. 83–92.

424 Gaunt, 'Fama–French model: Australian evidence', *Accounting and Finance*, 2004.

425 Gharghori, P.; Chan, H. and Faff, R. 'Are the Fama–French factors proxying default risk?', *Australian Journal of Management*, December 2007, vol. 32(2), pp. 223–249.

426 O'Brien, Brailsford, and Gaunt, 'Market factors in Australia', Australasian Finance and Banking Conference, 2008.

427 Kassimatis, K. 'Size, book to market and momentum effects in the Australian stock market', *Australian Journal of Management*, June 2008, vol. 33(1), pp. 145–168.

428 Gharghori, P.; Lee, R. and Veeraraghavan, M. 'Anomalies and stock returns: Australian evidence', *Accounting and Finance*, 2009, vol. 49, pp. 555–576.

429 Brailsford, T., Gaunt, C., and O'Brien, M. (2012), 'Size and book-to-market factors in Australia", *Australian Journal of Management*, 2012, vol. 37, pp. 261-81.

430 Brailsford, T., Gaunt, C., and O'Brien, M. (2012), 'The investment value of the value premium", *Pacific-Basin Finance Journal*, 2012, vol. 20, pp. 416-37.

778. Based on the comparison shown in Table 20, the Authority is of the view that these estimates are best characterised as an unsystematic observation of the estimates of the Fama–French risk premium. This is indicative of the inadequacy of estimates that are made on the basis of an empirical relationship without the foundation of an economic theory. This view is also confirmed when the estimates of the HML and SMB risk premia from the FFM are compared across studies for the Australian capital market, as shown in Table 20.

779. Table 20 shows that the ranges of the HML risk premia, from 14.6 per cent to 6 per cent, and of SMB risk premia, from 17.2 per cent to -9 per cent, can be considered too large to confirm the presence of the risk factors when using the FFM in Australia. The FFM predicts that the HML and SMB coefficients estimated from the models should be statistically significantly different to zero. On this prediction, except for an estimate of 4.3 per cent for the SMB risk premium in the 2008 O'Brien et al study, other estimates are significantly different from zero at the 5 per cent level of confidence. Additionally, the FFM also predicts that the intercept from the regression, which is the proportion of the observed return that is not explained by the FFM, should not be significantly different from zero. While there are some studies where the FFM performs well, such as Ghargori, Chan and Faff (24 out of 27 portfolios have intercepts that are not statistically significant from zero), there are studies in which the FFM performs poorly, such as Ghargori, Lee and Veeraghavan (only 2 out of 12 portfolios have intercepts that are not statistically significant from zero).

780. The Authority disagrees with SFG's view that a range of studies of variable quality produce a range of estimates and therefore should not be used as the basis for the outright rejection of the entire model and that a better approach is to consider the robustness and the reliability of the best available estimates of each model. The Authority is of the view that a consideration of various studies altogether will provide more comprehensive information in relation to the validity of the FFM. This view is supported by McKenzie and Partington in their report to the AER:[432]

> What are the objective criteria for low quality studies? Surely, SFG are not suggesting that empirical studies coming from academic colleagues such as Robert Faff, one of Australia's top finance professors, is a low quality study (Eg: Faff (2004)) just because it produces estimates that do not support the consultants view. We simply view the evidence of parameter instability from the empirical literature as symptomatic of the weakness of the model.

The Fama French three-factor model is not used by economic regulators either in Australia or overseas

781. The FFM has not been adopted in the estimation of a return on equity by any economic regulators, either in Australia or overseas (Table 21).

431 Vo, D. 'Which factors are priced: An application of the Fama French three factor model in Australia", *Economic Papers: A Journal of Applied Economics and Policy*, 2015, Vol. 34, No.4, December 2015, pp.290-301.

432 McKenzie, M. and Partington, G. "A Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 18.

Table 21 Fundamental models adopted by Australian and international regulators in estimating a return on equity

	Australia	Germany	New Zealand	USA	Canada	UK
Regulator	**Australian Energy Regulator (AER)**	**The Federal Network Agency (FNA)**	**The Commerce Commission (CC)**	**New York State Public Utilities Commission (NYSPUC)**	**The Ontario Energy Board (OEB)**	**The Office of Gas and Electricity Markets (Ofgem)**
Primary model	CAPM	CAPM/RPM	CAPM	DDM	RPM	CAPM
Secondary model				CAPM		
Other use of DDM	*Cross-check on MRP*		*Cross-check on MRP*		*Cross-check on MRP*	*Cross check on the overall cost of equity but not for individual firms*

Notes: CAPM: Sharpe Lintner Capital Asset Pricing Model

RPM: Risk Premium Model

DDM: Dividend Discount Model

Source: Sudarsanam, Kaltenbronn, and Park (2011)

782. In the report prepared for the AER in October 2014, Professors McKenzie and Partington concluded that:[433]

> the main discussion of this section of our report highlights the nascent literature suggesting that the use of the Fama and French model is no longer optimal, and may indeed lead to invalid, incorrect or misleading inference. Even the originators of this model, Fama and French (2014) themselves, have contributed to this literature. It would seem unusual to adopt a model 21 years after its publication, when its weaknesses are becoming more evident and contemporary research is just beginning to understand the possible causes and potential solutions.

and that:

> We do not view the FFM as having the ability to reliably estimate the required return on equity for a benchmark regulated network service provider. **The FFM is used to estimate the average return in the cross section and the benchmark regulated network services provider is not average given its relatively low economic risk**. The evidence suggests that the estimates for Australia using the Fama and French approach are unstable and depend on both the cross section of firms selected and the sample period chosen [emphasis added].

783. In addition, in the report prepared for the AER in 2015, Satchell and Partington noted that:[434]

> With the original Fama and French model under revision by its originators, this does not seem to be an appropriate time for the AER to adopt the FF model and follow a path that other regulators have avoided.

433 McKenzie, M. and Partington, G. “A Return on Equity”, a report prepared for the Australian Energy Regulator, October 2014, p. 19.

434 Partington, G. and Satchell, S. “Report to the AER: Analysis of Criticism of 2015 Determinations”, a report prepared for the Australian Energy Regulator, October 2015, p. 18.

CEG's review

784. CEG considered that it is unreasonable to prefer the Sharpe Lintner CAPM to the FFM on the grounds that the Sharpe Lintner CAPM is solidly based in theory and the others are based on empirical relationship.[435] CEG was of the view that the Authority should test the Sharpe Lintner CAPM and, if the Sharpe Lintner CAPM does not explain Australian stock market returns, it should also be rejected in favour of the Empirical CAPM.[436]

785. The Authority does not agree with CEG's view in relation to the Sharpe Lintner CAPM. The Authority is of the view that each of the inputs adopted in the model are selected based on various pieces of evidence. More importantly, the Authority notes that the overall return on equity derived from the Sharpe Lintner CAPM is crossed checked with other evidence to ensure that the final estimate is robust and reasonable. Detailed discussions in relation to the Sharpe Lintner CAPM can be found from paragraph above.

Authority's decision on the Fama French three-factor model

786. Based on the above analyses, the Authority is of the view that the Fama French three-factor model is neither relevant nor fit for the purpose of estimating a return on equity for a regulatory decision in Australia. As a result, the Authority remains of the view that the FFM should play no role in estimating a return on equity for DBP. This decision is based on the following considerations:

- The Fama French three-factor model was not developed on a theoretical basis.
- New factors that are now included in the new Fama French five factor model raise questions about the validity of the FFM three factor model.
- The estimates from the Fama French three factor model vary significantly and produce mixed results.
- The Fama French three factor model is not used by economic regulators either in Australia or overseas to estimate the expected return on equity.

192. The Authority notes that its decision in relation to the Fama French three-factor model to estimating the return on equity for DBP is fully supported by the most recent report prepared by Professors Partington and Satchell:[437]

> The foregoing are the reasons why McKenzie and Partington (2014) and Partington (2015), although suggesting that both the Fama and French and zero beta CAPM could have a role to play in determining the required rate of return, also suggest that it is not clear how, and in particular that we would not recommend using empirical estimates of the Fama and French model to determine the cost of capital in the Australian context.

The Dividend Growth Model

787. With regard to the DGM, the Authority in the Rate of Return Guidelines considered applying the DGM for the purpose of estimating the return on equity for the individual

435 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 16.

436 Competition Economists Group, "ERA treatment of asset pricing models", *a report prepared for DBP,* December 2014, p. 17.

437 Partington, G. and Satchell, S. "Report to the AER: Analysis of Criticism of 2015 Determinations", a report prepared for the Australian Energy Regulator, October 2015, p. 18.

infrastructure firm.[438] However, the Authority noted that the results are very sensitive to inputs, and hence to analyst discretion, particularly relating to growth rates. The Authority was not convinced that DGM estimates can be relied upon for individual equities, and hence for estimating the return on equity to the benchmark firm.

788. In this context, the Authority notes that the AER investigated the possibility of using the DGM for estimating the return on equity for individual infrastructure businesses in Australia.[439] The AER found that the DGM estimates could not be relied upon as, among other things, the average estimated return on equity is consistently higher than that of the market over recent periods from 2006, even with real growth of dividends at zero; thus failing a basic 'sanity check'.

789. Having considered these findings, the Authority remains of the view that the DGM cannot be relied upon for estimating the return on equity for the firm.

SFG's (2014) study

790. The Authority notes that SFG's (2014) study was not considered in its Rate of Return Guidelines, released in December 2013, as it post-dated that evaluation.[440]

791. The study is now considered with regard to the following key features:

- overall approach to estimating the return on equity for the market using a DGM;
- use of the model for estimating the return for the benchmark efficient entity'; and
- conversion from a 'without-imputation MRP' (or return on equity) to a 'with-imputation MRP' (or return on equity).

SFG's overall approach of estimating a return on equity using a DGM

792. The Authority notes that estimates of the market cost of equity over time under SFG's approach are conducted using a simultaneous estimation technique, where an estimate of the cost of equity is developed simultaneously with an estimate of long-term growth and returns on investment. SFG is of the view that if the long-term growth assumption is held constant, then all changes in share prices and analyst forecasts are captured in changes to the estimated discount rate.

793. SFG considers that this is unlikely to be true, on the basis that share prices are likely to fluctuate because of changes in expectations for growth in dividends outside of the explicit forecast period of two years, and because of changes in discount rates. SFG concludes that one reason why dividend discount model estimates of the cost of equity are met with distrust is that they fluctuate too much. SFG is of the view that estimates under the DGM approach fluctuate too much because of the fixed growth assumption.[441]

438 Economic Regulation Authority, Appendices to the Explanatory Statement for the Rate of Return Guidelines, 16 December 2013, p. 75.

439 Australian Energy Regulator, *Explanatory Statement: Rate of Return Guideline*, December 2013, p. 119.

440 SFG Consulting (2014) *Alternative versions of the dividend discount model and the implied cost of equity,* a report prepared for Jemena Gas Networks, ActewAGL, APA, Ergon, Networks NSW, Transend and TransGrid.

441 SFG Consulting (2014) *Alternative versions of the dividend discount model and the implied cost of equity,* a report prepared for Jemena Gas Networks, ActewAGL, APA, Ergon, Networks NSW, Transend and TransGrid, p. 46.

794. SFG argues that the main difference between its estimation technique, and that of the AER's DGM estimates, is that SFG's growth rate estimate is contingent upon the share price, earnings per share forecast, and dividends per share forecast. SFG notes that the AER's long run growth rate estimate is independent of the share price, earnings per share forecast, and dividend per share forecast.[442] In addition, SFG argues that its estimation technique generates cost of equity estimates that are more stable over time than a technique that assumes constant growth.

795. The Authority is of the view that the SFG's proposed approach in estimating a cost of equity is not well established and that the approach (or its deviations from the approach) has not been considered or adopted by any regulator in Australia and overseas. Further, the Authority considers that the approach is not developed on a robust theoretical basis.

796. The Authority's view is supported by the opinions of experts, which are summarised below.

797. In a report prepared for the AER in October 2014, Handley (2014) was of the view that:[443]

> The DGM proposed by SFG essentially adopts a brute force approach to estimating the implied cost of equity for the market. It substitutes a large number of combinations of a set of parameter estimates into an assumed valuation model – in this case, a ten-year three-stage DGM – with the objective of simultaneously determining the expected cash flows and discount rate which best fits the data, subject to certain assumed constraints.
>
> The model is interesting but the regulatory environment involving an aggregate regulatory asset base measured in the tens of billions of dollars is not an appropriate setting to trial a new model whose widespread use and acceptance is yet to be established.

798. In addition, Professors McKenzie and Partington were of the view that:[444]

> SFG (2013f) have added another choice to the mix, jointly estimate the cost of equity, the return on equity investment and the dividend growth rate, utilising a relation between the dividend growth rate the return on equity and the reinvestment rate. Clearly this has not yet become the definitive choice. As an additional choice among many, we are unconvinced about the merits of the SFG model. A reasonable requirement, before adopting the SFG model as a preferred choice over well-established models, would be substantial agreement on its superiority in the research literature and/or extensive use in practice.

799. McKenzie and Partington observed that application of this form of DGM could generate virtually any return on equity estimate depending on the specification of the model:

> SFG constrain the choices available by requiring that their estimates meet certain criteria. As we have pointed out before… the result is that assumptions about the long term growth rate are replaced by assumptions about how the massive set of available choices should be filtered. Since the available set of choices is limitless, the

442 SFG Consulting (2014) *Alternative versions of the dividend discount model and the implied cost of equity,* a report prepared for Jemena Gas Networks, ActewAGL, APA, Ergon, Networks NSW, Transend and TransGrid, p. 48.

443 Handley, J. "Advice on the Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 15.

444 McKenzie, M. and Partington, G. "A Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 27.

exact result we get will also be determined by how coarse a grid we apply in initial selection of the choices that we allow to enter the filtering process.

800. The Authority therefore has strong reservations about SFG's results.

SFG's approach of Estimating the return for the benchmark efficient entity

801. SFG estimates the return on equity for network businesses using the DGM for each of the analysts' forecasts. SFG then subtracts the risk free rate to obtain the equity risk premium (**ERP**) for each return on equity estimate. SFG then averages the resulting ERPs as a proportion of the market MRP estimated from the model (see above).

802. This delivers an average risk premium of 0.94. This may be interpreted as the equity beta estimate in the context of the Sharpe Lintner CAPM. However, this approach:[445]

- is not an econometrically sound approach to estimating beta;
- relies on a very much smaller dataset than the Authority's beta estimates;
- uses inappropriate weightings in the beta estimation process because SFG gives businesses with more analyst coverage greater weight; and
- delivers an equity beta that is implausibly high.

803. For these reasons, the Authority rejects use of the SFG DGM estimates as being a relevant approach to estimating the return on equity for the benchmark efficient entity.

SFG's approach of Grossing up returns for Imputation

804. SFG (2014) argues that in approaches that use data to produce ex-imputation estimates of the required return on the market the relationship between the ex-imputation return r_{ex} and the with-imputation return r_{with} is given by the standard Officer (1994) gross-up formula (34).

$$r_{ex} = r_{with}\left[\frac{1-t}{1-t(1-\gamma)}\right] \quad (34)$$

Where t is the corporate tax rate and represents the assumed value of imputation credits γ (gamma).

805. SFG argues that the above formula should be used to convert standard ex-imputation estimates of the MRP provided by survey respondents into regulatory estimates with-imputation.[446]

[445] Australian Energy Regulator, *Draft decision: Jemena Gas Networks (NSW) Ltd: Access arrangement 2015–20*, November 2014, Attachment 3: Rate of return, p. 3-229.

[446] SFG Consulting (2014) *Alternative versions of the dividend discount model and the implied cost of equity,* a report prepared for Jemena Gas Networks, ActewAGL, APA, Ergon, Networks NSW, Transend and TransGrid, p. 73.

806. However, the Authority notes that Professor Handley does not agree with SFG's view. In a report prepared for the AER in October 2014, Handley was of the view that:[447]

> The conversion formula (7) is indeed appropriate in the setting that Officer (1994) considers but is in general not correct in non-perpetuity settings.[448] In this case, it is appropriate to use theta to directly gross-up the imputation credits **associated with the dividend component of the return rather than grossing-up the entire return**.[449] For example, in relation to historic estimates of the equity premium (and historic stock returns) this is precisely the approach adopted by Brailsford, Handley and Maheswaran (2012) in their tables 2 and 3.[450] This approach should similarly be used to gross-up an ex-imputation MRP estimate from experts' estimates.

807. The Authority notes that Professors McKenzie and Partington hold the same views as Professor Handley on the issue.[451]

808. The Brailsford, Handley and Maheswaran approach utilises the following formula:[452]

> …we estimate the (weighted) average imputation credit yield c_t, for each year t, using the following model [35]:

$$c_t = p_t d_t \frac{T_t}{1-T_t} \qquad (35)$$

Where:

- d_t represents the annual dividend yield implied from the Historical Stock Price Index and the Historical Stock Accumulation Index;
- p_t is the (average) proportion franked; and
- T_t is the tax rate at which dividends are franked.

809. Using theta directly – to determine the value of credits distributed with the dividend each period – ensures that the grossed-up cash flow stream is expressed on an after-company-before-personal-tax basis. By definition, the resultant implied cost of equity will also be expressed on an after-company-before-personal-tax basis.[453] The equation set out in paragraph 808 may then be re-written as in equation (36).

447 Handley, J. "Advice on the Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 22.

448 Officer (1994) assumes a perpetuity framework whereby there is a full distribution of free cash flow and franking credits each period and returns are entirely in the form of fully franked dividends i.e. there are no capital gains. This means that γ = θ within the Officer framework.

449 It is noted that the SFG approach specifies gamma rather than theta in the conversion formula and so indirectly allows for less than full payout of credits based on the assumed distribution ratio *F* but this will not necessarily correspond to the actual payout of credits associated with the return.

450 See Brailsford T., Handley J. and Maheswaran K, Re-examination of the historical equity risk premium in Australia, *Accounting and Finance*, 48, 2008, pp. 84-85 for details.

451 McKenzie, M. and Partington, G. "A Return on Equity", a report prepared for the Australian Energy Regulator, October 2014, p. 37.

452 Brailsford T., Handley J. and Maheswaran K, Re-examination of the historical equity risk premium in Australia, *Accounting and Finance*, 48, 2008, p. 85.

453 J. Handley, *Advice on the Return on Equity*, October 2014, p. 23.

$$c_t = F \ x \ d_t \left(\frac{T_t}{1 - T_t} \right) x \ \theta \qquad (36)$$

Where:

- θ is the value of distributed imputation credits consistent with the Authority's estimate of gamma;
- d_t is the dividend yield in year t ;
- F is the proportion of dividends which are franked; and
- T_t is the corporate tax prevailing in that year.

810. On the basis of the above considerations, the Authority has concerns regarding the estimates of a market return on equity by SFG in its 2014 study. The Authority accounts for these concerns when determining the point estimate from within the estimated range.

Authority's decision on the DGM

811. The Authority remains of the view set out in the Rate of Return Guidelines that the DGM is relevant for the purpose of estimating the market return on equity for its regulatory decisions.

812. However, given the estimates of a market return on equity are unstable and sensitive to analysts' inputs, the Authority remains of the view that the DGM can only be used to inform the overall return on the market. This is used to inform the estimates of the forward looking MRP.

813. The Authority has reservations about SFG's DGM estimates of the return on the market in developing its proposed rate of return. The Authority will take those reservations into account in its determination of the point estimate of the MRP.

814. The Authority also rejects the use of SFG's estimates of the return on equity for the benchmark efficient entity.

815. The Authority remains of the view that DGM should not be used to directly estimate the market return on equity of the benchmark efficient entity in regulatory decisions.

Conclusions with regard to relevant models

816. The following conclusions have been reached in relation to the approach for estimating the return on equity in this Draft Decision for DBP:

- The Sharpe Lintner CAPM will be utilised to estimate the return on equity.
- The Fama French three factor model is not relevant and as such, this model is not used for the purpose of estimating a return on equity.
- The Black CAPM is relevant for the purpose of estimating a return on equity. However, given it is not reliable and practical to estimate a robust return on equity using this model, the model will not be used directly, but only to inform the judgment of the point estimate of the equity beta from within its range for input to the Sharpe Lintner CAPM.

- The DGM is a relevant model for informing the market return on equity and also the forward looking MRP.
- Other information such as historical data on equity risk premium; surveys of market risk and other equity analysts' estimates are also relevant for the purpose of estimating the MRP and the market return on equity. This other material will be used as a cross check for the return on equity.

817. For these reasons, the Authority remains of the view that its reasons for adopting the Sharpe Lintner CAPM are sound. The Authority considers that its application of the Sharpe Lintner CAPM meets the requirements of the NGR, and the allowed rate of return objective.

- The Authority does not agree with DBP's submission that it has not taken all of the relevant information into consideration with respect to its estimate of the return on equity. The Authority is of the view that all of the issues raised by DBP and its consultants have been considered in this Draft Decision.
- The Authority also disagrees with DBP's estimates of the rate of return on equity. The Authority has conducted significant research into the rate of return and has cross checked its estimate across various sources. The Authority's estimate for the rate of return is in line with other industry estimates.
- The Authority considers that the estimated return on equity adopted in this Draft Decision is commensurate with the equity costs incurred by a benchmark efficient entity with a similar degree of risk as DBP with respect to the provision of reference services. The Authority therefore considers that the estimated rate of return meets the allowed rate of return objectives and the requirements of the NGR and NGL.

Appendix 4A(i) Evaluating empirical results from the Black CAPM

818. This Appendix examines the properties of beta estimates from the Black CAPM model.

Theoretical Background

Sharpe Lintner CAPM

819. A mean-variance efficient portfolio is one that has the highest mean return for a given level of risk, as measured by the variance term. In essence, all diversifiable risk has been diversified away by investing in a weighted selection of assets, and the risk remaining is systematic risk only. A risk-averse investor who chooses a portfolio based purely on the mean and variance of the returns on the portfolio, and who can borrow or lend freely at a single risk-free rate, will select a portfolio which, for each asset, the following condition holds:

$$E\left(r_i\right)=r_f+\beta_i\left(E\left(r_m\right)-r_f\right) \quad (37)$$

where

$E\left(r_i\right)$ is the expected 'raw' return on asset i;

r_f is the risk-free return;

β_i is the 'beta' measure of the asset's contribution to a portfolio's risk; and

$E\left(r_m\right)$ is the mean return to a market portfolio.

820. This condition describes what can be termed as the 'classical' Sharpe Lintner CAPM model[454,455], that may be estimated from a series of asset and market returns:

$$r_{it}-r_f=\beta_i\left(r_m-r_f\right)+\varepsilon_{it} \quad (38)$$

where

ε_{it} is assumed identically and independently distributed (iid) as $N\left(0,\sigma^2\right)$.

821. The difference r_m-r_f is termed the market risk premium (MRP).

454 W.F. Sharpe, "Capital asset prices: A theory of market equilibrium under conditions of risk", Journal of Finance, 19, pp. 425-442, 1964.

455 J. Lintner, "The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets", Review of Economics and Statistics, 47, pp. 13-37, 1965.

822. In practice, the classical Sharpe Lintner CAPM can be augmented by including an unspecified intercept term, defining an 'empirical' Sharpe Lintner CAPM model that allows for 'abnormal' returns:

$$r_{it} - r_f = \gamma_{if} + \beta_i \left(r_m - r_f \right) + \varepsilon_{it} \quad (39)$$

where

γ_{if} is the abnormal return of the asset given a risk-free return r_f.

823. If the assumptions of the Sharpe Lintner CAPM hold, such as there being zero tax or transaction costs and investors share similar beliefs, and r_f is static (i.e., time-constant) then the beta estimates from the empirical and classical CAPM models are the same.

824. This assumption is used to support the approach implemented by the Authority to date, namely:

$$r_{it} = \alpha_i + \beta_i r_{mt} + \varepsilon_{it} \quad (40)$$

where

α_i is a free intercept term.

825. This model is termed here as the Henry Sharpe Lintner CAPM, as it reflects the empirical method adopted by Henry for his estimates of β_i[456,457]. Assuming r_f is relatively time-constant, i.e., of low variance, and the α_i term is deemed to be statistically non-significant then estimates of β_i between the Henry and classical Sharpe Lintner CAPM will be very similar.[458,459]

826. If the conditions for similarity of the Henry and classical CAPM estimates of β_i are satisfied then the Henry model is preferred as it circumnavigates the need to define a risk-free return. In this case arguments as to which risk-free return is to be used are irrelevant, such as those put forward by DBP.[460]

456 O.T. Henry, *Econometric advice and beta estimation,* Report for the Australian Energy Regulator, 28th November 2008.

457 O.T. Henry, *Estimating* β*,* Report for the Australian Energy Regulator, 23rd April 2009.

458 O.T. Henry, *Estimating* β *: An update*, Report for the Australian Energy Regulator, April 2014, page 6.

459 F. Black, "Capital market equilibrium with restricted borrowing", *Journal of Business*, 45, pp. 444-454, 1972.

460 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, Section 1.10.

827. The empirical and Henry models will estimate exactly the same β_i value when r_f is time-constant (i.e., static). Indeed:

$$\hat{\alpha}_i = \hat{\gamma}_{if} + r_f\left(1-\hat{\beta}_i\right) \quad (41)$$

828. Estimation of the Sharpe Lintner CAPM is straightforward through OLS in either its empirical or classical forms. Outputs between applications and operators are consistent, so long as the exact same model form is applied. This satisfies a requirement for a consistency of method (NGR 87(5)(b)).

Black CAPM

829. The Black CAPM[461] says that in practice firms are for the most part unable to access funds at the risk-free rate. Instead borrowing costs are higher and returns on lending are lower. It can thus be shown that when $r_l < E\left(r_z\right) < r_b$ and $r_l < r_f < r_b$, for a borrowing rate of r_b and lending rate of r_l, then:

$$E\left(r_i\right) - E\left(r_z\right) = \beta_i\left(E\left(r_m\right) - E\left(r_z\right)\right) \quad (42)$$

where

$E\left(r_z\right)$ is the expected return on a zero-beta portfolio.

830. The statistical model corresponding to the zero-beta condition may be termed the classical Black CAPM, with a zero-beta return r_z:

$$r_i - r_z = \beta_i\left(r_m - r_z\right) + \varepsilon_{it} \quad (43)$$

831. An empirical Black CAPM can be defined by including a free intercept in the model, namely the asset dependent γ_{iz}:

$$r_i - r_z = \gamma_{iz} + \beta_i\left(r_m - r_z\right) + \varepsilon_{it} \quad (44)$$

832. DBP claims that the classical Black CAPM is less biased than the classical Sharpe Lintner CAPM[462]. Regardless of the case, the classical Black CAPM will remain biased relative to the empirical form whenever it is estimated without an intercept term γ_{iz} to model abnormal returns.

461 M. Brennan, "Capital market equilibrium with divergent borrowing and lending rates", *Journal of Financial and Quantitative Analysis,* 6, pp. 1197-1205, 1971.

462 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, p. iv.

833. If r_z is static then the estimate of β_i from the empirical Black CAPM will be exactly the same as for the empirical and Henry Sharpe Lintner CAPM. In this case:

$$\hat{\alpha}_i = \hat{\gamma}_{if} + r_f\left(1-\hat{\beta}_i\right) = \hat{\gamma}_{iz} + r_z\left(1-\hat{\beta}_i\right) \tag{45}$$

834. In contrast, the empirical models and their classical counterparts differ in their estimates of $\hat{\beta}_i$, as the classical models exclude the intercept parameter. Moreover, the classical Sharpe Lintner and Black CAPM differ in their estimates of β_i as their predictors are different, namely the premium of the market return r_m above the effective risk-free rate (i.e., r_f or r_z).

835. The intercept term corrects the classical models by estimating the extent to which an asset has a mean valued return consistently above or below the market. Typically, financial markets are seen as too efficient to allow for an abnormal return to persist for long. Hence a non-zero value for the estimated intercept is seen largely as a temporary departure from the equilibrium market represented by the classical models.

Dynamic offsets

836. An offset within a regression context is a term to be added to a linear predictor with a known coefficient 1, rather than as term with a coefficient to be estimated. The effect of an offset is to increase or decrease the value of the response variable by a fixed amount, i.e., the value of the offset.

837. Both r_f and r_z are offsets in regression terms, occurring on the left-hand-side (LHS) of each of the CAPM equations above, and effectively decreasing the response variable r_i by a fixed amount.

838. If both r_f and r_z are static then the empirical Sharpe Lintner and Black CAPM are equivalent models. The Henry CAPM is equivalent, insofar as the offset of the Henry CAPM is zero. As may be surmised, offsets do not influence the slope parameter of a regression, but do influence the estimated value of the intercept parameter, so long as a free intercept term is present in the model to compensate for the inclusion of the offset within the relevant market premium (i.e., $r_m - r_f$, $r_m - r_z$ or $r_m - 0$, depending on the model).

839. The empirical Sharpe Lintner, empirical Black and Henry CAPM differ only when the offset is permitted to be dynamic (i.e., to be time-varying or time dependent). In this case, the empirical Sharpe Lintner and Black CAPM may be expressed as follows:

$$r_{it} - r_{ft} = \gamma_{if} + \beta_i\left(r_{mt} - r_{ft}\right) + \varepsilon_{it} \tag{46}$$

$$r_{it} - r_{zt} = \gamma_{iz} + \beta_i\left(r_{mt} - r_{zt}\right) + \varepsilon_{it}$$

where

r_{ft} is the risk-free return varying with time; and

r_{zt} the time-varying zero-beta return. The classical Sharpe Lintner and Black CAPM have equivalent forms.

840. Allowing dynamic offsets that are positive in value has a mathematical effect of increasing estimates of β_i in general (although not guaranteed always to do so). This increase in $\hat{\beta}_i$ is effectively compensating for the decrease in the relevant market premium; the market return is reduced by the dynamic offset to create a new time-varying predictor in the CAPM regression which is smaller than the market return itself. This is in contrast to the static offsets, where the time-varying predictor in the regression equation is simply r_{mt}. The market premium with a dynamic offset will therefore have to 'explain' just as much variation in the asset returns as the market return in the static model. Hence, $\hat{\beta}_i$ will likely increase whenever positive-valued offsets are included in a CAPM model and these offsets remain below the market return.

841. For similar reasons, estimates of β_i differ between the empirical Sharpe Lintner and Black CAPM whenever dynamic offsets are included.

842. The Henry CAPM is strictly a model with a static offset, as the time varying risk-free return is assumed away so as to obviate the need to define a risk-free return in the first place.

843. The different forms of the Sharpe Lintner and Black CAPM differ only through their use of intercept and offset. The market premium in each regression is given simply as the market return in excess of the offset. This is summarised in Table 22.

Table 22 Different forms of the Sharpe Lintner and Black CAPM

Model	Form	Offset Type	Intercept	Offset
SL	Classical	Static	0	r_f
		Dynamic	0	r_{ft}
	Empirical	Static	γ_{if}	r_f
		Dynamic	γ_{if}	r_{ft}
	Henry	Static	α_i	0
Black	Classical	Static	0	r_z
		Dynamic	0	r_{zt}
	Empirical	Static	γ_{iz}	r_z
		Dynamic	γ_{iz}	r_{zt}

Estimating the Zero-Beta Return

Method of Estimation

844. The zero-beta return may be estimated either directly, or indirectly through an estimate of the zero-beta premium (ZBP), which is the difference between the zero-beta return and the risk-free return $r_z - r_f$. Estimation of either the zero-beta return or ZBP requires two passes: the first pass where a panel of asset β_{it} estimates is developed for each r_{it} from data precedent to time t; and, a second pass which then estimates the zero-beta return or ZBP from this panel of β_{it} estimates[463,464].

845. The option exists to firstly order the assets into portfolios, usually by their mean β_i estimate, but also potentially by other criteria such as market capitalisation and book-to-market ratio.[465] The benefit is to lower computational requirements while maintaining the spread of values in the β_{it} estimates.

846. In the first pass we apply the empirical Sharpe Lintner CAPM to a rolling window of data of length S to generate the panel of β_{it} estimates:

$$r_{it-s} - r_{ft-s} = \gamma_{ift} + \beta_{it}\left(r_{mt-s} - r_{ft-s}\right) + \varepsilon_{it-s}, \quad s = 1,\dots,S \tag{47}$$

The length of data S is taken to cover 5 years, so if working with weekly data then $S \simeq 261$. In effect, the β_{it} is a time step forecast from the data covering the period $t-1$ to $t-S$. Although technically one could estimate the panel of β_{it} using a static risk-free return (i.e., effectively a Henry Sharpe Lintner CAPM), in common practice a dynamic risk-free return is applied.

847. The second pass estimates the time-varying ZBP. The method stated by NERA[466] defines a model that estimates the dynamic ZBP given by λ_{0t}:

$$\begin{aligned}
\left(r_{it} - r_{ft}\right) - \hat{\beta}_{it}\left(r_{mt} - r_{ft}\right) &= \left(1 - \hat{\beta}_{it}\right)\lambda_{0t} + \varepsilon_{it} \\
r_{it} &= r_{ft} + \left(1 - \hat{\beta}_{it}\right)\left(r_{zt} - r_{ft}\right) + \hat{\beta}_{it}\left(r_{mt} - r_{ft}\right) + \varepsilon_{it} \\
r_{it} &= \left(1 - \hat{\beta}_{it}\right) r_{zt} + \hat{\beta}_{it} r_{mt} + \varepsilon_{it}
\end{aligned} \tag{48}$$

463 E.F. Fama and J.D. Macbeth, "Risk, return and equilibrium: empirical tests", *Journal of Political Economy*, pp. 607-636, 1973.

464 R.H. Litzenberger and K. Ramaswamy, "The effect of personal taxes and dividends on capital asset prices: Theory and empirical evidence", *Journal of Financial Economics*, pp. 163-195, 1979.

465 SFG, *Cost of equity in the Black Capital Asset Pricing Model*, Report for Jemena Gas Networks, ActewAGL, Networks NSW, Transend, Ergon and SA Power Networks, 22 May 2014.

466 NERA, *Estimates of the Zero-Beta Premium*, A report for the Energy Networks Association, June 2013. Appendix A.

848. The last model form equates to the classical Black CAPM with dynamic offset given by the zero-beta return.

849. The reordering of the terms above allows the NERA[466] model to be compared with the SFG[467] model, who use the following equation to estimate the static zero-beta return:

$$r_{it} = \lambda_0 + \lambda_1\left(1-\hat{\beta}_{it}\right) + \lambda_2\hat{\beta}_{it}r_{mt} + \varepsilon_{it} \qquad (49)$$

850. This model is analogous to the empirical Black or Sharpe Lintner CAPM with a static offset. In effect, $\lambda_2 = 1$ gives the empirical CAPM whereas SFG[467] allows λ_2 to be unconstrained. Including an unconstrained term λ_2 potentially influences λ_1 as the estimate of the zero-beta return. Thus far, however, $\hat{\lambda}_2 \simeq 1$ for Australian gas infrastructure assets.[468] The intercept term λ_0 is to be estimated alongside λ_1 and λ_2. When constrained to zero, as occurs in NERA,[469] then in practice the zero-beta return estimate decreased marginally by 0.34 per cent from 9.36 per cent.[470]

851. The Authority follows the NERA second pass formulation as this supports the DBP[471] analysis. However, instead of simplifying the assets into a smaller set of ordered portfolios to maximise the spread of β_i values the zero-beta return is instead estimated from all individual assets listed in the All Ordinaries index.

852. A weighted least squares estimator of λ_{0t} may be formed that corrects for bias arising from the uncertain estimation of the β_{it} in the first pass:[472]

$$\hat{\lambda}_{0t} = \left(\sum_{i=1}^{N_t}\left(\sigma_{it}^{-2}\left(1-\hat{\beta}_{it}\right) - \tau\sigma_{mt}^{-2}\right)\right)^{-1}\sum_{i=1}^{N_t}\left(\sigma_{it}^{-2}\left(1-\hat{\beta}_{it}\right)\left(r_{it} - r_{ft}\left(1-\hat{\beta}_{it}\right) - \hat{\beta}_{it}r_{mt}\right) - \tau\sigma_{mt}^{-2}\left(r_{mt} - r_{ft}\right)\right) \qquad (50)$$

where $\tau = (S-2)/\left((S-1)(S-4)\right)$; σ_{mt}^2 is an unbiased variance estimate of the excess market return given the period described by S; and σ_{it}^2 the variance of the residuals in the first pass regression.

853. The different approaches to estimating the zero-beta return may be summarized in Table 23 (below). Although the Authority has taken a different approach from other

467 SFG, *Cost of equity in the Black Capital Asset Pricing Model*, Report for Jemena Gas Networks, ActewAGL, Networks NSW, Transend, Ergon and SA Power Networks, 22 May 2014, page 27.

468 NERA, *Estimates of the Zero-Beta Premium*, A report for the Energy Networks Association, June 2013. Appendix A.

469 NERA, *Estimates of the Zero-Beta Premium*, A report for the Energy Networks Association, June 2013. Appendix A.

470 SFG, *Cost of equity in the Black Capital Asset Pricing Model*, Report for Jemena Gas Networks, ActewAGL, Networks NSW, Transend, Ergon and SA Power Networks, 22 May 2014, page 27

471 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014.

472 J. Shanken, "On the estimation of beta pricing models", *Review of Financial Studies*, pp. 1-33, 1992.

proposals, for illustrative purposes, it can be seen that over the last 20 years a mean zero beta return over the long term of 9.88 per cent sits within the range of previous values derived by different proponents.

Table 23 Comparison of zero-beta return estimation methods

Tuning Parameter	DBP[473]	SFG[474]	NERA[475]	ERA (2015)	ERA (2015) – last 5 years
Period	Jan 1979 – Dec 2013	19th Jan 1994 – 22nd Jan 2014	Jan 1979 – Dec 2013	Nov 1995 – Oct 2015	Nov 1995 – Oct 2015
Assets	All ordinaries	All Ordinaries	All Ordinaries	All ordinaries	All ordinaries
Support	Monthly	Daily	Monthly	Monthly	Weekly
Fitting Window	5 years	28 days	5 years	5 years	5 years
Fitting Frame	Rolling window over each year[476]	Disjoint windows	Rolling window over one month	Rolling window over one month	Rolling window over one week
Evaluation Frame	One year ahead of rolling window	Within window	One month ahead of rolling window	One month ahead of rolling window	One week ahead of rolling window
Bias Correction (1st Pass)	Portfolio formation Degrees of freedom adjustment (NERA 2013)	Portfolio formation	Both with and without portfolio formation Degrees of freedom adjustment after Shanken (1992)	Degrees of freedom adjustment after NERA (2013)	Degrees of freedom adjustment after NERA (2013)
Portfolio Criteria for Evaluation Frame	Beta estimates in fitting frame (deciles)	Industry Type (10 types) Aggregate Market Capitalisation (90/10 rule) Book-to-market ratio (30/70 percentiles) Beta estimates (33/66 percentiles)	Beta estimates in fitting frame (decile)	No portfolio	No portfolio
Number of Portfolios	10	3 (beta) 180 (with other criteria)	1 (individual) 10 (portfolio)	1 (individual)	1 (individual)
Portfolio Weighting	Value-weighting	Value-weighting	Value-weighting Reciprocal of estimates of the idiosyncratic risk	Reciprocal of estimates of the idiosyncratic risk	Reciprocal of estimates of the idiosyncratic risk

473 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014. Appendix A.

474 NERA, *Estimates of the Zero-Beta Premium*, A report for the Energy Networks Association, June 2013.

475 SFG, *Cost of equity in the Black Capital Asset Pricing Model*, Report for Jemena Gas Networks, ActewAGL, Networks NSW, Transend, Ergon and SA Power Networks, 22 May 2014, page 27.

476 Detailed as part of model adequacy test method.

854. However, the differences in method illustrate that there are a significant number of decision variables involved in determining how a zero-beta return may be calculated. These different methods can influence the estimates of the zero-beta return. Moreover, the different methods seem to have undue influence on the calculation of the ratio of the zero-beta premium over the market return premium, ranging from 0.52 to 1.27 between methods (Table 24). This ratio is key to the betastar calculation proposed by DBP.[477]

Table 24 Zero-beta return estimates from different methods and support

Tuning Parameter	DBP (2014)	SFG (2014)	NERA (2013)	ERA (2015)	ERA (2015) – last 5 years
First Pass Model Estimating Beta panel	Zero beta premium provided by NERA (2013)	Not clearly specified, but assumed to be a classical SL CAPM with static offset.	Empirical SL CAPM with dynamic offset	Empirical SL CAPM with dynamic offset	Empirical SL CAPM with dynamic offset
Second Pass Model Estimating Zero Beta Return/ Premium	Zero beta premium provided by NERA (2013)	Empirical Black CAPM with static offset, and with an unconstrained λ_2 term.	Classical Black CAPM with dynamic offset	Empirical Black CAPM with dynamic offset	Empirical Black CAPM with dynamic offset
Bond	10 yr	10 yr	10 yr	5 yr	5 yr
Zero Beta Return (Annualised)	11.73%	9.36%	11.05% (individual) 13.95 (portfolios)	9.88%	4.77%
Zero Beta Premium (Annualised)	8.19%	3.34%	Not stated	4.32%	0.99%
Zero Beta Premium / Market Risk Premium	1.23	0.52	Not stated	1.27	0.77
Risk Free Return	3.54%	6.02%	Not stated	5.56%	3.78%
Market Return	10.1%	12.4%	Not stated	8.22%	5.12%

855. The questions that arise from these different methods are:

- What should be the period over which the analysis is run? e.g., 20 years or 40 years.
- Should the analysis be supported by daily, monthly or weekly data?
- What is the window over which a CAPM model is to be estimated? e.g., 5 years or 28 days.
- What should be considered as the portfolio generating market returns?
- How are estimates of the market risk premium to be corrected? e.g., portfolio formation or use of a maximum likelihood estimator.

477 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, page 68.

- How is uncertainty in beta estimates from the first pass to be accounted for in measures of standard errors of the zero beta return? e.g., propagation of error through Monte Carlo simulation or ignore.
- If portfolio formation is undertaken then by which critieria should portfolios be constructed? e.g., to apply book-to-market ratio as a criterion or not.
- How many percentiles should be defined over each of the criteria used to divide the portfolios?
- What should those criteria be? e.g., even splits on the criterion, or splits so that there is even representation between portfolio classes.
- Should the model estimating the asset return include an intercept or not, either at the first pass or the second pass?

856. The above decision variables are not an exclusive list of what is required to fully specify an estimation method for the zero-beta return. Some of these decision variables are explored in Table 25, namely the period covered by the data,[478] the use of 5 or 10 year Commonwealth Government Securities (**CGS**) as the risk-free return, and whether the support of the data is daily, weekly or monthly.

Table 25 Summary of zero-beta return estimates

Period Years	Support	CGS Bond Rate Years	Zero-Beta Return Annualised %	Zero-Beta Premium Annualised %	ZBP/ MRP	Risk-Free Return[1] Annualised %	Market Return[1] Annualised %
5	Daily	5	11.17	7.41	5.57	3.76	5.09
5	Daily	10	10.96	7.72	4.17	3.24	5.09
20	Daily	5	11.54	6.15	2.23	5.39	8.15
20	Daily	10	11.28	6.19	2.03	5.09	8.15
5	Weekly	5	6.80	3.16	2.87	3.64	5.12
5	Weekly	10	6.31	3.07	2.05	3.24	5.12
20	Weekly	5	7.31	1.93	0.68	5.38	8.20
20	Weekly	10	7.02	1.92	0.61	5.10	8.20
5	Monthly	5	4.77	0.99	0.73	3.78	5.13
5	Monthly	10	4.56	1.19	0.68	3.37	5.13
20	Monthly	5	9.88	4.32	1.27	5.56	8.22
20	Monthly	10	9.90	4.78	1.54	5.12	8.22

Notes 1) The daily estimate of the risk-free return and market return is more accurate, with the small differences in these estimates for weekly or monthly support due to aggregation and compounding errors.

Source ERA analysis

[478] Paragraph 7 in Appendix 4Bi below notes that there will be an 'optimal fitting frame', which will likely sit between a short and long period sample, given the bias-variance trade-off. The optimal fitting frame may be identified by completing the cross-validation profile.

857. DBP contends that:[479]

> A ten-year risk-free rate is used instead of the five-year rate used in the Guidelines. We consider the ERA is incorrect in the use of the five-year risk-free rate (something that affects equity as well) because the more standard regulatory and commercial practice is to use the ten-year rate.

858. This argument for or against a five-year rate has already been addressed in the Rate of Return Guidelines and elsewhere in this Draft Decision.[480] The only comment to be added here is that a five-year risk-free rate appears to increase the estimate of the zero-beta return by up to 0.5 per cent. Note that if the offset is treated as a static value then the question of whether the risk-free return is based on a five or ten year bond is irrelevant for the estimation of β_i in a CAPM model allowing abnormal returns.

859. Until a robust method is developed for estimating the zero-beta return, and the consequences of choosing different values for each decision variable are well understood, then the Black CAPM cannot be considered consistent or robust.

860. Inconsistency of method and the consequent rejection of the Black CAPM on practical grounds has been discussed in previous advice:[481:]

> Given the practical difficulties in implementing the Black CAPM we would not recommend the use of the current estimates from the network service providers to inform any beta adjustment … The problem in practice is estimating the return on the zero beta portfolio. This can be very sensitive to the choices made in its estimation as our prior work and the estimates of the consultants demonstrate.

861. Furthermore, estimates of zero-beta returns fluctuate in an inconsistent manner across different scenarios considering the duration of the selected CGS, when averaged over the last five or 20 years, and whether the support of the data is daily, weekly or monthly (with the evaluation frame taken to be the same as the support) (Table 25).

862. One issue causing the fluctuation in zero-beta return estimates is that the spread of zero-beta returns is much greater than that of the risk-free return (Figure 13). The distribution of zero-beta returns are positively skewed, with extreme values of up to 0.15 for daily data and a one day evaluation frame. If a period of interest (last 20 years or 5 years) happens to include one of these extreme values then the mean zero-beta return estimate can increase dramatically. This is evidenced by the difference between annualised mean (11.5 per cent) and median (5.5 per cent) zero-beta returns over a 20 year period. In no sense can the dynamic zero-beta return estimate be considered stable.

863. In contrast, the risk-free return has comparatively low variance. Indeed, this narrow variance is reason why the Henry Sharpe Lintner CAPM is applied by the Authority to estimate β to circumnavigate the need to provide an estimate of the risk-free return.

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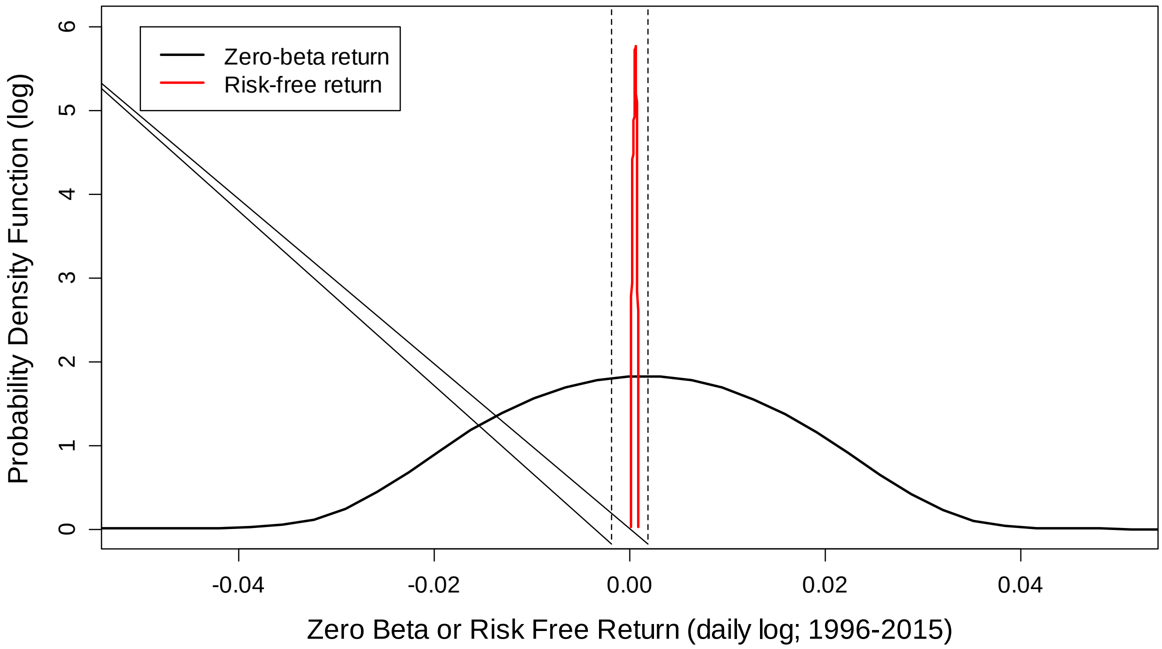
479 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, page ii.

480 ERA, *Explanatory Statement for the Rate of Return Guidelines,* December 2013, Section 7.2

481 G. Partington, *Return on Equity*, Report to the AER, April, 2015, p. 44.

Figure 13 Probability density estimates of the daily risk-free and zero-beta returns



Note The dashed vertical lines refer to annualised +/- 100% returns. The distribution of the zero-beta return displayed here excludes extreme estimates of zero-beta return of up to 0.15. The distribution of the risk-free return has been inflated horizontally by a factor of four for visual comparison purposes.

Source ERA analysis

864. It may be argued through the Law of Large Numbers that the mean zero-beta return is stable, as may be demonstrated by recursive estimates of the zero-beta premium for periods of greater than 20 years[482]. However, this does not resolve the issue of positive skewness of the distribution of zero-beta return estimates. Moreover, if a mean estimate of the zero-beta return is 'plugged into'[483], such that an empirical Black CAPM is in effect applied, then this provides a static offset. The consequence of a static offset is that the empirical Black CAPM devolves to an empirical Sharpe Lintner CAPM and, returns the same estimate of beta, thereby obviating the need for the Black CAPM in the first place.

865. A secondary issue with the Black CAPM method is the definition of a market portfolio. Traditionally, a market index such as the Australian All Ordinaries has been applied to define the market return. However, there is concern that the market index is not risk efficient in terms of maximising returns for a given magnitude of risk:[484]

> In any event, the key question is not what happens in relation to efficient portfolios, but rather what happens in the case of inefficient portfolios. This is because the results of NERA's various empirical analyses (most recently NERA, 2015) show that the reference portfolio they use is not on the efficient set ex-post. If it were, then there would be a perfect linear relation between the returns on securities and their betas calculated

482 NERA, *Estimates of the Zero-Beta Premium*, A report for the Energy Networks Association, June 2013. Figure 5.2, p. 18.

483 A 'plug-in' estimator is one that can be estimated in the data and inputted into a function of the parameter. Here the 'plug-in' estimator is the zero-beta return estimated by the two pass method, and 'plugged into' the CAPM expression to derive an estimate of β.

484 G. Partington, *Return on Equity*, Report to the AER, April, 2015, p. 44.

relative to the reference portfolio. Empirically, however, this is not the case. Therefore, the reference portfolio is not on the efficient set.

866. The only points forwarded here with regard to the efficiency of the market portfolio are these:

- For the empirical Sharpe Lintner CAPM with a static offset then any difference between a market index and a risk efficient portfolio given by the risk-free rate will likely be mostly captured through the abnormal return parameter, and so will minimally influence the estimate of β_i.
- If the offset is dynamic, the risk-efficient market portfolio corresponding to the All Ordinaries index will likely have a higher return. This will increase the MRP and likely decrease the estimate of β_i in a compensatory manner.
- For the empirical Black CAPM with dynamic offset the issue is similar. Not only will β_i likely decrease, but the estimate of the zero-beta return in the second pass of the two-pass method will also be influenced by the increased market return value, if a classical Black CAPM model is applied. Although what outcome will be achieved is uncertain, there is a risk that as $\left(1-\hat{\beta}_{it}\right)$ will likely increase and consequently the estimate of the zero-beta return will decrease.

Appendix 4A(ii) Updating beta estimates – the Authority's 2015 study

867. This Appendix updates Henry's estimates of beta for use in the Sharpe Lintner CAPM. To inform its analysis, the Authority has utilised the same companies used by Henry in his 2014 update to the Australian Energy Regulator (AER), and which are currently trading.[485]

868. This reduces the sample of benchmark assets to four (Table 26). The companies Envestra Limited (ENV) and Hastings Diversified Utilities Fund (HDF) have ceased trading since the last update, and have been excluded from the analysis.

Table 26 List of currently trading gas infrastructure assets

Name	Bloomberg's ticker	From	To	Proportional Value Weighting
APA Group	APA	13/06/2000	31/10/2015	0.351
AusNet Services	AST,SPN	14/12/2005	31/10/2015	0.285
DUET Group	DUE	13/08/2004	31/10/2015	0.198
Spark Infrastructure Group	SKI	16/12/2005	31/10/2015	0.166

869. The price data recorded the last daily price for all stocks provided by the Australian Stock Exchange (**ASX**), acquired through the Bloomberg Terminal (ticker ASA30). Dividend data used in the study were gross dividends including cash distributions, but omitting unusual items such as stock distributions and rights offerings. The dividend was then added to the closing price on the Friday after the ex-dividend dates as this is the first day the price would reflect the payout of the dividend in the data.

870. Returns are expressed as continuously compounding values:

$$r_{it} = \ln\left(\frac{p_{it} + d_{it}}{p_{i,t-1}}\right) \qquad (51)$$

where r_{it} is the return on asset i at time t; p_{it} is the price; and, d_{it} the dividend. Both the AER and Henry found no evidence that β estimates derived from continuously or discretely compounded data are manifestly different.[486]

871. Henry outlined in his advice to the AER that beta is estimated by applying a regression analysis to the following equation:[487]

485 O.T. Henry, *Estimating β : An update*, Advice Submitted to the Australian Competition and Consumer Commission. April 2014.

486 AER, *Explanatory Statement: Electricity transmission and distribution network service providers*, Review of the Weighted Average Cost of Capital (WACC) Parameters, www.aer.gov.au, p. 200.

487 O.T. Henry, *Estimating β*, Advice Submitted to the Australian Competition and Consumer Commission, 2009, p. 2.

$$r_{it} = \alpha_{it} + \beta_i r_{mt} + \varepsilon_{it} \quad (52)$$

where

α_{it} is a time-varying intercept term including abnormal returns over and above the risk free rate;

β_i is the equity beta for asset i ;

r_{mt} is the observed market returns; and

$\varepsilon_{it} \sim N\left(0, \sigma^2\right)$ are the residuals assumed to be identically and independently distributed normally, with a time-constant volatility measure σ^2.

872. Alternatives to the Henry model are discussed in Appendix 4A, including the Black CAPM model proposed by DBP.[488]

873. The above version of the Sharpe Lintner CAPM, termed here as the Henry CAPM, may be estimated in a number of different ways. Ordinary least squares (**OLS**) was supported by the robust estimation methods in **LAD** (least absolute deviation), **MM** (robust regression with the MM estimator) and **T-S** (Thiel-Sen). In general, these robust methods provide regression estimates that are less influenced by outliers and heteroscedasticity in the ε_{it} term. Technical descriptions of these estimators may be found in Appendix 17 of the Rate of Return Guidelines.[489]

874. A further two methods for the estimation of β have been trialled by applying **ARIMAX** (autoregressive integrated moving average) and **GARCH** (generalised autoregressive conditional heteroskedastic) models to the data, and which are described in brief in Appendix 4C. The ARIMAX model accounts for serial autocorrelation in the returns. The ARIMAX is a special case of the GARCH model where the volatility measure σ^2 is treated as time constant (i.e., homoscedastic). GARCH extends ARIMAX by allowing σ_t^2 to be time-varying as well, to be modelled in the simplest case as an ARMA (autoregressive moving average) process.

875. Hence, ARIMAX and GARCH are simply alternative ways to robust methods in accounting for heteroscedasticity in the data, and differ by modelling the heteroscedasticity as an explicit, parameterised process. The ARIMAX and GARCH estimates were not used here to form a decision on β.

876. The potential advantage of ARIMAX and GARCH is to reduce the standard error values of the β estimate, while correcting the small bias in β that may exist by omitting autoregressive terms from the model.

488 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014

489 ERA, Appendices to the Explanatory Statement for the Rate of Return Guidelines: Meeting the requirements of the National Gas Rules, 16th December 2013, Appendix 17.

877. All equity betas in the following analysis were de-levered using the relevant company's average gearing ratio over the period and re-levered using the 60 per cent assumption. The details of this de-levering/re-levering process can be found in Appendix 20 of the Rate of Return Guidelines.[490]

Results

878. For estimates of individual firms' β, the Authority considers that the sample period of 5 years with weekly intervals is appropriate as it reduces the possibility of structural breaks in the data set, whilst encompassing enough data points to estimate β with statistical accuracy.

879. In 2013, the ERA's analysis contained five portfolios corresponding to different 'epochs' defined by when the different assets were trading or not trading.[491] Here, only the latest epoch is considered, as it starts on 16/12/2005 when SKI enters the market (Table 26), long before the sample period starts on 1/11/2010. In this, portfolios are required to be recreated only when the constituents within the industry change (i.e., when a firm either leaves or enters the industry).

880. The key purpose of a portfolio analysis is to allow a single portfolio to be created and, as such, a single corresponding β value for that portfolio can be estimated as representative of the benchmark sample.

881. Two weighting scenarios were considered in this study, which is consistent with the approach adopted in Henry's 2014 study[492]: (i) equally-weighted portfolios (**EW**); and (ii) value-weighted portfolios (**VW**). Equally-weighted portfolios simply assigned a weight of ¼ to each of the four firms in the benchmark sample. To calculate a value-weighted portfolio the average market capitalisation was calculated for each firm. For each firm in the portfolio, its weight is determined by the ratio between the average of a single firm and the sum of the averages of all firms in each portfolio in terms of market capitalisation. The averages were taken over the sample period for all firms in each portfolio. The weights were then applied to their relevant firms in the portfolio. The construction of equally-weighted and value-weighted portfolios is reported in Appendix 21 of the Rate of Return Guidelines.[493]

882. Thin trading, which introduces a bias in the estimation of β, was found not to be in evidence during the 2013 analysis through a series of Dimson's tests.[494] For this reason thin-trading is not addressed here.

883. Table 27 reports estimates of each firm's beta across the different regression methodologies, with a data set from November 2010 to October 2015. Equally-weighted and value-weighted portfolios are also reported.

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[490] ERA, Appendices to the Explanatory Statement for the Rate of Return Guidelines: Meeting the requirements of the National Gas Rules, 16th December 2013, Appendix 20.

[491] ERA, Explanatory Statement for the Rate of Return Guidelines: Meeting the requirements of the National Gas Rules, 16th December 2013, Table 23, p. 172.

[492] O.T. Henry, *Estimating β: An update*, Advice Submitted to the Australian Competition and Consumer Commission. April 2014.

[493] ERA, Appendices to the Explanatory Statement for the Rate of Return Guidelines: Meeting the requirements of the National Gas Rules, 16th December 2013, Appendix 21.

[494] ERA, Explanatory Statement for the Rate of Return Guidelines: Meeting the requirements of the National Gas Rules, 16th December 2013, Section 12.2.4.

Table 27 Estimates of equity beta for individual firms and the two weighted portfolios in 2015 for different estimation methods

	APA	AST	DUE	SKI	Mean Assets	EW	VW	Mean Portfolios	Mean All
Gearing	0.436	0.568	0.661	0.231	**0.474**	0.474	0.482	**0.478**	**0.475**
OLS	0.713	0.616	0.261	0.702	**0.573**	0.673	0.695	**0.684**	**0.610**
LAD	0.657	0.605	0.267	0.751	**0.570**	0.794	0.778	**0.786**	**0.642**
MM	0.685	0.631	0.285	0.750	**0.588**	0.704	0.718	**0.711**	**0.629**
T-S	0.663	0.597	0.278	0.674	**0.553**	0.673	0.688	**0.680**	**0.596**
Mean OLS, LAD, MM, T-S	**0.680**	**0.612**	**0.273**	**0.719**	**0.571**	**0.711**	**0.719**	**0.715**	**0.619**
ARIMAX	0.716	0.571	0.273	0.656	**0.554**	0.654	0.678	**0.666**	**0.591**
GARCH	0.666	0.604	0.285	0.694	**0.562**	0.681	0.700	**0.691**	**0.605**
Mean All Methods	**0.683**	**0.604**	**0.275**	**0.705**	**0.567**	**0.696**	**0.709**	**0.703**	**0.612**

884. The results in Table 27 show that, on average, the MM estimator produced a higher equity β, and the T-S estimator a lower equity β, for each firm. Little difference was observed on average between the OLS and LAD estimates.

885. However, LAD estimates were higher for the equally- and value-weighted portfolios than OLS estimates. For the equally- and value-weighted portfolios the MM produced slightly higher and the T-S estimator slightly lower estimates of the equity β. This would be indicative of the DUE asset reporting a much lower β estimate, and with any extreme values in its returns receiving a low weighting and likely being largely ignored by the robust estimators, thereby pushing up the LAD estimate.

886. The ARIMAX and GARCH models, which estimated a small negative auto-regression coefficient, produced estimates that were consistently lower than the OLS estimator. Small negative auto-regression coefficients identify an oscillating autocorrelation process that dampens with time, indicative of an immediate selling response to positive price fluctuations, and a buying response to negative price fluctuations (i.e., demonstrative of price equilibrium).

887. Across the four firms β has increased on average from 0.368 to 0.619 from 2013 to 2015 across all estimators (OLS, LAD, MM, T-S). Hence, elasticity in the response of individual asset returns to market returns has increased within the gas infrastructure sector during a period when mean market returns have decreased.

888. Gearing on average has decreased from 2013 to 2015, from a mean value across the four assets of 0.584 to 0.474, as firms may be seeking to de-lever following lessons learned in the GFC. An across the board decrease in gearing may warrant a revision, if sustained, of the benchmark gearing level of 60% debt and 40% equity applied by Australian economic regulators to calculate equity β. This could occur at the next Guidelines review.

889. Bootstrap simulations of the estimates were performed using the naïve non-parametric approach outlined in Appendix 23 of the Rate of Return Guidelines,[495] where paired observations of asset and market returns are randomly sampled with replacement before applying the CAPM to the sampled dataset.

Table 28 Summary Bootstrap Simulated Statistics of OLS Estimators (B=10,000, n=261)

Model	Estimator	APA	AST	DUE	SKI	Mean Assets	EW	VW	Mean Portfolios	Mean All
OLS	$\hat{\beta}$	0.713	0.616	0.261	0.702	**0.573**	0.673	0.695	**0.684**	**0.610**
	Standard Error $\hat{\beta}$	0.086	0.079	0.057	0.119	**0.085**	0.068	0.067	**0.067**	**0.079**
	Bootstrap $\hat{\beta}$	0.712	0.614	0.263	0.698	**0.572**	0.674	0.694	**0.684**	**0.609**
	Bootstrap S.E. $\hat{\beta}$	0.082	0.070	0.057	0.122	**0.083**	0.070	0.068	**0.069**	**0.078**
	Bootstrap Bias	-0.001	-0.002	0.002	-0.003	**-0.001**	0.001	-0.001	**0.000**	**-0.001**
	Bootstrap LB 2.5%	0.555	0.473	0.151	0.454	**0.408**	0.538	0.562	**0.550**	**0.455**
	Bootstrap Median	0.712	0.616	0.263	0.699	**0.572**	0.675	0.695	**0.685**	**0.610**
	Bootstrap UB 97.5%	0.876	0.751	0.375	0.929	**0.733**	0.812	0.824	**0.818**	**0.761**

890. All OLS estimates of β were statistically significant at the 5 per cent significance level, as evidenced by the bootstrapped 95 per cent confidence band excluding the value of zero (Table 28). Standard errors for the portfolios estimated through OLS were 0.006 higher on average in 2015 compared to 2013, scaling with the increase in the estimated value of β over that period. The bootstrapped upper 97.5 per cent confidence bound was 0.733 when averaged across all four assets, and 0.818 for the mean of the portfolios (Table 29).

495 ERA, Appendices to the Explanatory Statement for the Rate of Return Guidelines: Meeting the requirements of the National Gas Rules, 16th December 2013, Appendix 23.

Table 29 Summary of Bootstrap Simulated Statistics of Robust Estimators (B=10,000, n=261)

Model	Estimator	APA	AST	DUE	SKI	Mean Assets	EW	VW	Mean Portfolios	Mean All
LAD	$\hat{\beta}$	0.657	0.605	0.267	0.751	**0.570**	0.794	0.778	**0.786**	**0.642**
	Standard Error $\hat{\beta}$ [1]	-	-	-	-	**-**	-	-	**-**	**-**
	Bootstrap $\hat{\beta}$	0.657	0.622	0.277	0.777	**0.583**	0.757	0.755	**0.756**	**0.641**
	Bootstrap S.E. $\hat{\beta}$	0.107	0.060	0.068	0.185	**0.105**	0.113	0.094	**0.103**	**0.105**
	Bootstrap Bias	0.000	0.017	0.010	0.026	**0.013**	-0.037	-0.023	**-0.300**	**-0.001**
	Bootstrap LB 2.5%	0.440	0.515	0.154	0.323	**0.358**	0.499	0.548	**0.524**	**0.413**
	Bootstrap Median	0.666	0.618	0.279	0.781	**0.586**	0.781	0.775	**0.778**	**0.650**
	Bootstrap UB 97.5%	0.843	0.750	0.414	1.082	**0.772**	0.907	0.887	**0.897**	**0.814**
MM	$\hat{\beta}$	0.685	0.631	0.285	0.750	**0.588**	0.704	0.718	**0.711**	**0.629**
	Standard Error $\hat{\beta}$	0.082	0.069	0.049	0.119	**0.080**	0.066	0.065	**0.066**	**0.075**
	Bootstrap $\hat{\beta}$	0.684	0.631	0.285	0.748	**0.587**	0.704	0.718	**0.711**	**0.628**
	Bootstrap S.E. $\hat{\beta}$	0.083	0.070	0.057	0.127	**0.084**	0.077	0.072	**0.074**	**0.081**
	Bootstrap Bias	-0.001	0.000	0.000	-0.002	**-0.001**	0.000	0.000	**0.000**	**0.001**
	Bootstrap LB 2.5%	0.527	0.493	0.172	0.494	**0.422**	0.551	0.577	**0.564**	**0.469**
	Bootstrap Median	0.683	0.630	0.285	0.751	**0.587**	0.705	0.718	**0.712**	**0.629**
	Bootstrap UB 97.5%	0.849	0.768	0.396	0.992	**0.751**	0.850	0.857	**0.854**	**0.786**
T-S	$\hat{\beta}$	0.663	0.597	0.278	0.674	**0.553**	0.673	0.688	**0.680**	**0.596**
	Standard Error $\hat{\beta}$ [1]	-	-	-	-	**-**	-	-	**-**	**-**
	Bootstrap $\hat{\beta}$	0.666	0.595	0.279	0.672	**0.553**	0.672	0.687	**0.679**	**0.595**
	Bootstrap S.E. $\hat{\beta}$	0.086	0.073	0.055	0.138	**0.088**	0.080	0.074	**0.077**	**0.085**
	Bootstrap Bias	0.003	-0.002	0.001	0.002	**0.000**	-0.001	-0.001	**-0.001**	**-0.001**
	Bootstrap LB 2.5%	0.501	0.447	0.172	0.398	**0.379**	0.511	0.539	**0.525**	**0.428**
	Bootstrap Median	0.663	0.596	0.278	0.676	**0.553**	0.673	0.689	**0.681**	**0.596**
	Bootstrap UB 97.5%	0.843	0.734	0.387	0.940	**0.726**	0.824	0.826	**0.825**	**0.759**

Notes 1) Standard errors of the estimate were either inconsistently returning solvable values (i.e., were not able to converge to a single value) for the LAD estimator, or there was no analytical solution for the T-S estimator. In these two cases the standard error of the estimate should be replaced by the bootstrapped standard error estimate.

891. Standard errors were inconsistently estimated for the LAD estimator, and cannot be derived by analytical means from the T-S estimator. For the LAD and T-S estimators the bootstrapped standard error is therefore used in drawing inference about β. Standard errors of β were higher for the LAD estimator, and to a lesser degree the T-S estimator, whereas they were lower for the MM estimator when compared with the OLS estimator.

892. The 97.5 per cent upper bound for the LAD and MM estimators was greater than for the OLS estimates, insofar as the mean upper bound for all assets was less than 0.8, and for both of the two portfolios was above 0.85 for the MM and LAD estimators. LAD had a lower mean β estimate and higher standard error, whereas MM had a higher β estimate (i.e., was more biased) but lower standard error (i.e., more efficient), leading to both returning a higher value for the OLS estimate of the upper bound. The T-S estimator was the only robust estimator that was of sufficiently low (or negative) bias and variance to provide upper confidence bands similar to that of the OLS estimator.

893. A bootstrap procedure was not implemented for ARIMAX or GARCH as these are time series models, and to simulate the data in this case a bootstrap procedure would be required to maintain the autocorrelation structure of the actual data themselves. Such procedures exist, such as variations of the block and sieve bootstraps, but these were not applied in what is a first look at the ARIMAX and GARCH models to estimate β for gas infrastructure.

894. This confidence interval was simply the z-normal confidence band given by 1.96 standard errors either side of the β estimate. Significantly, the z-normal and bootstrapped upper bounds were similar for both OLS and MM to within 0.01 (i.e., where a standard error measure was given), and so it is not incorrect to hypothesise that the ARIMAX and GARCH bootstrapped upper bounds will likewise be similar to their z-normal upper bound. The standard error estimates for ARIMAX and GARCH were very similar to those of OLS, with the GARCH estimates being marginally lower. Hence, the lower upper bound can be attributed primarily to the autoregressive component of both models producing a lower estimate of β. That said, the scale of difference is low and at most 0.02 (comparing the mean estimates of the upper bound in Table 30 (below).

Table 30 Summary Statistics of ARIMAX and GARCH Estimators

Model	Estimator	APA	AST	DUE	SKI	Mean Assets	EW	VW	Mean Portfolios	Mean All
ARIMAX	$\hat{\beta}$	0.716	0.571	0.273	0.656	0.554	0.654	0.678	0.666	0.591
	Standard Error $\hat{\beta}$	0.084	0.078	0.055	0.120	0.084	0.067	0.066	0.067	0.078
	Lower Bound 2.5%	0.551	0.418	0.166	0.421	0.389	0.522	0.549	0.535	0.438
	Upper Bound 97.5%	0.881	0.723	0.379	0.891	0.718	0.786	0.808	0.797	0.745
GARCH	$\hat{\beta}$	0.666	0.604	0.285	0.694	0.562	0.681	0.700	0.691	0.605
	Standard Error $\hat{\beta}$	0.084	0.070	0.053	0.112	0.080	0.060	0.064	0.062	0.074
	Lower Bound 2.5%	0.502	0.468	0.181	0.474	0.406	0.563	0.575	0.569	0.460
	Upper Bound 97.5%	0.830	0.741	0.39	0.914	0.719	0.799	0.825	0.812	0.750

Source ERA estimates

Appendix 4B DBP's model adequacy test

The approach

895. DBP submitted that a financial model will be of utility for directly estimating the return on equity if the following two criteria are met.[496]

- *First,* DBP considers that the model needs to have a firm grounding in relevant economic theory. That is, models that are proposed must have a solid theoretical underpinning in the literature, and/or have a sufficiently robust history of estimation in the literature. If they do not, then the models might be formed purely through some data-mining exercise and be unlikely to lead to robust, reliable results.
- *Second,* DBP is of the view that the direct application of the model must be demonstrably capable of contributing to the achievement of the ARORO and is consistent with the key principles and objectives which govern the process - the RPPs and the NGO. DBP considers that the empirical outcomes produced by a model must be shown to have sound predictive abilities in respect of the return on equity.

896. DBP considers that its first criteria, a criteria of relevance, has parallels in the criteria stipulated in the Authority's Rate of Return Guidelines released in December 2013.[497] DBP argues that the second of its criteria will involve an assessment of models and their relevant outputs because DBP considers that a model must not only be good in theory, but it must have sound predictive capability. Further, DBP notes that the Authority has not undertaken any empirical testing of the adequacy of each of the asset pricing models in light of the ARORO.[498]

897. Each of these two criteria developed by DBP is discussed in detail below.

A model's relevance - theory and principle – first criterion

898. DBP has conducted an assessment to consider whether or not each of three models, including the Sharpe Lintner CAPM, the Black CAPM, the Fama-French model, and the Dividend Growth is relevant in theory and principle for determining a return on equity consistent with the ARORO. DBP notes that the Dividend Growth Model is not subject to DBP's model adequacy test because it is difficult to obtain a long time series of relevant variables for this model.[499]

899. Based on CEG's report, DBP submitted that the Black CAPM and Fama French model are both relevant models from at least a theoretical and principled basis, and should be considered to provide relevant information. In addition, DBP argued that existing empirical work suggests that empirical estimations of the Sharpe Lintner CAPM are unlikely to provide relevant information. DBP then argued that reliance on a model which has theoretical support, buttressed by an ad-hoc adjustment to beta

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[496] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, pp. 45-6.

[497] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 46.

[498] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 47.

[499] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 47.

to address known problems of bias without ever testing the efficacy of this adjustment is unlikely to provide estimates of the return on equity which can be shown to meet the ARORO.

A model's role – the model adequacy test – second criterion

900. DBP submits that it has developed a step in the process (known as *the model adequacy test*) which involves taking each of the models that are relevant as a matter of theory and principle (i.e., Sharpe Lintner CAPM, the Black CAPM, and the Fama-French model), using them to forecast different points in time in the past, and comparing those forecasts to actual data. DBP submits that a model which, statistically, is shown not to be reliable in predicting actual outcomes (using historical data) seems unlikely to be appropriate as the sole relevant model going forward.[500]

901. DBP is of the view that:[501]

> The main purpose of using an asset pricing model, particularly in a regulatory context, lies in the ability of that model to predict the expected return on equity for the coming access period. An important question to ask, and indeed the question the ERA itself asked when using its Diebold Mariano tests is how well a model makes predictions about the required rate of return. The degree to which a prediction is "good" or "bad" could be a matter of precision; how close it gets to the "true" answer, and this is the basic premise behind the Diebold Mariano test.

DBP's model adequacy test

902. DBP's model adequacy test proceeds as follows.[502] *First*, DBP takes a financial model and parameterises it using data up to a point in time. *Second*, DBP uses it to make a prediction on future returns. *Third*, DBP compares predicted with actual returns and records any error. *Fourth*, having done that, DBP then compares the errors over many periods and many different portfolios to understand whether they are, on average, zero.

903. In applying the models, DBP submits that it assumed that the available data are an adequate reflection of the states of the world likely to prevail for investors. DBP defined an "error" of the model as a difference between predicted and actual outcomes. DBP argued that, if an error of a model is on average statistically different from zero, then that bias is sufficiently significant. In that case, there is only a one or five per cent likelihood that the model could deliver an unbiased outcome. DBP argues that it is, in this respect, truly a model adequacy test; i.e. it does not show which models are best, but rather identifies those financial models which, without material adjustment, could not deliver an NPV=0 outcome.[503]

500 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 49.

501 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 50.

502 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 51.

503 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 51.

904. DBP also submits that the statistical tests being used to test for bias are the t-test (for individual portfolios) and the Mincer-Zarnowitz (1969) and Wald test (for a collection of portfolios.

905. DBP considers that:[504]

> "Models" tested in the above approach need not be simply "the SL-CAPM", or "the Black CAPM", but could be combinations of models (say a model which uses these two models with a 60/40 weighting) or particular ways of implementing a model. As an example, we test the SL-CAPM using the 95th per centile of an estimate of the distribution of an ordinary least squares (OLS) estimator for beta rather than an estimate of the mean of the distribution (the OLS point estimate). We use the 95th percentile because this is the way the ERA has implemented the SL-CAPM and it has done so purportedly to remove the downward bias associated with estimates of the return on equity that the SL CAPM produces for low-beta stocks. In what follows, for simplicity, we will label these estimates, "95th per centile estimates of beta". All that is required is that models be formed in such a way that can be generalised. It is worthwhile noting that, at no point in time do we find a problem, propose a solution and then assert that this solution has solved the relevant problem; every solution becomes a new model, which is tested in exactly the same way.

Data and portfolio formation

906. DBP considers that it is appropriate to use the Share Price & Price Relatives (**SPPR**) database produced by SIRCA because this 'relevant' database provides monthly data on all stocks in the ASX going back to the early 1970s whereas Bloomberg data goes back only 15 years or so.[505] DBP also argues that it would be inappropriate to undertake its test using only stocks from the energy sector because these stock returns are driven, at least in part, by regulatory decisions about appropriate rates of return and revenues.

907. DBP submits that 10 value-weighted portfolios based on past estimates of beta were formed. This involved, for each year, estimating the betas for the largest 500 firms listed on the ASX at the end of the previous year, grouping the stocks into deciles, and then recording the returns to portfolios formed from these deciles, and then record the returns for this portfolio over the coming year.[506] DBP also provides an example to illustrate its exercise. For example, beta estimates using data from a 5-year period (from January 1969 to December 1973) for stocks that are in the top 500 by market capitalisation at the end of December 1973. These stocks are then allocated to 10 portfolios on the basis of the beta estimates. DBP then records the returns to the portfolios for each month of 1974. Next, DBP computes beta estimates using data from January 1970 to December 1974 for stocks that are in the top 500 by market capitalisation at the end of December 1974, allocates these stocks to 10 portfolios on the basis of the estimates and then records the returns to the portfolios for each month of 1975. And so on.[507]

908. Portfolios formed on the basis of past estimates of beta are presented as below.

504 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 51.

505 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 55.

506 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 56.

507 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 56.

Table 31 Portfolios formed on the basis of past estimates of beta - summary statistics

Portfolio	Average number of stocks per annum	Size in $ billions	Beta	Annualised mean excess return
1	27.5	5.287	0.536	8.278
2	28.0	5.984	0.608	8.641
3	28.5	6.634	0.576	7.947
4	28.3	11.714	0.766	9.617
5	28.3	15.832	0.857	7.982
6	28.7	10.319	0.882	6.583
7	28.3	11.618	0.966	4.461
8	28.3	14.396	1.182	5.213
9	28.4	7.591	1.362	1.474
10	27.9	3.577	1.384	2.765

Source: DBP, Table 5, p. 56.

909. DBP argues that:[508]

> Portfolio One is amongst the highest-earning portfolios, and the portfolios with higher betas have relatively low earnings. This finding is commonplace in the empirical literature, but is not in accordance with the theory of the SL-CAPM. We have examined the portfolios for errors or outliers, but find little evidence that these are driving returns. The basic message from Table 5, which ought to have profound importance for Australian regulatory practice, is that an investor looking for exposure to systematic risk at a level similar to that which affects the BEE (see Table 15 and note that the estimates, like those of the ERA, are around the same as Portfolio One above) who looks at empirical evidence of actual returns rather than a theoretical model, will expect a return much higher than that which the ERA believes is appropriate for energy firms. The outcomes in the ERA's Guidelines and recent ATCO Draft Decision are a clear signal to investors that energy is a poor investment prospect relative to other sectors of the Australian economy subject to similar levels of systematic risk exposure.

910. DBP then submits that once portfolios are developed, a second point of importance is the forecast period. In its analysis, DBP submits that the "month ahead" forecasts are undertaken.[509] DBP then considers that the t-test (for individual portfolios), and the Mincer-Zarnowitz and Wald test (for a collection of portfolios) can be used to test for bias.

911. DBP argues that:[510]

> The main focus of our discussion is our model adequacy test, which, as per paragraphs 5.55 to 5.63, is intended to ensure that only models that have a sound theoretical and empirical basis are used to calculate the rate of return on equity in Stages Two and Three. Our approach has been to start with the empirical SL-CAPM model, as applied by the ERA in its Guidelines (being the 95th percentile value of beta).[60] We estimate

[508] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 56.

[509] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 57.

[510] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 59.

> this model and test it using our model adequacy test above. We then test three other models that our in-principle analysis in paragraphs 5.39 to 5.48 suggest may be relevant (the empirical SL-CAPM using the mean estimate of beta, the Black CAPM and the Fama French model), before using this information to develop a final preferred model, which we also test. This model is then used to estimate parameters and rate of return results (using weekly Bloomberg data; as distinct from the monthly SPPR data used for the model adequacy test) in Stages Two and Three of the ERA's five-stage process.
>
> To presage the results discussed below, the ERA's implementation of the empirical SL-CAPM fails the model adequacy test, and we present evidence that it provides results which are statistically biased downwards. This is not improved by further manipulation within the same model using the 99th percentile of beta. The only model which conclusively passes the model adequacy test is the Black CAPM, and it is thus this model which forms the basis of our assessment of the rate of return in Stages Two and Three of the ERA's process. However, **we do not implement the Black CAPM directly, but rather use information from the model to modify beta in the SL-CAPM formula. We do this to minimise our departure from the ERA's Guidelines**. [emphasis added]

912. DBP then considers that:[511]

> Before we begin, it is worthwhile pointing out that we do not replicate the ERA's most recent position exactly. In particular, the ERA has proposed to use the five-year CGS as the proxy for the risk-free rate but, as discussed in Chapter 3, we believe this is an error. As such, we have used the ten-year CGS. We also use the estimate of market risk premium from NERA (2013a,b) which is currently 100 basis points higher than the ERA's most recent estimate of the market risk premium (see paragraphs 5.172 to 5.187 for our assessment of the problems associated with this estimate). The net effect of these two departures is that, where we find evidence that the ERA version of the empirical SL-CAPM is biased downwards, or just borderline, this implies that the actual model being used by the ERA is likely to perform even worse. Our results, therefore, can be viewed as an optimistic assessment of the ERA's approach, if the abovementioned errors with the risk free rate and the market risk premium are removed.

913. The approach purported by DBP as representing the Authority's use of the Sharpe Lintner CAPM, together with all other models, are then assessed using two different methods in assessing predictions.

914. *First*, Method A, the forecast of the excess return depends on: (i) an estimate of beta, which is computed using regression and monthly data from before month t; and (ii) a forecast of the market risk premium that is a long-run historical average.[512]

915. *Second*, Method B, in this method, the forecast of the market risk premium is replaced by the realisation of the return to the market in excess of the risk-free rate for the period being forecast.[513]

916. DBP argued that:[514]

> The practical effect of Method B is to remove noise created by market returns from the forecast errors that we construct, and so allow us to focus on whether the models that we consider have any tendency to systematically overestimate or underestimate the

511 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 60.

512 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, pp. 61-2.

513 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 61.

514 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 61.

> returns required on the 10 portfolios. In practice, however, whilst Method B can help in understanding whether a given model exhibits bias, **it cannot be used for making predictions for the next five years, because we do not know the MRP for the next five years**. Thus, **it is Method A which forms the basis of our final return on equity estimation. Method B is rather used to improve the power of our model adequacy tests**. [emphasis added]

Examining the models

917. DBP considers that the Sharpe Lintner CAPM, the Black CAPM, and the Fama-French model are relevant from a principled or theoretical perspective. DBP use these models to empirically examine whether each model passes DBP's model adequacy test and therefore meet the NPV=0 condition. DBP argues that failure to meet this fairly basic level of robustness is strong evidence that a given model is unlikely to contribute to the achievement of the ARORO.[515]

Sharpe Lintner CAPM

918. DBP presents the test outcome in relation to the Sharpe Lintner CAPM.[516]

Table 32 Wald and t-test results - ERA empirical Sharpe Lintner CAPM

		Method A		Method B	
Wald test		24.910		25.821	
Portfolio	Betas	Mean forecast error	T tests	Mean forecast error	T tests
1	0.623	-4.16%	-1.782	-4.85%	-2.621
2	0.692	-4.09%	-1.662	-4.85%	-2.676
3	0.653	-3.66%	-1.457	-4.40%	-2.546
4	0.839	-4.11%	-1.552	-4.93%	-2.925
5	0.927	-1.97%	-0.650	-2.87%	-1.663
6	0.947	-0.46%	-0.153	-1.50%	-1.005
7	1.031	2.23%	0.665	1.13%	0.661
8	1.250	2.91%	0.754	1.45%	0.771
9	1.443	8.15%	1.836	6.37%	2.709
10	1.516	7.28%	1.326	5.39%	1.403

Source: DBP analysis. Note – mean forecast errors are in percentage points per annum.

919. DBP then concludes that:[517]

> For the low-beta portfolios, the model has a statistically-significant negative bias at the five percent level under method B, and Portfolio One has a statistically significant negative bias at the ten percent level under Method A. Method B is more reliable than

515 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 60.

516 The "standard" five per cent critical value for a Wald test with 10 degrees of freedom is 18.3, whilst for the t-test it is 1.96 (1.645 and the ten per cent level).

517 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 62.

> Method A, because it produces more robust and statistically powerful results as it does not include variation in market returns.
>
> This bias is not only statistically significant, but economically significant as well, with a mean forecast error of around four percentage points per annum. This means that a regulator using the ERA's approach setting prices which provide investors with returns that are four percentage points lower than they could be earning by facing similar levels of systematic risk elsewhere in the economy. This error is between half and two thirds of the overall allowed rate of return in recent Jemena (8.1 per cent – see AER 2014) an ATCO (6.8 per cent – see ERA 2014b) Draft Decisions. We would suggest that recognition of this error would lead to a materially preferable outcome (as per Section 259(4a) of the NGL) in respect of the regulators' estimates of the return on equity.

920. DBP further concludes that:[518]

> The overall conclusion from the analysis above is that the version of the empirical SL-CAPM implemented by the ERA has significant limitations and should not be utilised, in Stages Two and Three of the ERA's five stage process; it is demonstrably downwardly biased and cannot contribute to the achievement of the ARORO.
>
> However, we recognise that the SL-CAPM itself has a solid theoretical grounding. The problem is not necessarily with the SL-CAPM in theory, but with this particular empirical implementation of the SL-CAPM. As will be clear from the conclusion of the arguments presented below, we consider that a version of the SL-CAPM can still be considered relevant and utilised in Stages Two and Three of the ERA's five-stage process; **albeit applied using only the formula of the SL-CAPM, rather than its empirical estimation of beta**. [emphasis added]

921. In addition, DBP also considers the 99th percentile of beta estimate in the Sharpe Lintner CAPM. Based on its results, DBP argues that the use of the 99th percentile of beta in the Sharpe Lintner CAPM does not appear to sufficiently to solve the problem of bias. DBP notes that:[519]

> The evidence presented above suggests there are problems with the ERA's implementation of the empirical SL-CAPM. The extent of the bias in the empirical SL-CAPM for low-beta portfolios is so extensive that it is not removed by using the 95th per centile estimate of beta. An obvious extension is to use the 99th per centile estimate of beta in the implementation of the empirical SL-CAPM. This is the second model we assess. As the results in Table 7 below show, this does not appear sufficient of itself to solve the problem of bias either; most particularly when the focus is on the low-beta portfolios that are most similar to the BEE in respect of the level of the systematic risk they face. For these portfolios, the downward bias of the model is both statistically and economically significant.

922. DBP submits that the analysis follows exactly the same structure as the assessment of the Authority's version of the empirical Sharpe Lintner CAPM above, and uses the data from the SPPR database. However, the Fama-French Model and Black CAPM introduce (between them) three new parameters which the Sharpe Lintner CAPM does not require. These are the zero-beta premium in the Black CAPM and the high-minus-low (HML) and small-minus-big (SMB) factors in the Fama-French model.

923. DBP then submits that in its model adequacy tests, zero-beta premium estimates prepared by NERA (2013c) are used. In addition, DBP also notes that the HML factor for the FFM have been sourced from the website of Ken French whereas the SMB

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518 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 63.

519 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 62.

have been estimated using SPPR data up to 2013 using the returns to the top and bottom 30 firms within the ASX 500 each month.

Black CAPM

924. With respect to Black CAPM, DBP's model adequacy test presents the results as below.[520]

Table 33 Black CAPM - Wald and t-test results

		Method A		Method B	
Wald test		8.7331		9.8798	
Portfolio	Betas	Mean forecast error	T tests	Mean forecast error	T tests
1	0.536	-1.43%	-0.604	-2.09%	-1.120
2	0.608	-1.88%	-0.756	-2.60%	-1.421
3	0.576	-1.19%	-0.467	-1.91%	-1.074
4	0.766	-2.93%	-1.098	-3.71%	-2.213
5	0.857	-1.40%	-0.461	-2.27%	-1.306
6	0.882	-0.06%	-0.019	-1.08%	-0.716
7	0.966	2.02%	0.605	0.98%	0.570
8	1.182	1.09%	0.286	-0.28%	-0.148
9	1.362	4.81%	1.100	3.15%	1.364
10	1.384	3.45%	0.640	1.77%	0.472

Source: DBP Analysis. Note – mean forecast errors are in percentage points per annum

925. DBP then concludes that:[521]

> Here, the Black CAPM passes the aggregate Wald test for both Method A and Method B, and shows no evidence of bias under either method, even at the ten-per cent level of significance. The scale of the mean forecast errors has also substantially decreased; by around three-quarters. They are still relatively large (around 150 basis points per annum for low-beta portfolios) but they are not statistically-significantly different from zero.

Fama French model

926. DBP's model adequacy test for Fama French model provides the following results as shown in Table 34 (below).[522]

520 The "standard" five per cent critical value for a Wald test with 10 degrees of freedom is 18.3, whilst for the t-test it is 1.96 (1.645 and the ten per cent level).

521 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 65.

522 The "standard" five per cent critical value for a Wald test with 10 degrees of freedom is 18.3, whilst for the t-test it is 1.96 (1.645 and the ten per cent level).

Table 34 Fama-French model - Wald and t-test results

				Method A		Method B	
Wald test				14.902		14.684	
Portfolio	betaMRP	betaHML	betaSMB	Mean forecast error	T tests	Mean forecast error	T tests
1	0.625*	0.064	0.156*	-2.93%	-1.178	-3.76%	-2.072
2	0.735*	0.249*	0.075	-1.91%	-0.714	-2.85%	-1.619
3	0.734*	0.220*	0.080	-1.52%	-0.562	-2.48%	-1.490
4	0.815*	0.250*	0.007	-3.11%	-1.090	-4.04%	-2.479
5	0.927*	0.195*	0.017	-0.92%	-0.286	-1.90%	-1.112
6	0.963*	0.186*	0.002	0.76%	0.239	-0.39%	-0.265
7	1.027*	0.237*	0.009*	3.77%	1.073	2.48%	1.493
8	1.209*	0.044	-0.034	3.01%	0.782	1.72%	0.921
9	1.299*	-0.152*	-0.053	5.92%	1.400	4.23%	1.849
10	1.466*	-0.117*	0.238*	8.15%	1.515	6.46%	1.775

Source: DBP Analysis. Note- mean forecast errors are in percentage points per annum

927. DBP then concludes that:[523]

> Fama-French model performs better than the SL-CAPM (see below) and the ERA's implementation of the empirical SL-CAPM, but not as well as the Black CAPM. Although it is unbiased overall (as evinced by the Wald statistics) it shows evidence of being biased downwards for Portfolios One and Four.

928. Based on the above findings from its Model Adequacy Test, DBP concluded that the Fama French model are not an adequate model to use in Stages Two and Three. DBP considers that these models (being the Sharpe Lintner CAPM and FFM) might play a role as cross checks, but should not play a role in the estimation of the return on equity in Stages Two and Three of the Authority's process.[524]

A final model: the Black CAPM

929. DBP argues that, two things guide it for an adoption of the final model: (i) a model with statistical robustness; and (ii) a model that departs as little as possible from the Authority's Guidelines.[525]

930. On the basis of its so-called "model adequacy test" (to test the predictive capacity of the models), DBP submitted that only Black CAPM passes this test and the model then becomes relevant for the purpose of estimating a return on equity.

523 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 66.

524 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 66.

525 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 67.

931. In addition, DBP is of the view that:[526]

> In principle, we could have implemented the Black CAPM directly. We might also have used adaptations of the FFM (like using different points on confidence intervals for its betas, or forming the portfolios in a way more favourable to the model). However, doing so would have involved a more significant departure from the Guidelines than is perhaps necessary. Instead, we have endeavoured to maintain the basic framework of the SL-CAPM, whilst using information from the results we obtain above for the Black CAPM. This involves adjusting the estimate of beta by more than choosing a different point on a confidence interval for the parameter.

932. Starting with the Sharpe Lintner CAPM, DBP replaces beta by the so-called *Betastar* which can be expressed as below:[527]

$$\beta^*_{jt} = \left(1 - \frac{\hat{z}_{0t}}{\hat{z}_{mt}}\right)\hat{\beta}_{jt} + \frac{\hat{z}_{0t}}{\hat{z}_{mt}} \quad (53)$$

933.

where:

- z_{0t} is an estimate of the zero-beta premium computed using data from before month t;
- z_{mt} is an estimate of the market risk premium computed using data from before month t; and
- β_{jt} is an estimate of the beta of portfolio j computed using data from before month t

934. DBP submits that a forecast of the return required on portfolio j in excess of the risk-free rate that uses a bias-adjusted beta estimate is:

$$\hat{z}_{jt} = \beta^*_{jt}\,\hat{z}_{mt} \quad (54)$$

935. Substituting *Betastar* as presented above into this equation and the following final equation is derived:

$$\hat{z}_{jt} = \hat{z}_{0t} + \hat{\beta}_{jt}\left(\hat{z}_{mt} - \hat{z}_{0t}\right) \quad (55)$$

[526] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 67.

[527] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 68.

936. DBP argues the above equation expresses a forecast of the return required on portfolio j in excess of the risk-free rate that uses an empirical version of the Black CAPM.[528]

937. DBP submits that:[529]

> In making use of the framework or formula of the SL-CAPM in this way, whilst incorporating key information not gleaned from empirical estimation of parameters of the SL-CAPM (namely the empirical beta), we are not in fact making a significant departure from regulatory practice. Despite different regulators starting a process of empirical estimation of beta in 2009 (Henry, 2009), regulators have not historically used these empirically-estimated betas, but have instead used the formula of the SL-CAPM substituting in their own beta estimates formed by other means. For example, in DBP's last access arrangement, despite acknowledging the work of the AER in obtaining empirical estimates of beta that suggested a range of 0.4 to 0.7, the ERA chose to continue its past practice of using a beta of 0.8 (ERA, 2011, paragraph 486-82).

and that:

> This is also not particularly different from standard commercial practice. Appendix 29 of the Explanatory Statement to the Guidelines (paragraph 55 to 57) highlights several surveys of market practice that show that analysts regularly form an estimate via the SL-CAPM, and then adjust this to reflect other information. This might take the form of a simple additive adjustment (indeed, the evidence from Grant Samuel cited by the ERA in its ATCO Draft Decision - paragraph 786 - adjusts the SL-CAPM due to the "shortcomings and limitations" of the model) or it might take the form of an adjustment in beta as we have done. The ERA, by calculating an estimate of beta of 0.48, but then not using this estimate in implementing the SL-CAPM, has done essentially the same thing as we have done, and indeed, in response to the same problem, albeit, the methodology used for the ERA's adjustment is a non-transparent exercise of regulatory judgment. The key differences are that the ERA has made a smaller adjustment; and not tested the result.

938. DBP then concludes that:[530]

> Our approach of using the SL-CAPM formula and a beta formed exogenous to the SL-CAPM is no different from standard practice amongst regulators and in the wider commercial world, except that we have chosen **a particular means of adjusting beta which we can show has a solid theoretical basis,** and we actually test the results of our model formed in this way. [emphasis added]

939. In relation to DBP's Model Adequacy Test, DBP presents the following results for its final model, as shown in Table 35 (below).[531]

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528 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 68.

529 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 68.

530 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 69.

531 The "standard" five per cent critical value for a Wald test with 10 degrees of freedom is 18.3, whilst for the t-test it is 1.96 (1.645 and the ten per cent level).

Table 35 Betastar model - Wald and t-test results

		Method A		Method B	
Wald test		8.733		9.379	
Portfolio	Betas	Mean forecast error	T tests	Mean forecast error	T tests
1	1.057	-1.43%	-0.604	-2.75%	-1.202
2	1.042	-1.88%	-0.756	-3.13%	-1.513
3	1.044	-1.19%	-0.467	-2.48%	1.295
4	1.028	-2.93%	-1.098	-4.08%	-2.312
5	1.016	-1.40%	-0.461	-2.55%	1.480
6	1.009	-0.06%	-0.019	-1.24%	-0.839
7	0.999	2.02%	0.605	0.87%	0.509
8	0.974	1.09%	0.286	0.00%	0.001
9	0.956	4.81%	1.100	3.74%	-1.480
10	0.952	3.45%	0.640	2.37%	0.604

Source: DBP Analysis. Note – mean forecast errors are in percentage points per annum

940. DBP submits that the above results are identical with those examining the Black CAPM. DBP considers that:[532]

> This ought not be surprising, as the two models give the same predictions. Note, however, the difference in beta; whereas it **is around 0.53 in the Black CAPM, betastar is now 1.06**. This is the issue that we raise in paragraph 5.140 above; **there is a difference in the assumptions between the Black CAPM and the SL-CAPM in respect of the rates at which investors can lend and borrow** (the intercept of the security market line), and if one ignores the fact that investors cannot in fact lend and borrow at the risk free rate, because there are so few parameters in the model, one has to adjust beta in order to make the model give predictions that reflect actual returns. [emphasis added]

941. DBP then concludes that:[533]

> DBP does not claim that energy firms in general, or the BEE in particular, are riskier than the market. The evidence from the SL-CAPM and Black CAPM shows that this is not the case. What leads to biased predictions in the SL-CAPM (but not the Black CAPM) appears to be the incorrect assumption that investors can borrow and lend at the risk-free rate. We **attempt to correct for the bias in the SL-CAPM by adjusting beta in the betastar model, and since we load all of the correction onto a single parameter, the adjustment is very large**. However, **the resultant beta is an adjustment for bias, not a statement about the level of systematic risk faced by the BEE, this is exemplified by the level of the beta in the Black CAPM; around 0.53**. [emphasis added]

532 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 68.

533 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 69.

942. To form a range for Betastar, DBP selects the 20th percentile and the 99th percentile and the results are presented in Table 36.[534]

Table 36 Beta and betastar

Estimate Type	Estimate
Beta	0.55
Betastar	1.11
20th per centile of betastar (lower bound of unbiased results)	0.94
99th per centile of betastar (upper bound of unbiased results)	1.57

Source: DBP analysis. Note that the standard error for betastar is 0.195

Authority's considerations

943. The Authority responds in terms of (i) the conceptual aspects of DBP's analysis; and (ii) the empirical aspects of DBP's analysis.

Conceptual elements of DBP's approach

944. In relation to the conceptual elements of the DBP's model adequacy test, the following issues are considered.

The relevance of the "predictive power" test to the return on equity

945. The Authority notes DBP's claim that its model adequacy test is based on a similar test process developed and adopted by the Authority in the past. The Authority notes that:

> Our approach is not novel. Using historical data to test the predictions of models or hypotheses is standard practice in economics and other social sciences where experiments are generally not possible and such an approach is clearly contemplated by the ARORO test (see discussion in paragraphs 2.18 and 2.26). It is not novel in the context of regulation, but is rather based on precedent developed by the ERA itself. In the Western Power decision process (see ERA 2012, Appendix 9), an hypothesis was developed by the service provider that a longer averaging period would provide a better result. Rather than rely upon opinion about this hypothesis, the ERA tested it by using Diebold Mariano (1995) tests. Whilst we do not agree entirely with the way these tests were implemented in a technical sense, and the interpretation of their results for the return on debt (see Box 2), we believe the ERA's response to this hypothesis advanced by a service provider was entirely correct; treat a model as a hypothesis and test it. **This is exactly what we propose to do here for the return on equity**. [emphasis added]

946. The Authority does not agree that DBP is comparing "apples" with "apples". In order to conduct its Diebold Mariano test, the Authority starts with the basis of a well-established economic theory, which is the efficient market hypothesis (**EMH**) which was developed by Professor Fama in 1960. The Authority notes that the efficient market hypothesis states that at any given time and in a liquid market, security prices fully reflect all available information. The EMH exists in various degrees: (i) weak; (ii) semi-strong and (iii) strong, which addresses the inclusion of non-public information in market prices. This theory contends that since markets are efficient and current

534 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 77.

prices reflect all information, attempts to outperform the market are essentially a game of chance rather than one of skill.[535]

947. The Authority is not convinced that a test of “predictive power” – as configured by DBP – is appropriate for the purpose of testing the Authority’s expected return on equity.

948. It is noted that a return on equity can generally be decomposed into two components: (i) a risk free rate of return; and (ii) the equity premium. The Authority notes that the equity premium was considered as a puzzle in a well-regarded academic paper by Mehra and Prescott in 1985.[536] Ibbotson (2011) considers that the equity risk premium is a concept that seems to mean different things to different people. Some people treat it as the equilibrium long-run return, whereas others treat it as their own personal estimate of the long-run return. Some discuss it as a future return, whereas others discuss it as a realized return. Some compare equity returns with long-term bond returns or yields, whereas others compare equity returns with short-term bond returns or yields.[537]

949. The complicated nature of the estimates of the equity risk premium can be best captured in a summary from the CFA Institute as follows:[538]

> The past 10 years have shown that the ERP, far from being a settled matter, continues to challenge analysts. The research and observations in this volume have a number of implications for investment practice and theory. First, investors and analysts should take care to be explicit about their estimates of the ERP. We still too often use different definitions of, assumptions about, and approaches to the ERP, or leave it altogether implicit in our analyses of asset markets and valuations. Further clarity may help reduce the number of occasions when we are talking past each other. Second, we should be clear about what model we are using when we offer a forecast or explanation of the ERP. We have seen that variations in our estimates can be the result of different approaches to objective, circumstantial, and behavioural factors. Third, differing circumstances among investors lead to true, irreducible differences in the ERP that each investor may face at any given time. This final consideration underscores how the interplay of these multiple circumstantial forces can lead to a risk premium that is far more multifaceted and complex than typically envisioned in the standard discount models, even when we take into account structural and cyclical changes in the more objective factors. The papers contained in this volume richly illustrate this interplay.

950. The Authority considers that, while historical data provides relevant information as to future returns, the data is not solely used for estimating the forward looking return on equity. So for example, in its Final Decision for the ATCO Gas Distribution System, the Authority utilised various sources of information for estimating the MRP, including (i) forward looking information such as estimates of the MRP from the DGM; and (ii) backward looking information such as historical data on risk premium in determining the MRP.

535 Morningstar, *Efficient Market Hypothesis, 2015.* Available at http://www.morningstar.com/InvGlossary/efficient_market_hypothesis_definition_what_is.aspx .

536 Mehra, R. and Prescott, E. “The Equity Premium: A Puzzle”, *Journal of Monetary Economics* 15 (1985) 145-161, North Holland.

537 Ibbotson, R. G. “The Equity Risk Premium” in *Rethinking the Equity Risk Premium,* Hammond, Leibowitz, Siegel (eds), 2011, Research Foundation of CFA Institute.

538 Hammond, P. and Leibowitz, M. “Rethinking the Equity Risk Premium: An Overview and Some New Ideas” in *Rethinking the Equity Risk Premium,* Hammond, Leibowitz, Siegel (eds), 2011, Research Foundation of CFA Institute.

951. The Authority considers that relying on the predictive power of a Sharpe Lintner CAPM, utilising an MRP based on Ibbotson historical data alone – as is tested by DBP – is misplaced, as the MRP is not stationary. This is a key reason for the change in the Authority's approach to estimating the return on equity following the development of the Rate of Return Guidelines.[539]

952. DBP chooses to dismiss these crucial differences in method, stating:[540]

> In the ATCO Draft Decision, the ERA changed the way it forms its estimate of the MRP, but as discussed below, this new approach does not appear to be very robust, and in any case cannot be implemented back into history for lack of data. Thus, we use the long-run historical average for the MRP that has been widely used by regulators in Australia in the past.

953. DBP calls this (historic average MRP) Sharpe Lintner CAPM estimate, referred to in the above quote, 'Method A'.

954. It is noteworthy that DBP acknowledges in the quote that the Authority's method cannot be tested through the model adequacy approach.

955. DBP then goes on to evaluate a second method, 'Method B', which takes the actual historic annual MRP outcome, estimated as the difference between the actual market return and the 10 year risk free rate, as the prediction for the subsequent five years. DBP submits that the effect of this is to 'remove noise', so as to focus on 'whether the models that *we consider* [our emphasis]' have any systematic bias across the beta sorted portfolios.[541] However, again, the Authority's view is that this Sharpe Lintner CAPM model tested by DBP through Method B is not the Authority's method, as:

- First, it tests an ex post outcome for the MRP, not the Authority's forward looking approach to estimating the MRP.
- Second, it does not test the Wright interpretation of the historic data, which the Authority considers provides relevant information, and which is taken into account when the Authority determines its forward looking estimate of the return on equity.
- Third, it does not account for other forward looking information, which is also taken into account in its determination of the forward looking estimate.

539 Economic Regulation Authority, *Explanatory Statement for the Rate of Return Guidelines*, 16 December 2013, pp. 136 – 137.

540 DBP, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12*, 31 December 2014, p. 61.

541 DBP, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12*, 31 December 2014, p. 61.

956. In this context, the Authority notes that its estimate of the MRP for the ATCO GDS Final Decision, of 7.6 per cent as at 2 April 2015, was significantly higher than either of the corresponding historic estimates implied by DBP's test methods (Method A and Method B) The relevant historic estimates of the MRP, available for that decision, would have been the 128 years of historic data, through to calendar year 2014, for the return on the market and the risk free rate Based on that available historic evidence, the two methods tested by DBP would imply that the Authority's forward looking MRP would have been:

- Method A – a long run average of the historic annual Ibbotson MRPs through to 2014, which DBP submits was 6.5 per cent.[542]
- Method B – the point estimate of the MRP, which using the most recent 2014 return on the market and the 2014 average 5 year risk free rate, would have been 3.8 per cent.[543]

957. This illustrates starkly just how different the Authority's forward looking Sharpe Lintner CAPM approach is, as compared to the Sharpe Lintner CAPM methods tested by DBP.

958. Therefore, relying on a narrow interpretation of the historical data alone – as DBP does – for testing the relative adequacy of the Authority's approach, is erroneous. Other forward looking information needs to be taken into account, as the Authority does in its approach to estimating the return on equity. It follows that DBP's model adequacy approach does not actually test the Authority's approach in using the Sharpe Lintner CAPM for estimating the return on equity. DBP is setting up a straw man, and not actually evaluating the Authority's method at all.

The violation of integrity for the Sharpe Lintner CAPM and Black CAPM

959. From DBP's model adequacy test, the Authority notes that all Australian listed stocks are allocated into 10 different portfolios which are formed based on their relevant beta. These 10 portfolios are then used to test for bias (or predictive power) for all three models: (i) the Sharpe Lintner CAPM; (ii) the Black CAPM; and (iii) the Fama French model. The Authority is not convinced that portfolios are relevant for both the Sharpe Lintner CAPM and the Black CAPM.

960. The Authority is concerned with the approach DBP has adopted. DBP considers that the Black CAPM can be implemented directly. However, in its analysis, DBP states that its preference is not to implement the Black CAPM directly, but rather use information from the model to modify beta in the Sharpe Lintner CAPM formula. DBP states that this preference is to minimise departure from the ERA's Guidelines.

961. The Authority considers that DBP's proposed approach will violate the integrity of the Sharpe Lintner CAPM. The Authority is of the view that, assuming that tests must be conducted to test the predictive power of a model, then the model itself with its components must be used.

542 DBP, *Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12*, 31 December 2014, p. 80. The Authority considers that DBP's estimate of the long run average Ibbotson MRP of 6.5 per cent is high, as its own estimate of the long run average from the Brailsford, Handley and Maheswaran (**BHM**) data is 6.2 per cent (updated – for references see paragraph 373).

543 Based on an average of the bond and bill yields, as a proxy for the 5 year rate, from the BHM data (updated – see paragraph 373 for relevant references). The 2014 return on the market, grossed up, was 6.54 per cent in nominal terms. The 5 year risk free rate was estimated at 2.76 per cent for 2014 from the BHM data (updated). The difference between the two, rounded, is 3.8 per cent.

962. For example, the Authority notes that the Sharp-Lintner CAPM explains the expected return, $E(r_t)$, on any financial asset i in terms of the rate of return on a risk-free asset, r_f, and a premium for risk, $(E(r_M)-r_f)\times\beta_i$, where $E(r_M)$ is the expected rate of return on a market portfolio of assets, the term $(E(r_M)-r_f)$ represents the market risk premium (MRP) and β_i is the equity beta of asset i and is defined as $\beta_i = \text{cov}(r_i, r_M)/\text{var}(r_M)$:

$$r_e = r_f + (E(r_M)-r_f)\times\beta_i \tag{56}$$

963. In addition, the Black CAPM was developed from the Sharp-Lintner CAPM, but without assuming the existence of a risk free rate asset and without assuming unrestricted borrowing and lending. In Black's derivation of CAPM, the return on a portfolio, known as the zero-beta portfolio $(E(r_z))$, for which the return is uncorrelated with the return on the market portfolio, acts as the equivalent of the risk free return.

$$r_e = E(r_z) + (E(r_M)-E(r_z))\times\beta_i \tag{57}$$

964. The main findings from the Black CAPM are that: (i) when β is low, the expected return predicted by the Sharp-Lintner CAPM is less than the expected return predicted by the Black CAPM; and (ii) when β is high, the expected return predicted by the Sharp-Lintner CAPM is greater than the expected return predicted by the Black CAPM.

965. Based on the above fundamentals insights from the Sharpe Lintner CAPM and Black CAPM, the Authority concludes the following.

966. *First*, to test the validity of the Sharpe Lintner CAPM, the estimates of the inputs including (i) a risk free rate, (ii) a return on equity market, and (iii) the equity beta should be used.

967. *Second*, to test the validity of the Sharpe Lintner CAPM, the estimates of the inputs including (i) a zero beta premium, (ii) a return on equity market, and (iii) the equity beta should be used.

968. The Authority notes that DBP has considered that it is possible to isolate the difference between $r_f + (E(r_M)-r_f)\times\beta$ as presented in equation (1) above and $E(r_z) + (E(r_M)-E(r_z))$ as presented in equation (2) above. This difference is then incorporated into β_i presented in equation (2) to become DBP's *Betastar*.

969. The Authority notes DBP's argument that doing so to obtain the Betastar in its analysis which now incorporates the effects of: (i) systematic risk from a particular entity; and (ii) a bias correction from the Sharpe Lintner CAPM.

970. The Authority is not convinced it is appropriate to test in this way. In support, the Authority is not aware of any literature and/or empirical studies which conduct analyses in the similar approach as DBP does. The Authority also notes that DBP fails to provide a single reference to support its view that the Betastar transformation is well established or at least follows any standard economic or statistics theories.

971. On balance, the Authority is of the view that it is inappropriate to consolidate the effect from two components: (i) the systematic risk; and (ii) bias adjustment into the so-called *Betastar* which is considered as the beta under the Black CAPM but the estimate is then utilised in the formulation of the Sharpe Lintner CAPM.

DBP's Model Adequacy Test is incomplete and untested

972. It is noted that a key purpose of DBP's model adequacy test is to compare the predictive power of each of the three models (being the Sharpe Lintner CAPM, the Black CAPM, and the Fama French three-factor model). The Authority notes that the DGM is not tested due to data constraints. DBP argued that a model must not only be good in theory, but it must have sound predictive capability.

973. The Authority is of the view that DBP's analysis is unsupported, untested and incomplete. This view is based on the following considerations.

974. *First*, as noted above, DBP's analysis does not reflect the Authority's current position on the implementation of the Sharpe Lintner CAPM which was stipulated in detail in its Rate of Return Guidelines released in 2013 and its Final Decision on ATCO released in 2014. For example, the Authority's current approach is to retain the Sharpe Lintner Capital Asset Pricing Model as the primary method for estimating the return on equity. However, information from other relevant models – including the Black CAPM and the Dividend Growth Model are utilised to establish the value of parameters in the Sharpe Lintner CAPM to ensure that the return on equity reflects the prevailing market condition. The Black CAPM is then considered in the process of selecting a point estimate from an appropriate range of equity beta. In addition, a final estimate of the market risk premium is drawn from various approaches, including various estimates from the DGM; from historical equity risk premium; and recognising that a return on equity is generally stationary and mean reverting.

975. *Second*, DBP concludes that Black CAPM performs best on the test as compared to the Sharpe Lintner CAPM and Fama French models. The Authority notes that this finding is not confirmed by any other studies in Australia or overseas. It appears that DBP's finding is the only analysis which confirms the validity of the Black CAPM for the purpose of estimating the return on equity for regulated businesses. The Authority is not aware of any regulator, decision maker, academic studies that supports DBP's conclusion that the Black CAPM is the only appropriate model to determine the return on equity.

976. As noted above, the Authority does not accept quantitative estimates from either the Black CAPM or the FFM are robust in an Australian context. The Authority also notes that Black CAPM has not been adopted by any regulators and practitioners for the purpose of estimating a return on equity. This view is supported by evidence presented in Table 37 below.

Table 37 Models adopted by Australian and international regulators in estimating a return on equity

	Australia	Germany	New Zealand	USA	Canada	UK
Regulator	**Australian Energy Regulator (AER)**	**The Federal Network Agency (FNA)**	**The Commerce Commission (CC)**	**New York State Public Utilities Commission (NYSPUC)**	**The Ontario Energy Board (OEB)**	**The Office of Gas and Electricity Markets (Ofgem)**
Primary model	CAPM	CAPM/RPM	CAPM	DDM	RPM	CAPM
Secondary model				CAPM		
Other use of DDM	*Cross-check on MRP*		*Cross-check on MRP*		*Cross-check on MRP*	*Cross check on the overall cost of equity but not for individual firms*

Source: *Sudarsanam, Kaltenbronn, and Park (2011)*

Notes: CAPM: *Sharpe Lintner Capital Asset Pricing Model*
RPM: *Risk Premium Model*
DDM: *Dividend Discount Model*

Systematic risk plays a minor role in DBP's Betastar

977. The Authority notes that beta in both the Sharpe Lintner CAPM and the Black CAPM represents a level of systematic risk an entity faces. A higher beta is associated with a higher level of systematic risk. The only difference between the Sharpe Lintner CAPM and the Black CAPM lies in one assumption when the models were developed. The Sharpe Lintner CAPM assumes that all investors can lend and borrow at the risk-free rate, whilst the Black CAPM relaxes this assumption. The Authority notes that the Black CAPM predicts that the Sharpe Lintner CAPM underestimates for a low asset beta whereas it will overestimate for a high asset beta.

978. The Authority notes that, assuming that the Black CAPM's predictions are valid even though the Authority notes that the debate is far from complete, an adjustment is required. In these instances, an upward adjustment is required for a low asset beta to remove its downward bias whereas a downward adjustment is needed for a high asset beta.

979. The Authority notes that the zero-beta portfolio from the Black CAPM is a theoretical concept. The key findings from the Black CAPM is the introduction of the zero beta portfolio whose return should be higher than a risk free rate of return from the Sharpe Lintner CAPM. However, the Black CAPM is silent in relation to how this difference (between a zero beta portfolio return and a risk free rate) can be measured. The Authority notes that the zero-beta portfolio premium must lie between the risk free rate and the market return on equity. The Authority notes DBP's argument that:[544]

> In theory, the zero-beta premium in the Black CAPM should lie between the lending and borrowing rates if such rates exist. In practice it need not do so, though, because empirical implementations of the model do not use series of returns to the market

544 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 66.

> portfolio of all risky assets but instead use series of returns to the market portfolio of stocks.

and that:[545]

> The assumption in the SL-CAPM that investors can borrow and lend at the risk-free rate is clearly false. We are not aware of any Australian corporates who are able to borrow on better terms than the Federal Government. The fact that this leads the results of empirical SL-CAPM estimations to be biased is well-known (see, for example, Friend & Bloom, 1970, Fama & MacBeth, 1973 and Brealey, Myers & Allen, 2011). If one accepts that investors cannot borrow and lend at the risk-free rate and uses an empirical, rather than a theoretical intercept for the security market line, then it is possible to predict, with a high degree of empirical validity (note the t-stats in Table 8 for the Black CAPM and the much lower mean forecast errors) what returns investors will demand in order to bear a certain level of systematic risk. If, however, one keeps the theoretical intercept, correcting the downwardly-biased predictions that result requires a very large adjustment to beta. This is a topic taken up in our discussion of our final model below.

980. Irrespective of any argument, the Authority considers that both Sharpe Lintner CAPM and Black CAPM are derived for the purpose of estimating the return on equity in which a systematic risk component is the central concept underpinning the two models. The Authority is of the view that beta, in essence, represents the level of systematic risk that an entity faces. However, DBP's findings from its analysis are not consistent with this view. As presented in Table 38 below, the Authority notes that the bias adjustment has made a very substantial contribution to overall estimate of Betastar obtained from DBP's analysis. The Authority is not convinced that the bias in beta is as large as indicated – the adjustment is therefore picking up other abnormal return elements.

Table 38 Betastar: A decomposition of a systematic risk and bias correction

Portfolio	Beta	Betastar	Betastar being decomposed into		Ratio
			Systematic risk	Bias Adjustment	
1	0.536	1.507	0.536	0.971	181%
2	0.608	1.042	0.608	0.434	71%
3	0.576	1.044	0.576	0.468	81%
4	0.766	1.028	0.766	0.262	34%
5	0.857	1.016	0.857	0.159	19%
6	0.882	1.009	0.882	0.127	14%
7	0.966	0.999	0.966	0.033	3%
8	1.182	0.974	1.182	-0.208	-18%
9	1.362	0.956	1.362	-0.406	-30%
10	1.384	0.952	1.384	-0.432	-31%

Source: The ERA's analysis

981. As presented in Table 38 above, as an illustration, for portfolio 1, a calculated equity beta (in the Sharpe Lintner CAPM) is 0.536. DBP then estimated its *Betastar*, which

[545] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 66.

it argued to be the equity beta for the Black CAPM. However, this Betastar is then used in the Sharpe Lintner CAPM to estimate the return on equity.

982. The Authority considers that DBP's *Betastar* can be decomposed into two components: (i) the systematic level of 0.536 and (ii) a bias correction of 0.971. As such, the Authority notes that the bias correction is significantly larger than the systematic risk. In this example, the bias correction is 181 per cent of a systematic risk level. The Authority is not convinced that the results are valid because a level of systematic risk for firms included in Portfolio 1 now plays a very minor role in comparison with DBP's correction of bias.

983. As another example in which beta is revised downwards to reflect the argument that Sharpe Lintner CAPM overestimates a high beta asset. Portfolio 10 indicates that its level of systematic risk is 1.384. DBP's estimate of *Betastar* is 0.952, which indicates that the estimate of a correction bias is -0.432 which accounts for more than 31 per cent in comparison with the level of systematic risk.

984. In addition, the Authority notes DBP's argument that the values for Betastar are much higher than the range of values for beta that the Authority used in the Guidelines, from 0.3 and 0.7, in its application of the Sharpe Lintner CAPM. The Authority also notes that DBP's proposed equity beta is 1.06 which is higher than the equity beta of the entire Australian equity market. The Authority notes DBP's argument that it is not suggesting that the benchmark efficient entity is riskier than the market as a whole. Instead, DBP considers that *Betastar* reflects both systematic risk and the zero beta premium. DBP considers it is a consequence of the manipulation of the Black CAPM into a Sharpe Lintner CAPM formula and not a reflection of systematic risk per se. DBP argued that the Black CAPM model that underpins the formation of *Betastar* calculates a level of systematic risk identical to the mean beta in the empirical Sharpe Lintner CAPM.

985. The Authority is not convinced that DBP's argument is valid. As long as beta is more than one in the Sharpe Lintner CAPM, then it reflects the fact that the systematic risk of a firm is higher than that of the entire equity market. In this instance, DBP proposed equity beta for a benchmark firm, which is proxied by Portfolio 1 in DBP's analysis, of 1.06, it means that the systematic risk of firms included in Portfolio 1 is higher than that of the entire equity market.

Overall conclusion on the theoretical aspects of DBP's analysis

986. On balance, the Authority is of the view that DBP's model adequacy test is inappropriate to provide evidence to support DBP's conclusion that Black CAPM is the only model which is relevant for the purpose of estimating the return on equity and that Betastar represents for a level of systematic risk for DBP in the application of the Sharpe Lintner CAPM.

987. The Authority is of the view that DBP's model adequacy test:

- does not test the Authority's forward looking approach to estimating the return on equity using the Sharpe Lintner CAPM, but rather versions based on historic MRP outcomes;
- compares two models that are not robust in the Australian context (the Black CAPM and FFM), with another method that is not relied on either (the Sharpe Lintner CAPM, using an MRP that is based on historic data only).

988. The Authority considers that DBP's analysis does not follow any standard finance/economic theory. Its approach is not tested and unsupported by any independent source of evidence. The Authority considers that DBP's analysis is fundamentally flawed and its approach is unable to produce any sensible estimates.

989. In conclusion, the Authority considers that DBP's model adequacy test is invalid, and as such, not fit for the purpose of estimating equity beta.

Empirical elements of the DBP approach

990. As noted above, the Authority is of the view that DBP's analysis is conceptually flawed and should not be used. However, for completeness, the Authority also considers the following major issues in relation to DBP's analysis.

The selection of data

991. The Authority notes that, in its model adequacy test, DBP used zero-beta premium estimates prepared by NERA in 2013. In addition, HML factors for the Fama French model have been sourced from the website of Ken French whereas the SMB factors were estimated using SPPR data. The Authority notes that data on the HML and SMB factors are available back to 1975 (1974) for the HML (SMB) factor for Australia. In relation to the estimates of zero beta premium by NERA, further details will be discussed below.

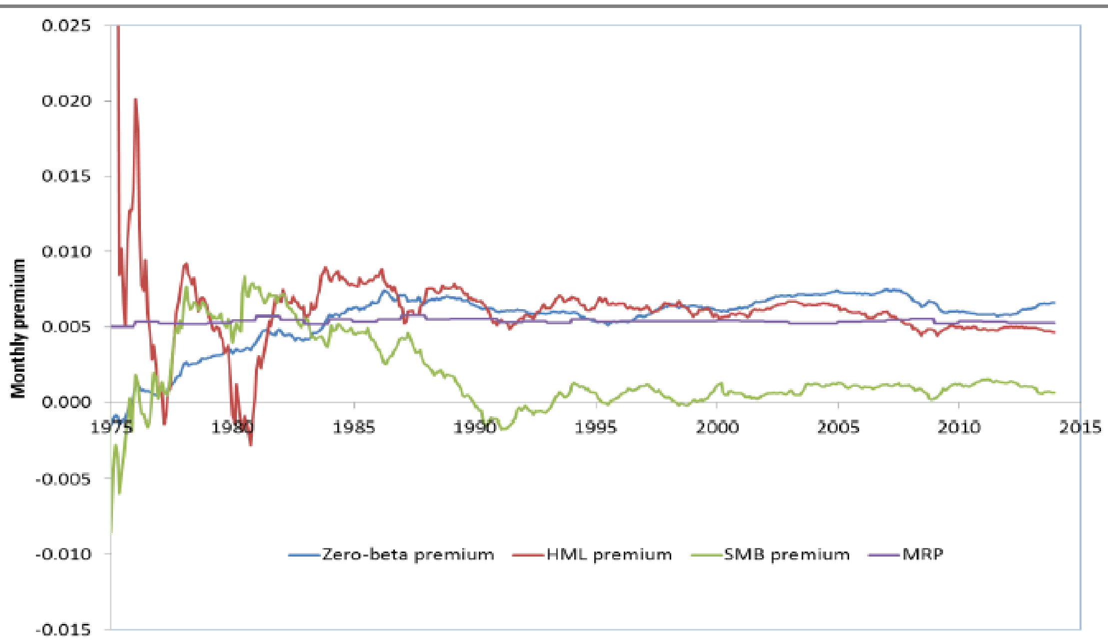
992. It is unclear why DBP has sourced data from various sources, in particular for SMB and HML factors which are utilised in the same model (the FFM). For the application of the Fama French model, the Authority notes that these two sources of data (the HML and SMB factors) are used to derive the return on equity. The Authority is of the view that each of the data sources may have used different underlying assumptions. As such, it is not appropriate to do so. The DBP does not provide any evidence to support its decision to use the data on the HML factor from the website of Ken French whereas SMB factor is calculated by itself.

993. On balance, the Authority is not convinced that the findings from DBP's analysis are robust given its choice of data sources are ungrounded. The Authority also has concerns about the magnitude of variation in the findings, which will be discussed further below.

The estimates of zero beta premium from NERA (2013) study

994. The Authority notes that in its model adequacy tests, DBP makes use of zero-beta premium estimates prepared by NERA (2013c) which used data back to the 1960s (which comes from the SPPR database; which has coverage of larger firms prior to the early 1970s when it commences full coverage of the ASX). DBP considers that, in this study, the zero-beta premium estimates are stable and that the estimates are formed following the two-pass methodology of Fama & Macbeth (1973) and Litzenberger and Ramaswamy (1979), using the modified estimator from Shanken (1992). The Authority notes that the zero beta premiums vary within a wide range from -0.1 per cent to 1.0 per cent per month, which is approximately equivalent to -1.0 per cent and 12 per cent per year.

Figure 14 HML SMB, MRP and zero-beta premia



Source: DBP analysis based on SPPR data (SMB), http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html NERA (2013a,b,c)

995. Given zero beta premium is argued to lie with the range of the risk free rate and the market return on equity, the Authority is not convinced that the estimates of zero beta premia, as presented in Figure 14 above, are appropriate to be used in DBP's analysis.

996. The Authority is aware of the view from Professors McKenzie and Partington (2012) in relation to the validity of the estimates of the zero beta premia. In relation to NERA's estimates of zero beta premium, Professors McKenzie and Partington are of the view that:[546]

> There are many potential sources of error and bias in the estimation of zero beta returns and consequently such estimates should be viewed with great caution. Even if the foregoing problems were set aside, there are also question marks over the standard errors of the zero beta return estimates. This is an important unresolved issue given that the magnitude of the standard error is the basis for concluding whether estimated zero beta returns differ from zero.

997. In addition, in relation to the robustness of the estimated zero beta, McKenzie and Partington (2012) are of the view that robustness means that there is little or no variation of the estimated parameter in response to sensible alternative approaches to estimation. On this ground, McKenzie and Partington argue that NERA's estimates of the zero beta premiums are not robust. They also argued that:[547]

> We make a more general and more important point that "the empirical zero beta portfolio" is not unique. Consequently, there are many different zero beta returns that might be estimated and very large differences in the value of that return could be obtained.

[546] McKenzie, M and Partington, G. *Review of NERA report on the Black CAPM,* The Securities Industry Research Centre of Asia Pacific (SIRCA) Limited, 22 August 2012, p. 5.

[547] McKenzie, M and Partington, G. *Review of NERA report on the Black CAPM,* The Securities Industry Research Centre of Asia Pacific (SIRCA) Limited, 22 August 2012, p. 4.

998. The Authority also notes that estimates of zero-beta premiums for both the US or for Australia vary significantly across studies. In addition, these studies have very large standard errors. For example, the Authority notes some relevant evidence to confirm its view.

Table 39 Summary of Existing Evidence on the Black CAPM

Study	Period	Zero-beta premium (standard error in brackets)
US evidence		
Fama and MacBeth (1973) [548]	1935-1968	5.76 (2.28)
Campbell (2004) [549]	1929-1963	2.76 (3.36)
Lewellen, Nagel and Shanken (2008)[550]	1963-2004	11.60 (3.65)
Campbell (2004) [551]	1963-2001	8.28 (3.12)
Australia evidence		
Lajbcygier and Wheatley (2009) [552]	1979-2007	9.96 (2.04)

999. Table 39 above reconfirms McKenzie and Partington's view that estimates of zero beta premiums are problematic. They consider that:[553]

> There is no generally accepted empirical measurement of the zero beta return in the Black CAPM. This is because the empirical measurement of the zero beta return is neither simple, nor transparent. There are many possible zero beta portfolios that might be used and the return on these portfolios is not directly observed, but has to be estimated. In the estimation process for the zero beta return, there are also inputs that cannot be observed and they too have to be estimated. The resulting estimate of the zero beta return is sensitive to the choices made in regard to the input variables and methods of estimation.

1000. The Authority notes that empirical estimates have been conducted by consultants for network service providers in Australia. Key findings from these studies are summarised as follows:

- CEG (2008) used Australian data from 1964 to 2007 and reported estimates of the zero beta premium that range between 7.21 per cent per annum and 10.31 per cent per annum using various cross-sections of stocks traded on the ASX data formed into 10 portfolios on the basis of past estimates of beta.[554]

548 Fama, E and J. MacBeth, Risk, return, and equilibrium: Empirical tests, *Journal of Political Economy* 71, pp. 607-636.

549 Campbell, J. And T. Vuolteenaho, Bad beta, good beta, *American Economic Review* 94, pp. 1249-1275.

550 Lewellen, J., S. Nagel and J. Shanken, A skeptical appraisal of asset pricing tests, *Journal of Financial Economics*, forthcoming

551 Campbell, J. And T. Vuolteenaho, Bad beta, good beta, *American Economic Review* 94, pp. 1249-1275.

552 Lajbcygier, P. and Wheatley, S. (2009), Dividend Yield, Imputation Credits and Returns, Working Paper, Monash University.

553 McKenzie, M and Partington, G. *Review of NERA report on the Black CAPM,* The Securities Industry Research Centre of Asia Pacific (SIRCA) Limited, 22 August 2012, p. 8.

554 CEG (September 2008) *Estimation of, and correction for, biases inherent in the Sharpe CAPM formula,* a report prepared for the Energy Networks Association Grid Australia and APIA.

- NERA (2013) used Australian data from 1974 to 2012 and reports estimates of the zero beta premium that range between 8.74 per cent per annum and 13.95 per cent per annum using both individual stocks and stocks formed into portfolios on the basis of past estimates of beta.[555]
- SFG (2014) reported an estimate of the zero beta premium of 3.34 per cent per year. This study was based on 20 years of returns information from 1994 and 2013.[556]

1001. In their recent report prepared for the AER, Partington and Satchell also concluded that:[557]

> Beaulieu, Dufour and Khalaf have been working on this problem [of estimating zero beta return] for over a decade and have developed improved estimation procedures. Applying these procedures they conclude that the estimate of the zero beta return is unstable over time. Although these improved procedures are a valuable contribution to the research literature, they involve complex econometrics and are not yet widely accepted. Consequently, we would not currently recommend them for regulatory use.

1002. Partington and Satchell noted that:[558]

> Given that an inefficient portfolio is used as the proxy for the market portfolio there is an infinite possible set of zero beta returns and even when you constrain the estimate by using a regression model, what you get is very much determined by what you do. Hence the wide range of estimates previously submitted by regulated business.

1003. And that:[559]

> First, the estimate of the return on the zero beta portfolio is sensitive to the choice of the portfolio used to represent the market and it can be very sensitive to this choice. Second the sensitivity depends on the curvature of the efficient frontier lying between alternative portfolios used to represent the market.
>
> At a theoretical level the choice of portfolio to represent the market leads to a multiplicity of possible values for the zero beta return and what you get in empirical work depends very much on what you do. The very substantial variation in the estimates provided by the regulated businesses, and the theoretical and empirical work showing the unreliable nature of zero beta return estimates, clearly suggests that estimates of zero beta returns are not appropriate for use in determining regulated returns.

1004. On balance, the Authority considers that there are still many unsolved issues in relation to the estimates of the zero beta premiums. As such, the Authority considers that it may be problematic for the use of zero beta premium estimates in the analysis. The Authority is convinced that the unsolved issues in relation to the estimates of the zero beta premium may well explain why the Black CAPM has never been adopted by any practitioners.

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555 NERA Economic Consulting (June 2013) *Estimates of the Zero-Beta Premium,* a report prepared for the Energy Networks Association, p. 16 and p. 23.

556 SFG Consulting (2014) *Cost of equity in the Black Capital Asset Pricing Model,* a report prepared for Jemena Gas Networks, ActewAGL, Ergon, Transend, TransGrid, and SA PowerNetworks, p. 27.

557 Partington, G. and Satchell, S. “Report to the AER: Analysis of Criticism of 2015 Determinations”, a report prepared for the Australian Energy Regulator, October 2015, p. 19.

558 Partington, G. and Satchell, S. “Report to the AER: Analysis of Criticism of 2015 Determinations”, a report prepared for the Australian Energy Regulator, October 2015, p. 20.

559 Partington, G. and Satchell, S. “Report to the AER: Analysis of Criticism of 2015 Determinations”, a report prepared for the Australian Energy Regulator, October 2015, p. 26.

DBP's model adequacy test produces nonsensical outcomes

1005. The Authority notes that based on the findings from its model adequacy test, DBP is of the view that the bias in its analysis is not only statistically significant, but economically significant as well, with a mean forecast error of around four percentage points per annum. DBP considers that this means that a regulator using the ERA's approach setting prices which provide investors with returns that are four percentage points lower than they could be earning by facing similar levels of systematic risk elsewhere in the economy.[560]

1006. Table 40 illustrates the nonsensical nature of the outcomes produced from DBP's model adequacy test for the Sharpe Lintner CAPM.[561]

Table 40 Wald and t-test results - ERA empirical Sharpe Lintner CAPM

		Method A		Method B	
		24.910		25.821	
Portfolio	Betas	Mean forecast error	T tests	Mean forecast error	T tests
1	0.623	-4.16%	-1.782	-4.85%	-2.621
2	0.692	-4.09%	-1.662	-4.85%	-2.676
3	0.653	-3.66%	-1.457	-4.40%	-2.546
4	0.839	-4.11%	-1.552	-4.93%	-2.925
5	0.927	-1.97%	-0.650	-2.87%	-1.663
6	0.947	-0.46%	-0.153	-1.50%	-1.005
7	1.031	2.23%	0.665	1.13%	0.661
8	1.250	2.91%	0.754	1.45%	0.771
9	1.443	8.15%	1.836	6.37%	2.709
10	1.516	7.28%	1.326	5.39%	1.403

Source: DBP analysis. Note – mean forecast errors are in percentage points per annum

1007. Based on the above analysis, DBP concluded that:[562]

> For the low-beta portfolios, the model has a statistically-significant negative bias at the five percent level under method B, and Portfolio One has a statistically significant negative bias at the ten percent level under Method A.64 Method B is more reliable than Method A, because it produces more robust and statistically powerful results as it does not include variation in market returns.

And that:

> This bias is not only statistically significant, but economically significant as well, with a mean forecast error of around four percentage points per annum. **This means that a regulator using the ERA's approach setting prices which provide investors with returns that are four percentage points lower than they could be earning by facing**

[560] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 60.

[561] The "standard" five per cent critical value for a Wald test with 10 degrees of freedom is 18.3, whilst for the t-test it is 1.96 (1.645 and the ten per cent level).

[562] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 62.

> **similar levels of systematic risk elsewhere in the economy.** This error is between half and two thirds of the overall allowed rate of return in recent Jemena (8.1 per cent – see AER 2014) an ATCO (6.8 per cent – see ERA 2014b) Draft Decisions. We would suggest that recognition of this error would lead to a materially preferable outcome ((as per Section 259(4a) of the NGL) in respect of the regulators' estimates of the return on equity. [emphasis added]

1008. The Authority considers that the implication for DBP's finding is that the expected return on equity for low beta assets such as ATCO and DBNGP needs to be increased by 4 percentage points, based on DBP's analysis and conclusion.

Illustration 1

1009. The Authority uses the final estimates that the Authority adopted in its recent Final Decision for the ATCO Gas Distribution System to illustrate its concern. In that Final Decision, a risk free rate of 1.96 per cent; the MRP of 7.6 per cent and an equity beta of 0.7 were adopted. As a result, the expected return on equity is 7.28 per cent. To be consistent with DBP's finding, this expected return would need to be adjusted upward to 11.28 per cent (an increase of 4 per cent based on DBP's analysis).

1010. In its Final Decision for ATCO, the Authority evaluated the long run average market return observed from the Brailsford, Handley and Maheswaran (**BHM**) series in the Rate of Return Guidelines. The BHM (2012) series spanned 128 years and so was considered the most appropriate data set for determining the long run average market return on equity and the related MRP. With regard to data quality, the BHM historic series are claimed to be downwardly biased on account of an inadequate adjustment made to the dividend yields employed in the data. To address this perceived issue, in 2013 NERA produced an Australian stock market total return series that readjusted the dividend yields prior to 1957.[563]

1011. In the Final Decision for ATCO, the Authority extended the BHM and NERA series through to 2014, based on the most recent data.[564] The difference between the long run average (nominal) market return on equity based on the BHM and NERA series is 36 basis points (Table 41).

Table 41 BHM and NERA long run historic nominal and real annual average market returns for 1883 to 2014 (excluding imputation credits)

	NERA approach	BHM approach	Difference
Nominal return	12.00%	11.64%	0.36%
Real return	8.76%	8.40%	0.36%

Source: NERA (2013), Brailsford, Handley and Maheswaran (2012) and ERA Analysis

1012. Handley's advice to the AER prepared in October 2014 raised a number of concerns regarding the analysis underlying the NERA (2013) data. In particular, he highlighted

563 NERA Economic Consulting, *The Market Risk Premium: Analysis in Response to the AER's Draft Rate of Return Guideline*, A Report for the Energy Networks Association, October 2013.

564 Daily ASX All Ordinaries (AS300) and Accumulation (ASA300) indices were sourced from Bloomberg. Annual outcomes were calculated consistent with the method set out by BHM in their 2012 study (see T.J. Brailsford, J.C. Handley and K. Maheswaran, The Historical Equity Risk Premium in Australia: Post-GFC and 128 Years of Data, *Accounting and Finance*, 52, 2012, section 2, p. 238). Bond and bill yields were extended based on the Reserve Bank of Australia statistics (90 day Bank Accepted Bills were used for 2013 and 2014 as there is no 3 month Treasury bills data for those years). Gamma was assumed at 0.4 consistent with the Authority's estimate for ATCO Final Decision.

a lack of consistency between NERA's source of dividend yields and those employed by Lamberton on which the BHM series was based.[565] Additionally, he highlighted that NERA had not reconciled their adjusted yields with those of Lamberton. The Authority therefore is of the view that the analysis underlying the NERA (2013) data is insufficient grounds to justify the full upward adjustment to the BHM series performed by NERA.

1013. Given the uncertainty surrounding the most appropriate adjustment to the market return series, the Authority will use an average of the two series to minimise any potential error with use of either series alone. The real returns of both series are used (Table 42), removing inflation on a consistent basis (informed by the estimates of historic inflation set out in the BHM data).[566]

1014. The estimate of inflation for the next 5 years used in for the ATCO Final Decision is 1.90 per cent. This estimate is used to inflate the resulting average real return geometrically (based on the Fisher equation). This produces a nominal estimate for the average return on the market of 11.01 per cent for the NERA based data and 10.64 per cent for the BHM based data. The Authority notes that the average of the two series is 10.83 per cent.

1015. Based on its model adequacy test, DBP argue that the expected return for DBP or ATCO (a low asset beta) using historical data on DBP's model adequacy test should be 11.28 per cent (see paragraph 1009 above). The Authority notes that the market return on equity for a long period, as presented in Table 42, is approximately 10.83 per cent, which is lower than the claimed expected return for the low asset betas such as DBP and ATCO, even at a time of low risk free rates. These pieces of evidence reconfirm the Authority's view that DBP's model adequacy test produces a nonsensical results.

Table 42 Average annual imputation credit yields and grossed up arithmetic average returns (nominal, consistent with the estimate of gamma of 0.4)

	NERA	BHM	Average
Nominal returns excluding imputation yield (1883-2014)	12.00%	11.64%	11.82%
Nominal imputation credit yield (**1988**-2014)	0.88%	0.88%	0.88%
Grossed up nominal returns (1883-2014)	12.19%	11.83%	12.01%
Grossed up real returns (1883-2014)	8.94%	8.58%	8.76%
Expected inflation for AA4	1.90%	1.90%	1.90%
Grossed up nominal return commensurate with current inflation expectations	11.01%	10.64%	10.83%

Source: ERA Analysis, NERA (2013), Brailsford, Handley and Maheswaran (2012)

Illustration 2

1016. The Authority now uses evidence also presented by DBP for Portfolio 9, as presented in Table 40, with the high asset beta such as the TPI in Western Australia. Black

565 J. Handley, *Advice on the Return on Equity*, A Report prepared for the Australian Energy Regulatory, 16 October 2014, p. 19.

566 T.J. Brailsford, J.C. Handley and K. Maheswaran, The Historical Equity Risk Premium in Australia: Post-GFC and 128 Years of Data, *Accounting and Finance*, 52, 2012, p. 241; NERA Economic Consulting, *The Market Risk Premium: Analysis in Response to the AER's Draft Rate of Return Guideline*, A Report for the Energy Networks Association, October 2013, Table 2.7, p. 28.

CAPM considered that the Sharpe Lintner CAPM overestimates the return on equity for this high asset beta firm. It is assumed that the equity beta of 1.30 is adopted.

1017. DBP's analysis confirms that these estimates for Portfolio 9 are statistically significant under both Method A and Method B, a (positive) bias is 8.15 per cent (for Method A) and 6.37 per cent (for Method B). Given the risk free rate of 1.96 per cent and the MRP of 7.6 per cent, together with equity beta of 1.43, the return on equity for this hypothetical business is 12.93 per cent. Taking into account a positive bias (i.e. the Sharpe Lintner CAPM overestimates the high beta assets), then the return on equity for this particular business would need to be reduced to approximately 4.78 per cent (for Method A) and 6.56 per cent (for Method B). Both estimates of return on equity in these two cases are lower than the cost of debt for this business.

1018. On balance, the Authority is of the view that the findings of DBP's analysis are not robust and the approach produces a nonsensical outcomes.

Other aspects of DBP's model adequacy test

1019. As previously discussed in previous sections, the Authority is of the view that DBP's model adequacy test fails on both grounds: (i) the theoretical considerations; and (ii) the practical considerations.

1020. In addition, the Authority also notes the following two aspects which support the Authority's view that DBP's model adequacy test is not robust and as such, the model should not be used. These two aspects include: (i) the bias-variance trade-off; and (ii) specific critiques to DBP's model adequacy test.

1021. Each of these two aspects is considered in turn below.

Bias-Variance Trade-off

1022. There are many possible measures of model performance, and these include bias, variance, efficiency, and consistency (which itself is closely tied with prediction). Of these, it is agreed a key criterion of model performance is the model's ability to predict an independent sample of 'test' data that was not previously included within the sample of 'training' data used to estimate the model. This section aims to clearly define the statistical properties of estimators that are applied to assess prediction performance. In so doing, a consistent framework for evaluating new models, estimation methods, and model evaluation methods will be established.

1023. Prediction, or generalization, error is the error in predicting observations within an independent test sample. This prediction error may be expressed either as a mean square error or as a mean absolute deviation[567]:

$$Err = \begin{cases} \dfrac{1}{N_{test}} \displaystyle\sum_{i=1}^{N_{test}} \left(Y_i - \hat{f}\left(X_i\right)\right)^2 & \textit{squared error} \\ \dfrac{1}{N_{test}} \displaystyle\sum_{i=1}^{N_{test}} \left|Y_i - \hat{f}\left(X_i\right)\right| & \textit{absolute error} \end{cases} \tag{60}$$

567 T. Hastie, R. Tibshirani & J. Friedman, *The Elements of Statistical Learning: Data mining, inference and prediction*, Springer, New York, 2009, Chapter 6.

where:

- Y_i are the observations (shorthand Y);
- X_i the explanatory variables (shorthand X);
- $\hat{f}(\bullet)$ the estimated CAPM; and N_{test} the size of the test sample to be tested for prediction accuracy.

1024. The prediction error can be decomposed into both a bias component and a variance component. For an expected squared-error loss this may be expressed as:

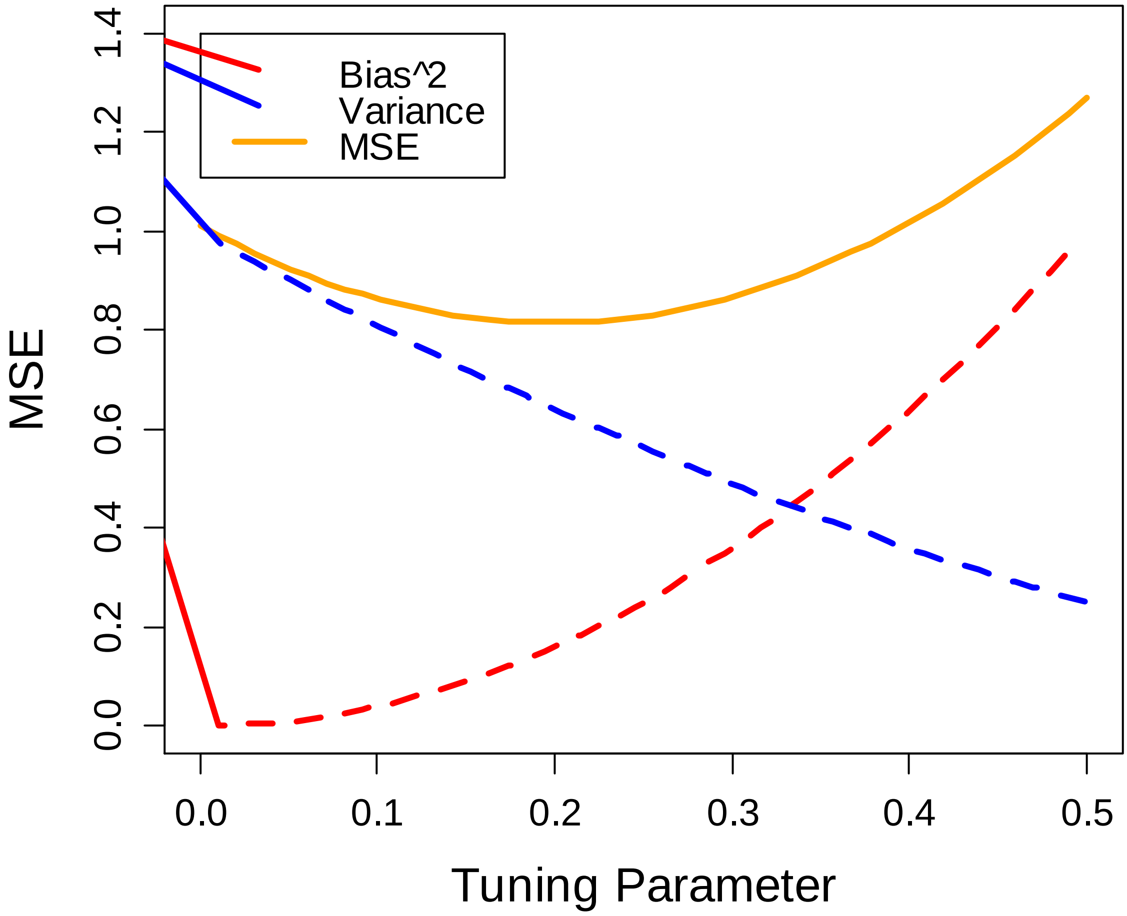
(61)

$$\begin{aligned} E(Err) &= E\left[\left(Y - \hat{f}(x_0)\right)^2 \middle| X = (x_0)\right] \\ &= \sigma_\varepsilon^2 + Bias^2\left(\hat{f}(x_0)\right) + Var\left(\hat{f}(x_0)\right) \end{aligned}$$

where σ_ε^2 is an irreducible error component, and the remainder of the expression describes the variance and squared bias of the model as a predictor of new data. The bias describes the distance between the model predictions and the true value on average when applied to multiple test samples, whereas the variance measures the mean distance between the predictions generated for each test sample and the mean prediction over all test samples.

1025. The bias-variance trade-off describes the situation where increasing a model's complexity may reduce bias but increase variance (Figure 15). Alternately, if a model is estimated that fits the training set data extremely well (i.e., too well), then it may have high bias. In this instance the model may be 'over-fitted' to the singular features characteristic to the training data but that are not shared by other possible samples of data (e.g., when coping with one specific outlier). Hence, estimating a model with minimal prediction error above the irreducible component σ_ε^2 involves a trade-off between fitting the training data too well (high bias) and not explaining the training data well enough (high variance).

Figure 15 Variance-bias trade-off and the MSE of prediction



Note In this illustrative example the prediction error is minimised at a value of 0.2 for the tuning parameter.

Source ERA analysis.

Specific critique of DBP's Model Adequacy Test

1026. DBP describe bias and variance,[568] suggesting that a test of bias is a better indicator of how well a model makes predictions about the required rate of return than the Diebold-Mariano tests that had previously been implemented and questioned by the Authority itself.

1027. DBP then proceed to outline a model adequacy test:[569]

(a) first we take a financial model and parameterise it using data up to a point in time.

(b) then we use it to make a prediction on future returns.

(c) then we compare predicted with actual returns and record any error.

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568 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, Section 5.58 – 5.60.

569 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, Section 5.62.

(d) having done that, we compare the errors over many periods and many different portfolios to understand whether they are, on average, zero.

A t-test is then applied to the individual portfolios, and Wald and Mincer-Zarnowitz[570] tests applied to the predictions globally across all portfolios.

1028. The model adequacy test described suffers from several immediate issues, each of which will be further detailed below:

- The test does not evaluate prediction bias as claimed by DBP[571], only overall prediction accuracy which is comprised of irreducible, bias and variance components.
- The test does not include uncertainty of prediction estimates within the test.
- The testing of each portfolio through the use of a t-test will suffer from the multiple comparison problem, which will increase with the number of portfolios.
- The method of generating predictions potentially suffers from pseudo-replication.
- The t-test is not specified, and for discussion purposes it is assumed to be a two-sample t-test. In contrast, a paired t-test is a uniformly more powerful test in discriminating differences between two dependent samples of data.
- The model adequacy test described is not de rigueur in the statistical literature for assessing model performance, with no reference in the literature in defence of the method cited by the authors.

1029. While significant prediction bias will result in the DBP model adequacy test to identify a model generating low quality predictions, the test does not discriminate between the different error components of models. Importantly, if predictions are biased then there are many different sources of bias, quite apart from any bias in the parameter estimate. Bias in predictions should not be confounded with bias in parameter estimates.

1030. As argued in Appendix 1, the Henry implementation of the Sharpe Lintner CAPM does form a Best Linear Unbiased Estimator (BLUE) of the beta parameter when applying OLS.[572] From a statistical perspective these parameter estimates cannot be viewed as biased under the Gauss-Markov theorem. If the Sharpe Lintner CAPM estimate of β is biased then it is likely due to the failings typically associated with employing a simple linear model, insofar as there may be unknown predictor variables and/or variance components omitted from the model, a failing that is shared with the Black CAPM.

1031. Other sources of bias in either the Sharpe Lintner and Black CAPMs may include:

- Input bias occurs where a predictor variable within a model is biased in its estimate. The Black CAPM may, for example, be subject to input bias insofar as the zero-beta premium estimated from the two-pass estimation method will likely itself be biased, forming an input bias into beta estimates of individual

570 Mincer JA and V Zarnowitz. *The evaluation of economic forecasts,* Economic Forecasts and Expectations: Analysis of Forecasting Behavior and Performance. NBER, 1969. 3-46.

571 DBP, *Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return*, Supporting Submission: 12, 31st December 2014, firstly in Section 5.63 and then throughout.

572 Henry, OT “Estimating β: An update”, Advice Submitted to the Australian Competition and Consumer Commission. April 2014.

equities. Moreover, for example, DBP claim that the risk-free return is downwards biased as no firm can borrow at that rate in the market in practice.[573]

- Model bias is known as Type III error, and suggests that a model appropriately describing changes in returns is required to avoid introducing biased parameter estimates. For linear models this can be due to either omitted or committed variable bias, where model bias is due to either omitting key predictor terms from the model or including unnecessary predictor terms. For example, the Henry method of estimating beta allows for an intercept term that doesn't require specification of the risk-free return at all.[574] In comparison, the classical Sharpe Lintner CAPM is input biased as it includes no intercept term. Model selection processes are on the whole designed to minimise model bias. However, model selection processes are still susceptible to model fallacy, i.e., where a model predicts well a set of 'test' observations, but the underlying model of the data generation process is actually wrong.
- Zero-inflation bias can be due to thin client trading.[575] The Rate of Return Guidelines has examined the influence of possible thin client trading on estimates of beta through the Dimson's test, and found the securities forming the All Ordinaries index were largely free of zero-inflation bias. If zero-inflation bias were present then zero-inflation or hurdle models analogous to the Sharpe Lintner CAPM may be applied.[576]
- Sampling bias occurs when the small proportion of data sampled is highly likely lead to an estimate far from the value of the population parameter being estimated (in this case β). Sampling bias is not a feature of the available data on asset prices, although it will feature when asset returns on a Tuesday are compared with those on a Friday. However, as sample size increases (as a proportion of the data) then sampling bias decreases. The key way to minimise sampling bias of asset returns is to lengthen the time series available to estimate a population parameter. However, as time series are often non-stationary then increasing sample size does not necessarily lead to greater accuracy of the estimator at a single point in time, due to a bias-variance trade-off.

1032. Predictions are inherently uncertain, and strict tests comparing an estimate with an observed value should include the measure of uncertainty of the estimate within the test. The net effect is an inflation of the test's standard error associated with combining two samples into a single sample under the null hypothesis. This inflation of the estimated error reduces the power of the test in discriminating a difference between the predicted and observed values.

1033. The multiple comparison problem says that with a Type I error rate of say, 5 per cent, of a statistical test then for, say twenty statistical tests, then one of those tests will on average declare a statistically significant difference although the samples are drawn from the one and same population. In the current context, the more portfolios that

573 DBP, *Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return*, Supporting Submission: 12, 31st December 2014, section 5.14, citing paragraph 147 in ERA 2013.

574 Henry, OT "Estimating β: An update", Advice Submitted to the Australian Competition and Consumer Commission. April 2014, p. 7.

575 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, p. 7.

576 Frees, E. W. Regression Modeling with Actuarial and Financial Applications Cambridge University Press, 2011.

constructed to examine the behaviour of different segments of the market then the greater the rate of false positives overall when applying a t-test to each portfolio. Such multiple comparisons should be corrected in some manner, such as through a Bonferroni correction.

1034. Pseudo-replication arises when measures are taken at a finer temporal scale, but the change in support is not explicitly reflected in the model.[577,578] By applying predictions at a finer time scale then a larger sample can be generated for the DBP t-test, thereby artificially increasing the power of the test with the increased sample size. In effect, models are potentially discriminated against that perhaps should not be discriminated against. Pseudo-replication is suggested in DBP's model adequacy test,[579] where a five year average for predictions is discarded in favour of month-ahead predictions so as to boost sample size. Similarly, arbitrarily increasing the number of portfolios tested using a Wald statistic should not lead to a more powerful test if the same underlying assets are utilised.[580] Ideally, a criterion for accepting or discarding different models should be as practically possible free of influence of how a single sample is divided.

1035. It is assumed, as it is not specified, that the t-test employed by DBP[581] is a two-sample t-test. However, the model predictions and observations may be classed as statistically dependent as they refer to the same time stamp (i.e., an observation and a prediction exists for each observation). In such a case then paired t-tests (or similar) should be employed on the difference between corresponding predictions and observations. Explicit modelling of the dependence between the two samples being tested uniformly increases the power of the test to identify differences between predictions and observations.

1036. A proposed model adequacy test based on a Wald test or t-test is not explicitly referenced in the statistical literature. Typically t-tests and Wald tests, within the context of model fitting, are used to identify whether a hypothesized parameter value falls within the sampling distribution of a sample estimate of that parameter, thereby forming a goodness-of-fit test.[582] Wald tests and t-tests are generally not applied in the statistical literature to a comparison of predictions and their equivalent out-of-sample observations. The Diebold-Mariano[583] test does perform a paired t-test between the residuals of two series of forecasts, and perhaps is the closest analogy of the proponent's t-test. The Mincer-Zarnowitz test is perhaps technically more valid, but may still suffer from pseudo-replication, insofar as applying the test to an increased number of predictions, generated from the model with longer forecasts, will

577 S.H. Hurlbert, "Pseudoreplication and the Design of Ecological Field Experiments", *Ecological Monographs*, 54, 187-211, 1984.

578 S.E. Lazic, "The Problem of Pseudoreplication in Neuroscientific Studies: Is it affecting your analysis?", *BMC Neuroscience*, 11, p. 5, 2008.

579 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, Section 5.94.

580 NERA, *Empirical Performance of Sharpe Lintner and Black CAPMs*, A report for Jemena Gas networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy, Feburary 2015, Table 5.1, p. 39.

581 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, Section 5.97.

582 T. Hastie, R. Tibshirani & J. Friedman, *The Elements of Statistical Learning: Data mining, inference and prediction*, Springer, New York, 2009, Chapter 6.

583 F.X. Diebold and R. Mariano, "Comparing Predictive Accuracy", *Journal of Business and Economic Statistics*, 13, pp. 253-265, 1995.

increase the power of the test without the underlying prediction error of the CAPM model changing.

1037. Lastly, the predictions on which the model adequacy test was based were derived from the classical Sharpe Lintner and classical Black CAPM. These models are known to be more biased in their predictions than their empirical counterparts. Predictions of the empirical models with the corresponding estimated intercept term included would be a fairer basis for comparison. In the case where both r_f and r_z are static then the predictions from the empirical Sharpe Lintner and Black CAPM are identical to the predictions from the Henry Sharpe Lintner (Appendix 1).

1038. The Authority also notes that when the two models are compared, it is more appropriate to use the cross validation method for the purpose. Further details of the method is set out in Appendix 4Bi.

Overall conclusions

1039. The Authority is of the view that DBP's model adequacy test does not follow standard finance/economic/statistical theory. Its approach is not tested and appears unsupported by any source. The Authority considers that DBP's analysis is flawed and its approach does not produce sensible estimates.

1040. DBP's model adequacy test fails on both conceptual and empirical considerations. Most importantly, the Authority is of the view that DBP's model adequacy test:

- does not test the Authority's forward looking approach to estimating the return on equity using the Sharpe Lintner CAPM, but rather versions based on historic MRP outcomes;
- compares two models that are not robust in the Australian context (the Black CAPM and FFM), with another method that is not relied on either (the Sharpe Lintner CAPM, using an MRP that is based on historic data only).

1041. In addition, the Authority is of the view that other fundamental issues such as bias-variance trade-off are too important to be ignored. The Authority considers that it is inappropriate to utilise DBP's model adequacy test to compare models. If such a task is required, then the cross validation method should be used.

1042. In conclusion, the Authority is of the view that DBP's model adequacy test is not fit for the purpose of comparing the prediction properties of models, and as such, the test, as proposed, should not be used.

Appendix 4B(i) The cross validation method of model adequacy testing

1043. A more appropriate framework for assessing prediction accuracy, and hence model adequacy, is to utilise the cross-validation measure of prediction error. This framework can be extended to explicitly decompose prediction error into its irreducible, bias and variance components by employing jack-knife methods[584]. Moreover, cross-validation is a widely applied framework within the statistical literature[585], and its strengths and failings have been well researched.

1044. Cross-validation estimates expected prediction error. There are different cross-validation schemes which aim to estimate the out-of-sample prediction error purely from within-sample data. Other schemes for estimating out-of-sample prediction error include splitting the sample into discrete training and test sets (i.e., a holdout scheme).

1045. Ideally, separate samples of data should be applied to the two separate tasks for model estimation and model evaluation: a training (or calibration) sample for model estimation (or fitting), and a test (or validation) sample for model evaluation. However, this approach is not efficient unless data are abundant. Hence the idea behind cross-validation is to recycle the one sample of data by switching the roles of training and test samples within the sample, thereby maximising the use of available data for model estimation

1046. K-fold cross-validation divides a data set into K sets. A model is trained on K-1 sets, and then validated on the Kth set that was set aside for this purpose. We do this for the sets $k = 1, 2, \ldots, K$. It has been argued that K-fold cross-validation with sizeable K is useful for model selection. In contrast leave-one-out cross-validation, where the size of the Kth set is simply a single observation, provides a better estimate of prediction error for validation purposes[586]. Larger sized sets applied in K-fold cross-validation tend to over-estimate prediction error, i.e., result in a cross-validation estimate of lower variance but higher bias. Denoting $\hat{f}^{-i}(x_i)$ as the prediction of the i^{th} observation from the model $f(\bullet)$ gives the leave-one-out cross-validation estimate of prediction error:

$$CV(\hat{f}) = \frac{1}{N}\sum_{i=1}^{N}\left(y_i - \hat{f}^{-i}(x_i)\right)^2 \qquad (62)$$

1047. A month-ahead, moving window forecast is a form of cross-validation, as applied in the DBP model adequacy test. Such a cross-validation scheme is not considered as efficient as K-fold schemes, in terms of the number of predictions they generate for the same sample of data. Step-ahead forecasting is designed to reduce the impact

584 Jack-knife resampling is applied to variance and bias estimation and predates the bootstrap. For a sample of size *N* it involves aggregating the estimates from each subsample of size *N-1*. B. Efron, “Bootstrap methods: another look at the jackknife”, *Annals of Statistics*, 7, pp. 1–26, 1979.

585 T. Hastie, R. Tibshirani & J. Friedman, The Elements of Statistical Learning: Data mining, inference and prediction, Springer, New York, 2009.

586 R. Kohavi, “A study of cross-validation and bootstrap for accuracy estimation and model selection”, Ijcai, 14, pp. 1137-1145, 1995.

of non-stationary effects on estimates of the out-of-sample prediction error. However, there is little evidence that K-fold schemes perform less well for non-stationary time series than step-ahead forecasting.[587] Importantly, deploying K-fold schemes largely voids the concerns expressed DBP[588], where a month-ahead scheme is recommended so as to generate sufficient out-of-sample data for the model adequacy test.

1048. The cross-validation estimate of prediction error can be profiled with a tuning parameter η. For example, η may be the window size of a month-ahead prediction, and so different window sizes can be evaluated in terms of their ability to minimise prediction error by profiling the cross-validation estimate across different values of η. Similarly, how far to predict ahead may also be answered using a profile approach, combined perhaps with an integrated error loss function.[589] Hence:

$$CV\left(\hat{f},\eta\right)=\frac{1}{N}\sum_{i=1}^{N}\left(y_i-\hat{f}^{-i}\left(x_i,\eta\right)\right)^2 \qquad (63)$$

and so different sampling issues (e.g., window size), model selection where the size of the model is somehow linked to a tuning parameter η; and parameter values can be selected for.

1049. Hence, a potential use of the cross-validation criterion with tuning parameter is to explore the influence of sampling parameters on prediction error. For example, the correctness of choosing a fitting frame of five years to produce an estimate of β may be examined by trialling fitting frames of different lengths, say from one to ten years, with the tuning parameter being the length of the fitting frame. A short fitting frame may be considered as having high error due to it being highly influenced by recent data, whereas a longer fitting frame may be incorporating information from previous periods that no longer apply to the current market. An optimal fitting frame will likely sit in the middle, given the bias-variance trade-off, and may be identified by completing the cross-validation profile. Other tuning and decision parameters used to generate estimates of β may also be applied.

1050. Alternatives to cross-validation include bootstrap estimates of prediction error, namely the .632+ estimator[590]. The .632+ estimator performs similarly in estimating prediction error as cross-validation, but is more complicated conceptually. Splitting data into strict training and test sets to develop and validate predictive models, such

587 C. Bergmeir and J.M. Benitez, “On the use of cross-validation for time series predictor evaluation”, *Information Science*, 191, pp. 192-213, 2012.

588 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, Section 5.94.

589 DBP, *Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return*, Supporting Submission: 12, 31st December 2014, identified as a concern in Section 5.93.

590 The .632+ bootstrap estimator is applied specifically to measuring prediction error, and may be considered a smooth version of cross-validation, which often is subject to high variance in the estimation of prediction error. The term .632 comes from the concept that as sample size increases then approximately 0.632 of the original data sample is represented within each bootstrap sample given bootstrap samples allow sampling with replacement. The ‘+’ refers to a correction for overfitting of the model when overfitting is in evidence. B. Efron and R. Tibshirani, “Improvements on cross-validation: the 632+ bootstrap method”, *Journal of the American Statistical Association*, 92, pp. 548–560, 1997.

as employing a 70:30 holdout rule[591], provides perhaps a less biased mechanism for estimating prediction error, but requires significantly more data to return an accurate measure of prediction error. In most cases the cross-validation estimate is sufficient as a measure of prediction error.

1051. Cross-validation itself does not assess the components of prediction error. Instead, methods such as the jack-knife should be employed to estimate prediction bias.[592] However, these methods tend to add another layer of computation to calculations of prediction error, and will only be practically worthwhile if it is adjudged that the main focus of the analysis is to quantify bias, as this matches the NPV=0 condition.[593]

1052. There are a number of other tests designed to identify model bias and model adequacy. As mentioned above, the Mincer-Zarnowitz test involves a regression of model predictions on the equivalent observations. A Diebold-Mariano test will construct a t-test of the residuals from the forecasts of two models, while allowing for serial autocorrelation and cross-covariance in the residuals. Similar to the model adequacy t-test of DBP, the standard error of the test is in practice not inflated by uncertainty surrounding model predictions of asset returns as statistical theory would require. The Kan[594] goodness-of-fit test deals also with the forecasts of two competing models, but considers R^2 as the discriminating statistic. In general, employing R^2 measures in goodness-of-fit tests is to be avoided, as R^2 only provides an estimate of the strength of a relationship between model and data, and says little about patterning in the residuals that result from miss-specified models, leading to low predictive accuracy.

1053. Indeed some authors assert that goodness-of-fit tests should not be used for model selection, as goodness-of-fit tests generally under-estimate the generalization error (i.e., out-of-sample prediction error[595,596]). Goodness-of-fit tests are invariably constructed from a residual sum of squares (RSS) measure.

1054. If pairwise tests such as the proposed model adequacy tests are to be applied, then if there is a multiplicity of candidate models then there will be a combinatorically larger number of pairwise comparisons of those models. For example, if there are 10 candidate models or scenarios, then there are 45 possible pairwise comparisons to be made. In contrast, by assessing the prediction error through cross-validation then the number of quantities or tests calculated and reported on are much less. Essentially one estimate of CV prediction error is required for each model or scenario.

1055. As many different statistical tests can potentially be proposed to demonstrate the superiority of one model over another it remains uncertain as to how the regulator should identify which test, or set of tests, are parsimoniously useful. No test will offer the common framework that the cross-validation criterion does in allowing for the optimal selection of sampling and modelling parameters through profiling of a tuning

591 The 70:30 holdout rule is a rule-of-thumb frequently applied in the statistical learning literature, where 70% of the data is used to fit a model and the remainder 30% is used to evaluate its prediction accuracy.

592 A. Cameron and P.K. Trivedi, Microeconometrics: methods and applications. Cambridge University Press, New York, 2005, p. 375.

593 DBP, Proposed Revisions DBNGP Access Arrangement, 2016-2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31st December 2014, Section 5.110.

594 R. Kan, C. Robotti, and J. Shanken, *Pricing Model Performance and the Two-Pass Cross-Sectional Regression Methodology*, Working Paper, Reserve Bank of Atlanta, 2009.

595 B. Efron, “How biased is the apparent error rate of a prediction rule”. *Journal of the American Statistical Association*, 81, pp. 461-470, 1986.

596 T. Hastie, R. Tibshirani & J. Friedman, The Elements of Statistical Learning: Data mining, inference and prediction, Springer, New York, 2009.

parameter. Adoption of the cross-validation framework will obviate many of the issues identified with the proposed model adequacy test, and indeed any other applied to data used to estimate the return on equity, while remaining aligned with the original intent of the model adequacy test to discriminate between different models based on their prediction accuracy. Tests may still be employed for confirmatory or exploratory purposes. However, decisions such as what model should be preferred over another on an empirical basis should refer to estimates of the expected prediction error as much as possible.

Appendix 4C The relationship between the required return on debt and the return on equity

1056. DBP consider that the return on debt can be used as a quantitative cross check for the return on equity, while giving form to the consistency requirements of NGR 87(5) and NGR 87(11).[597]

SFG's approach

1057. In the report prepared for DBP in December 2014 in relation to the relationship between the required return on debt and equity, SFG argued that:[598]

> There is an interrelationship between the return on equity and the return on debt because both equity and debt securities depend on the assets of the same firm. Debt and equity simply represent different claims over the same assets. Consequently, there is an interrelationship between the return on equity and the return on debt, the estimate of one is relevant to the estimate of the other, and the two estimates must be consistent with each other.

1058. SFG also argued that the linkage between the required returns on debt and equity in the same benchmark firm appears to be central to the NGR 87(5) requirements to have regard to all relevant evidence, consistency, and interrelationships between parameters for equity and debt.[599]

1059. SFG submitted that Merton (1974) concluded that equity and debt are contingent claims over the assets of the same firm. Both become less valuable as the assets of the firm decline in value and both become more valuable as the assets of the firm rise in value. Both are linked to the value of the assets of the firm. Thus, if there are certain factors that drive changes in the value of the assets of the firm, those same factors will drive the returns to debt and equity in that firm. SFG argued that this means that there is a positive relationship between the return on debt and the return on equity in the same firm.[600]

1060. SFG agreed with the Authority's decision that a return on equity should exceed the return on debt and that prevailing market conditions should also be taken into account when determining whether the relativities between the return on debt and equity are reasonable at the time the regulatory decisions are made. However, SFG argued that:[601]

> Such a comparison is one of the necessary preconditions for consistency – given that equity in the benchmark firm must be riskier than debt in the same benchmark firm at the same point in time, it must be the case that the required return on equity is higher than the required return on debt. However, this is not a sufficient condition for

[597] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, p. 84.

[598] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 1.

[599] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 1.

[600] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 2.

[601] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 4.

consistency – it is possible that the estimates of the required returns on equity and debt are inconsistent even though the return on equity is higher than the return on debt.

1061. SFG submitted that based on Merton (1974) model, equity is considered as a call option on the value of the firm. SFG noted that Merton (1974) models the equity of a firm as a call option on the firm's assets, with a strike price equal to the face value of the firm's debt.[602]

1062. In addition, SFG submitted that debt is considered as a put option on the value of the firm. SFG also submitted that lenders to a firm can be modelled as owing a riskless bond and being short (i.e. having sole) a put option on the firm assets.[603]

Modern application of the contingent claims framework

1063. SFG submitted that one of the key insights of the Merton framework is that the equity risk premium and the debt risk premium, as illustrated in Campello, Chen and Zhang (2008) paper, must be linked by:[604]

$$E[r_e] - r_f = \Omega_{e,d}\left(E[r_d] - r_f\right) \qquad (64)$$

Where $\Omega_{e,d}$ represents for the elasticity of equity relative to debt:

$$\Omega_{e,d} = \frac{\partial E / E}{\partial D / D} \qquad (65)$$

1064. In addition, SFG submitted that Friewald, Wagner and Zechner (2013) examined the relationship between returns on debt and equity within the Merton framework. SFG considered that, from this study, the elasticity is equal to the ratio of the volatilities:

$$\Omega_{e,d} = \frac{\sigma_e}{\sigma_d} \qquad (66)$$

1065. Based on the above considerations, SFG concluded that:[605]

> The linkage between the required returns on debt and equity in the same benchmark firm appears to be central to the NGR 87(5) requirements to have regard to all relevant evidence, consistency, and interrelationships between parameters for equity and debt. The Merton model provides the standard framework for modelling the linkage between the required returns on debt and equity in the same firm. The Merton framework shows that there are clear linkages between the required return on equity, the required return

602 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 6.

603 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 6.

604 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 6.

605 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 13.

on debt, the elasticity between equity and debt and the relative volatilities of equity and debt.

1066. SFG then argued that the above framework can be used in the regulatory setting as a check of the consistency between the allowed return on equity, a check of the interrelationships between parameters that are common to the return on equity and the return on debt, and as a check on the overall reasonableness of the allowed return on equity relative to the allowed return on debt.[606]

1067. SFG proposed two different approaches in which the checks can be performed. *First*, an allowed return on debt and an empirical estimate of elasticity jointly provide information about what would be a reasonable range for the required return on equity. *Second*, an allowed return on debt and an allowed return on equity jointly imply a particular elasticity, which can then be tested against elasticity benchmarks for the regulated firm.[607]

1068. In its report, SFG emphasised that SFG does not suggest that this framework can be used to obtain a single point estimate of the required return on equity from the analysis of primary data.[608] SFG argued that the Merton framework is very useful when considering the relationship between the required return on equity and the required return on debt for the same firm and that this framework provides valuable insights into the relativity between these two quantities.[609]

SFG's estimation

1069. SFG submitted that Schaefer and Strebulaev (2008) paper empirically examined the ability of the Merton model to explain the relationship between equity and debt risk premiums in the same firm. In this study, the so-called "hedge ratio", which is the inverse of the Merton elasticity, is presented:

$$h_e = \frac{\partial E/E}{\partial D/D} = \frac{1}{\Omega_{e,d}} \qquad (67)$$

Then:

$$h_e = \left(\frac{1}{\Delta} - 1\right)\left(\frac{1}{L} - 1\right) \qquad (68)$$

where Δ represents the derivative of equity value with respect to the value of the assets of the firm and L is the market value leverage.

1070. SFG submitted that, within the Merton framework, the Δ parameter is in the form of the standard call option delta originally derived by Black and Scholes (1973):

606 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 13.

607 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 14.

608 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 14.

609 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 14.

$$\Delta = N(d_1) \tag{69}$$

where $N(\bullet)$ represents the cumulative normal distribution function and:

$$d_1 = \frac{\ln(V/D) + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}} \tag{70}$$

where V is the value of the firm, D is the face value of the firm's debt, T is the time to maturity of the firm's debt, and σ is the volatility of the return on the firm's assets.

1071. SFG then concluded that the Merton elasticity (which is the inverse of the hedge ratio) varies directly with the equity delta and market value leverage.[610]

1072. SFG submitted that it used the Schaefer and Strebulaev (2008) approach to estimate Merton hedge ratios for a range of input parameters. SFG's base case parameter estimates include: (i) a risk free rate of 3.6 per cent; (ii) amount of debt of 60 per cent of the value of the assets of the firm; (iii) term of debt of 10 years and volatility of 40 per cent.

1073. SFG then presented its estimates of the elasticity in three scenarios: (i) the elasticity is sensitive to the term of debt and to the risk-free rate; (ii) the elasticity is also sensitive to the volatility of the returns on the firm's assets; and (iii) for debt of 10 years, the elasticity is sensitive to the risk-free rate and volatility.[611]

1074. Based on its estimates for the above three scenarios, SFG concluded that there is no reasonable combination of parameters that produces an elasticity parameter value below 6.0. In addition, SFG argued that this places a constraint on the relativity between the expected returns on debt and equity.[612]

SFG's application of the above estimate of the elasticity to the regulatory framework

1075. SFG considered that 6 is a reasonable lower bound for elasticity.[613]

1076. SFG used the Authority's cost of debt from its Draft Decision on ATCO of 5.2 per cent, including a spread of 1.80 per cent.[614] SFG argued that the 1.8 per cent

610 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 14.

611 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 16.

612 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 17.

613 DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 17.

614 The Authority notes that the estimate of 1.80 per cent, which is the estimated 10 year spread to swap, does not represent for a debt risk premium in the calculation of the WACC. The Authority's calculation indicated that the (regulated) debt risk premium is 2.27 per cent, which is the difference between the 10-year cost of debt of 5.215 per cent and the estimated 5-year risk free rate of 2.95 per cent (paragraph 895 on page 202 of the Authority's Draft Decision on ATCO).

represents a promised spread and not an expected spread. As such, SFG considered that the promised spread of 1.80 per cent can be converted into the expected spread via a deduction for expected default.

1077. Using Standard & Poor's default rate on BBB+ corporate bonds of 0.15 per cent per year over the last 30 years, together with an average recovery rate of 50 per cent for BBB+ corporate bonds, SFG's calculations indicated that the expected return on debt is 4.4 per cent.[615]

1078. SFG then concluded that the adjustment for expected default is 0.8 per cent, which is the difference between the cost of debt of 5.2 per cent and the expected return on debt of 4.4 per cent. SFG argued that the adjusted debt spread, or the expected return on debt is 1 per cent, which is the difference between the spread of 1.8 per cent and the adjustment for expected default of 0.8 per cent.[616]

1079. Based on the above considerations, SFG submitted that the lower bound reasonableness test is as follows.

$$E[r_e] - r_f > \Omega_{\min} \left(E[r_d] - r_f \right)_{\min} \quad (71)$$

$$E[r_e] - r_f > 6 \times 1.0\% = 6.0\%.$$

1080. SFG then concluded that, given the debt risk premium, internal consistency requires that the equity risk premium must be at least 6.0 per cent.[617]

SFG's application of its proposed framework

1081. SFG was instructed by DBP that it proposed a total cost of debt within the range of 5.66 per cent to 5.77 per cent (net of any new issue premium and the 15 basis points for debt issuance costs). SFG then implemented the following calculations to derive the equity risk premium for DBP.[618]

1082. *First*, a range of the debt risk premium of 2.13 per cent to 2.24 per cent was calculated. This range was based from the cost of debt of 5.66 per cent to 5.77 per cent and the risk-free rate of 3.54 per cent.

1083. *Second,* using the same 0.82 per cent adjustment for expected default, the expected debt risk premium falls within the range of 1.31 per cent to 1.42 per cent.

1084. *Third,* multiplying the expected DRP by its lower bound elasticity estimate of 6.0, SFG's calculation indicated that the equity risk premium falls within the range of 7.86 per cent to 8.52 per cent.

[615] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 18.

[616] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 18.

[617] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 18.

[618] DBP, Proposed Revisions DBNGP Access Arrangement, 2016 – 2020 Regulatory Period, Rate of Return, Supporting Submission: 12, 31 December 2014, Appendix L, p. 18.

1085. Using the risk free rate of 3.54 per cent, the above range of the equity risk premium of 7.86 per cent to 8.52 per cent implies the range of return on equity for DBP of 11.4 per cent and 12.06 per cent.

The Authority's considerations

1086. In response to SFG's analysis in relation to the relationship between the cost of debt and the return on equity, the Authority has considered both important aspects of the approach: (i) the theoretical considerations; and (ii) the practical considerations. Each of these aspects is discussed in detail below.

The Authority's theoretical considerations

1087. The Authority is not in the position to provide response to the three key studies, Merton (1974); Campello, Chen and Zhang (2008); and Schaefer and Strebulaev (2008), which SFG has relied on to support its analysis. However, the key point of emphasis is whether or not it is relevant to use the findings from these three papers to provide evidence to support the link between the cost of debt and the return on equity as SFG did.

1088. *First*, the Authority notes that Merton (1974) considered that the value of a particular issue of corporate debt depends essentially on three items: (i) the required rate of return on riskless (in terms of default) debt (e.g., government bonds or very high-grade corporate bonds); (ii) the various provisions and restrictions contained in the indenture (e.g., maturity date, coupon rate, call terms, seniority in the event of default, sinking fund, etc.); and (iii) the probability that the firm will be unable to satisfy some or all of the indenture requirements (i.e., the probability of default).[619]

1089. However, Merton (1974) argued that while a number of theories and empirical studies has been published on the term structure of interest rates (item 1), there has been no systematic development of a theory for pricing bonds when there is a significant probability of default.

1090. As a result, the Authority is of the view that the key motivation for Merton was to develop a theory of the risk structure of interest rates.

1091. *Second*, the Authority notes that Campello, Chen and Zhang (2008) constructed firm-specific measures of expected equity returns using corporate bond yields. In their study, standard ex post average returns were replaced with their expected-return measures in asset pricing tests. Key and fundamental findings from Campello, Chen and Zhang (2008) are that the market beta is significantly priced in the cross section of expected returns. The expected size and value premiums are positive and countercyclical, but there is no evidence of positive expected momentum profits.[620]

1092. In addition, the Authority notes that Campello, Chen and Zhang (2008) acknowledged one of the key caveats in their empirical approach:[621]

619 Merton, R., 1974, "On the pricing of corporate debt: The risk structure of interest rates", *Journal of Finance* 29, 449-470.

620 Campello, M., L. Chen and L. Zhang, 2008, "Expected returns, yield spreads, and asset pricing tests," *Review of Financial Studies*, 21, 3, p. 1297.

621 Campello, M., L. Chen and L. Zhang, 2008, "Expected returns, yield spreads, and asset pricing tests," *Review of Financial Studies*, 21, 3, p. 1332.

> The simple contingent-claim framework `a la Merton (1974) allows us to derive a conditionally linear relation between expected equity and bond excess returns. Under more general conditions, the relation might not be conditionally linear. We therefore emphasize that our empirical approach is only motivated by the Merton-style framework, as opposed to being a literal structural test of that framework.

1093. *Third*, the Authority considers that Schaefer and Strebulaev (2008) focuses on the issue of bond prices. The authors argued that structural models of credit risk provide poor predictions of bond prices on the following two bases.[622] *First*, structural models might fail to predict accurately the probability of default. *Second*, corporate bond prices are influenced by factors that are unrelated to credit risk and therefore absent from structural models altogether.

1094. The Authority is of the view that neither of the three papers used by SFG provides relevant and direct findings in relation to the investigation of the direct link between the cost of debt and the return on equity. All these papers focus on the term structure of interest rate or bond prices.

1095. On the ground of these considerations, the Authority is not convinced that the findings from the above three papers, as SFG claims, are relevant for the purpose of determining the relationship between the cost of debt and the return on equity within the regulatory framework in Australia.

1096. In addition, the Authority is of the view that the quantitative constraint between the cost of debt and the return on equity is not robustly established. The Authority further considers the following two theoretical and practical issues to support its view that the quantitative link between the cost of debt and the return on equity cannot be established

The link between return on equity and cost of debt

1097. The Authority notes that one of SFG's key conclusions is that there is an inconsistency between the approaches used to estimate the return on equity and the return on debt. SFG argues that this inconsistency means that the estimates of the return on equity and the cost of debt can move in different directions over time, and that the spread between the return on equity estimate and the cost of debt is not constrained in any quantitative manner. SFG notes the Authority's view that it would not make sense for the return on equity to be less than the cost of debt. However, SFG argues that apart from constraining the return on equity estimate at a lower bound, movement in debt yields are not used to estimate the return on equity.[623]

1098. SFG argued that its proposed approach provides a direct link between the return on equity; the cost of debt; the risk-free rate; the market return and leverage. Specifically, the estimated return on equity under SFG's proposed approach is estimated based on the assumed values of: (i) the cost of debt; (ii) the risk-free rate; (iii) the market return; and (iv) the leverage. The Authority also notes that SFG adopt various other assumptions, but not limited to: (i) the standard deviation of the market return; (ii) the debt recovery ratio; and (iii) the link in relation to the payoff in a *good* market and a *bad* market.

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622 Schaefer, S. and I. Strebulaev, 2008, "Structural models of credit risk are useful: Evidence from hedge ratios on corporate bonds", Journal of Financial Economics 90, 1–19.

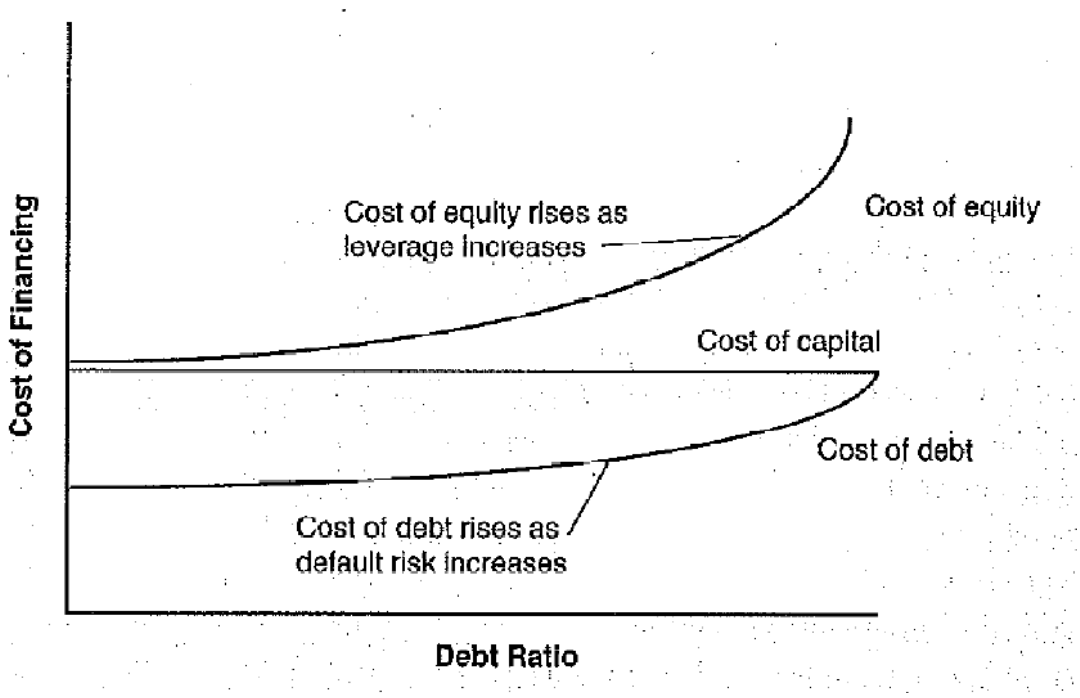
623 SFG Consulting, Cost of equity for the Goldfields Gas Pipeline, *Report for Goldfields Gas Transmission*, 22 July 2014, p. 58.

1099. However, the Authority considers that it is unreasonable to draw such strong conclusions with regard to the existence of a systematic link between the equity market and the debt market.

1100. In the context of Australian economic regulation, Professor Grundy from the University of Melbourne sought to derive the relationship between the debt risk premium (DRP) and the equity risk premium (ERP) in 2010.[624]

1101. In his analysis, Professor Grundy adopted the figure from Damodaran's (2009) textbook, reproduced at Figure 16 below, which illustrates the cost of debt initially increasing very little as the debt ratio grows from a very low level. However, when a firm becomes increasingly debt-financed, the cost of debt rises rapidly to become equal to the firm's cost of capital, as the debtholders' claim on the firm comes increasingly closer to 100 per cent of the firm's cash-flows.

Figure 16 Cost of Capital in the Miller-Modigliani World



1102. Professor Grundy argued that the convexity of the relationship between the two implies that a lower bound for the DRP can be derived from the ERP for a given firm. With the gearing level of 60 per cent, Professor Grundy concluded that:[625]

> If the firm has 60 per cent debt financing and the asset pricing model does not imply an Equity Risk Premium at least 2.66 the observed Debt Risk Premium, then the asset pricing model is underestimating the true return on equity for the firm.

1103. In a report prepared for the AER, Professor Davis, also from the University of Melbourne, argued that Professor Grundy's argument was based on the view that finance theory does provide some consistency checks on the relative cost of debt and equity. Professor Davis notes that this argument is derived from the Modigliani-

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[624] Grundy, B. 2010, The Calculation of the Cost of Capital, *A Report for Envestra*, 30 September 2010.

[625] Grundy, B, The Calculation of the Cost of Capital, *A Report for Envestra*, 30 September 2010, p. 18.

Miller (MM) irrelevance theorem, whereby the value of the firm is unaffected by leverage. He noted that the result from Professor Grundy's analysis is based on a number of assumptions, including zero corporate taxes and no financial distress costs. Professor Davis was of the view that the assumption of zero taxes is clearly inconsistent with reality – unless it is assumed that franking credits are fully valued ($\gamma = 1$) such that corporate taxes are washed out.[626]

1104. In addition, Professor Davis argued that:[627]

> More importantly, this argument does not, of itself, provide any substantive information about the relationship between the debt premium and the return on equity. The reason is straightforward. The MM relationship, when expressed in terms of rates of return on debt and equity, applies to the expected rates of return. The debt premium, and cost of debt commonly used in a WACC calculation, relate to a contractual (promised) rate of return on debt – which will generally exceed the expected return because of default risk.

1105. Associate Professor Handley, also from the University of Melbourne, has also considered the validity of the Grundy's analysis. In his report to the AER, Professor Handley was of the view that there are three key steps in Grundy's analysis, viz:

- *First*, Grundy claims – based on the shape in Figure 16 – that the cost of debt of a firm is an increasing, convex, bounded function of the (market) debt-to-value ratio of the firm.[628] However, Handley notes a different interpretation to that of Grundy, which was presented in Merton (1974), showing the return on equity is an increasing, concave, unbounded function of the (market) *debt-to-equity* ratio of the firm and the cost of debt is an increasing, S-shaped, bounded function of the (market) debt-to-equity ratio of the firm, which is reproduced in below. In this figure, the top line is the return on equity, the bottom line is the cost of debt and the middle line is the firm's cost of capital which is constant in accordance with Modigliani and Miller's proposition II.
- *Second,* Professor Handley considered that, taking the convexity as given, the second step is Grundy's observation that the above diagram leads to an implied relationship between the equity risk premium ERP and the debt risk premium DRP of the firm. In particular, the equity risk premium of the firm (at a 60 per cent leverage) must be at least 2.66 times the debt risk premium of the firm (at a 60 per cent leverage).
- *Third,* Professor Handley then stated that, taking the observed cost of debt and so the estimated debt risk premium as given, the third step is Grundy's conclusion that if the relevant asset pricing model (in this case, the Sharpe Lintner CAPM) does not result in an estimate of the equity risk premium at least 2.66 times the estimated debt risk premium in accordance with equation (2), then the asset pricing model is underestimating the true return on equity for the firm.

1106. Handley concluded that:

> The above graph from Damodaran (2001) [Figure 16 above] suggests that the cost of debt is a convex function of leverage, when measured by the (market) **debt-to-value** ratio of the firm whereas the previous figure from Merton (1974) [reproduced as below] suggests that the cost debt is neither a convex nor a concave function of leverage, when measured by the (market) **debt-to-equity** ratio of the firm. It is not clear from where

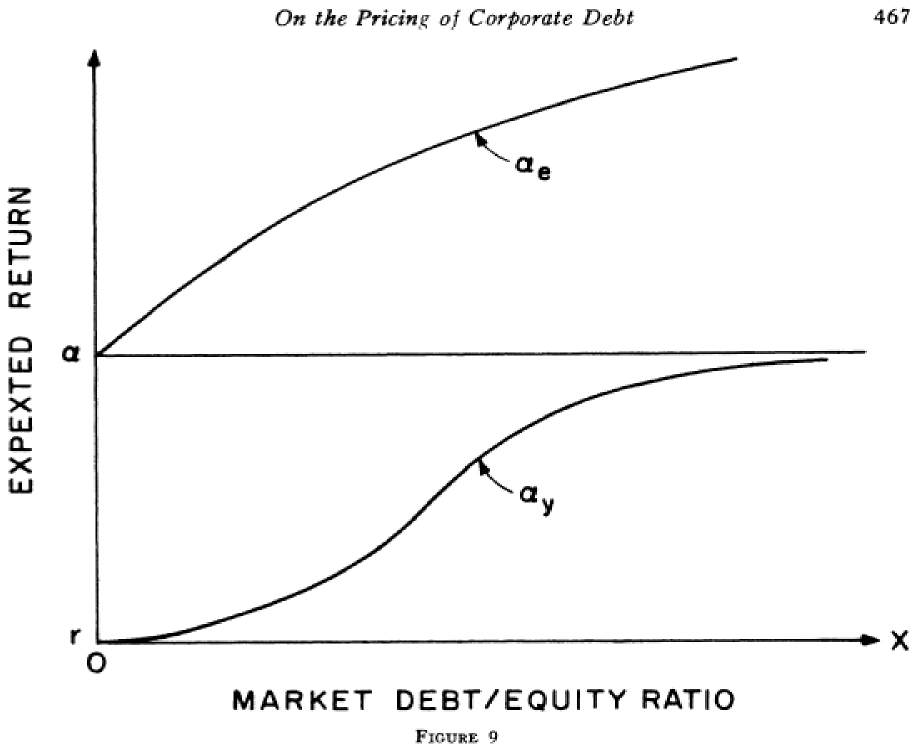
626 Grundy, B, The Calculation of the Cost of Capital, *A Report for Envestra*, 30 September 2010, p. 19.

627 Grundy, B, 2010, The Calculation of the Cost of Capital, *A Report for Envestra*, 30 September 2010, p. 19.

628 Handley, J, Peer Review of Draft Report by Davis on the Cost of Equity, *A Report for The Australian Energy Regulator*, 18 January 2011, p. 7.

Damodaran (2001) has sourced this diagram and so I have not been able to confirm the convexity of the relationship, but I note that a similar diagram appears in Copeland, Weston and Shastri (1995).

Figure 17 Merton (1974)'s link between Cost of Debt and Cost of Capital



1107. However, importantly, Professor Handley considered that:[629]

> Stiglitz (1969), Rubinstein (1973), Merton (1974) and Galai and Masulis (1976) have all shown that (under certain assumptions) the Modigliani-Miller theorem holds in the presence of risky debt. An implicit assumption common to all four papers, is that both the equity and debt securities in the firm are priced according to the same relevant asset pricing framework – i.e. a general equilibrium state preference framework in the case of Stiglitz (1969), a mean-variance framework in the case of Rubinstein (1973), an option pricing framework in the case of Merton (1974) or a combined CAPM/option pricing framework in the case of Galai and Masulis (1976). In other words, the validity of the Modigliani-Miller theorem in the presence of risky debt is based on **the implicit assumption that equity and debt are priced in the (same) integrated market rather than being priced in (separate) segmented markets**. [emphasis added]

and that:[630]

> In this case, not only is it possible to derive a lower bound on the firm's equity risk premium relative to its debt risk premium but rather one can derive an exact relationship between the firm's cost of debt and its return on equity and accordingly an exact relationship between the firm's equity risk premium and its debt risk premium. This is

629 J. Handley, *Peer Review of Draft Report by Davis on the Cost of Equity*, A Report for The Australian Energy Regulator, 18 January 2011, p. 8.

630 Handley, J, Peer Review of Draft Report by Davis on the Cost of Equity, *A Report for The Australian Energy Regulator*, 18 January 2011, p. 9.

precisely what is implied by the diagrams of Damodaran (2001) and Merton (1974) above.

1108. Professor Handley then argued that there are joint hypothesis considerations in comparing the observed cost of debt to the estimated return on equity. He argued that if:[631]

> …the equity risk premium is less than 2.66 times the debt risk premium then this could imply either: (i) that the equity and debt are priced in an integrated market and the equity risk premium is too low; or (ii) that the equity and debt are priced in an integrated market and the debt risk premium is too high; or (iii) that the equity and debt are priced in segmented markets and so **the Modigliani-Miller theorem cannot be used to infer that the equity is mispriced relative to the debt**. [emphasis added]

1109. Handley's observations suggest that comparisons between the expected return on equity and the expected return on debt in the WACC are not straightforward. They depend crucially on whether debt and equity are priced in an integrated market. To the extent that markets are segmented, then the law of one price does not hold, and the MM theorem will break down. That is, it would not be irrelevant whether a firm held debt or equity, if one was significantly cheaper than the other, given constant levels of risk of default.

Overall conclusion

1110. On balance, the Authority is of the view that evidence presented in SFG's analysis to support the relationship between the cost of debt and the return on equity is inconclusive and that the link between the two markets is not robustly established. As such, SFG's proposed approach, which states that the return on equity can be directly derived from the observed cost of debt, is not relevant for the purpose of a crosscheck for economic regulation in Australia.

The Authority's empirical considerations

1111. The Authority notes that SFG's analysis is not robust. Some simple evaluations indicate that a lower bound of the elasticity between the cost of debt and the return on equity in SFG's analysis is much higher than 6. The Authority notes that SFG's analysis produce nonsensible outcomes in relation to the MRP/return on equity when various estimates of the elasticity between the cost of debt and the return on equity are used.

1112. The Authority has concerns that the outcomes of the estimates of elasticity are very sensitive to the input parameters and to any associated interpretation of the evidence. The Authority considers the following two estimates: (i) the elasticity between the cost of debt and the return on equity; and (ii) the adjusted debt spread from SFG's analysis. The Authority is of the view that with the change in one of the above two estimates, SFG's analysis produces a very nonsensible outcome.

1113. *First*, the Authority considers that the evidence assembled by SFG in its Figures 1, 2 and 3 suggests that the elasticity in the Australian context should be 7 or higher, given an average term of debt for the benchmark firm of 10 years.[632] The Authority is

[631] Handley, J, Peer Review of Draft Report by Davis on the Cost of Equity, *A Report for The Australian Energy Regulator*, 18 January 2011, p. 9.

[632] SFG Consulting, The relationship between the required return on debt and equity, *A Report for DBNGP Pty Ltd,* pp. 15-6.

not convinced that the elasticity of 6.0, as SFG's claims, is appropriately derived from Figures 1, 2, and 3 from SFG's analysis.

1114. *Second*, using the cost of debt of 5.2 per cent from the Authority's Final Decision on ATCO, SFG's calculations indicate that the expected return on debt is 4.4 per cent. As a result, SFG considered that the adjustment for expected default is 0.8 per cent, being the difference between the cost of debt of 5.2 per cent the expected return on debt of 4.4 per cent. SFG then concluded that the adjusted debt spread of 1.0 per cent, being the difference between the spread of 1.8 per cent and the adjustment for expected default of 0.8 per cent.

1115. The Authority notes that the spread was 2.041 per cent adopted in the Authority's Final Decision on ATCO,[633] not 1.80 per cent as adopted in SFG's analysis.

1116. As previously discussed, SFG considered that the lower bound reasonableness test is as follows.

$$E[r_e]-r_f > \Omega_{\min}\left(E[r_d]-r_f\right)_{\min} \quad (72)$$

$$E[r_e]-r_f > 6\times 1.0\% = 6.0\%.$$

1117. Based on the above, SFG concluded that, given the debt risk premium, internal consistency requires that the equity risk premium must be at least 6.0 per cent.

1118. The Authority notes that SFG's conclusion on a lower bound of a reasonableness test depends on two components: (i) the elasticity of 7.0; and (ii) the adjusted debt spread of 1.241 (being the difference between the spread to swap of 2.041 per cent and the adjustment for expected default of 0.8 per cent).

1119. Table 43 below provides a summary of SFG's lower bound when the elasticity and/or the spread changes.

633 In the Authority's Final Decision for ATCO, as at 2 April 2015, the 10-year cost of debt was 4.879 per cent and the 10-year Australian dollar swap rate was 2.838 per cent. As such, the spread to swap was 2.041 per cent, being the difference between the cost of debt and the swap rate.

Table 43 The Authority's sensitivity analysis

	SFG's analysis	Change of the elasticity of 7	Change of the spread of 2.041	Change of the elasticity of 7 and the debt spread of 1.241
Lower bound	6	7	7.45	8.69
Lower bound for the equity risk premium (Per cent) (using the expected DRP of 1.31 to 1.42 per cent)	7.86 – 8.52	9.17 – 9.94	9.76 – 10.8	11.38 – 12.34
Implied MRP using equity beta of 0.7 from ATCO Final Decision (Per cent)	11.23 – 12.17	13.1 – 14.2	13.94 – 15.11	16.26 – 17.63

Source: ERA analysis

1120. The Authority considers that these numbers are unsupportable. The implied MRP is well outside the range for the MRP considered reasonable, and used for ATCO Final Decision. The value is also extremely sensitive to inputs such as the credit spread.

The Authority's Draft Decision

1121. In conclusion, the Authority is of the view that SFG's proposed approach to estimating the quantitative relationship between the cost of debt and the return on equity for DBP is fundamentally flawed and as a result, this approach should not be adopted. The Authority notes that SFG's proposed approach does not follow any standard finance theory. The approach is not well established and is untested. In addition, based on the Authority's sensitivity analyses, there are fundamental issues attached to SFG's proposed approach, setting aside its failure on theoretical grounds.

Appendix 4D Converting Foreign Currency Yields into Australian Dollar Equivalents

1122. The Authority's process for converting foreign currency yields into Australian dollar equivalents is detailed here. This provides for replicability and transparency of the Authority's approach. The Authority considers that the method adopted is reflective of the costs, including of conversion.[634]

1123. Bloomberg LP have recently developed functionality that allows for the conversion of foreign currency bond yields into hedged Australian dollar equivalents for historical dates. The solution requires a Bloomberg users' account to be enabled to access the 'Swaps Toolkit (beta)'. Once enabled a user can interface with Bloomberg's Swap Manager through Microsoft Excel. A sample of bonds with their associated fields can then be loaded into Excel where historical yields and spreads for each bond can be converted into hedged Australian dollar equivalents by accessing Bloomberg's swap manager function.

1124. The facility can convert the yields on the following instruments:

- fixed rate instruments which receive a fixed coupon payment;
- a floating rate instrument for which the coupon payments consist of a spread (quoted margin) over an index such as the bank bill swap rate in Australia or London Interbank Offered Rate (Libor) in foreign markets; or
- a variable instrument which receives a coupon for that can vary due factors additional to the index.

Asset Swap Spreads

1125. The starting point is to acquire the 'mid' asset swap spread for instrument in the sample. This is calculated as the average of the bid and ask asset swap spreads (ASW spreads) returned from Bloomberg's asset swap calculator.

1126. The ASW spread is the spread between the instruments yield and the relevant point on the swap curve (index) for the currency of each instrument in question. This is calculated using a 'par/par breakeven asset swap spread' formula which solves for an ASW spread such that the present value of the bonds cash flows on the fixed side of the swap equals the present value of cash flows based on the index plus ASW spread (at each future payment date).

1127. The swap has two legs; a floating leg in which the ASW spread plus index is received; and a fixed side which pays the floating leg in exchange for the fixed payment. If the payments made on the fixed side are in a currency other than Australian dollars (due to the instrument being issued in a foreign currency) the currency of the instrument in question is input into the swap calculation making it a 'cross currency' swap so that the floating payments received are converted into Australian dollars. The costs of swapping from this currency to Australian dollars are determined using Bloomberg's default cross currency basis curves.

634 The Authority does not accept DBP's contention that it has ignored conversion costs (DBP, Proposed Revisions DBNGP Access Arrangement 2016 – 2020 Regulatory Period Response to ERA Issues Paper Submission 26, 2 June 2015, p. 10).

1128. The ASW spread is calculated assuming a quarterly payment frequency and is adjusted to account for differences between the frequencies of payments on the fixed and floating side of the swap.

1129. The Australian dollar ASW mid spread is then effectively converted to a yield to maturity using the Bloomberg swap manager.

Bloomberg Swap Manager

1130. The swap manager is a facility used for calculating various aspects of a swap such as premiums, notional principal and spreads. For the purposes of converting the mid Australian dollar ASW spread into an effective yield to maturity, the swap is treated as a 'fixed float swap' where a fixed payment (which effectively represents the yield to maturity) is received in exchange for a floating payment (discussed above) made.

1131. The main input is the 'mid' Australian dollar ASW spread which is treated as the spread component of the floating payment made. The output is a fixed coupon payment fully hedged in Australian dollars.[635] This fixed coupon payment can effectively be treated as the yield to maturity for two reasons. Firstly, it uses the Australian swap curve as the index to which the calculated hedged Australian dollar spread is added. It therefore reflects Australian interest rates for the date the calculation is made. Secondly, it is calculated on the assumption that the premium on the fixed leg of the swap is zero.[636] In other words it is trading at 'par' per 100 Australian dollars. When the fixed instrument is traded at par the coupon per 100 dollars is effectively equal to the yield to maturity. On the fixed leg the payment frequency is set to semi-annual while on the floating leg the payment frequency is set to quarterly. The reset frequency is also set at quarterly.

1132. The priority of pricing sources or 'pricing water fall' used in the conversions to Australian dollar equivalent yields in Excel are shown in Table 44.

Table 44 Pricing Waterfall Set in Bloomberg for AUD Equivalent Yield Conversion

Currency of Issuance	1st Pricing Source	2nd Pricing Source
USD	BVAL	TRAC
EUR	BVAL	BGN
GBP	BVAL	BGN
AUD	BVAL	CBBT

[635] The 'BPRICE' formula in Excel that calls the Swap Manager must have 'Target' set to 'FixedCoupon' while the 'BView' formula must be set to output the fixed coupon.

[636] The 'BPRICE' formula in Excel that calls the Swap Manager must have 'Premium' set to zero.

Appendix 4E International Bond Sample

Table 45 Sample of Bonds with Australia as Country of Risk as at 2 April 2015

Ticker	S&P Credit Rating	Industry	Country of Risk	Coupon Type	Issue Date	Maturity Date	Currency	AUD Amount Issued
EJ1181084 Corp	BBB	Utilities	AU	FIXED	11/04/2012	11/04/2017	AUD	265000000
ED9016905 Corp	BBB-	Utilities	AU	FLOATING	20/04/2005	25/04/2017	AUD	275000000
EJ1389117 Corp	BBB+	Utilities	AU	FIXED	27/04/2012	27/04/2017	AUD	200000000
EI5951831 Corp	BBB+	Utilities	AU	FLOATING	12/01/2007	15/07/2017	AUD	300000000
EI5951997 Corp	BBB+	Utilities	AU	FLOATING	12/01/2007	15/07/2017	AUD	275000000
EJ2797904 Corp	BBB	Consumer Discretionary	AU	FIXED	18/07/2012	18/07/2017	AUD	300000000
EI7021435 Corp	BBB-	Industrials	AU	FIXED	21/07/2010	21/07/2017	USD	165126000
EF0695496 Corp	BBB+	Industrials	AU	FLOATING	10/11/2005	10/11/2017	AUD	300000000
EJ5156389 Corp	BBB+	Consumer Staples	AU	FIXED	24/01/2013	6/02/2018	AUD	100000000
EI6300228 Corp	BBB	Industrials	AU	FIXED	7/04/2011	7/04/2018	USD	716400000
CP5029097 Corp	BBB+	Energy	AU	FIXED	14/04/1998	15/04/2018	USD	231285000
EI6460709 Corp	BBB+	Materials	AU	FIXED	20/04/2011	20/04/2018	EUR	677745000
EF3590199 Corp	BBB-	Utilities	AU	FLOATING	26/04/2006	26/04/2018	AUD	325000000
EI6849026 Corp	BBB	Industrials	AU	FIXED	25/05/2011	6/07/2018	AUD	100000000
EJ3377821 Corp	BBB+	Consumer Staples	AU	FIXED	6/09/2012	6/09/2018	AUD	200000000
EJ8660791 Corp	BBB-	Utilities	AU	FIXED	9/10/2013	9/10/2018	USD	847040000
EI1562293 Corp	BBB-	Industrials	AU	FIXED	15/10/2008	15/10/2018	USD	119400600
EJ8818027 Corp	BBB-	Industrials	AU	FIXED	1/11/2013	1/11/2018	AUD	500000000
EI8834174 Corp	BBB+	Energy	AU	FIXED	23/11/2011	23/11/2018	AUD	150000000

Ticker	S&P Credit Rating	Industry	Country of Risk	Coupon Type	Issue Date	Maturity Date	Currency	AUD Amount Issued
EJ7922069 Corp	BBB	Materials	AU	FIXED	21/08/2013	21/02/2019	AUD	200000000
EH7350695 Corp	BBB+	Energy	AU	FIXED	3/03/2009	1/03/2019	USD	940800000
EK0838251 Corp	BBB+	Utilities	AU	FLOATING	27/02/2014	1/04/2019	AUD	150000000
EI6030205 Corp	BBB	Materials	AU	FIXED	16/03/2011	16/04/2019	EUR	777018000
EI6204404 Corp	BBB	Industrials	AU	FIXED	4/04/2011	9/07/2019	AUD	200000000
EJ3879651 Corp	BBB-	Utilities	AU	FIXED	11/10/2012	11/10/2019	EUR	629735000
EJ4265850 Corp	BBB-	Utilities	AU	FIXED	8/11/2012	11/10/2019	AUD	300000000
EJ4333419 Corp	BBB+	Consumer Staples	AU	FIXED	13/11/2012	13/11/2019	AUD	150000000
EK5876389 Corp	BBB	Consumer Discretionary	AU	FIXED	18/11/2014	18/11/2019	AUD	450000000
EK5989620 Corp	BBB-	Materials	AU	FIXED	19/11/2014	19/11/2019	AUD	125000000
EI0704078 Corp	BBB	Materials	AU	FIXED	10/12/2009	10/12/2019	USD	872880000
EI1592092 Corp	BBB+	Industrials	AU	FIXED	31/12/2004	31/12/2019	USD	139192620
EI1608021 Corp	BBB+	Industrials	AU	FLOATING	31/12/2004	31/12/2019	AUD	72000000
EJ5984160 Corp	BBB+	Utilities	AU	FLOATING	25/03/2013	25/03/2020	AUD	150000000
EI2000491 Corp	BBB+	Materials	AU	FIXED	31/03/2010	1/04/2020	USD	545150000
EK2849330 Corp	BBB-	Industrials	AU	FIXED	30/05/2014	29/05/2020	AUD	100000000
EJ6899243 Corp	BBB+	Consumer Staples	AU	FIXED	4/06/2013	4/06/2020	AUD	205000000
EI7021476 Corp	BBB-	Industrials	AU	FIXED	21/07/2010	21/07/2020	USD	130962000
EI3253362 Corp	BBB	Energy	AU	FIXED	22/07/2010	22/07/2020	AUD	300000000
EJ7588209 Corp	BBB	Industrials	AU	FIXED	23/07/2013	23/07/2020	AUD	150000000
EJ7646361 Corp	BBB	Industrials	AU	FIXED	29/07/2013	29/07/2020	AUD	300000000
EI4098048 Corp	BBB	Industrials	AU	FIXED	23/09/2010	23/09/2020	USD	632280000

Ticker	S&P Credit Rating	Industry	Country of Risk	Coupon Type	Issue Date	Maturity Date	Currency	AUD Amount Issued
EK5107249 Corp	BBB-	Utilities	AU	FIXED	1/10/2014	1/10/2020	AUD	100000000
EJ8616397 Corp	BBB+	Industrials	AU	FIXED	8/10/2013	8/10/2020	EUR	720135000
EJ8798880 Corp	BBB	Industrials	AU	FIXED	21/10/2013	21/10/2020	AUD	350000000
EJ6371623 Corp	BBB-	Utilities	AU	FIXED	23/04/2013	23/10/2020	EUR	950175000
EJ8893137 Corp	BBB+	Industrials	AU	FIXED	28/10/2013	28/10/2020	AUD	525000000
EJ9225768 Corp	BBB+	Consumer Staples	AU	FIXED	25/11/2013	25/11/2020	AUD	100000000
EI5615311 Corp	BBB+	Utilities	AU	FIXED	11/02/2011	11/02/2021	GBP	399350000
EI4214900 Corp	BBB	Industrials	AU	FIXED	7/10/2010	22/02/2021	USD	508900000
EK1048710 Corp	BBB+	Utilities	AU	FIXED	12/03/2014	12/03/2021	AUD	350000000
EK1306886 Corp	BBB	Industrials	AU	FIXED	25/03/2014	25/03/2021	AUD	400000000
EI6641167 Corp	BBB+	Energy	AU	FIXED	10/05/2011	10/05/2021	USD	645960000
EK2622026 Corp	BBB+	Consumer Staples	AU	FIXED	21/05/2014	21/05/2021	AUD	100000000
EK3554137 Corp	BBB	Industrials	AU	FIXED	7/07/2014	7/07/2021	AUD	200000000
EI7486208 Corp	BBB+	Consumer Staples	AU	FIXED	22/07/2011	22/07/2021	AUD	45000000
EK4152378 Corp	BBB+	Consumer Staples	AU	FIXED	12/08/2014	12/08/2021	AUD	100000000
EI6010694 Corp	BBB+	Utilities	AU	FLOATING	15/08/2007	15/08/2021	AUD	300000000
EI8144731 Corp	BBB+	Consumer Staples	AU	FIXED	27/09/2011	27/09/2021	AUD	30000000
EJ8598074 Corp	BBB-	Utilities	AU	FIXED	4/10/2013	4/10/2021	EUR	1149496000
EI8364461 Corp	BBB-	Utilities	AU	FIXED	14/10/2011	14/10/2021	USD	483550000
EK5737813 Corp	BBB	Utilities	AU	FIXED	5/11/2014	5/11/2021	AUD	600000000
EI8703494 Corp	BBB-	Materials	AU	FIXED	15/11/2011	15/11/2021	USD	736875000
EG0640763 Corp	BBB	Industrials	AU	FLOATING	8/12/2006	20/11/2021	AUD	200000000

Ticker	S&P Credit Rating	Industry	Country of Risk	Coupon Type	Issue Date	Maturity Date	Currency	AUD Amount Issued
EK6279310 Corp	BBB	Industrials	AU	FIXED	8/12/2014	8/12/2021	AUD	250000000
EI6011379 Corp	BBB+	Utilities	AU	FLOATING	15/08/2007	17/01/2022	AUD	630000000
EK8055148 Corp	BBB	Energy	AU	FIXED	20/03/2015	22/03/2022	EUR	974344000
EK3157451 Corp	BBB+	Utilities	AU	FIXED	30/06/2014	30/06/2022	EUR	725780000
EJ2714362 Corp	BBB+	Consumer Staples	AU	FIXED	11/07/2012	11/07/2022	AUD	30000000
EJ3784331 Corp	BBB-	Materials	AU	FIXED	1/10/2012	1/10/2022	USD	723900000
EG0219857 Corp	BBB	Industrials	AU	FLOATING	15/12/2006	11/10/2022	AUD	750000000
EJ3906165 Corp	BBB	Energy	AU	FIXED	11/10/2012	11/10/2022	USD	730725000
EJ4317107 Corp	BBB-	Industrials	AU	FIXED	13/11/2012	13/11/2022	USD	479200000
EJ4068577 Corp	BBB	Industrials	AU	FIXED	23/10/2012	22/03/2023	USD	803715000
EJ5962760 Corp	BBB	Materials	AU	FIXED	22/03/2013	22/03/2023	EUR	373101000
EJ6105286 Corp	BBB-	Utilities	AU	FIXED	5/04/2013	5/04/2023	EUR	187699500
EI6307918 Corp	BBB	Industrials	AU	FIXED	7/04/2011	7/04/2023	USD	238800000
EJ3849779 Corp	BBB+	Utilities	AU	FIXED	9/10/2012	9/04/2023	USD	489950000
EJ8324406 Corp	BBB	Industrials	AU	FIXED	19/09/2013	19/09/2023	GBP	509580000
EK1561159 Corp	BBB	Industrials	AU	FIXED	23/04/2014	23/04/2024	EUR	1040963000
EK3156859 Corp	BBB+	Industrials	AU	FIXED	12/06/2014	12/06/2024	EUR	718810000
EK4655081 Corp	BBB+	Industrials	AU	FIXED	16/09/2014	16/09/2024	EUR	855024000
EK4685294 Corp	BBB+	Industrials	AU	FIXED	18/09/2014	18/09/2024	EUR	718685000
EJ4508010 Corp	BBB	Energy	AU	FIXED	26/11/2012	26/11/2024	GBP	536025000
EK6424791 Corp	BBB	Industrials	AU	FLOATING	16/12/2014	16/12/2024	AUD	200000000
EK7758478 Corp	BBB+	Energy	AU	FIXED	5/03/2015	5/03/2025	USD	1285000000

Ticker	S&P Credit Rating	Industry	Country of Risk	Coupon Type	Issue Date	Maturity Date	Currency	AUD Amount Issued
EK8078215 Corp	BBB	Energy	AU	FIXED	23/03/2015	23/03/2025	USD	1395790000
EK8055387 Corp	BBB	Energy	AU	FIXED	20/03/2015	22/03/2027	EUR	904748000
EK8055262 Corp	BBB	Energy	AU	FIXED	20/03/2015	22/03/2030	GBP	1153920000
EK8078397 Corp	BBB	Energy	AU	FIXED	23/03/2015	23/03/2035	USD	380670000
EJ3049461 Corp	BBB-	Energy	AU	FLOATING	4/09/2012	15/09/2037	AUD	550000000
EI8704930 Corp	BBB-	Materials	AU	FIXED	15/11/2011	15/11/2041	USD	491250000
EI4096521 Corp	BBB-	Energy	AU	VARIABLE	22/09/2010	22/09/2070	EUR	1401130000

Source: Bloomberg and ERA Analysis

Appendix 4F Evaluation of capital expenditure weighting the hybrid trailing average estimate of the DRP

1133. By weighting the trailing average to account for new capex, it can be made to ensure that the cost of capital for new capex reflects prevailing rates. This efficiency consideration is a key concern of the Authority, given the requirements of the NGL and NGR.

1134. This adds significant complexity. However, the Authority considers that QTC and DBP have demonstrated that a spreadsheet calculation relating to weights could be implemented, at least for the Post Tax Revenue Model (**PTRM**) approach.

1135. Weights may be based on the following approaches:

- actual debt issuance data – this approach would require an ex post true up of the rate of return, once actual debt issuance data became available;
- actual changes in the debt component of the RAB, consistent with the benchmark gearing – again, this approach would require an ex post true up of the rate of return, once actual debt issuance data became available; or
- weights based on the (forecast ex ante) debt issuance assumptions in the PTRM – this approach has the advantage of not requiring an ex post true up for the rate of return.[637]

1136. QTC in a submission to the AER proposed that the weighting method should be based on the forecast new capex approved for use in the PTRM for the forthcoming access arrangement:

> QTC considers that a weighted average based on the PTRM debt balances is appropriate to ensure that changes in the debt balance are correctly compensated at the prevailing cost of debt. An example of the proposed approach is provided in Appendix B.[638]
>
> …This approach is computationally simple and transparent, which should alleviate any concerns around complexity. A simple spreadsheet model can be used to perform the calculations.
>
> The return on debt would be calculated as a simple average of the adjusted rates. This approach is consistent with the use of a single set of weights (eg, 10 per cent for each annual observation based on a 10-year debt tenor), but still results in the changes in the PTRM debt balance being compensated at the prevailing cost of debt.

[637] GGT in its submission on the 4 March 2015 Discussion Paper on estimating the return on debt stated that (Goldfields Gas Transmission, *GGT submission on ERA return on debt discussion paper*, 25 March 2015, p. 5):

Paragraph 152 of the Discussion Paper advises that the ERA considers that adoption of the weighting implicitly assigned to debt issues in the Australian Energy Regulator's Post Tax Revenue Model (PTRM) would ensure a return on debt which provides appropriate incentives for new capital expenditure.

Use of the PTRM, a model designed initially for use in the electricity sector, is not required under the access regulatory regime of the National Gas Law and the National Gas Rules. However, any properly constructed model for post-tax revenue determination (which is effectively required by rule 87(4)) is likely to incorporate the active debt management policy which is implicit in the PTRM, whereby the gearing is maintained at 60% (the gearing of the benchmark efficient entity).

However, the Authority agrees with GGT when it subsequently states that its post tax revenue model shares relevant features with the AER's PTRM for the purposes of this discussion.

[638] Queensland Treasury Corporation, *Submission to the Draft Rate of Return Guideline*, 11 October 2013, p. 21.

Worked example

Consider an example where the PTRM debt balance increases from $100 to $115 over a 1-year period. The service provider is assumed to have been operating under the trailing average approach for at least 10 years, so the underlying interest rates in the trailing average reflect the historical rates over the last 10 years. For the purpose of this example, a series of hypothetical rates have been used to populate the trailing average.

Regardless of how the return on debt is calculated, the final estimate will be applied to the PTRM debt balance to determine the dollar value of the return on debt allowance. As such, the following weights will apply (either explicitly or implicitly) to the interest rates associated with the existing and new debt:

Weight applying to existing debt = $100 ÷ $115 = 0.8696

Weight applying to change in debt = $15 ÷ $115 = 0.1304

Table 4 displays the adjustments to the rates in the trailing average based on QTC's proposed method, which compensates the increase in the debt balance at the prevailing cost of debt (6.25 per cent).[639]

Table 46 Adjusted Rates Using the Prevailing Cost of Debt and Change in the PTRM Debt Balance

Observation	Rates before new borrowing (%)	Rate adjustments based on change in PTRM debt balance	Rates after new borrowing (%)
-9	8.00	8.00 x 0.8696 + 6.25 x 0.1304	7.77
-8	8.50	8.50 x 0.8696 + 6.25 x 0.1304	8.21
-7	9.00	9.00 x 0.8696 + 6.25 x 0.1304	8.64
-6	8.00	8.00 x 0.8696 + 6.25 x 0.1304	7.77
-5	6.00	6.00 x 0.8696 + 6.25 x 0.1304	6.03
-4	6.00	6.00 x 0.8696 + 6.25 x 0.1304	6.03
-3	7.00	7.00 x 0.8696 + 6.25 x 0.1304	6.90
-2	8.00	8.00 x 0.8696 + 6.25 x 0.1304	7.77
-1	7.00	7.00 x 0.8696 + 6.25 x 0.1304	6.90
Prevailing	6.25	6.25 x 0.8696 + 6.25 x 0.1304	6.25
Return on debt	7.38		7.23

Source ERA analysis.

1137. An advantage of the PTRM approach would be that it allows for prevailing rates to apply to new investments. This occurs because the prevailing rate is adjusted through the weighting, at the time of the access arrangement review, to the extent that the forecast capex adds to the outstanding debt in the PTRM. The result is that the prevailing rate becomes the marginal cost of debt for the new forecast capex.

Should capex weights be trued up ex post?

1138. The question arises as to whether capex weights, if adopted, would be revised ex post, at the next access arrangement review, based on actual approved capital expenditure.

639 Queensland Treasury Corporation, *Submission to the Draft Rate of Return Guideline*, 11 October 2013, p. 28.

1139. This could create incentives to bring forward or over-invest in the event that interest rates were abnormally high, as it would increase the weighting for that year in the following access arrangement. However, offsetting this effect, high interest rates would discourage additional investment, as projects would be less likely to be profitable at the margin.

1140. Overall, the Authority considered that it would be sensible to adjust PTRM weights (if adopted) ex post at the next access arrangement review, to allow for actual PTRM outcomes. Such an approach would be consistent with the treatment of capex in the PTRM more broadly, where actual capex outcomes for the past access arrangement are used for the next access arrangement.

1141. DBP in its submission on the Authority's 4 March 2015 Discussion Paper on estimating the return on debt considered that there was some confusion as to exactly what was being proposed with regard to ex post true up for capex weights.[640]

1142. Therefore, for the removal of doubt, the Authority reiterates that where such an ex post true up was undertaken at the next access arrangement review, there would be no retrospective adjustment of tariffs and revenue – that would remain based on the forecast capex established at the start of the access arrangement period.

No capex weights for historic trailing average data

1143. The Authority considered the application of PTRM capex weights in the forward years. The objective of weighting the trailing average in this way is to ensure that forecast new capex is remunerated by the most timely estimate of the prevailing return on debt.

1144. As to the past, DBP submitted:[641]

> The third and final caveat applies to models without a transition period. The ATCO Hybrid Approach provides for a weighting of ten percent per annum on debt from the past ten years. However, this is not in keeping with the efficiency arguments which underpin the PTRM weighting model. If a regulated service provider did not incur any debt in 2009, when debt risk premia were very high, the apportioning ten percent to that year would over-reward the service provider and provide a windfall gain. The weights, therefore, should bear some resemblance to efficient debt actually incurred, just as the case going forward, rather than an arbitrary figure such as ten percent.
>
> Although public data on actual debt incurred by service providers (including debt instruments such as derivatives) are available on sources such as Bloomberg, the Rules require the ERA to consider the benchmark efficient entity, not the actual firm. Thus, it is not sufficient to look at actual debt as it was incurred and assume this is efficient. Instead, regulators ought to look at the reason for incurring the debt; more specifically, expansion of the RAB and other capital spending. If this is deemed to be efficient capital spending, and the efficient way of issuing debt is a ten-year bond (as regulators agree that it is) then the PTRM weighting approach, applied to actual capital spending from the past, should be applied. This is because it captures the cost of debt when efficient spending of capital was actually incurred, and thus reflects the cost of debt which the benchmark efficient entity would have on its books today if it undertook the capital spending when regulators deemed it to be efficient. Thus, if the ERA accepts the ATCO Hybrid Approach, it should not accept a weighting of ten percent per annum, but should

640 Dampier Bunbury Pipeline, Estimating the Return on Debt: Response to ERA Discussion Paper of 4 March 2015, 25 March 2015, p. 10.

641 Dampier Bunbury Pipeline, Estimating the Return on Debt: Response to ERA Discussion Paper of 4 March 2015, 25 March 2015, p. 11.

implement the PTRM model starting with a RAB in 2005, and capturing actual capital spending since that point in time.

1145. The Authority notes these points, but does not accept that past estimates of the DRP should be capex weighted, in the event that weights were adopted.

1146. First, investment in the past has already been expended, so incentives for that investment through the introduction of capex weights will not have any influence on the timing of that investment.

1147. Second, the Authority considers that there would be considerable uncertainty as to the timing of debt raising in the past by the benchmark efficient entity, as it would not have been seeking to replicate any clear financing strategy for the DRP under the previous on the day regime. It could have opportunistically raised debt finance at those times that it considered best lowered its cost of debt, which may have been removed in timing terms from the actual capital expenditure profile. To ascribe capex weights to the past data then runs the risk of over or under compensating the benchmark efficient entity.

1148. The Authority considers that the best estimate of the DRP relating to debt raised at unknown points in the past will be the simple, equally weighted annual averages applicable to those periods.

Implementing capex weights as an overlay to the simple trailing average

1149. There are two ways to implement an approach for incorporating the PTRM capex weights. The first is that proposed by the QTC, which is outlined above. The second is the method proposed by DBP. Both approaches produce identical outcomes, but the method of calculation is different.

1150. The Authority considered the method proposed by DBP.[642] This method accords with the approach suggested by ATCO's consultant CEG:[643]

> 123. Calculating a weighted trailing average DRP is not complex to model on a forward-looking basis. Suppose that an initial RAB of a regulated business consists of 10 year debt staggered so as to expire evenly across a 10 year period. That is, the starting position is a simple trailing average. However, let the business have a significant net capital expenditure requirement in a given year such that the RAB will grow. This simply means that the weight of that year in future trailing averages should be higher.
>
> 124. If the business finances the increase in the RAB with debt that is, on average, 10 year maturity but is itself staggered[644] then a smoothly staggered refinance profile will continue to be maintained in the future.
>
> - the DRP on financing (and refinancing) the pre-existing RAB is simply the trailing average 10 year cost of debt over the last 10 years; and
> - the cost of debt on each 'vintage' of change in RAB from the pre-existing level is modelled as a transition from the initial staggered debt raising (of, say, 6 to 14 years maturity) at the time of the change in RAB back to a trailing average 10 year cost of debt (the same as the pre-existing RAB). The transition

642 Dampier Bunbury Pipeline, Proposed Revisions DBNGP Access Arrangement: 2016 – 2020 Regulatory Period: Rate of Return: Supporting Submission: 12, Appendix J (excel file version available on the Authority's website).

643 ATCO Gas Australia, Response to the ERA's Draft Decision on required amendments to the Access Arrangement for the Mid-West and South-West Gas Distribution System, 27 November 2014, Appendix 9.2, p. 39.

644 For example, the business finances the increase in the RAB with debt ranging from 6 to 14 year debt.

is straightforward to model - as each tranche of the staggered (initial 6-14 year) debt expires and is replaced with 10 year debt. At which point that tranche of change in RAB can simply be treated the same as the pre-existing RAB.

125. The weighted trailing average cost of debt in any year is then simply the average across the cost of debt for the RAB and subsequent changes in RAB, weighted by the associated RAB amount.

1151. Under such an approach, the PTRM capex weighting overlay could apply to each of the forward looking estimators from 2015 (t=0) to 2019 (t=4). Each PTRM capex weight could be consistent with the capex forecast to occur in each regulatory year. So for:

- the DRP to apply in calendar year 2015, the PTRM capex weight to apply to the estimate t=0 would be the forecast capex to occur over the period 1 January 2015 to 31 December 2015, as a proportion of the closing value of the RAB at 31 December 2015;[645]
- for the DRP to apply in calendar year 2016, the PTRM capex weight to apply to the:
  - t=1 estimate would be the forecast capex to occur over the period 1 January 2016 to 31 December 2016, as a proportion of the closing value of the RAB at 31 December 2016; and
  - t=0 estimate would be the forecast capex to occur over the period 1 January 2015 to 31 December 2015, as a proportion of the closing value of the RAB at 31 December 2015.
- for the DRP to apply in calendar year 2017, the PTRM capex weight to the:
  - t=2 estimate would be the forecast capex to occur over the period 1 January 2017 to 31 December 2017, as a proportion of the opening value of the RAB at 31 December 2017.
  - t=1 estimate would be the forecast capex to occur over the period 1 January 2016 to 31 December 2016, as a proportion of the closing value of the RAB at 31 December 2016; and
  - t=0 estimate would be the forecast capex to occur over the period 1 January 2015 to 31 December 2015, as a proportion of the closing value of the RAB at 31 December 2015.
- for the DRP to apply in calendar year 2018, the PTRM capex weight to the:
  - t=3 estimate would be the forecast capex to occur over the period 1 January 2018 to 31 December 2018, as a proportion of the opening value of the RAB at 31 December 2018.
  - t=2 estimate would be the forecast capex to occur over the period 1 January 2017 to 31 December 2017, as a proportion of the opening value of the RAB at 31 December 2017.
  - t=1 estimate would be the forecast capex to occur over the period 1 January 2016 to 31 December 2016, as a proportion of the closing value of the RAB at 31 December 2016; and

645 In what follows, it is assumed that gearing remains at 60 per cent across all periods. Therefore there is equivalence between the proportion of depreciated new capex in the depreciated RAB, as compared to the same proportions that are funded by debt.

- t=0 estimate would be the forecast capex to occur over the period 1 January 2015 to 31 December 2015, as a proportion of the closing value of the RAB at 31 December 2015.

- for the DRP to apply in calendar year 2019, the PTRM capex weight to the:
  - t=4 estimate would be the forecast capex to occur over the period 1 January 2019 to 31 December 2019, as a proportion of the opening value of the RAB at 31 December 2019.
  - t=3 estimate would be the forecast capex to occur over the period 1 January 2018 to 31 December 2018, as a proportion of the opening value of the RAB at 31 December 2018.
  - t=2 estimate would be the forecast capex to occur over the period 1 January 2017 to 31 December 2017, as a proportion of the opening value of the RAB at 31 December 2017.
  - t=1 estimate would be the forecast capex to occur over the period 1 January 2016 to 31 December 2016, as a proportion of the closing value of the RAB at 31 December 2016; and
  - t=0 estimate would be the forecast capex to occur over the period 1 January 2015 to 31 December 2015, as a proportion of the closing value of the RAB at 31 December 2015.

Calculating capex weights

1152. Capex weights work to adjust the simple (equally weighted) trailing average, so as to account for the relative proportion of new capex in the RAB which is less than 10 years old. That ensures the forecast new capex initially faces the prevailing rate. So for example, if capex comprised the same proportion of the depreciated RAB (opening value) in each year, then the weights would be 10 per cent for each year of the trailing average. However, where the new capex proportions of the RAB vary between years, then the weights in the trailing average will diverge from the equal weighting (see paragraph 1136 above for the QTC's summary of the effect of capex weights).

1153. An equivalent approach to the QTC method for incorporating weights is to transition new capex progressively from an initial on the day annual estimate to a full trailing average over 10 years (see paragraph 577 for an outline of how transition weights work). This approach, submitted by DBP, is essentially the same transition approach followed by the AER for its full trailing average, but in this instance applied to new forecast capex.[646] It is equivalent to the QTC's PTRM weights method in outcome, but works slightly differently in the calculation. The calculation is explained in the following hypothetical example.

1154. First, the data required to calculate the capex weights for each of the years 2015-16 to 2019-20 in a typical regulatory period are established (Table 47).

1155. An asset life of 60 years is assumed, to allow for depreciation of the new capex. The weight of any new capital expenditure depends on its depreciated proportion of the closing asset value of the RAB.

[646] For a spreadsheet example of DBP's method, see Dampier Bunbury Pipeline, *Proposed Revisions DBNGP Access Arrangement: 2016 – 2020 Regulatory Period: Rate of Return: Supporting Submission: 12*, Appendix J (excel file version available on the Authority's website)

1156. Second, the trailing averages of rates that will be weighted by the old and new capex are established (Table 48). For the sake of this simplified example, it is assumed that an illustrative prevailing (t=0) rate of 6.36 per cent applied over the previous 9 years from t=-9 to t=-1. The prevailing rate then changes from 2016-17 on. The values in this table involve the most complex step of the DBP method to establish and describe.

Table 47 Data for capex weights example

Row		2015-16	2016-17	2017-18	2018-19	2019-20
1	**Opening PTRM RAB**	$10,041.50	$10,651.70	$11,233.30	$11,748.10	$12,311.50
2	**Closing PTRM RAB**	$10,651.70	$11,233.30	$11,748.10	$12,311.50	$12,867.00
3	**Benchmark gearing**	60%	60%	60%	60%	60%
4	**Opening debt portfolio**	$6,024.90	$6,391.00	$6,740.00	$7,048.90	$7,386.90
5	**Closing debt portfolio**	$6,391.00	$6,740.00	$7,048.90	$7,386.90	$7,720.20
6	**Change in debt portfolio**	$366.10	$349.00	$308.90	$338.00	$333.30
7	**Prevailing rate**	6.36%	7.00%	7.75%	8.00%	8.25%
8	**Pre 2015-16 debt weighting**	94.27%	89.39%	85.47%	81.56%	78.04%
9	**2015-16 new debt weighting**	5.73%	5.43%	5.19%	4.96%	4.74%
10	**2016-17 new debt weighting**	0.00%	5.18%	4.95%	4.72%	4.52%
11	**2017-18 new debt weighting**	0.00%	0.00%	4.38%	4.18%	4.00%
12	**2018-19 new debt weighting**	0.00%	0.00%	0.00%	4.58%	4.38%
13	**2019-20 new debt weighting**	0.00%	0.00%	0.00%	0.00%	4.32%
14	**Total debt weighting**	100.00%	100.00%	100.00%	100.00%	100.00%
15	**Capex weighted average rate**	6.36%	6.45%	6.64%	6.85%	7.08%

Source ERA analysis.

Table 48 Transition weighted interest rates for capex weights example

Row	Column	(1) 2006-07 (t=-9)	(2) 2007-08 (t=-8)	(3) 2008-09 (t=-7)	(4) 2009-10 (t=-6)	(5) 2010-11 (t=-5)	(6) 2011-12 (t=-4)	(7) 2012-13 (t=-3)	(8) 2013-14 (t=-2)	(9) 2014-15 (t=-1)	(10) 2015-16 (t=-0)	(11) 2016-17 (t=+1)	(12) 2017-18 (t=+2)	(13) 2018-19 (t=+3)	(14) 2019-20 (t=+4)
1		6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	7.00%	7.75%	8.00%	8.25%
2		6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.42%	6.56%	6.73%	6.92%
3			6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.42%	6.56%	6.73%	6.92%
4				6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.42%	6.56%	6.73%	6.92%
5					6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.42%	6.56%	6.73%	6.92%
6						6.36%	6.36%	6.36%	6.36%	6.36%	6.36%	6.42%	6.56%	6.73%	6.92%
7							6.36%	6.36%	6.36%	6.36%	6.36%	6.42%	6.56%	6.73%	6.92%
8								6.36%	6.36%	6.36%	6.36%	6.42%	6.56%	6.73%	6.92%
9									6.36%	6.36%	6.36%	6.42%	6.56%	6.73%	6.92%
10										6.36%	6.36%	6.42%	6.56%	6.73%	6.92%
11											6.36%	6.42%	6.56%	6.73%	6.92%
12												7.00%	7.08%	7.18%	7.30%
13													7.75%	7.78%	7.83%
14														8.00%	8.03%
15															8.25%

Source ERA analysis.

1157. In Table 48:

- Row 2 gives the 10 year equally weighted rates, comprising the sum of 10 per cent of the rate of each of the 10 prior years in the relevant columns:
  - the equally weighted 10 year sum in 2015-16 is 100 per cent of 6.36 per cent, given that the prior 10 years of rates are all 6.36 per cent;
  - the equally weighted 10 year sum in 2016-17 is 90 per cent of 6.36 per cent and 10 per cent of 7 per cent, giving a weighted sum of 6.42 per cent;
  - the equally weighted 10 year sum in 2017-18 is 80 per cent of 6.36 per cent, 10 per cent of 7 per cent and 10 per cent of 7.75 per cent, giving a weighted sum of 6.56 per cent;
- and so on;
- Row 3 gives the 9 year weighted sum for 2015-16, and the 10 year equally weighted rates thereafter:
  - the 9 year sum in 2015-16 is 100 per cent of 6.36 per cent, given that the prior 9 years of rates are all 6.36 per cent (for all 9 year estimates, 20 per cent weight is applied to the first year term and 10 per cent to each year term thereafter, following the transition method – see paragraph 577 above for a discussion of transition weights);
  - the equally weighted 10 year sum in 2016-17 is 90 per cent of 6.36 per cent and 10 per cent of 7 per cent, giving a weighted sum of 6.42 per cent;
  - the equally weighted 10 year sum in 2017-18 is 80 per cent of 6.36 per cent, 10 per cent of 7 per cent and 10 per cent of 7.75 per cent, giving a weighted sum of 6.56 per cent;
- and so on;
  - Row 4 gives the 8 year weighted sum for 2015-16, the 9 year weighted sum for 2016-17 and the 10 year equally weighted rates thereafter:
  - the 8 year sum in 2015-16 is 100 per cent of 6.36 per cent, given that the prior 8 years of rates are all 6.36 per cent (for all 8 year estimates, 30 per cent weight is applied to the first year term and 10 per cent to each year term thereafter, following the transition method);
  - the 9 year sum in 2016-17 is 90 per cent of 6.36 per cent, 10 per cent of 7 per cent, giving a weighted sum of 6.42 per cent;
  - the equally weighted 10 year sum in 2017-18 is 80 per cent of 6.36 per cent, 10 per cent of 7 per cent and 10 per cent of 7.75 per cent, giving a weighted sum of 6.56 per cent;
  - the equally weighted 10 year sum in 2018-19 is 70 per cent of 6.36 per cent, 10 per cent of 7 per cent, 10 per cent of 7.75 per cent and 10 per cent of 8.00 per cent, giving a weighted sum of 6.73 per cent;
- and so on;

- Row 5 gives the 7 year weighted sum for 2015-16, the 8 year weighted sum for 2016-17, the 9 year weighted sum for 2017-18 and the 10 year equally weighted rates thereafter:
- the 7 year sum in 2015-16 is 100 per cent of 6.36 per cent, given that the prior 7 years of rates are all 6.36 per cent (for all 7 year estimates, 40 per cent weight is applied to the first year term and 10 per cent to each of the 6 year terms thereafter, following the transition method);
- the 8 year sum in 2016-17 is 90 per cent of 6.36 per cent, 10 per cent of 7 per cent, giving a weighted sum of 6.42 per cent;
- the equally weighted 10 year sum in 2017-18 is 80 per cent of 6.36 per cent, 10 per cent of 7 per cent and 10 per cent of 7.75 per cent, giving a weighted sum of 6.56 per cent;
- the equally weighted 10 year sum in 2018-19 is 70 per cent of 6.36 per cent, 10 per cent of 7 per cent, 10 per cent of 7.75 per cent and 10 per cent of 8.00 per cent, giving a weighted sum of 6.73 per cent;

- and so on;
- through to;
  - Row 11 gives the 1 year weighted sum for 2015-16, the 2 year weighted sum for 2016-17, the 3 year weighted sum for 2017-18, the 4 year weighted sum for 2018-19, and the 5 year weighted sum for 2019-20:
  - the 1 year sum in 2015-16 is 100 per cent of 6.36 per cent (100 per cent weight is applied to the first year);
  - the 2 year sum in 2016-17 is 90 per cent of 6.36 per cent, 10 per cent of 7 per cent, giving a weighted sum of 6.42 per cent (for a 2 year estimate, 90 per cent weight is applied to the first year term and 10 per cent to the second year term, following the transition method);
  - the 3 year sum in 2017-18 is 80 per cent of 6.36 per cent, 10 per cent of 7 per cent and 10 per cent of 7.75 per cent, giving a weighted sum of 6.56 per cent (80 per cent weight is applied to the first year term and 10 per cent to the second and third year terms, following the transition method);
- and so on;
- through to;
  - Row 15 gives the 1 year weighted sum for 2019-20;
  - the 1 year sum in 2019-20 is 100 per cent of 8.25 per cent (100 per cent weight is applied to the first year term, which is the prevailing rate in this case).

1158. Third, the contribution of various vintage (illustrative) depreciated capex in the closing asset value in each year is developed (Table 49).

Table 49 Composition of closing asset values (existing capital and new capital in $ million)

Row	Column	(10) 2015-16 (t=-0)	(11) 2016-17 (t=+1)	(12) 2017-18 (t=+2)	(13) 2018-19 (t=+3)	(14) 2019-20 (t=+4)
1		6024.90	6031.00	6042.92	6059.99	6082.69
2						
3						
4						
5						
6						
7						
8						
9						
10		366.10	360.00	353.90	347.80	341.69
11			349.00	343.18	337.37	331.55
12				308.90	303.75	298.60
13					338.00	332.37
14						333.3
		6391.00	**6740.00**	**7048.90**	**7386.90**	**7720.20**

Source ERA analysis.

1159. Fourth, capex weights are developed that correspond to the column proportions in Table 50.

Table 50 Capex weights to apply to each year for the trailing average

Row	Column	(10) 2015-16 (t=-0)	(11) 2016-17 (t=+1)	(12) 2017-18 (t=+2)	(13) 2018-19 (t=+3)	(14) 2019-20 (t=+4)
1		94.27%	89.39%	85.47%	81.56%	78.04%
2						
3						
4						
5						
6						
7						
8						
9						
10		5.73%	5.43%	5.19%	4.96%	4.74%
11			5.18%	4.95%	4.72%	4.52%
12				4.38%	4.18%	4.00%
13					4.58%	4.38%
14						4.32%
		100%	**100%**	**100%**	**100%**	**100%**

Source ERA analysis.

1160. Finally, the 'sumproduct' of corresponding columns (10 through to 14) in each of Table 50 and Table 47 are calculated to give the capex weighted trailing average to apply in each year (Table 51).

Table 51 Capex weighted trailing average rate in each year

Column	(10) 2015-16 (t=-0)	(11) 2016-17 (t=+1)	(12) 2017-18 (t=+2)	(13) 2018-19 (t=+3)	(14) 2019-20 (t=+4)
	6.36%	**6.45%**	**6.64%**	**6.85%**	**7.07%**
	6.36%	6.42%	6.56%	6.73%	6.92%
	6.36%	7.00%	7.75%	8.00%	8.25%

Source ERA analysis.

1161. It may be observed that the capex weighted trailing average is below the prevailing rate in most years, in this illustrative example. This occurs because prevailing rates are rising strongly, while the majority of capex was undertaken in years prior to

2015-16, when interest rates were low. However, the capex weighted trailing average is above the simple (equally weighted) trailing average, reflecting the influence of the capex weights in this example, lifting the influence of the later years when rates are higher.

Appendix 4G Automatic updating formulas for the return on debt

1162. This appendix sets out the method and automatic formulas for updating the debt risk premium (**DRP**) for each regulatory year. The annual update will contribute to the revised tariff that is published at each annual tariff variation. Annual tariff variations for DBP will occur on 1 January 2017, 1 January 2018, 1 January 2019 and 1 January 2020.[647]

1163. The Authority has determined that the return on debt will be estimated as the sum of the:

- risk free rate;
- spread of the bank bill swap rate over the risk free rate (BBSW spread);
- DRP; and
- relevant debt raising and hedging transactions costs.

1164. The risk free rate and BBSW spread are estimated with the same term as the regulatory period, that is, 5 years. These two components are estimated once every 5 years at the start of the regulatory period, so do not require annual updating.

1165. The DRP is estimated using a 10 year trailing average consisting of a DRP for the current year and a DRP for each of the 9 prior years and so must be updated each year. The DRP for each yearly update is based on:

- a term to maturity of 10 years;
- a BBB band credit rating;
- the Authority's revised bond yield approach; and
- a corresponding 10 year bank bill swap rate estimation.

1166. The revised bond yield approach uses international bonds that have their country of risk identified by Bloomberg as Australia to estimate the cost of debt each year. The DRP represents the risk spread of the cost of debt estimated over the 10 year bank bill swap rate estimation in any given year.

1167. The debt raising and hedging transactions costs, like the 5 year risk free rate and swap spread, are estimated only once, at the start of the regulatory period, and so do not require annual updating.

Averaging period

1168. The DRP estimates that are to be included the 2017, 2018 and 2019 tariff variations are based on an averaging period of 40 trading days.[648] This averaging period must fall within a window at least two months prior to, but no longer than eight months before the regulatory year. Therefore, the Authority requires that the nominated averaging period occur in the period 1 June to 31 October in each year. For example, the updated DRP for inclusion in the 1 January 2017 tariff variation will be

[647] The tariff variation for 1 January 2016 is not required given that the Final Decision will occur after that date.

[648] With the trading days based on the eastern states' public holidays.

based on an averaging period that falls within the window 1 June 2016 to 31 October 2015.

1169. The averaging periods must be nominated in advance. The Authority requires DBP nominate the averaging periods for 2017 to 2020 as soon as practicable following the release of this Draft Decision. The Authority does not require that the nominated 40 business day averaging period for each of the four years be identical periods, only that they occur in the period 1 June to 31 October.

Method for estimating the DRP

The simple equally weighted trailing average

1170. The estimate of the DRP for each year will be a simple trailing average.

1171. The trailing average estimate of the DRP will weight the most recent 10 years of annual DRP estimates, which have been estimated consistent with debt with a 10 year term in the BBB credit rating band.

1172. Annually updating the resulting 10 year trailing average will involve adding in the most recent estimate of the DRP and dropping the estimate from 10 years ago. The weights for a simple hybrid trailing average DRP estimate will be 10 per cent each.

1173. The automatic formula for the equally weighted trailing average of the DRP to apply in any regulatory year as shown below:

(73)

1174. $$TA\ DRP_0 = \frac{\sum_{t=0}^{-9} DRP_t}{10}$$

Where

$TA\ DRP_0$ is the equally weighted trailing average of the DRP to apply in the following year as the annual update of the estimate used in the current year; and

DRP_t is the DRP estimated for each of the 10 regulatory years t = *0, -1, -2…. , -9*.

1175. All years are in the same year convention as year *0*. For example, if year *0* is the regulatory year 2016, *t* = *-9* is the calendar year 2007 because 2016 is a calendar year in this Access Arrangement. Similarly, if year *0* is the regulatory year 2017, *t* = *-9* is the calendar year 2008.

1176. For example, the DRP trailing average estimate for the calendar 2016 regulatory year will be:

(74)

1177. $$TA\ DRP_{2016} = 0.1 \times DRP_{2016} + 0.1\times DRP_{2015} + 0.1 \times DRP_{2014} + 0.1 \times DRP_{2013} + 0.1\times DRP_{2012} + 0.1 \times DRP_{2011} + 0.1 \times DRP_{2010} + 0.1 \times DRP_{2009} + 0.1 \times DRP_{2008} + 0.1 \times DRP_{2007}$$

1178. In terms of the notation used by the Australian Energy Regulator (but in the Authority's case applying just to the DRP trailing average), the foregoing TA DRP for the 2016 calendar year may be written as follows:[649]

(75)

$$_{2015}kd_{2016} = 0.1 \times {}_{2006}R_{2007} + 0.1 \times {}_{2007}R_{2008} + 0.1 \times {}_{2008}R_{2009} + 0.1 \times {}_{2009}R_{2010} + 0.1 \times {}_{2010}R_{2011} + 0.1 \times {}_{2011}R_{2012} + 0.1 \times {}_{2012}R_{2013} + 0.1 \times {}_{2013}R_{2014} + 0.1 \times {}_{2014}R_{2015} + 0.1 \times {}_{2015}R_{2016}$$

1179. Equivalently, where 't=0' specifies the year 2016 in this case:

(76)

$$_{-1}kd_{0} = 0.1\times {}_{-10}R_{-9} + 0.1\times {}_{-9}R_{-8} + 0.1\times {}_{-8}R_{-7} + 0.1\times {}_{-7}R_{-6} + 0.1\times {}_{-6}R_{-5} + 0.1\times {}_{-5}R_{-4} + 0.1\times {}_{-4}R_{-3} + 0.1\times {}_{-3}R_{-2} + 0.1\times {}_{-2}R_{-1} + 0.1\times {}_{-1}R_{0}$$

Post-March 2015 Estimates of the DRP for inclusion in the trailing average DRP estimate

1180. The estimates of the DRP applying to each calendar year will be estimated using the Authority's revised bond yield approach. Resulting estimates of the DRP will be included in the trailing average.

1181. The first estimate is that made for the *indicative* 20 day period ending 2 April 2015, which has been included as the estimate of the DRP for calendar year 2015 included in this Draft Decision. This 2015 estimate will be revised for the Final Decision, to be published in 2015, based on RBA data for the actual credit spreads for 2015. An estimate for 2016 will also be provided as part of the Final Decision.

1182. The first annual update estimate that will be made for DBP will fall in the period 1 June to 31 October 2016, (DRP_{2017}), and will be incorporated in the trailing average DRP to apply in 2017 (that is, TA DRP_{2017}).

1183. The following automatic formulas will apply, and will remain unchanged for the duration of the AA3 period, and hence will apply for the estimates made for DRP_{2017}, as well as for the estimates DRP_{2018}, DRP_{2019} and DRP_{2020}.[650]

649 Australian Energy Regulator, *Draft Decision: Jemena Gas Networks (NSW) 2015-20*, November 2014, Attachment 3, p. 3-288.

650 As part of the response to the consultation on the proposed changes to the ATCO Final Decision, the automatic formulas for the annual update in this section were amended. However, the Authority

Techniques to estimate the debt risk premium

1184. The Authority's approach to estimating the debt risk premium (DRP) is designed so that a stakeholder can replicate the debt risk premium calculation implemented by the Authority. The process is outlined in sufficient detail such that replicating it should incur minimal research and development costs for stakeholders whilst maintaining transparency and removing discretion in the application. Once the approach has been established in Bloomberg and Excel for the first time the settings and spreadsheet templates do not need to be established again. The estimation process thereafter requires significantly less time and becomes mechanistic. ***The footnotes in this section provide assistance with Bloomberg commands.***

1185. The Revised Bond Yield Approach consists of the following six processes.

- Determining the Benchmark Sample
  - Identifying a sample of bonds based on the benchmark sample selection criteria. This will comprise a 'cross section' of bonds.
- Collecting Data
  - Collecting data for those bonds over the averaging period in question, for example 20 trading days). This represents 'time series' data related to each bond.
- Converting Yields to Australian Dollar Equivalents
  - Converting yields for bonds denominated in foreign currencies into Australian dollar (**AUD**) equivalents so that all yields are expressed as an AUD equivalent.
- Averaging Yields over the Averaging Period
  - Calculating an average AUD equivalent bond yield for each bond in the cross section across the averaging period. For example, where a 20 trading day averaging period applies, each bond will have a single 20 day 'average yield' calculated.
- Estimating 'Curves'
  - Estimating three yield curves based on different methodologies and using the average yield for each bond; its remaining term to maturity; and AUD face value.[651]
- Calculating the DRP
  - Calculating the DRP by subtracting the average of the 10 year AUD interest rate swap (**IRS**) rate from the 10 year cost of debt estimate, with the latter calculated as the average of the three estimated yield curves at the ten year tenor.

Step 1: Determining the benchmark sample

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determined not to amend some aspects of the approach used to estimate the 2 April 2015 estimate of the DRP that was set out in the ATCO Final Decision (for example, the constraints on the Nelson-Siegel Svennson curve parameters). Therefore, applying the amended methods set out below will not reproduce the exact DRP estimated for the *indicative* return on debt (see paragraphs 537 to 553 in the main body for the 2 April 2015 value of the DRP and the method adopted to estimate it).

[651] The three curves are based on the Gaussian Kernel, the Nelson Siegel and the Nelson Siegel Svennson methodologies. The Gaussian Kernel approach produces a series of point estimates as opposed to a curve. However, each point estimate can be seen as points that compose a curve.

1186. The benchmark sample of bonds should be identified as soon as practicable, but 24 hours after the date identified as the final trading day in the averaging period in order to allow the sample from Bloomberg to 'settle' to its final form.

1187. The first step in determining the benchmark sample, or cross section of bonds is to identify the appropriate benchmark credit rating. For Gas Access Arrangements, the Standard & Poors' credit rating for the benchmark firm is outlined in the Economic Regulation Authority's Rate of Return Guidelines and is currently the BBB band.[652]

1188. The Bloomberg search SRCH <GO> facility is used to conduct a search for bonds with a Standard & Poors' issue level (as opposed to issuer) rating that matches the benchmark firm's credit rating, and other criteria set out in Table 52.[653] This is carried out between 24 and 48 hours after the date that marks the final trading day in the averaging period in order to allow global markets to close. The exception here is where this 24 hour period overlaps a Western Australian non-trading day, in which case this process is carried out on the next Western Australian trading day.[654]

Table 52 Revised Bond Yield Approach Search Criteria – Bloomberg Search Structure

Criteria	ERA's approach
Country of risk	Australia
S&P Rating	BBB+ to BBB-
Currency	Australian Dollar, United States Dollar, Euro Currency and British Pound
Maturity Date	>= 2 years from now
Maturity Type	Bullet or Callable or Putable but not Perpetual
Security Type	Exclude Inflation Linked Note
Sector/Industry Group	Exclude 'Financials' (based on Bloomberg Industry Classification System Level 1 Sector Name)
Was Called	No

1189. A screen shot of how this would look in the Bloomberg SRCH<GO> function is presented in Figure 18. The security status defaults to 'active'. It is important to note that in the top left hand corner of this figure the 'Asset Classes' criteria has been enabled to consolidate duplicate bond issues. The consolidation option is accessed by typing 11 in the top left hand corner to the left of <HELP> and then hitting <GO>. Ensure that *only* the 'Corporate' and 'Consolidate Duplicate Bonds' option is checked before clicking 'Update'. The remaining criteria are entered into the Bloomberg SRCH function as shown in Figure 18 by typing the keywords into the 'Field' column and hitting <GO> after each of the criteria are entered to add new criteria. The criteria in the Bloomberg search panel can be edited by clicking the pencil icon to the right of each criteria.[655]

652 Economic Regulation Authority, Explanatory Statement for the Rate of Return Guidelines: Meeting the Requirements of the National Gas Rules, 16 December 2013, pp. 44-52.

653 <GO> is the Bloomberg equivalent of hitting the enter key after entering commands in the top left hand corner of the screen to the left of <HELP>. For example, type SRCH and then hit the <GO> key.

654 Note that the revised bond yield approach is based on Eastern States trading days for consistency with Commonwealth Government Security data used in risk free rate and inflation calculations.

655 For the maturity date change the boundary condition to 'years from now' by selecting 'Y'.

Figure 18 Bloomberg 'SRCH' Function Populated with Sample Selection Criteria

Source: Bloomberg

1190. The results of this bond search are exported into Microsoft Excel.[656] The only information that is collected from the search result output into Excel at this stage is the 'Bloomberg ID' or 'ticker' for each bond.[657] Each ticker needs to be appended with " Corp" so that formulas used in the next step can recognise them as a corporate bond. This can be carried out using the structure in Microsoft Excel below.[658]

Table 53 Appending Bloomberg Bond Tickers for use in Pricing Formulas– Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Pasted value of bond ticker (example)	A2 down	EXXXXXXXX Corp
Bond ticker appended with " Corp"	B2 down	=A2&" Corp"

1191. The bond tickers in B2 down should be pasted as values (as opposed to Excel commands) into a separate worksheet for use in subsequent calculations.

656 Click the 'Results' button and in the resulting screen click 'Actions' and then 'Export to Excel'.

657 It is important to save a copy of this search for future reference if help is requested from Bloomberg Helpdesk.

658 It is recommended that formulas presented in these Excel structure tables are copy and pasted from an electronic copy of this document.

Step 2: Collecting Data and Conversion of yields into AUD equivalents

1192. Data is collected between 24 and 48 hours after the date that marks the final trading day in the averaging period in order to allow global markets to close. The exception here is if a Western Australian non-trading day falls in this period, in which case this process is carried out on the next Western Australian trading day.[659]

1193. Before data for each of the bond identifiers in the sample (established in the previous section) is retrieved, some 'pricing source defaults' need to be set in the Bloomberg terminal, to ensure that data sources are consistent and of similar quality. This determines the source that formula outlined further below use to draw bond pricing from.

1194. Table 54 provides the 'pricing source defaults' for bonds issued in the relevant range of currencies.

Table 54 Pricing Waterfall Set in Bloomberg for Retrieving Bond Price Data

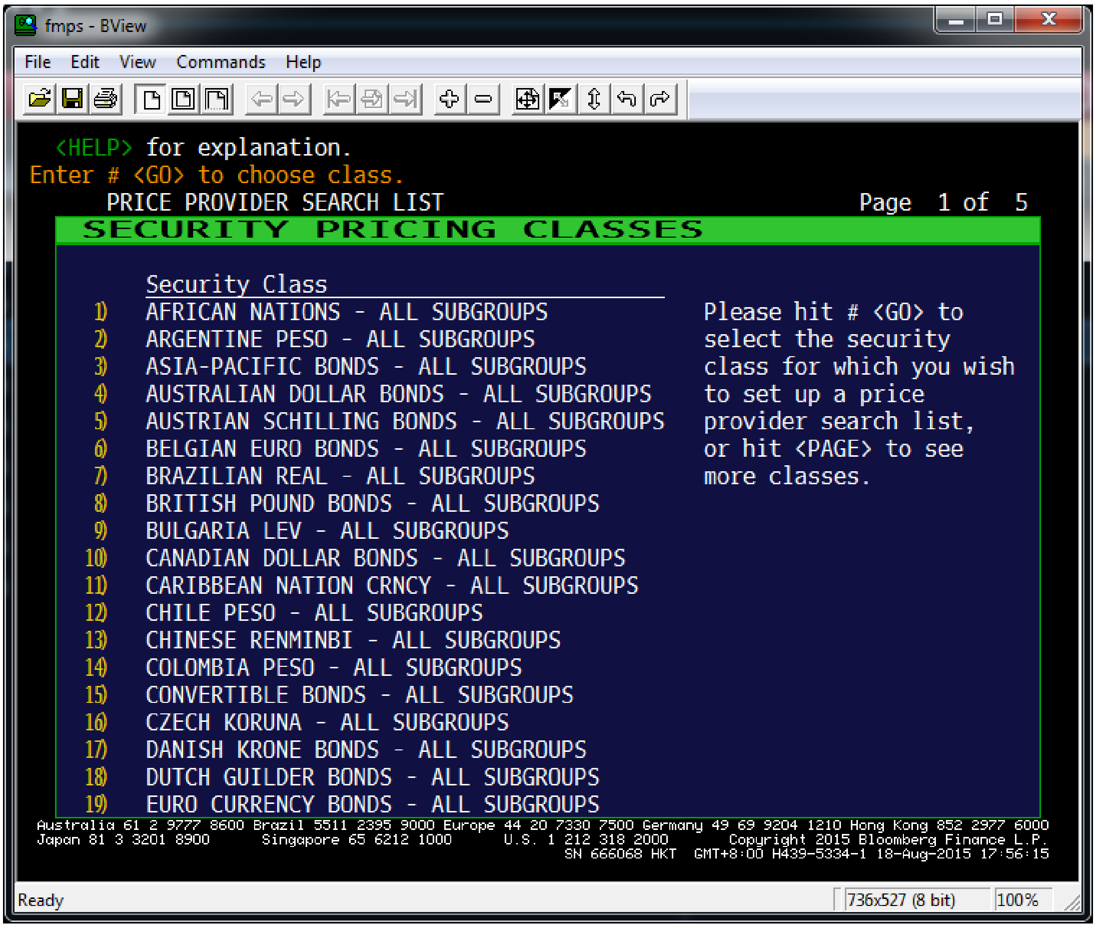
Currency of Issuance	1st Pricing Source	2nd Pricing Source
USD	BVAL	TRAC
EUR	BVAL	BGN
GBP	BVAL	BGN
AUD	BVAL	CBBT

1195. To set these as the default sources in the Bloomberg terminal for each currency use FMPS <GO> shown in Figure 19.[660] Scroll down to reveal 'US Denominated Corporate Bonds – All Subgroups'. Select this and in the resulting window select US Denominated Corporate Bonds – All Subgroups' again.

659 Note that the revised bond yield approach is based on Eastern States trading days for consistency with Commonwealth Government Security data used in risk free rate and inflation calculations. The Authority will maintain a copy of the pricing sources used for each bond in the sample so that third parties can replicate the pricing sources for all bond yield observations retrospectively.

660 The Authority considers that in practice the BVAL pricing source will find pricing data in the majority of cases. If the first preference contains any observations of historical data FMPS ensures that all observations will rely on this one pricing source for consistency. Events such as US Federal public holidays can result in days within the averaging period where no prices will be returned from the first preference. In these rare cases the bond ticker is manually appended with "@PCS Corp" to hard code the preferred pricing source. For example in Table 55 further below the ticker would be modified to "EXXXXXXXX@BGN Corp" as second preference for Euro denominated bonds. If no pricing is available from the second preference the observation is left blank. The Authority will maintain a copy of the pricing sources used for each bond in the sample so that third parties can replicate the pricing sources for all bond yield observations.

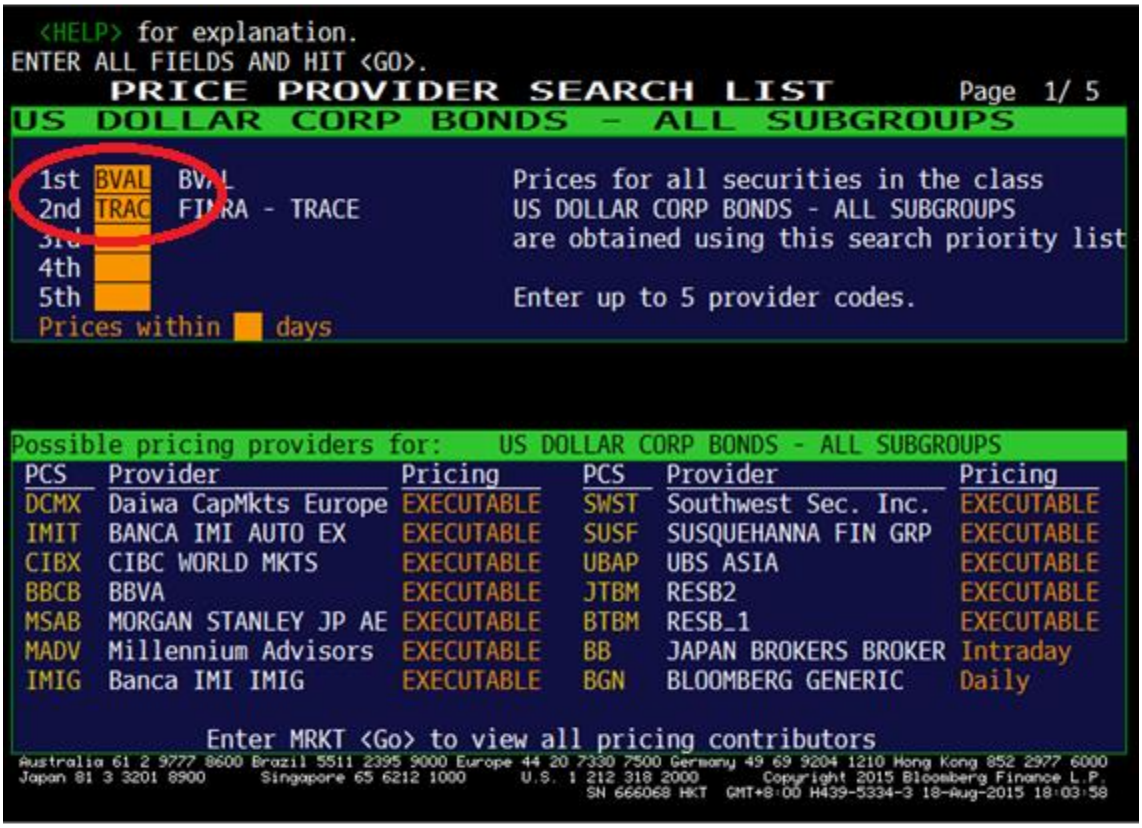
Figure 19 Security Pricing Classes List



Source: Bloomberg

1196. Figure 20 shows where the pricing source settings in Table 54 should be entered in the pricing source window using the US dollar denominated bonds as an example. In particular, the first pricing source should be entered to the right of ‘1st’ and the second pricing source to the right of ‘2nd’. Once this is complete select <GO> followed by 1 <GO> to save.

Figure 20 Pricing Source Window Default Setting - US Dollar Corporate Bond Example



Source: Bloomberg

1197. Repeat the steps outlined in paragraphs 1195 and 1196 for the remaining currencies selecting:

- 'Euro Currency Bonds – All Subgroups' > 'Original EUR Issued Bonds and Other Redenominated Bonds' > 'Euro Currency Bonds – All Subgroups' for Euro denominated bonds;
- 'British Pound Bonds – All Subgroups' > 'British Pound Bonds – All Subgroups' for GBP denominated bonds; and
- 'Australian Dollar Bonds – All Subgroups' > 'Australian Dollar Bonds – All Subgroups' for AUD denominated bonds.

1198. Data is collected through a Microsoft Excel spreadsheet that interfaces with Bloomberg through the Bloomberg Application Programming Interface (**API**). The 'tickers' identifying each bond in the sample selection step above are the key input into this spreadsheet. The bond tickers are appended with " Corp" so that they can be read by the "Bloomberg Data Point" (**BDP**) or "Bloomberg Data History" (**BDH**) function in Excel which then retrieves various attributes for each bond in question.[661] Once the pricing source defaults have been set, some key attributes are be exported into Excel:

- Maturity date (MATURITY);
- Currency (CRNCY);

661 The space before " Corp" is intentional. BDP retrieves current values while BDH is used to retrieve historical data.

- Amount issued (AMT_ISSUED);
- Issue date (ISSUE_DT);
- Bid price for the bond (px bid);
- Ask price for the bond (px ask); and
- Asset swap spread bid (asset swap spd bid);
- Asset swap spread ask (asset swap spd ask);
- Australian dollar exchange rate with each bond's native currencyat date of issue (for example for the US/Australian dollar exchange rate; USDAUD Curncy).

1199. The key formulas for exporting the Bloomberg data into Excel are provided in Table 55. All formulas B2 through to E2 should be filled downward in Excel to retrieve the attributes for the entire cross section of bonds.

1200. Once these key attributes have been exported, the formulas in then convert the mid asset swap spread highlighted in K2 into a hedged Australian dollar equivalent. The formulas in Table 55 and should be contained in the same spreadsheet. All formulas P2 through to R2 should be filled downward in Excel to retrieve the converted yields for the cross section of bonds.[662]

1201. The Excel worksheet based on the formulas in Table 55 and provides a template to calculate the hedged AUD bond yields for the entire cross section of bonds in the benchmark sample on any given trading day. Specifically, once a trading date is entered into cell A1, the hedged AUD bond yield is returned in cells R2 downward.[663] The hedged yields for the entire cross section of bonds are saved as values (rather than excel formulas) for each day in the 20 day averaging period.

Table 55 Formula to Retrieve Bond Prices and Attributes– Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Bond Ticker	From A2 down	EXXXXXXXX Corp
Trading day date	A1	mm/dd/yyyy
Currency to convert to	B1	AUD
Payment frequency	C1	Q
Issue date	B2 down	=BDP(A2,"ISSUE_DT")
Maturity date	C2 down	=BDP(A2,"MATURITY")
Currency of bond issue	D2 down	=BDP(A2,"CRNCY")
Amount issued –currency of issuance (bond face value)	E2 down	=BDP(A2,"AMT_ISSUED")

662 The Bloomberg Swaps Toolkit must be enabled so that these formulas can call the swap manager tool in the Bloomberg terminal through Excel. Further information and example templates can be found in the Swaps Toolkit under DAPI <GO> in the Bloomberg terminal.

663 Note that this process can take a few minutes to populate. It is important to ensure the yields have populated fully and without error each time the date is changed in cell A1. At times this may require restarting Excel.

Amount issued – Australian dollars (bond face value)	F2 down	=IF(D2="AUD",E2,E2*BDH(D2&"AUD Curncy","px_last",B2,B2))
Bid Price Label	G1	PX BID
Ask Price Label	H1	PX ASK
Bond bid price[664]	G2 down	=BDH(A2, "px bid", $A$1, $A$1, "QuoteType", "P","fill","P")
Bond ask price	H2 down	=BDH(A2, "px ask", $A$1, $A$1, "QuoteType", "P","fill","P")
Asset swap spread bid[665]	I2 down	=BDP(A2,"asset swap spd bid",$G$1,G2,"ASW_SWAP_CURRENCY",$B$1,"ASW_SWAP_PAY_RESET_FREQ",$C$1,"SETTLE_DT",TEXT($A$1,"YYYYMMDD"),"OAS_CURVE_DT",TEXT($A$1,"YYYYMMDD"))
Asset swap spread ask[666]	J2 down	=BDP(A2,"asset swap spd ask",$H$1,H2,"ASW_SWAP_CURRENCY",$B$1,"ASW_SWAP_PAY_RESET_FREQ",$C$1,"SETTLE_DT",TEXT($A$1,"YYYYMMDD"),"OAS_CURVE_DT",TEXT($A$1,"YYYYMMDD"))
Asset swap spread mid	K2 down	=AVERAGE(I2:J2)
Determination Date	$L$1 down	dd/mm/yyyy
Remaining term to maturity from determination date (dd/mm/yyyy)	L2 down	=YEARFRAC($L$1,C2,)

Source: ERA Research, Bloomberg

[664] The Authority considers that the “fill” “P” option will not return values after the bond has matured, however will ensure a contiguous series whilst the bond is on issue.

[665] The Authority considers that using the option adjusted spread curve date is an appropriate override in order to explicitly fix this curve date to the trading day date entered through Excel.

[666] The Authority considers that using the option adjusted spread curve date is an appropriate override in order to explicitly fix this curve date to the trading day date entered through Excel.

Table 56 Formula for Converting to Hedged Australian Dollar Equivalent Yields– Microsoft Excel Template Structure (continued on from Table 55)

Attribute	Cell	Formula or entry
Payment frequency for fixed leg of swap (leg 1)	M1 down	Semiannual
Payment frequency for floating leg of swap (leg 2)	N1 down	Quarterly
Deal type (fixed float)	O1 down	FXFL
Deal Structure ID (called from Bloomberg terminal)[667]	P2 down	=BSTRUCTURE($O$1,"Leg[2].Currency",$B$1,"Leg[1].Currency",$B$1,"Leg[2].Spread",K2,"EffectiveDate",$A$1,"MaturityDate",C2,"Leg[1].PayFrequency",$M$1,"Leg[2].PayFrequency",$N$1,"Leg[2].ResetFrequency",$N$1)
Valuation ID (called from Bloomberg terminal)	Q2 down	=BPRICE(P2,"Target=Leg[1].FixedCoupon","Premium=0","Leg[2].Spread",K2,"ValuationDate",$A$1,"MarketDate",$A$1,"headers=false")
Australian dollar equivalent yield	R2 down	=BView(Q2,"Leg[1].FixedCoupon","headers=false")

Source: ERA Research, Bloomberg

Step 3: Averaging yields over the averaging period

1202. The 20 day averaging period is based on eastern states trading days with the last day of the averaging period being on the DRP determination date. A table of AUD equivalent bond yields is established for the cross section of bonds in the sample with observations for every day across the averaging period.[668] To build up this time series, the date entered in cell A1 at Table 55 should be changed to each of the trading days in the averaging period. The series of observations for each bond is then assessed to ensure it has a number of observations equal to at least half of the averaging period. Bonds that do not meet this requirement are deleted from the sample. The sample of yields for each bond is then averaged. This results in one averaged observation for each bond.

1203. The Excel worksheet for calculating the 20 day average bond yield for each bond in the benchmark samples is provided at Table 57.

667 The Authority considers that setting the effective date to the trading date is appropriate to ensure the tenor of the swap matches the remaining term to maturity of the bond.

668 This is done by cutting and pasting observations from cell R2 down in as values into B2 down in Table 57. To avoid 'overloading' the Excel API only one spreadsheet using the structure in should be run on a Bloomberg terminal at a time.

Table 57 Averaging Yields over the Averaging Period - Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Trading Day Dates	B1:U1	Each trading day date in the averaging period (20 dates for this Decision)
Bond Ticker	A2 down	EXXXXXXXX Corp
Australian dollar equivalent yields for first trading day	B2 down :U2 down	Bond values from R2 down in for the 1st trading day through to the 20th trading day.
Average of 20 day yields	V2 down	=AVERAGE(B2:U2)

Step 4: Apply curve fitting techniques

1204. To improve the validity of the yield estimates, three techniques are used to fit curves as part of the automatic formula to estimate the 10 year cost of debt used in the calculation of the annually updated DRP. These are:

- the Gaussian Kernel Methodology;
- the Nelson-Siegel Methodology; and
- the Nelson-Siegel-Svennson Methodology.

1205. For ease of replication by third parties only Microsoft Excel is used for processing the data. Each of these techniques is discussed in turn below.[669]

Gaussian Kernel Methodology

1206. The Gaussian Kernel Methodology is consistent with the approach used by the Reserve Bank of Australia as published in 'New Measures of Australian Corporate Credit Spreads'.[670] The Excel worksheet that replicates the Gaussian Kernel Methodology is provided in Table 58.

1207. Note that the inputs required for each bond in the benchmark sample are: remaining term to maturity; bond face value in Australian dollars; and Australian dollar equivalent yield. These are the outputs reported in cells L2 and F2 in Table 55 and cell R2 in respectively.

[669] Microsoft Excel 2013 (15.0.4745.1000) 32 bit as part of Microsoft Office Professional Plus 2013 is the version currently used for these calculations.

[670] Reserve Bank of Australia, 'New Measures of Australian Corporate Credit Spreads', Bulletin, December quarter 2013.

Table 58 Gaussian Kernel Point Estimation Methodology – Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Remaining term to maturity	A1 down	L2 as output in Table 55
Amount issued – Australian dollars (bond face value)	B1 down	F2 as output in Table 55
Australian dollar equivalent yield	C1 down	Values in V2 down in Table 57
Absolute deviation from target tenor	D1 down	=ABS(A1-$K$1)
Squared deviation from target tenor	E1 down	=(A1-$K$1)^2
Gaussian kernel	F1 down	=(EXP(-E1/(2*$K$4)))/$K$8
Joint Weighting	G1 down	=F1*B1
Sum of Joint Weighting	Last cell column G	=SUM(G1:GSecond last row)
Weight	H1 down	=G1/(GLast row)
Weighted yield	I1 down	=C1*H1
Weighted maturity	J1 down	=A1*H1
Sum weighted maturity (effective term to maturity)	Last cell column J	=SUM(J1:JSecond last row)
Target tenor	K1	Input target tenor (eg 10 for 10 years)
Smoothing parameter (sigma)	K2	1.5
Actual sigma	K3	=STDEV(A:A)
Sigma squared	K4	=K2^2
mean	K5	=AVERAGE(A:A)
pi	K6	=PI()
2 x Square root of pi	K7	=SQRT(2*K6)
2 x Square root of pi x smoothing parameter	K8	=K7*K2
Target tenor yield	K9	=SUM(I:I)

1208. As the Gaussian kernel methodology is non-parametric, and thus requires no estimation of curves, the output for any target tenor input into cell K1 is instantly reported in cell K8.

1209. The target tenor yields are calculated for 3, 5, 7 and 10 year terms. The associated effective term to maturity in the last cell of column J is also recorded for each tenor. A linear extrapolation out to an effective tenor of 10 years and interpolation to 7 years is performed using the following formula.

1210.
$$y_t(t) = y_t\left[et(7)\right] + \left(\frac{y_t\left[et(10)\right] - y_t\left[et(7)\right]}{et(10) - et(7)}\right)\left(t - et(7)\right) \quad (73)$$

Where:

t is the tenor to be interpolated or extrapolated to;

$y_t(t)$ is the semi-annual yield extrapolated out to 10 years;

τ is the input target tenor (for example in cell K1 above);

$y_t\left[\tau\right]$ is target tenor yield output from the Gaussian kernel method; and

$et(\tau)$ is the effective tenor output from the Gaussian kernel method.

1211. The Excel Worksheet for calculating the target tenor yields is provided at Table 59 (below).

Table 59 Linear Interpolation and Extrapolation of Gaussian Kernel Estimates – Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Tenor	A1:D1	Values 3, 5, 7 and 10.
3 year target tenor yield (semi-annual basis)	A2	From cell K9 in Table 58.
5 year target tenor yield (semi-annual basis)	B2	From cell K9 in Table 58.
7 year target tenor yield (semi-annual basis)	C2	From cell K9 in Table 58.
10 year target tenor yield (semi-annual basis)	D2	From cell K9 in Table 58.
3 year effective tenor	A3	Last row of column J in Table 58.
5 year effective tenor	B3	Last row of column J in Table 58.
7 year effective tenor	C3	Last row of column J in Table 58.
10 year effective tenor	D3	Last row of column J in Table 58.
3 year target tenor annualized yield	A4	=((1+A2/200)^2-1)*100
5 year target tenor annualized yield	B4	=((1+B2/200)^2-1)*100
7 year target tenor annualized yield	C4	=((1+C2/200)^2-1)*100
10 year target tenor annualized yield	D4	=((1+D2/200)^2-1)*100
Interpolated 7 year yield (semi-annual basis)	E2	=C2+((D2-C2)/(D3-C3))*(7-C3)
Extrapolated 10 year yield (semi-annual basis)	F2	=C2+((D2-C2)/(D3-C3))*(10-C3)
Interpolated 7 year yield annualized	E4	=((1+E2/200)^2-1)*100
Extrapolated 10 year yield annualized	F4	=((1+F2/200)^2-1)*100

1212. The value for F4 in Table 59 is the Gaussian Kernel cost of debt extrapolated to a tenor of 10 years. This value averaged with the 10 year cost of debt estimate from the other two methods is the Authority's final 10 year cost of debt estimate.

The Nelson Siegel method

1213. The first step in the Nelson Siegel methodology involves the estimation of the value for the decay factor (λ) that provides the tenor at which the medium-term factor (β_{2t}) reaches its maximum influence. Diebold and Li (2006) propose that

30 months (2.5 years) is commonly used as a medium-term tenor.[671] Setting τ to 2.5 and substituting it into the weighting factor attached to β_{2t} in the Nelson Siegel specification gives:

1214.

$$Max\left(\frac{1-e^{-2.5\lambda}}{2.5\lambda}-e^{-2.5\lambda}\right) \quad (74)$$

1215. The Excel worksheet and Excel solver settings that are used to determine the value of λ that maximises β_{2t} are provided at Table 60, Figure 21 and Figure 22 respectively. Note that the GRG non-linear solver is used to find the maximum point (or peak) on a non-linear function, hence the selection of 'GRG Nonlinear' and 'Max' in Figure 21.

Table 60 Nelson Siegel Decay Factor Estimation – Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
β_{2t} weighting factor	A1	=(((1-EXP(-$A$3*A2))/($A$3*A2))-EXP(-$A$3*A2))
Tenor (maturity) τ	A2	2.5
Decay factor λ (Starting value used)	A3	0.00000000000001 (that is 1E-14)

671 F. Diebold and C. Li, 'Forecasting the term structure of government bond yields', *Journal of Econometrics,* vol.130, no.2, pp. 337-364.

Figure 21 Nelson Siegel Decay Factor Estimation – Microsoft Excel Solver Settings

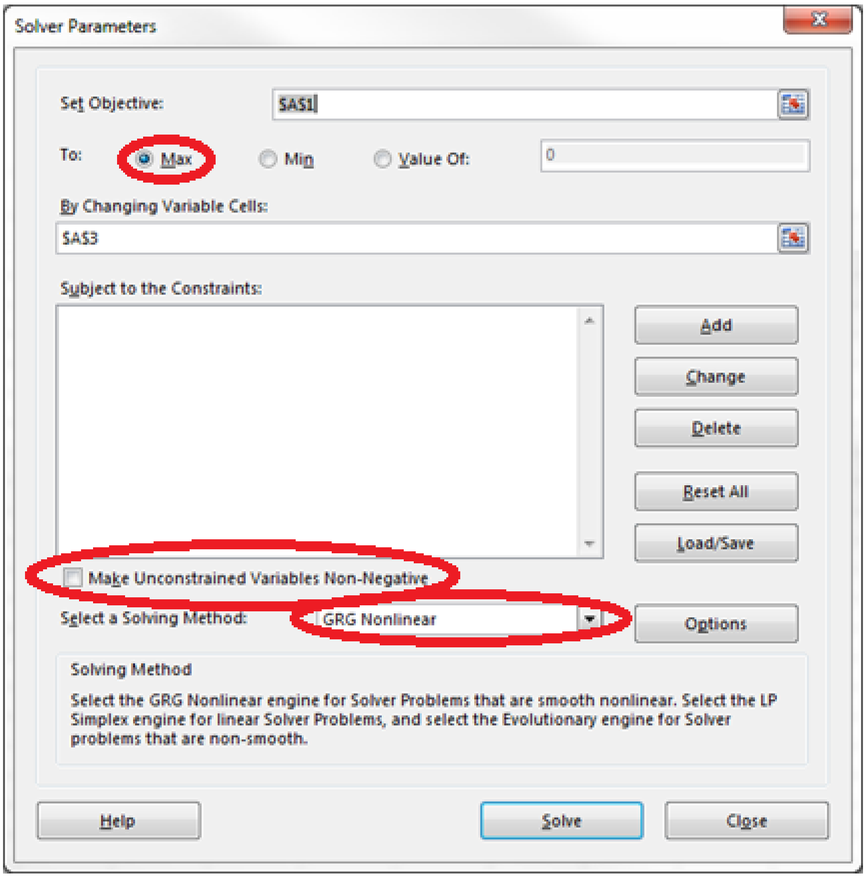
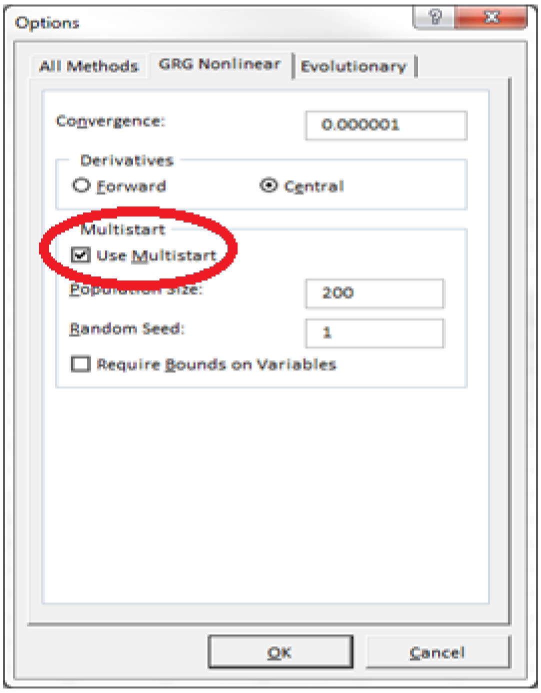


Figure 22 Microsoft Excel GRG Nonlinear Solver Settings



1216. The convergence of 0.000001 is considered precise enough such that the solver will stop when the solution in the last iterations change by this amount.[672] To ensure

672 Diebold and Li (2006) published their decay method to 4 decimal places.

the peak is a global maximum (as opposed to just local) the solver carries out the optimisation from many different random starting points on the function reflected by the selection of the 'Multistart' option in Figure 22. The number of different starting points is based on the 'Population size' field and setting the 'Random seed' to 'one' ensures that the random selection process is always based on the same seed each time the solver is used. The central difference derivative method is selected for the greatest accuracy. In this case the problem is unconstrained and so no bounds are required on variables.

1217. This estimation process yields a value for λ of 0.71731 which will be used as a starting value in the final fitting of the NS yield curve.[673]

1218. Starting values are still required for $\beta_{0t}, \beta_{1t}, \beta_{2t}$. These are obtained by:

- substituting the decay factor value (λ) as a constant into the terms attached to

$$\beta_{1t},\ \left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right) \text{ and } \beta_{2t},\ \left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}-e^{-\lambda\tau}\right); \tag{74}$$

- setting these terms as a function of each bond's remaining term to maturity as shown for cell L2 in Table 55, which will provide a β_{1t} weight and β_{2t} weight for every bond in the sample; and
- performing Ordinary Least Squares (**OLS**) regression using the Excel Data Analysis tools' 'Regression' function. The Excel structure for setting out the data to which the OLS regression is applied is shown in Table 61.

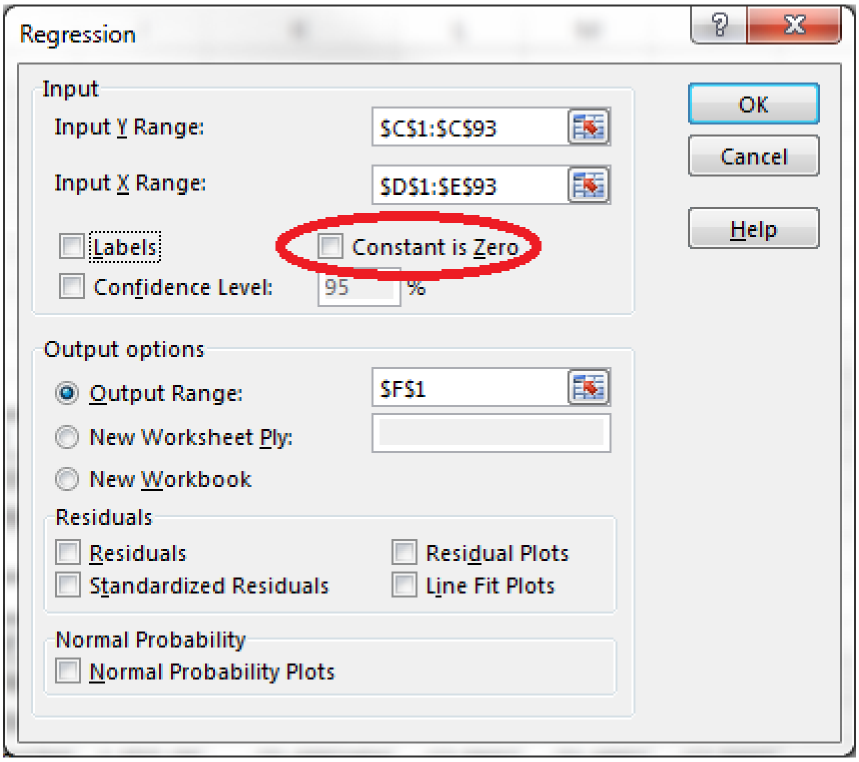
1219. The Excel worksheet and regression settings are provided at Table 61 and Figure 23 respectively. The Y input values are the Australian dollar yield equivalents output for each bond as shown in cell R2 in . The X input values are the entire series of β_{1t} and β_{2t} weights associated with each of the bonds. Note that the 'Constant is zero' box shown in Figure 23 should be left unchecked so that an intercept term is included in the regression which will serve as a starting value for β_{0t}.

Table 61 Nelson Siegel Starting Value Regression – Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Decay factor λ	A1	Link to solution in cell A3 in Table 60.
Maturity (τ)	B1 down	The results of from cell L2 in Table 55
Australian dollar equivalent yield	C1 down	Values in V2 down in Table 57
β_{1t} weight factor	D1 down	=((1-EXP(-$A$1*B1))/($A$1*B1))
β_{2t} weight factor	E1 down	=(((1-EXP(-$A$1*B1))/($A$1*B1))-EXP(-$A$1*B1))

673 This solution is output in cell A3 in Table 60 once the solver has found a solution.

Figure 23 Nelson Siegel Starting Value Regression – Microsoft Excel Regression Settings



1220. The intercept, X Variable 1 and X Variable 2 that appear under the coefficients in the Excel regression output table are used respectively as the starting value estimates for β_{0t}, β_{1t} and β_{2t} in the Nelson Siegel curve fitting process while the value in cell A1 in Table 61 is used as the starting value for λ.[674]

1221. The Excel worksheet that replicates the Nelson Siegel curve fitting process is provided at Table 62.

674 This is output into cells G17,G18 and G19 in the example set out above.

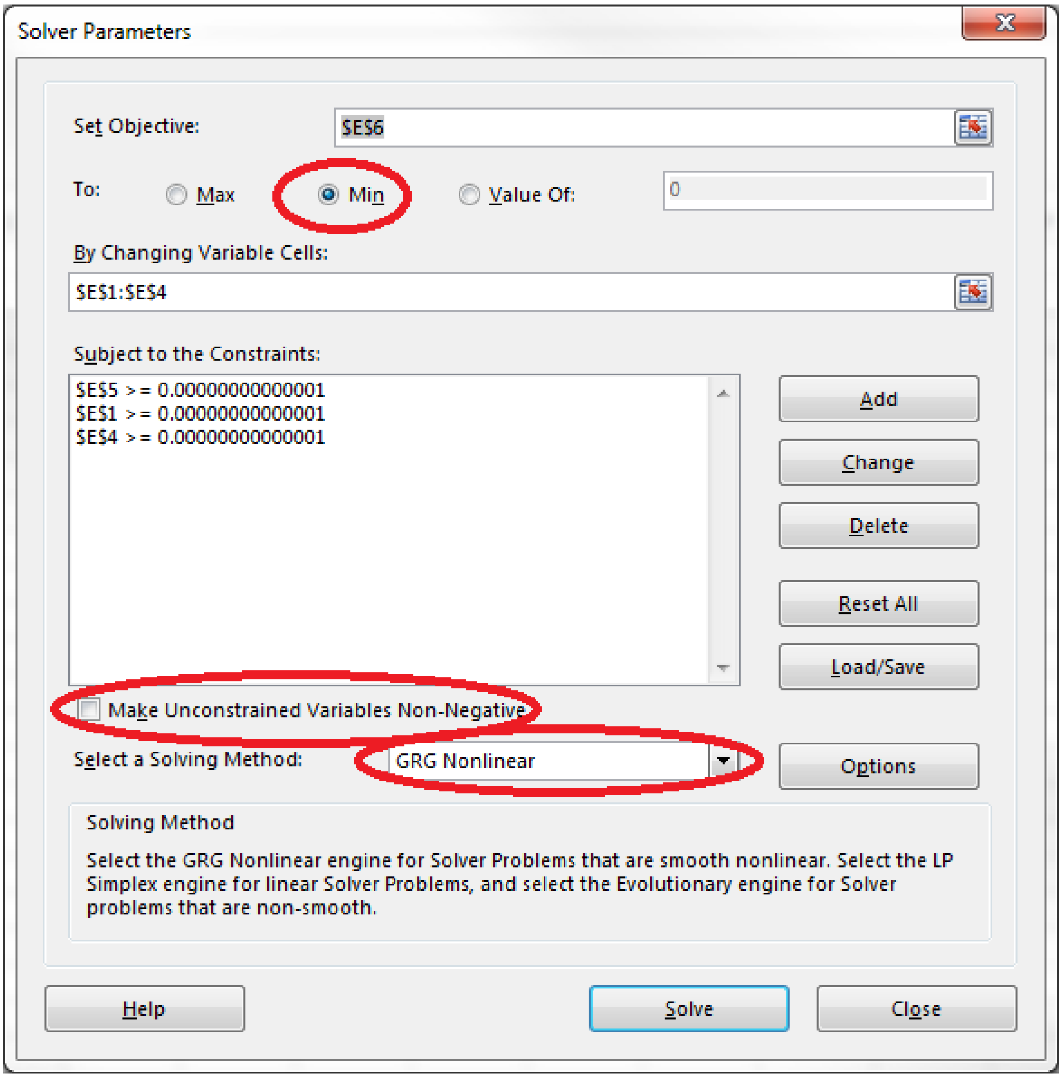
Table 62 Nelson Siegel Curve Fitting Methodology – Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Remaining Term to Maturity	A1	Values as calculated by cell L2 in Table 55
Australian dollar equivalent yield	B1	Values in V2 down in Table 57
NS Functional Form	C1 down	=$E$1+$E$2*((1-EXP(-$E$4*A1))/($E$4*A1))+$E$3*(((1-EXP(-$E$4*A1))/($E$4*A1))-EXP(-$E$4*A1))
Squared Residual	D1 down	=(B1-C1)^2
β_{0t}	E1	Starting value for β_{0t} calculated above
β_{1t}	E2	Starting value for β_{1t} calculated above
β_{2t}	E3	Starting value for β_{2t} calculated above
λ	E4	Starting value for λ calculated above[675]
$\beta_{0t}+\beta_{1t}$	E5	= E1+E2
Sum of Squared Residuals	E6	=SUM(D:D)

1222. The Excel solver settings (including constraints) that are required to minimize the sum of the squared residuals at cell E6 in Table 62 (by changing the values in the cells E1 through to cell E5) are provided in Figure 24. The associated GRG Nonlinear solver settings are provided at Figure 22.

675 This cell is linked to the exact solution for the decay factor in order to avoid issues associated with truncating decimal places.

Figure 24 Nelson Siegel Parameter Constraints - Excel Solver Settings



1223. The final solutions for $\beta_{0t}, \beta_{1t}, \beta_{2t}$ and λ in cells E1 to E4 in Table 62 must be entered back into the Nelson Siegel functional form to obtain tenor yields for 3, 5, 7 and 10 year terms.

1224. The Excel Worksheet that calculates the semi-annual yields at each tenor (that is, as if bond interest payment are made every 6 months) is provided at Table 63. The additional Excel calculations that are required to annualise the output values for A2, B2, C2 and D2 in Table 63 (below) so that it represents an effective annual interest rate at each tenor is provided in Table 64 (below).

Table 63 Nelson Siegel Yield Estimation Methodology – Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Tenor	A1:D1	Values 3, 5, 7 and 10.
3 year AUD yield (semi-annual basis)	A2	=$E1+$E2*((1-EXP(-$E4*A1))/($E4*A1))+$E3*(((1-EXP(-$E4*A1))/($E4*A1))-EXP(-$E4*A1))
5 year AUD yield (semi-annual basis)	B2	=$E1+$E2*((1-EXP(-$E4*B1))/($E4*B1))+$E3*(((1-EXP(-$E4*B1))/($E4*B1))-EXP(-$E4*B1))
7 year AUD yield (semi-annual basis)	C2	=$E1+$E2*((1-EXP(-$E4*C1))/($E4*C1))+$E3*(((1-EXP(-$E4*C1))/($E4*C1))-EXP(-$E4*C1))
10 year AUD yield (semi-annual basis)	D2	=$E1+$E2*((1-EXP(-$E4*D1))/($E4*D1))+$E3*(((1-EXP(-$E4*D1))/($E4*D1))-EXP(-$E4*D1))
β_{0t}	E1	Solution for β_{0t} output in cells E1 Table 62.
β_{1t}	E2	Solution for β_{1t} output in cells E2 Table 62.
β_{2t}	E3	Solution for β_{2t} output in cells E3 Table 62.
λ	E4	Solution for λ output in cells E4 Table 62.

Table 64 Annualising Semi-Annual Bond Yields - Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
3 year AUD yield (annual basis)	A3	=((1+A2/200)^2-1)*100
5 year AUD yield (annual basis)	B3	=((1+B2/200)^2-1)*100
7 year AUD yield (annual basis)	C3	=((1+C2/200)^2-1)*100
10 year AUD yield (annual basis)	D3	=((1+D2/200)^2-1)*100

1225. The value for D3 in Table 64 is the Nelson Siegel 10 year cost of debt estimate. This value averaged with the 10 year cost of debt estimate from the other two methods is the Authority's final 10 year cost of debt estimate.

The Nelson-Siegel Svennson Methodology

1226. The Nelson-Siegel Svennson Methodology assumes that the term structure of the cost of debt has the parametric form shown below:

$$\hat{y}_t(\tau) = \beta_{0t} + \beta_{1t}\left(\frac{1-e^{-\tau/\lambda_1}}{\tau/\lambda_1}\right) + \beta_{2t}\left(\frac{1-e^{-\tau/\lambda_1}}{\tau/\lambda_1} - e^{-\tau/\lambda_1}\right) + \beta_{3t}\left(\frac{1-e^{-\tau/\lambda_2}}{\tau/\lambda_2} - e^{-\tau/\lambda_2}\right) \tag{75}$$

Where

$y_t(\tau)$ is the yield at time t for maturity τ ; and

$\beta_{0t}, \beta_{1t}, \beta_{2t}, \beta_{3t}, \lambda_1, \lambda_2$ are the parameters of the model to be estimated from the data.

1227. The Nelson-Siegel Svennson (**NSS**) methodology uses observed data from the bond market to estimate the parameters $\beta_{0t}, \beta_{1t}, \beta_{2t}, \beta_{3t}, \lambda_1$ and λ_2 by using the observed yields and maturities for bonds. A yield curve is produced by substituting these estimates into the above equation and plotting the resulting *estimated* yield $\hat{y}_t(\tau)$ by varying the maturity τ . $\hat{y}_t(\tau)$ has the interpretation of being the *estimated yield* for a benchmark bond with a maturity of τ for a given credit rating.

1228. The NSS methodology uses two decay factors λ_1 and λ_2. At each annual update the starting values for these parameters are based on the previous years' final estimates. The first annual update will use the values 1.6416 and 4.5834 for λ_1 and λ_2 respectively. The values for these decay factors in the subsequent annual update will use the final values for the decay factors resulting from the process set out below, and so forth for the following years. An exception to this is if the previous years' yield curve estimates are determined to be non-robust as set out in Table 70. In this situation the decay factors λ_1 and λ_2 from the latest set of robust yield curve estimates will be used.

1229. Starting values are still required for β_{1t}, β_{2t} and β_{3t}. These are obtained by:

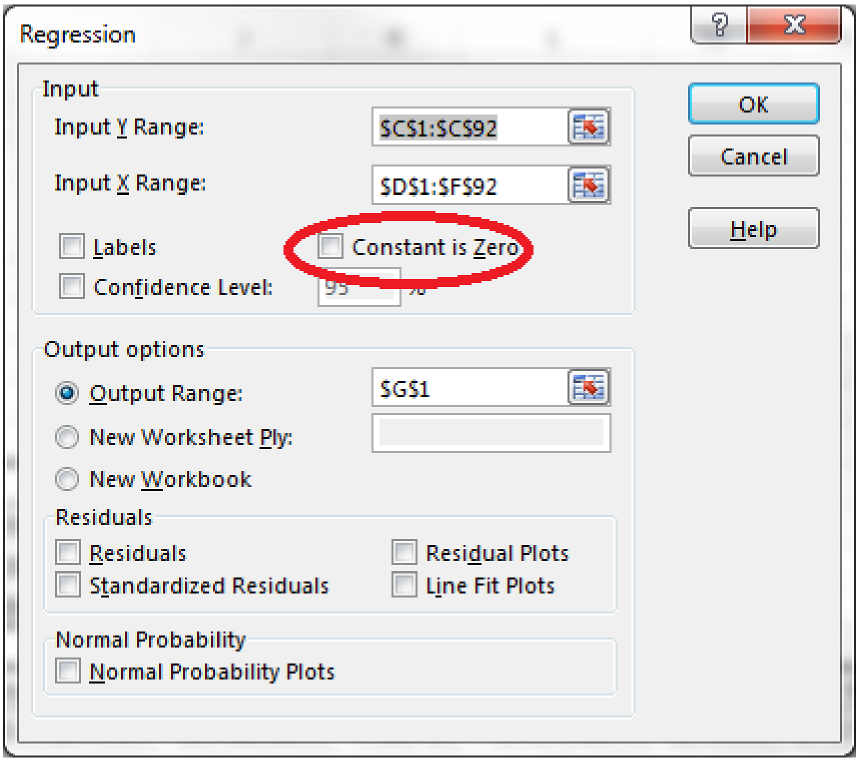
- substituting the decay factors (λ_1 and λ_2) as substitutes as constants into the terms attached to β_{1t} $\left(\frac{1-e^{-\tau/\lambda_1}}{\tau/\lambda_1}\right)$, β_{2t} $\left(\frac{1-e^{-\tau/\lambda_1}}{\tau/\lambda_1}-e^{-\tau/\lambda_1}\right)$ and β_{3t} $\left(\frac{1-e^{-\tau/\lambda_2}}{\tau/\lambda_2}-e^{-\tau/\lambda_2}\right)$;
- setting these terms as a function of each bond's remaining term to maturity as shown for cell L2 in Table 55. This will result in a β_{1t} weight, β_{2t} weight and β_{3t} weight for every bond in the sample.
- performing an Ordinary Least Squares (**OLS**) regression is carried out using the Excel Data Analysis tools' 'Regression' function. The Excel structure for setting out the data to which the OLS regression is applied is shown in Table 65 (below).

Table 65 Nelson Siegel Svennson Starting Value Regression – Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Decay factor λ_1	A1	Last years' λ_1.
Decay factor λ_2	A2	Last years' λ_2.
Maturity (τ)	B1 down	The results of from cell L2 in Table 55
Australian dollar equivalent yield	C1 down	Values in V2 down in Table 57
β_{1t} weight factor	D1 down	=((1-EXP(-B1/$A$1))/(B1/$A$1))
β_{2t} weight factor	E1 down	=((((1-EXP(-B1/$A$1))/(B1/$A$1)))-(EXP(-B1/$A$1)))
β_{3t} weight factor	F1 down	=((((1-EXP(-B1/$A$2))/(B1/$A$2)))-(EXP(-B1/$A$2)))

1230. The Excel worksheet and regression settings are provided at Table 65 and Figure 25 respectively. The Y input values are the Australian dollar yield equivalents output for each bond as shown in cell R2 in Table 56. The X input values are the entire series of β_{1t}, β_{2t} and β_{3t} weight factors associated with each of the bonds. Note that the 'Constant is zero' box shown in Figure 25 should be left unchecked so that an intercept term is included in the regression which will serve as a starting value for β_{0t}.

Figure 25 Nelson Siegel Svennson Starting Value Regression – Microsoft Excel Regression Settings



1231. The intercept, X Variable 1, X Variable 2 and X Variable 3 that appear under the coefficients in the Excel regression output table are used respectively as the starting value estimates for $\beta_{0t}, \beta_{1t}, \beta_{2t}$ and β_{3t} in the Nelson-Siegel Svennson curve fitting process while the values in cell A1 and A2 in Table 65 are used as the starting values for λ_1 and λ_2.[676]

1232. The Excel worksheet that replicates the Nelson-Siegel Svennson curve fitting process is provided at Table 66 (below).

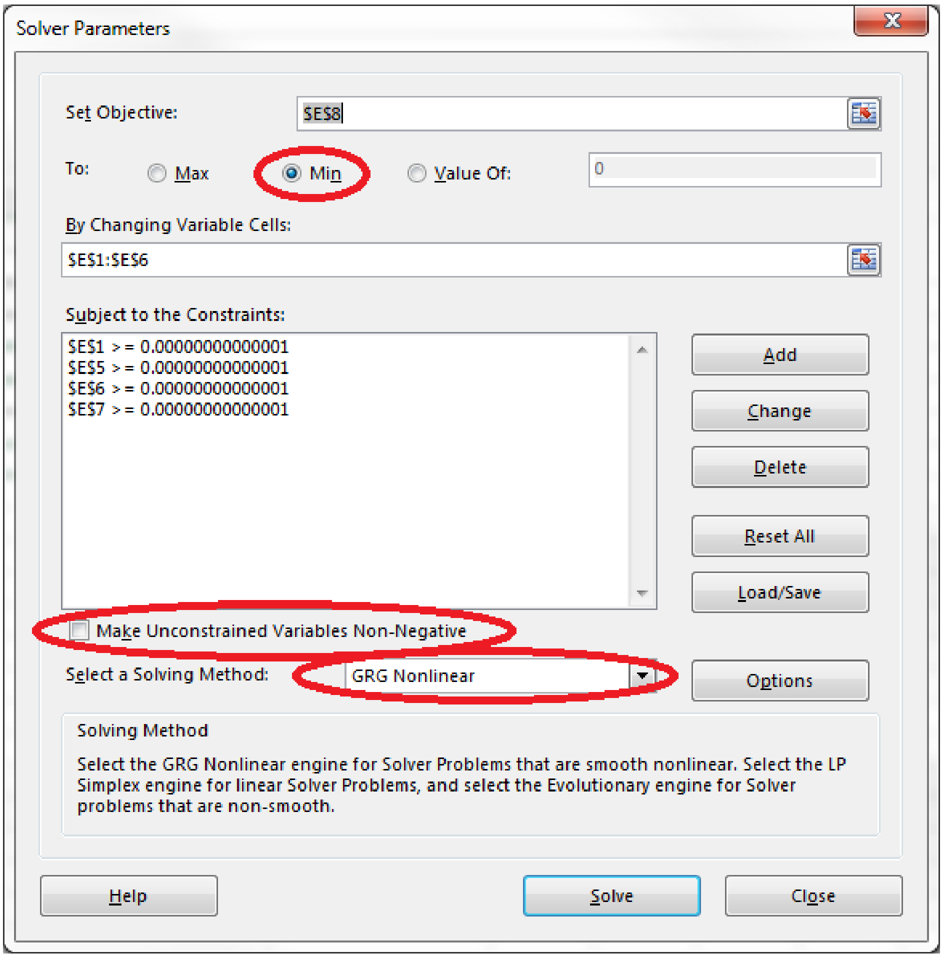
676 This is output into cells H17, H18, H19 and H20 in the example set out above.

Table 66 Nelson Siegel Svennson Yield Curve Estimation Methodology – Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Remaining Term to Maturity	A1	Values as calculated by cell L2 in Table 55
Australian dollar equivalent yield	B1	Values in V2 down in Table 57
NSS Functional Form	C1	=$E$1+$E$2*((1-EXP(-A1/$E$5))/(A1/$E$5))+$E$3*((((1-EXP(-A1/$E$5))/(A1/$E$5)))-(EXP(-A1/$E$5)))+$E$4*((((1-EXP(-A1/$E$6))/(A1/$E$6)))-(EXP(-A1/$E$6)))
Squared Residual	D1	=(B1-C1)^2
β_{0t}	E1	Starting value for β_{0t} calculated above
β_{1t}	E2	Starting value for β_{1t} calculated above
β_{2t}	E3	Starting value for β_{2t} calculated above
β_{3t}	E4	Starting value for β_{3t} calculated above
λ_1	E5	Last years' λ_1.
λ_2	E6	Last years' λ_2.
$\beta_{0t} + \beta_{1t}$	E7	= E1+E2
Sum of Squared Residuals	E8	=SUM(D:D)

1233. The Excel solver settings (including constraints) that are required to minimize the sum of the squared residuals at cell E8 in Table 66 (by changing the values in the cells E1 through to cell E6) are provided in Figure 26. The associated GRG Nonlinear Solver Settings are provided at Figure 22.

Figure 26 Nelson Siegel Svennson Parameter Constraints – Microsoft Excel Solver Settings



1234. The final solutions for $\beta_{0t}, \beta_{1t}, \beta_{2t}, \beta_{3t}, \lambda_1$ and λ_2 output in cells E1 to E6 in Table 66 must be entered back into the Nelson-Siegel Svennson functional form to obtain tenor yields for 3, 5, 7 and 10 year terms.

1235. The Excel worksheet that calculates semi-annual yields at each tenor (that is, as if bond interest payment are made every 6 months) is provided at Table 67. The additional Excel Calculations that are required to annualise the output values for A2, B2, C2 and D2 in Table 67 (below), so that outputs represent an effective annual interest rate at each tenor, are provided at Table 68 (below).

Table 67 Nelson Siegel Svennson Yield Estimation Methodology – Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Tenor	A1:D1	Values 3, 5, 7 and 10.
3 year AUD yield (semi-annual basis)	A2	=$E1+$E2*((1-EXP(-A1/$E5))/(A1/$E5))+$E3*((((1-EXP(-A1/$E5))/(A1/$E5)))-(EXP(-A1/$E5)))+$E4*((((1-EXP(-A1/$E6))/(A1/$E6)))-(EXP(-A1/$E6)))
5 year AUD yield (semi-annual basis)	B2	=$E1+$E2*((1-EXP(-B1/$E5))/(B1/$E5))+$E3*((((1-EXP(-B1/$E5))/(B1/$E5)))-(EXP(-B1/$E5)))+$E4*((((1-EXP(-B1/$E6))/(B1/$E6)))-(EXP(-B1/$E6)))
7 year AUD yield (semi-annual basis)	C2	=$E1+$E2*((1-EXP(-C1/$E5))/(C1/$E5))+$E3*((((1-EXP(-C1/$E5))/(C1/$E5)))-(EXP(-C1/$E5)))+$E4*((((1-EXP(-C1/$E6))/(C1/$E6)))-(EXP(-C1/$E6)))
10 year AUD yield (semi-annual basis)	D2	=$E1+$E2*((1-EXP(-D1/$E5))/(D1/$E5))+$E3*((((1-EXP(-D1/$E5))/(D1/$E5)))-(EXP(-D1/$E5)))+$E4*((((1-EXP(-D1/$E6))/(D1/$E6)))-(EXP(-D1/$E6)))
β_{0t}	E1	Solution for β_{0t} output in cells E1 Table 66
β_{1t}	E2	Solution for β_{1t} output in cells E2 Table 66
β_{2t}	E3	Solution for β_{2t} output in cells E3 Table 66
β_{3t}	E4	Solution for β_{3t} output in cells E4 Table 66
λ_1	E5	Solution for λ_1 output in cells E5 Table 66
λ_2	E6	Solution for λ_2 output in cells E6 Table 66

Table 68 Annualising Semi-Annual Bond Yields - Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
3 year AUD yield (annual basis)	A3	=((1+A2/200)^2-1)*100
5 year AUD yield (annual basis)	B3	=((1+B2/200)^2-1)*100
7 year AUD yield (annual basis)	C3	=((1+C2/200)^2-1)*100
10 year AUD yield (annual basis)	D3	=((1+D2/200)^2-1)*100

1236. The value at D3 in Table 68 is the NSS 10 year cost of debt estimate. This value averaged with the 10 year cost of debt estimate from the other two methods is the Authority's final 10 year cost of debt estimate.

Step 5: Estimate the regulatory debt risk premium

1237. The annualized 10 year cost of debt estimate from each of the three methodologies provided above is averaged to arrive at the Authority's final estimate of the 10 year cost of debt. Specifically, this is the simple average of cell F4 in Table 59, D3 in Table 64 and D3 in Table 68. The DRP is then calculated as the spread between the 10 year cost of debt and the average value of the AUD 10 year IRS rate averaged over the same averaging period used for the observed AUD equivalent bond yields above. The average value of the AUD 10 year IRS rate is obtained by downloading AUD 10 year IRS rate data from Bloomberg for each of the trading days in the averaging period; calculating the average of these observations; and then annualising assuming semi-annual payments. The Excel worksheet that calculates the Authority's final estimate of the 10 year cost of debt is provided at Table 69.

Table 69 Debt Risk Premium Calculation - Microsoft Excel Template Structure

Attribute	Cell	Formula or entry
Trading day date	A1 down	dd/mm/yyyy
AUD 10 year IRS rate	B1 down	=BDH("ADSWAP10 Curncy","PX_LAST",A1,A1)
Average (20 day averaging period example)	B21	=AVERAGE(B1:B20)
Annualized average AUD 10 year IRS rate	B22	=((1+B21/100/2)^2-1)*100
10 year final cost of debt estimate	B23	=AVERAGE(Table 6!F4,Table 11!D3,Table 15!D3)[677]
10 year DRP	B24	=B23-B22

1238. The value at cell B24 in Table 69 is the Authority's final 10 year DRP estimate that is used in calculating the return on debt.

Contingency approaches to data related issues

1239. In the event that there are unexpected problems with the data or results of applying the automatic formulas, the Authority will adopt the following actions outlined in Table 70.

677 This formula assumes that the Excel worksheets have been named after the tables outlined above. For example, Table 6 Linear Interpolation and Extrapolation of Gaussian Kernel Estimates – Microsoft Excel Template Structure is a worksheet in Excel labelled "Table 6". Table 6!F4 makes reference to cell F4 in Table 6.

Table 70 Contingency approaches to data related issues

Event	Changes to Approach
A) No bonds in the sample – resulting from the application of the bond yield approach criteria in Table 1 – have a remaining term to maturity equal to or greater than 10 years (from the last day of the nominated averaging period).	A linear extrapolation will be carried out using the formula outlined below this table. The yield inputs into that formula will be the averages of all three methods (Gaussian kernel, NS and NSS) at: • a 7 year tenor (where this means "effective tenor" when applied to the Gaussian kernel); and • at the effective tenor (where this means "effective tenor" when applied to the Gaussian kernel) that is equal to the effective tenor that results from adopting a target tenor of 10 years in the Gaussian kernel method. The effective tenor is the weighted average tenor of the sample using the Gaussian kernel weights associated with the target tenor.
B) The number of bonds in the sample result in non-robust parametric curve estimates.	Non-robust is defined as the standard deviation between each of the three yield estimates using each method (Gaussian kernel, NS and NSS reported on a semi-annual basis) being equal to or greater than 105 basis points using the '=stdev' formula in Microsoft Excel.[678] Under this circumstance the averaging period will be extended back into the past by 20 trading day increments at a time, back from the earliest day in the averaging period. The averaging period will continue to be extended this way until the standard deviation between the three estimates falls under 105 basis points.
C) Bloomberg bond data becomes inaccessible.	The Reserve Bank of Australia (**RBA**) 'Aggregate Measures of Australian Corporate Bond Spreads and Yields' bond yield data for the BBB band credit rating will take the place of the Authority's estimates and will be extrapolated to 10 years using the equation outlined in paragraph 1240 below this table.

1240. The following formula allows interpolation to 10 years:

$$y_t(10) = y_t[7] + \left(\frac{y_t[et(10)] - y_t[7]}{et(10) - 7} \right)(10 - 7) \qquad (75)$$

Where:

$y_t[et(10)]$ is the average of all three methods estimated cost of debt (as per event A in Table 70) or the RBA's data (as per event C in Table 70).

678 The Authority has added further clarification on this contingency to ensure the yield estimates from the three different methods are used as inputs in the standard deviation formula.

$et(10)$ is the effective tenor resulting from the 10 year target reported by the Authority's Gaussian kernel approach (as per event A in Table 70) or that corresponding to the effective tenor corresponding the RBA's 10 year estimate (as per event C in Table 70).

$y_t[7]$ is the average of all three methods estimated cost of debt at a 7 year tenor (as per event A in Table 70) or the RBA's data at the target tenor of 7 years (as per event C in Table 70).[679]

Estimates prior to DRP_{2015}

1241. The Reserve Bank of Australia's (**RBA**) data provides an available source of historic credit spreads for 10 year non-financial corporate bonds. The Authority has determined to adopt the RBA credit spread estimates for the historic DRP estimates – up to 31 March 2015 – for incorporation in the trailing average for this Draft Decision.[680] For the Final Decision, the RBA credit spread estimates up to the beginning of DBP's nominated averaging period will be used.

1242. The RBA monthly estimates for the 10 year BBB spread (the series 'Non-financial corporate BBB-rated bonds – Spread to swap – 10 year') for the period June 2005 to March 2015 are used for estimating the past DRP, prior to the Authority's 2 April 2015 estimate.

1243. The monthly RBA estimates are interpolated to daily estimates, and a simple average of each year of daily observations is then made.

1244. In this case, the DRP_t is estimated as shown below:

$$DRP_t = \frac{\sum_{D=1}^{Days\ in\ year} DRP_D}{Days\ in\ year} \qquad (76)$$

Where

DRP_D is the DRP for day D in regulatory year t.

1245. So for example:

- the average of daily DRPs for the period 1 January 2006 to 31 December 2006 provides the estimated annual DRP for 2006, which gives the first term DRP_{2006} in the trailing average DRP estimate for 2015, $TA\ DRP_{2015}$;
- it may be noted here that given the automatic formula for the trailing average, the term DRP_{2006} in the trailing average DRP estimate for 2015 would drop out of the trailing average estimate for 2016, $TA\ DRP_{2016}$, and be automatically replaced by the term DRP_{2016};

679 Event A requires the procedure outlined above interpolate the cost of debt at the 7 year tenor for the Authority's Gaussian kernel approach. This is not required for the NS and NSS curve 7 year estimates.

680 Reserve Bank of Australia, *Aggregate Measures of Australian Corporate Bond Spreads and Yields - F3*, www.rba.gov.au/statistics/tables/index.html#interest-rates, updated monthly.

- the final term *DRP2015* in the trailing average DRP estimate for 2015, *TA DRP2015*, is given by the daily interpolated RBA estimates for the period 1 January 2015 to 30 March 2015, with daily estimates for the final period of the financial year for 1 April 2015 to 31 December 2015 given by the Authority's 2 April 2015 estimate of the DRP, which is 1.982 per cent. The resulting year of daily estimates is averaged to give the DRP estimate for 2015 for inclusion in the trailing average estimate to apply for calendar year 2015. This is shown in detail in the next section.

Composition of DRP estimators for the AA3 regulatory period

1246. As noted above, the annual update of the trailing average debt risk premium component of the rate of return in each year of the Access Arrangement Period is to be calculated by applying the following automatic formula:

$$TA\ DRP_0 = \frac{\sum_{t=0}^{-9} DRP_t}{10} \qquad (77)$$

Where

$TA\ DRP_0$ *TA DRP0* is the equally weighted trailing average of the DRP to apply in the following year as the annual update of the estimate used in the current year; and

DRP_t is the DRP estimated for each of the 10 regulatory years t = *0, -1, -2…. , -9*.

1247. For the 2016 calendar year estimate (which will apply from 1 January 2016 to 31 December 2016, before being superseded by the 1 January 2017 update), the following estimates are included in the *indicative* trailing average (note this indicative estimate for 2016 is actually *TA DRP2015*, this will be updated to be *TA DRP2016* in the Final Decision, based on the nominated 2016 averaging period):

- t=-9: January to December 2006: DRP_{2006}: simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-8: January to December 2007: DRP_{2007}: simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-7: January to December 2008: DRP_{2008}: simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-6: January to December 2009: DRP_{2009}: simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-5: January to December 2010: DRP_{2010}: simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-4: January to December 2011: DRP_{2011}: simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-3: January to December 2012: DRP_{2012}: simple average of (interpolated daily) RBA DRP estimates for the period;

- t=-2: January to December 2013: DRP_{2013}: simple average of (interpolated daily) RBA DRP estimates for the period;
- t=-1: January to December 2014: DRP_{2014}: simple average of (interpolated daily) RBA DRP estimates for the period;
- t=0: January to December 2015: DRP_{2015}: weighted average comprising 25% (interpolated daily) RBA DRP estimates for the period January to March 2015 and 75% the Authority's current (t=0) DRP estimate (interpolated daily to the prior RBA 31 March 2015 estimate).

1248. As noted above, the Authority's 2 March 2015 estimate contributes to the t=0 estimate in the indicative DRP hybrid trailing average, for that period that falls after March 2015 (prior to that date, RBA actual data is available).

1249. The DRP_t estimates, consistent with the above, contributing to the calendar 2016 trailing average DRP indicative estimate for this Draft Decision (which is based on TA DRP_{2015}, and which is estimated as being 2.502 per cent), are published here as follows:

calendar year 2006: DRP_{2006}: 0.724 per cent;

calendar year 2007: DRP_{2007}: 1.241 per cent;

calendar year 2008: DRP_{2008}: 3.489 per cent;

calendar year 2009: DRP_{2009}: 4.624 per cent;

calendar year 2010: DRP_{2010}: 2.127 per cent;

calendar year 2011: DRP_{2011}: 2.371 per cent;

calendar year 2012: DRP_{2012}: 3.172 per cent;

calendar year 2013: DRP_{2013}: 3.068 per cent;

calendar year 2014: DRP_{2014}: 2.250 per cent;

calendar year 2015: DRP_{2015}: 1.953 per cent.