Appendices to the Explanatory Statement for the Rate of Return Guidelines

Meeting the requirements of the National Gas Rules

16 December 2013

Economic Regulation Authority

WESTERN AUSTRALIA

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Appendix 1 Criteria for informing regulatory judgment

1. This Appendix considers the criteria that the Authority will use to help inform stakeholders of its reasoning when determining the best approach for meeting the requirements of the National Gas Law (**NGL**), National Gas Objective (**NGO**), National Gas Rules (**NGR**) and the allowed rate of return objective.

Principles or criteria?

2. 'Principles' are the fundamental truths that serve as the foundation for laws, systems or reasoning, whereas 'criteria' are the principles or standards by which judgments or decisions can be made.[1] Overall, there appears to be little to distinguish between the two terms.

3. It is worth noting in this context that the Australian Energy Market Commission (**AEMC**) set out in its Final Decision that principles are an important driver in the new arrangements, informing the exercise of judgment and achievement of best practice:[2]

4. One of the criteria the AEMC applied to determine the best framework for the National Electricity Rules (**NER**) and the NGR was allowing methodologies for parameters to be driven by principles and to reflect current best practice.

5. The Authority considers that the use of the separate term criteria would support its clear intent that the criteria are separate and subordinate to the laws, principles and rules set out in the National Gas Law (NGL) and the NGR.

6. The Authority does not consider that the term 'considerations' is appropriate, as the term is defined either with relation to 'careful thought' or to a 'fact or motive' that is taken into account.[3] These elements do not describe what is intended. Raising the status to 'criteria' will provide greater certainty for stakeholders as to the framework that will be used to inform the exercise of regulatory judgment.

7. On balance, the term criteria is used as it:
   - is closely related to the term principle;
   - clearly captures the intent (see below); and
   - creates a clear separation from the superior requirements of the NGL and NGR.

8. Accordingly, the term 'criteria' is used in what follows.

Criteria

9. Each criterion to be adopted by the Authority is discussed in turn.

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1 See for example, oxforddictionaries.com/definition/english/criterion.

2 Australian Energy Market Commission 2012, *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*, www.aemc.gov.au, p. 56.

3 See for example, oxforddictionaries.com/definition/english/consideration

Theoretical underpinning

10. In its Draft Guidelines the Authority proposed that regulatory judgment should be informed by approaches which 'have a strong theoretical underpinning'. Similarly, the AER proposed that rate of return methods should be driven by economic principles and have a strong theoretical foundation.[4]

11. This principle was intended to recognise that a theoretical underpinning for an approach to regulation is highly desirable. This desirability was grounded within an interpretation of the NGO and its requirement for regulation to:[5]

> ...promote efficient investment in, and efficient operation and use of, natural gas services for the long term interests of consumers of natural gas with respect to price, quality, safety, reliability and security of supply of natural gas.

12. Economic theory provides important insights relating to conditions for the achievement economic efficiency, including for the setting of revenue and prices for monopoly networks. Economic theory has also demonstrated how economically efficient outcomes are in the long term interests of consumers. Hence this criteria was intended to draw on these theoretical insights to maximise the likelihood that regulatory outcomes would be consistent with economic efficiency, and thus would best meet the NGO.

13. The Australian Energy Regulator (**AER**) in its Issues Paper proposed that regulatory discretion be 'driven by economic principles'. This is a broader reference than simply that of economic theory, and is considered a better term for capturing the intent of this principle. Economic principles can be considered to be based on the established scientific method of observation, theory and empirical testing.

14. Expanding this criterion from economic theory to encompass economic principles should address the concerns of Australian Pipeline Industry Association (**APIA**) and Dampier to Bunbury Pipeline (**DBP**), who were concerned that a narrow emphasis on economic theory might 'unnecessarily restrict the types of evidence the regulator would consider.[6,7]

15. With regard to this criterion, Energy Networks Association (**ENA**) suggested that:[8]

> The term "economic" is inappropriate either as a description of what these items consists of or as a basis for distinguishing the first group of considerations from the others and the term "driven" is likely to set too high a threshold for these matters to appropriately constitute considerations.

16. The Authority considers that the reference to 'economic' principles is important, as it relates to the achievement of efficiency, as set out above. It is less likely that other methods – that are not grounded in the concept of economic efficiency – would necessarily be as effective in achieving the NGO. With regard to the term 'driven', the Authority does not accept that some softening of this term is appropriate, given the clear support for this approach by the AEMC (refer to paragraph 3 above above).

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4 Australian Energy Regulator 2012, *Better Regulation: Rate of Return Guidelines: Issues Paper*, December 2012, www.aer.gov.au/node/18859, p. 11.

5 Western Australian Government Gazette 2009, *National Gas Access (WA) Act 2009*, www.slp.wa.gov.au, p. 76.

6 The Australian Pipeline Industry Association 2013, Rate of Return Review, www.erawa.gov.au, p. 21.

7 DBNGP (WA) Transmission 2013, *Response to the Consultation Paper*, www.erawa.gov.au, Att. 3, Table1.

8 Energy Networks Association 2013, *Authority Consultation Paper – Rate of Return Guidelines*, www.erawa.gov.au, Att. 1, p. 10.

17. The ENA also considers that this criterion needs to be amended to ensure the avoidance of bias and also to reflect a strong empirical performance:[9]

> (b) there is data available that enables the theory to be practically implemented without significant biases in the overall rate of return decision; and
>
> (c) the methodologies should at their current state of development perform well empirically.

18. The Authority considers that the first point, relating to bias is dealt with under the criterion 'implemented in accordance with best practice' (see below), so is considered further there.

19. The Authority notes that while good empirical performance is desirable, it is unlikely to provide for a strong criterion on its own. This inference reflects the need to avoid the pitfalls of data mining, and the potential for outcomes that are removed from the objective of economic efficiency. As noted above, economic principles require strong foundations in both theory and empirics. For these reasons, it is considered that empirical support, while important, is strongest when it is linked to theoretical support.

20. In summary, the Authority considers that methods that are desirable are:

- Driven by economic principles:
  - based on a strong theoretical foundation, informed by empirical analysis.

Are fit for purpose

21. The Authority proposed that rate of return methods that 'are well accepted' would help to deliver the allowed rate of return objective. The intention here was to ensure that there was widespread recognition and acceptability of the method, as this would enhance the credibility and acceptability of a decision.

22. DBP responded directly to the use of this term, stating that:[10]

> "well-accepted" is not a term used in the new rule 87 and is likely to be inconsistent with the rule 87(5)(a) where regard must be had to 'relevant' estimation methods, financial models, market data and other evidence.
>
> It is DBP's view that the regulator would be beyond power if it maintained its establish approach to determining whether a model is 'well-accepted' as it has done under the old rule 87. The pursuit of the most "well accepted" model assumes that one single model can determine a rate of return that is consistent with the objective. The AEMC was at pains in its reasoning in the final Rule Determination to move away from this approach in the new NGR.

23. However, the Authority does not accept that the AEMC rejected the use of the term 'well accepted'. Rather, the only reference made by the AEMC to the term was in the following paragraphs from its decision:[11]

> The Tribunal also held that "implicit (or explicit) criticisms of modelling... must be minimised, if not negated, by the requirement that the approach and the model used must be well accepted by those who undertake and use such approaches and models for that purpose". As a result "it is almost inherently contradictory then to say

9 Ibid.

10 DBNGP (WA) Transmission 2013, *Response to the Consultation Paper*, www.erawa.gov.au, Att. 3, Table1.

11 Australian Energy Market Commission 2012, *Rule Determination, National Gas Amendment (Price and Revenue Regulation of Gas Services) Rule 2012*, www.aemc.gov.au, 29 November, p. 48.

> that the approach or the model is not likely to produce a reliable output - assuming that the inputs are appropriate – if that approach and that model are well accepted".
>
> The Commission considered that this conclusion presupposes the ability of a single model, by itself, to achieve all that is required by the objective. The Commission is of the view that any relevant evidence on estimation methods, including that from a range of financial models, should be considered to determine whether the overall rate of return objective is satisfied.

24. It is clear from the second paragraph that the Commission took issue with the Tribunal's conclusion that a single model could achieve all that is required by the objective, rather than with the 'acceptance' or otherwise of a particular model. In this context therefore, it remains desirable that a method be well accepted, although it is not necessary that a method be the single most accepted approach.

25. Nevertheless, on review, the Authority considers that well accepted does not link back to the NGL and NGR per se. What is sought here is a criterion that encompasses the idea of performance relating to the task at hand, which is to determine the rate of return commensurate with the efficient financing costs of a benchmark entity with a similar degree of risk in respect of the provision of reference services of the service provider, over the regulatory years of the access arrangement period. To this end, the Authority considers that the AER's term 'fit for purpose' is better.

26. A method which could be demonstrated to perform best in estimating the cost of debt and the cost of equity – and hence the rate of return over the regulatory years of the access arrangement period – would be most fit for purpose.[12]

27. To the extent that a method performed well in terms of this criterion, it would also be likely to enhance the credibility and acceptability of the decision.

28. The ENA took issue with the use of the term 'fit for purpose' in the AER's list of principles, on the basis that its import is uncertain. The Authority considers that it should now be clear that this term relates to the ability of a method to 'perform well' in terms of estimating the cost of equity and the cost of debt over the regulatory years of the review period.

29. In summary, methods that are desirable are:

    - Fit for purpose:
        - able to perform well in estimating the cost of debt and the cost of equity over the regulatory years of the access arrangement period.

Implemented in accordance with best practice

30. The Authority proposed that rate of return methods that are robust, transparent, replicable, internally consistent, derived from available, current and credible datasets would help to deliver the allowed rate of return objective. The AER proposed a similar sub-principle in its Issues Paper.[13] The intention was to ensure that the empirical analysis and data supporting the estimation of the rate of return was undertaken in a sound manner.

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12 Refer to NGR 87(4) for reference to the requirement that the allowed rate of return objective be achieved for the regulatory years of the access arrangement period.

13 Australian Energy Regulator 2012, *Better Regulation: Rate of Return Guidelines: Issues Paper*, December 2012, www.aer.gov.au/node/18859, p. 11.

31. The AER set out this overall criterion as 'implemented in accordance with best practice'. The Authority considers that this criterion captures well the notion of sound estimation approaches, and therefore that it provides a better descriptor. The desirability of best practice methods in achieving the allowed rate of return objective was referred to explicitly by the AEMC (refer to paragraph 3 above).

32. In commenting on the AER's principles, ENA accepted the notion of best practice, although it considered that it needed to be conditioned by the term 'consistent with the intention of the rules'.[14] However, the Authority considers that the rules are a given, and as noted above, are explicitly recognised as superior to these criteria. As a result, the Authority does not consider it necessary to restate this in the criteria.

33. ENA also considered that the terms current and relevant be dropped from the principle:[15]

> 'Current' and 'relevant' wording replicates obligations already contained in the Rules. It is appropriate that datasets be reliable.
>
> This amendment is to make it clear that for some parameters the best approach is to use historical databases. In discussing the requirement for regard to be had to prevailing market conditions the AEMC noted: "However, this requirement does not mean that the regulator is restricted from considering historical data in generating its estimate of the required return on equity. Rather, it ensures that current market conditions are fully reflected in such estimates to ensure that allowed rates are sufficient for efficient investment and use."

34. ENA also consider that reference to adjustments and filtering should be as follows:[16]

> That manual adjustments (including filtering) should only be undertaken if there is an economic basis for doing so.

35. The Authority generally accepts these points made by the ENA, but the Authority does not accept that the term 'economic basis' in the last point provides a sole rationale for manual adjustments. The Authority considers that adjustment and filtering of data needs to be undertaken only for sound reasons, for example based on statistical best practice, hence the term should be 'avoids arbitrary filtering or adjustment'.

36. In commenting on the AER's principles, APIA noted that:[17]

> Transparent and replicable decisions are implicitly part of good regulatory practice and the use of sound judgement. APIA is concerned that some stakeholders may consider the use of judgement to be at odds with either characteristic.
>
> Uncertainty needs to be recognised and accounted for. This is a preferable approach to dismissing analysis because of uncertainty,
>
> ...as with uncertainty, high sensitivity should not lead to analysis being dismissed. High sensitivity should be accounted for.

37. The Authority notes that its original sub-principles referred to 'analysis and estimation' methods that are transparent and replicable. The Authority does not consider that this term referred more broadly to the overall decision, and thus does not accept APIA's first point set out above. That said, the Authority considers that the AER's broader sub-principle – for approaches which 'promote reasoned, transparent and predictable

[14] Energy Networks Association 2013, *Authority Consultation Paper – Rate of Return Guidelines*, www.erawa.gov.au, Att. 1, p. 11.

[15] Ibid.

[16] Ibid.

[17] The Australian Pipeline Industry Association 2013, Rate of Return Review, www.erawa.gov.au, p. 22.

decision making' – is useful, such that it is included under 'specific regulatory aims' (see below).

38. The Authority proposed that a sub-principle relating to 'deal with uncertainty' would inform the principle 'flexibility to reflect changing market conditions'. This is considered under the next heading below.

39. Finally, with regard to APIA's point relating to high sensitivity, the Authority notes that the sub-criteria involving the term 'sensitive' would not necessarily preclude relevant analysis being considered, unless it did not pass a threshold of statistical soundness. To the extent that the threshold was passed, the degree of sensitivity would then bear on the judgment relating to the degree of relevance of that information.

40. DBP stated in its submission to the Authority:[18]

> ...as "estimation methods that are internally consistent" is already a requirement of rule 87(5)(b) it is unnecessary to include as a subordinate 'criteria'.
>
> Criteria which require "lead to outcomes from quantitative modelling that are sufficiently robust" fails to recognise that the rule does not prescribe a mechanical process and will require the regulator to apply its judgment at a number of qualitative steps in the process. It is clear that the AEMC was not envisaging a mechanical approach to distilling information from a number of methods when it said –
>
> "In many circumstances it could be the case that the likelihood of achieving the NEO or the NGO may be increased by examining a range of methods and data and making judgements aided by, for example, the location and/or clustering and/or statistical precision of estimates. That is, formulaic rules such as giving particular methods a fixed weighting may not be the best way to assess the information"8.

41. With regard to internal consistency, the Authority notes that NGR 87(5)(b) states that regard must be had to the 'desirability of using an approach that leads to consistent application of any estimates or financial parameters that are relevant to the estimates of, and that are common to, the return on equity and the return on debt...'. The Authority accepts that this rule effectively encompasses the criteria of internal consistency, and thus that it does not need to be repeated.

42. The Authority does not consider that robust outcomes from quantitative modelling necessarily prescribe mechanical interpretation. Best practice statistical approaches will help to deliver robust estimates. To the degree that estimates are not robust or statistically sound, then the regulator should take that performance into account in terms of making a judgment as to the effectiveness of that particular method. On this basis, the Authority does not accept DBP's point.

43. In summary, methods that are desirable are:

- 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 inputs data;
  - based on quantitative modelling which avoids arbitrary filtering or adjustment of data, which does not have a sound rationale.

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[18] DBNGP (WA) Transmission 2013, *Response to the Consultation Paper*, www.erawa.gov.au, Att. 3, Table1.

Have the capability to reflect changing market conditions and new information

44. The Authority proposed that rate of return methods that 'have the flexibility to reflect changing market conditions and new information as appropriate' would help to deliver the requirements of the NGL and the NGR. The AER proposed that methods should 'have regard to prevailing market conditions'.[19] The intent of this criterion was to recognise that estimation methods, data and other evidence are more likely to be relevant if they are responsive to changing market conditions.

45. DBP noted in its submission to the Authority that this was a reasonable aim, but questioned whether this criterion was in conflict with NGR 87 generally:[20]

> In DBP's view flexibility and the ability to deal with changing market conditions are reasonable aims. However, including such a criteria creates uncertainty in how they may operate with rule 87 as (1) the AEMC's has clearly designed the rule to allow the regulator the flexibility to address changing market conditions and therefore unnecessary to include as a criteria, and (2) rule 87(7) already includes the requirement that in estimating the return on equity under subrule 87(6), regard must be had to the prevailing conditions in the market for equity funds.

46. In this case, the Authority considered that while the NGR refer to the need to have regard to prevailing market conditions under 87(7), this does not capture what is meant by this criterion. What is intended here is that relevant estimation methods have the capability to capture effectively relevant changes in prevailing market conditions or changes that have occurred over historic periods. For example, a sufficiently capable estimation method would be based on timely, available updates to data as to allow the specific method to perform well in meeting the requirements of the NGL and the NGR. Such capability could assist a method to meet the requirement that the return on equity reflect prevailing conditions in the market, or could assist another method to meet the requirement that the return on debt reflect either the return on debt at the time or shortly before the time of the decision, or the average return on debt that would have been required over an historic period. The key point here is, that if the method was able to capture these changes in a timely way, then it could, in the case of the return on equity, diverge from the prevailing conditions in the market for equity funds (refer NGR 87(7)) or, in the case of the return on debt, lead to a lack of minimisation of 'any difference between the return on debt and the return on debt of a benchmark efficient entity' (NGR 87(11(a)).

47. APIA also questioned the AER's explicit reference to prevailing market conditions. However, that requirement is clearly set out in the NGR, and therefore does not need to be repeated in the principles.

48. In summary, methods that are desirable are:

    - capable of reflecting changes in market conditions and able to incorporate new information as it becomes available.

Are supportive of specific regulatory aims

49. The Authority proposed that it would be desirable if rate of return methods 'lead to consistent regulatory decisions across industries, service providers and time'. Similarly, the AER proposed that methods be 'supportive of broader regulatory aims'

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19 Australian Energy Regulator 2012, *Better Regulation: Rate of Return Guidelines: Issues Paper*, December 2012, www.aer.gov.au/node/18859, p. 11.

20 DBNGP (WA) Transmission 2013, *Response to the Consultation Paper*, www.erawa.gov.au, Att. 3, Table1.

and be 'consistently applied across industries, service providers, regulators and time'.[21] The intent of this principle was to recognise that the NGL and the NGR have a range of specific aims, some of which are explicit, and some of which are implicit, which reflect the principles of incentive regulation.

50. The desirability of achieving the specific aims of incentive regulation may be linked back to the efficiency requirements of the NGL and NGR. For example, the Revenue and Pricing Principles (**RPP**) refer explicitly to the need to provide effective incentives to promote economic efficiency:[22]

> (3) A service provider should be provided with effective incentives in order to promote economic efficiency with respect to reference services the service provider provides. The economic efficiency that should be promoted includes— (a) efficient investment in, or in connection with, a pipeline with which the service provider provides reference services; and (b) the efficient provision of pipeline services; and (c) the efficient use of the pipeline.

51. Accordingly, the Authority considers that this sub-heading should state the criterion as being that desirable methods 'are supportive of specific regulatory aims' under the NGL and the NGR. These are intended to refer back to the explicit requirements of the NGL and NGR – as captured in the NGO, the allowed RPP, the rate of return objective, as well as the other requirements of the NGR – as well as to the associated, implicit, outcomes that are consistent with the broad incentive regulation approach and good regulatory practice.

52. It is implicit, for example, that the incentives provided in the exercise of regulatory discretion under the NGR should account for the conditions in the broader economy, faced by other industries, whether regulated or otherwise. Inconsistent incentives could lead to distortions between industries, which would diminish the achievement of economic efficiency. Equally, incentives should avoid creating inter-temporal distortions.

53. The Authority also considers it implicit that the specific aims of the NGL and the NGR are to achieve:

- rates of return that are consistent with the outcomes of effectively competitive markets, as these are efficient;
- a net present value of returns is sufficient to cover a service providers' efficient expenditures (the 'NPV=0' condition);
- simple over complex approaches where appropriate;
- reasoned, predictable and transparent decisions;
- credible and acceptable decisions.

54. With regard to this criterion (as set out by the AER in its Issues Paper), APIA stated:[23]

> The principles articulated in 5(a to c) are valid aims but should be considered sub-ordinate to other principles. They are not a prime requirement of the law.

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21 Australian Energy Regulator 2012, *Better Regulation: Rate of Return Guidelines: Issues Paper*, December 2012, www.aer.gov.au/node/18859, p. 11.

22 Western Australian Government Gazette 2009, *National Gas Access (WA) Act 2009*, www.slp.wa.gov.au, p. 76.

23 The Australian Pipeline Industry Association 2013, Rate of Return Review, www.erawa.gov.au, p. 22.

> 5(a) Although APIA would not like to see the approach applied to the rate of return shift dramatically from one guideline to the next, APIA sees no requirement in rule 87 to apply methodologies consistently across industries, service providers, regulators and time. In fact, as is outlined in the Brattle Report, while stability and robustness of models are desirable features of models, they must also be able to adjust to changes in economic conditions. Arguably, the energy sector has its own specific regulator because there does not need to be a level of consistency between the energy industry and other industries. APIA considers that the rule now affords the regulator the flexibility to respond to prevailing conditions in the market. Additionally, methodologies must recognise that differences, not just similarities, apply across industries, service providers, regulators and time.
>
> 5(b) Methodologies do not need to be comprehensible and accessible to all. To try and achieve this would fail to recognise the complexity of the task. Methodologies should be understood and explained well by regulators and businesses.
>
> 5(c) APIA does not agree that rule 87 require that simple models be afforded preference over complex models.

55. In response to these points made by APIA, the Authority:

- considers that all the criteria for the exercise of regulatory discretion are subordinate to the NGL and NGR, hence this should not be a cause to reject these criteria;
- considers as noted above that the ability to reflect changing market conditions is a desirable feature, however consider this to be a separate issue to the desirability of regulatory consistency in the application of incentive regulation;
- accepts that methods need not be comprehensible and accessible by all, but considers it desirable for this to be achieved as far as is possible; and
- considers that simple models that perform as well as complex models should be preferred, all other things equal.

56. The ENA considers that transparency in the regulator's decision making is important, and suggested that a criterion in this set should relate to this.[24] The Authority considers that the ENA's view is reasonable. However, the Authority considers that this feature is captured in a succinct way along the lines of principle 4(a) set out in the AER's Issues Paper; that the methods promote reasoned, predictable and transparent decision making.

57. The ENA also was concerned that this criteria 'was ambiguous and could be interpreted as a suggestion that regulatory powers might be exercised for extraneous purposes', and that therefore this criteria should be excluded.[25] However, as set out above, the Authority considers that the desirability of achieving specific regulatory aims is tied explicitly to the efficiency requirements of the NGL and the NGR, as well as to the generally desirable characteristics for regulation of transparency, simplicity and accessibility.

[24] Energy Networks Association 2013, *Authority Consultation Paper – Rate of Return Guidelines*, www.erawa.gov.au, Att. 1, p. 12.

[25] Ibid.

58. The Authority also notes the ENA's suggestion for the need to account for the effect on incentives to finance efficiently.[26] This element belongs squarely within the intent of this principle, and has therefore been included.

59. DBP had similar views to the ENA with regard to this criteria:

> It is unclear what is meant by the use of the term 'consistent'. DBP would have significant concern if the use of consistent meant that the regulator envisages a 'one size fits all' process applied at each determination and failed to address the allowed rate of return objective.
>
> It is also unclear what the Authority intends as a 'common to approach regulation' does the Authority intend to apply a common approach across all entities regulated by the Authority including gas, electricity and rail despite operating under significantly different regimes? Or does the Authority suggest that commonalities should exist between the Authority and AER?
>
> DBP fails to see the requirement in either the NGO, RPP the allowed rate of return objective or Rule 87 that would require a common approach to regulation, rather the rule promotes a flexible approach to the determination of rate of return ensuring that the allowed rate of return objective is met in each determination for each service provider.

60. In response, the Authority refers to the rationale for this criteria set out above, which is to be mindful of the specific aims of the NGL and the NGR, particular relating to incentives for the promotion of economic efficiency. The Authority also reiterates that these criteria point to desirable outcomes for the exercise of its regulatory discretion within the boundaries of the NGR, not to outcomes which rigidly lead to a 'one size fits all approach'.

61. In summary, the Authority considers methodologies that are desirable are:

- supportive of specific regulatory aims; and thereby:
  - recognise the desirability of consistent approaches to regulation across industry, 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 providers' efficient expenditures (the 'NPV=0' condition);
  - provide incentives to finance efficiently;
  - promote simple over complex approaches where appropriate;
  - promote reasoned, predictable and transparent decision making;
  - enhance the credibility and acceptability of a decision.

[26] Energy Networks Association 2013, *Authority Consultation Paper – Rate of Return Guidelines*, www.erawa.gov.au, Att. 1, p. 11.

Appendix 2 The present value principle

1. The Authority considers that, in a regulated environment in which output prices are set or capped, the present value of the revenue earned from an asset must be equal to the initial investment to ensure that the total costs incurred are recovered. If no more than or no less than the total costs are recovered, in discounted terms, then the net present value is zero (**NPV=0**, or the 'present value principle' hereafter).

2. Stakeholders have noted that the condition should be written as NPV≥0, to be consistent with section 24(2) of the NGL, which refers to 'a service provider should be provided with a reasonable opportunity to recover at least the efficient costs the service provider incurs'.[27]

3. This is a reasonable interpretation. However, the Authority considers NPV=0 as being the efficient condition, consistent with section 24(3) of the National Gas Law (**NGL**), which states that 'a service provider should be provided with effective incentives in order to promote economic efficiency'. The 'greater than or equal to' condition would then be consistent with NGL 24(2), which states that the service provider should be provided with 'a reasonable opportunity to recover at least the efficient costs' it incurs. In what follows, the Authority considers the efficient condition as the boundary, but accepts that it is a bound 'from below'.

4. Dampier to Bunbury Pipeline (**DBP**) emphasise the point by noting:[28]

> This also reflects sound economic principles found in the incentive regulation literature, which are summarized very briefly in Section 3 of this paper. The basic problem is that regulation is applied ex-poste and investment is assessed ex-ante, when information about demand is uncertain. If demand is greater than expected, the regulator will curtail the upside, but if it is below expectations, it will not compensate the downside, and this well-known asymmetry leads to rational investors reducing or delaying investment. In fact, as Dobb (2004) shows, a simple price cap cannot jointly optimize investment incentives and post-investment pricing; there is, as Vogelsang (2010) outlines, a trade-off between the two.

5. In response, the Authority considers that it assesses the efficiency of investment ex ante, through the provisions of National Gas Rules (**NGR**) 79(2), under which capital expenditure is justifiable if, among other things (paraphrased):
   - the overall economic value of the expenditure is positive; or
   - the present value of the incremental revenue exceeds that of the capital expenditure; or
   - it is necessary to maintain and improve the safety, integrity or ability to meet existing demand.

6. The Authority also notes that the service provider may propose price cap regulation under NGR 97 (2) (b), which provides for a tariff basket price control. Under price cap regulation, demand may vary around that forecast, providing symmetric potential for over or under remuneration in an access arrangement period. Forecast demand may then be adjusted for the next access arrangement, such that normal returns are earned on investment.

27 DBNGP (WA) Transmission Pty Ltd 2013, *ERA Draft Rate of Return Guidelines: DBP Response*, www.erawa.com.au, 23 September, p. 15.

28 DBNGP (WA) Transmission Pty Ltd 2013, *ERA Draft Rate of Return Guidelines: DBP Response*, www.erawa.com.au, 23 September, p. 15.

7. Thus it is not clear that the regulator 'will curtail the upside' as suggested by DBP – once an investment is accepted and rolled into the capital base, then the service provider is entitled to earn the weighted average cost of capital (**WACC**) on that investment. To the extent that demand exceeds that forecast at the start of the regulatory period, then it is possible for the service provider to gain upside on the investment where it elects a price cap control.[29]

8. The Authority remains of the view that setting the terms of the components for the rate of return to match the regulatory control period – which is generally five years in Australia and New Zealand – will satisfy the present value principle.[30] This view is supported by a number of studies, principally by Associate Professor Lally and Professor Davis, which are summarised briefly in what follows.

Lally's analysis

9. Lally builds on previous work by authors such as Marshall (1981)[31] and Schmalensee (1989)[32], who noted the NPV=0 condition as a condition for a fair return on investment in a regulatory setting. In other words, where output prices are set to cover costs, the rate of return should ensure that the present value of future cash flows equals the initial investment.[33]

The 2004 paper – the present value principle with cost and demand shocks, and alternative methods for depreciation

10. Lally (2004) extended the present value framework to consider cost and demand shocks, and risks arising from depreciation methods in which the aggregate depreciation allowed by the regulator may diverge from the cost of the assets. The author concludes that if the rate of return is revised at the end of each regulatory cycle, in accordance with the prevailing rate, then the appropriate term for that rate should be that matching the regulatory period.[34]

11. In the 2004 paper, Lally constructs a model of the regulatory cycle where a regulated project is initiated at time 0 with a life of T years. It is assumed that revenues arise at times 1,2, ... T years, with output prices being set by the regulator at time 0, with revisions occurring at time 1,2, ... T-1 years (in other words, over multiple regulatory periods). Lally notes that the assumption of a one-year regulation cycle is for

29 The issue raised by Dobbs is that uncertainty about the rate of growth of demand may constrain investment by the regulated firm past the time where it would be efficient to add capacity. As 'a consequence, prices to final customers are always higher than in competitive markets'. However, this effect should be transitory, perhaps only to delay the commissioning of the investment to the end of the regulatory period. Thereafter, under the NGR, the regulated firm has a virtual certainty that it will earn a reasonable return, as demand will be adjusted in each following regulatory period. This should largely eliminate uncertainty, and by corollary, any expectation of a consistent downside for the regulated firm under price cap regulation. See Dobbs I.M. 2004, Intertemporal price cap regulation under uncertainty, *Economic Journal*. Vol. 114, p. 433.

30 The exception is for any estimate that is annually updated. In that case, the regulatory term becomes one year.

31 Marshal, W., Yawitz, J. And Greenberg, E. (1981), 'Optimal Regulation Under Uncertainty', The Journal of Finance, vol 36, pp. 909-22.

32 Schmalensee R., 1989, "An Expository Note on Depreciation and Profitability Under Rate-of-Return Regulation", Journal of Regulatory Economics, Volume 1, No.3, pp. 293-298.

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

34 Lally M. 2004, "Regulation and the Choice of the Risk Free Rate", *Accounting Research Journal*, Volume 17, No. 1, 2004, pp. 18-23.

convenience only, and that results derived will hold under any regulatory cycle length. Lally assumes that operating costs and demand levels are uncertain.

12. Using this framework, Lally implicitly assumes that the allowed rate of return is revised at the end of each regulatory cycle and that the assets are entirely equity financed. Lally utilises the building block approach to set the output price allowed at time t such that the expected revenues realized at time t+1 are equal to the sum of: (i) the expected operating costs at t+1, (ii) the depreciation allowed for the next period; and (iii) an allowed rate of return applied to the book value of assets as follows:

$$E_t(REV_{t+1}) = E_t(C_{t+1}) + DEP_{t,t+1} + BV_t R_t \quad (1)$$

where

$E_t(REV_{t+1})$ is the expected revenue for time t+1 at time t;

$E_t(C_{t+1})$ is the expected operating costs at t+1 at time t;

$DEP_{t,t+1}$ is the depreciation allowed at time t;

BV_t is the book value at time t; and

R_t is the allowed rate of return at time t.

13. Lally argues that the allowed rate of return, R_t, should be set such that the present value of the future cash flows equals the initial outlay for investment, as outlined by Marshal et al(1981); and Schmalensee (1989).[35] This condition is equivalent to the NPV=0 principle used by Australian regulators, to ensure that the present value of revenue earned by a regulated asset is equal to the initial investment. Lally proves that to satisfy this criterion R_t must equal the prevailing one-period risk-free rate,[36] $R^f_{t,t+1}$ plus an appropriate risk premium, p_t to compensate investors for the demand risk and operating cost risk.[37] Lally does this by demonstrating that under an upward sloping risk-free term structure, a rate of return with a longer maturity than the regulatory cycle leads to revenues being too large; violating the "NPV=0" principle. In the converse situation, with a downward slopping risk-free term structure, a shorter maturity results in revenues being too small to cover the expected costs, again violating the NPV=0 principle. Lally thus concludes that the appropriate rate of return required under a regulatory environment is one where the risk-free rate matches the term of the regulatory period.

35 Schmalensee, R. (1989), 'An Expository Note on Depreciation and Profitability Under Rate-of-Return Regulation', *Journal of Regulatory Economics,* vol.1, pp. 293,298.

36 One period in this context refers to the length of the regulatory period.

37 Given the all equity financing assumption, Lally suggests that the appropriate risk premium p_t reflects the systematic cost and demand risks as suggested by Capital Asset pricing theory.

The 2007 paper – debt and equity financing

14. Lally (2007) extends the 2004 study by allowing for the regulated entity to be partly financed by equity, and partly by debt, with the firm having the option of being able to choose the duration of its debt financing.[38]

15. The purpose of the 2007 study was to consider the implications of the regulated firm being at least partly debt financed, as well as the possibility of the firm choosing a duration for this debt finance that diverges from the length of the regulatory cycle. Lally concluded that the NPV = 0 principle is only satisfied on the following two conditions: (i) the terms of the risk free rate and the debt risk premium must be set equal to the regulatory control period; and (ii) the regulated businesses choose their borrowing to match the regulatory cycle. Lally also concluded that departure from either of these conditions will lead to violations of the NPV = 0 principle.[39]

16. Lally agreed that these findings do not consider any re-financing risk – the risk arising due to the exposure to unusual conditions in the debt markets at the time the debt needs to be refinanced. In response to this potential problem, Lally argued that a company may seek to stagger the roll-over of the debt in such a way that the same proportion – which is relatively small – is to be refinanced each year. Lally argued that the company's actual schedule of debt can be converted into the schedule that aligns with the regulatory control period using swap contracts available in the market (interest rate swaps would be used to deal with the risk free rate of return component and credit default swaps would deal with the debt premium).

17. Lally begins the analysis by assuming that the only source of risk relates to changes in the risk-free rate, from which he concludes the firm's cost of debt is equal to the risk-free rate. In addition, Lally adopts a framework of assuming a regulatory cycle of one year, output prices being set at the beginning of the year with revenue arising from this at the end of the year, the regulated asset has a life of 2 years and there are no operating costs associated with the regulated asset. Additionally, Lally assumes a constant gearing of L in book value terms which the firm constantly maintains.

18. Lally outlines 4 scenarios that represent the firm's and regulator's choices under this framework, given that firms have 2 debt strategies (two-year debt[40] or one-year debt with rollover after one year[41]) and the choice of the regulator to using the one-year risk-free rate[42] or the residual life of the asset.[43] Lally outlines the consequences for the "NPV=0" concept under each scenario. Table 1 shows the scenarios as named by Lally:

38 Lally M. 2007, "Regulation and the Term of the Risk Free Rate: Implications of Corporate Debt", *Accounting Research Journal,* Volume 20, No.2, 2007, pp. 73-80.

39 Lally M. 2007, "Regulation and the Term of the Risk Free Rate: Implications of Corporate Debt", *Accounting Research Journal*, Volume 20, No. 2, 2007, pp. 73–80.

40 This situation reflects firms matching the maturity of their debt and the remaining life of the regulated asset.

41 This situation reflects firms matching the maturity of their debt and the length of the regulatory period.

42 Reflecting that the term to maturity of the risk free rate should equal the regulation period.

43 Reflecting that the term to maturity of the risk free rate should match the life of the regulated asset.

Table 1 Scenarios outlined by Lally (2007)

	Firm debt maturity matches regulatory period	Firm debt maturity exceeds regulatory period
Regulator awards return with maturity that matches the length of the regulatory period	Policy 1	Policy 3
Regulator awards return with maturity that exceeds the length of the regulatory period	Policy 2	Policy 4

19. Utilising this framework, Lally proves that only under Policy 1 does the present value of cash flows equal that of the initial investment, satisfying the NPV=0 criterion. Lally notes that this analysis is a simplified version of reality, in that it considers only interest rate risk in the risk-free rate. Lally notes that a firm may in reality choose a shorter debt maturity than the regulatory period if it expects its credit rating to improve, or may choose a longer maturity debt to reduce "re-contracting risk", the risk that the debt margin will change in the future. Lally notes that recontracting risk only exists if regulators award efficient costs, and not actual costs.

20. Extending the previous framework, Lally now assumes that regulators award a debt risk premium of p, with this premium assumed to match the actual debt risk premium incurred by the firm, for both one-year and two-year debt. However, after one year, the premium awarded by the regulator is constant but the actual debt risk premium incurred by the firm (on any newly issued debt) is allowed to differ (denoted as p_1). This updated framework therefore allows for the existence of recontracting risk, as p_1 is allowed to differ from p.

21. Lally explores each scenario in Table 1 with the possibility of refinancing risk and shows that only under Policy 1 is the "NPV=0" principle satisfied. Lally also shows that whilst longer term debt can reduce equity holder's exposure to refinancing risk, it increases their exposure to interest rate risk. Lally therefore concludes that if firms are able to fund their assets via a combination of debt and equity, with the existence of re-contracting risk and interest rate risk, the NPV=0 is satisfied under 2 conditions: (i) The term of the risk-free rate and debt risk premium match the regulatory period; and (ii) The regulated business choose to match their debt maturity with that of the regulatory period.

22. Goldfield Gas Transmission (**GGT**) considers that the Lally (2007) conclusions – that only Policy 1 allows for NPV=0 – are incorrect.[44] GGT asserts that Lally's conclusions with regard to policies 2, 3 and 4 from Table 1 above are subject to error in that:

- an incorrect regulated rate of return is used in the analysis of policy 2; and

[44] Goldfields Gas Transmission 2013, *Submission on the Economic Regulation Authority's Draft Rate of Return Guidelines*, www.erawa.com.au, 19 September, p. 31.

- an incorrect discount factor is used in the present value calculations of policies 3 and 4.

23. On this basis GGT doubts Lally's conclusions. GGT states that Lally falls into similar error as Davis, which is discussed in further detail below.

24. DBP also takes Lally to task, but in specific detail with regard to these perceived errors.

25. First, DBP asserts that:[45]

> ...there is no two year risk free rate in Lally's model, only the one year rate applying in the second year of the two period model – this means only policy 1 can meet the NPV=0 condition.

26. This is a perplexing comment. Lally makes quite clear that there are a number of different rates used in his model:[46]

> We denote the current one year rate as R_{01} and the one year rate that will arise in one year as R_{12}. By contrast, in respect of two year rates, the spot rate may differ from the yield to maturity. We denote the current two year spot rate as R^s_{02} and the two year spot rate that will arise in one year as R^s_{13} whilst the corresponding yields to maturity are denoted R^y_{02} and R^y_{13}. The rates R_{12}, R^s_{13} and R^y_{13} are currently uncertain.

27. If these are thought of as coupon bonds, R^s_{02} will correspond with R_{02} and R^y_{02} at time 0. R^y_{02} will then diverge from R_{02} over the course of the two years, depending on how the corresponding prevailing rate is changing compared to the R^s_{02} expectations (R^y_{02} should match R_{12} for example at time 1). Only at maturity and payment will R^y_{02} coincide with R^s_{02}.

28. Second, DBP considers that Lally, despite admitting that owners of firms face refinancing risk, and that, in addition, there is a risk that the Regulated Asset Base (**RAB**) will not equal its expected value with certainty, errs in discounting second year returns at the risk free rate at the end of year one.[47] DBP contend this is wrong, stating that if returns are uncertain (for debt holders, due to the risk of default), they should be discounted at the two year spot rate, not the risk free rate.

29. These points are misleading, for the following reasons:

- First, Lally does not deal with refinancing risk until the later article Lally (2010) – it is assumed away here (for a discussion of Lally (2010) see below). In any event, Lally is talking about the term of the risk free rate, not the size of the debt risk premium, which as noted above, is assumed away here.
- Second, if there were additional risks relating to the value of the regulated asset base, then these would be part of the premium. Lally deals with a debt risk premium in his 2004 article referenced above (see para 13 above).

45 DBNGP (WA) Transmission Pty Ltd 2013, *ERA Draft Rate of Return Guidelines: DBP Response*, www.erawa.com.au, 23 September, p. 37.

46 Lally M. 2007, "Regulation and the Term of the Risk Free Rate: Implications of Corporate Debt", *Accounting Research Journal,* Volume 20, No.2, 2007, p. 74.

47 With regard to the risk that the RAB will not equal its expected value with certainty, DBP quote support from the AER (p. 183),

- Third, in any event, risks relating to the value of the RAB are small – the regulatory contract in Australia has an established precedent that the firm is able to claim full depreciation of the real RAB, and that the RAB will not be written down for impairment. Quite the contrary, in the event of any potential impairment, accelerated depreciation may be allowed.
- Fourth, under all policies the regulator does not set the second period R at time 0, but rather at time 1. In the case of policy 1, the regulator sets the return for period 2 at time 1 using the prevailing R_{12}. Hence it is correct for Lally to use R_{12} to discount the second period revenue in policy 1, received at time 2, back to time 1. This is then added to the policy 1 revenue in period 1, received at time 1, and discounted back to time 0 at R_{01}, to show that discounted revenue at time 0 covers costs. Only under policy 1 will NPV=0.[48]

30. Third, DBP contends that if these perceived errors are corrected, the outcome of policy 4 is the same as policy 1. It suggests that this supports the view that the term of the debt used by the regulator ought to be the same as the term of debt used by the firm, rather than that of the regulatory period. However, this argument is flawed. As noted above, it would be misleading to apply R_{s02} yield to discount period 2 revenues, as the regulator resets revenue for year 2.

31. DBP also considers that Lally's findings apply for rate of return regulation, and are not proven for price cap regulation. DBP contends that Lally's conclusions under policy 1, the simplest framework, only hold in a price cap framework if: [49]

    - expected demand is identical to the regulator's expectation of demand; or
    - the regulator makes exactly the same proportion mistake in the forecast of demand, as compared to actual demand, in every regulator period.

32. Again, this argument is flawed; these are risks which are abstracted away from in Lally's 2007 analysis, as the analysis is considering the term of the risk free rate. Demand risks relate to the debt premium, which is not considered in this analysis. Lally examines demand risks in the simpler model of Lally (2004). In that analysis, where a risk premium is included, Lally finds that his proof, which follows the same process as Lally (2007) still holds.

48 With regard to policy 2, the regulator is assumed to use the longer two year risk free rate (for year 1, but the one year rate in year 2) while the firm uses the one year debt in both periods. Lally concludes that the second year period term is unchanged compared to policy 1, as R_{12} is assumed under this policy to be used by the regulator for year 2 . However, the NPV=0 condition fails when Ry_{02} is used to discount period 1, rather than R_{01}. The first year period is thus incorrect from the NPV=0 perspective.

Policy 3 - where the regulator uses the one year rate in each period, but the firm finances for two years - is less interesting. Here, NPV does not equal zero, but it is the regulated firm that (potentially) loses out, not customers. Lally indicates that the result arises because in both the periods, there is a potential difference between R_{01} or R_{12} and Ry_{02} (the latter is paid by the firm to creditors, but is recompensed at the former).

With regard to policy 4, the regulator uses two year debt (in year 1, but one year debt in year 2) and the firm uses two year debt. This is a highly relevant case, as the first period corresponds to using 10 year debt with a five year regulatory period. The analysis is the same for period 2 as it is for policy 3. The analysis for period 1 is the same as for policy 2. Both period returns are now incorrect. The outcome arises due to the discrepancy between Ry_{02} and R_{01} used to discount the return.

49 DBNGP (WA) Transmission Pty Ltd 2013, *ERA Draft Rate of Return Guidelines: DBP Response*, www.erawa.com.au, 23 September, p. 37.

33. DBP also references the critique of Lally's 2007 paper by Hall (2007). Hall concludes that Lally's approach is flawed because he assumes that forward rates are an unbiased predictor spot future spot rates. DBP say:[50]

> With respect to issues of finance theory, Lally's model is based upon the view that the firm is immunised against interest rate risk outside the regulatory period because, whatever the interest rate is next period, the regulated rate of return will be reset to match this rate. Hall, instead, states that the value of the asset in the market today will be set with reference to expectations for all interest rates over the life of the asset. There is an expectation of the regulated rate of return next period, which is used to estimate expected cash flows, and these expected cash flows are discounted today at a rate relevant to that second regulatory period. Now if the term to maturity is set equal to the regulatory period, the expected rate which is used to determine the cash flows is the five year rate expected to prevail next period. The NPV = 0 equation will only hold if these cash flows are also discounted at the expected five year rate next period. In turn, this only holds if the pure expectations hypothesis of interest rates is correct – that forward rates today are an unbiased predictor of expected future spot rates.

34. However, the Authority considers that Hall mistakenly assumes that the regulator is setting the regulated return for period 2 at time 0. In this case, it would be correct to discount the revenue for period 2 at the forecast of the forward rate (what Hall calls $R^F{}_{12}$). Hall's critique is thus not well founded. Lally in his rejoinder states that he makes no such assumption:[51]

> In particular, Hall defines R_{12} as "the expected interest rate on a one-year Government bond in one year's time" and he defines F_2 as the "expected cash flow" to equity holders at time 2. However, in Lally (2007, section 2), R_{12} is defined as "the one year rate that will arise in one year" and F_2 as the "cash flow" to equity holders at time 2, i.e., these are outcomes rather than expectations.

35. DBP also submits that the Authority needs to consider three further implications of Lally's conclusions.[52]

36. First, DBP states that the term of the regulatory period has nothing to do with prices expected to prevail in a competitive market, and so cannot be said to related to it. However, the Authority does not agree. When set ex ante, the risk free rate component is usually based on the prevailing rate that would apply in an effectively competitive market. The present value principle requires that the risk free rate needs to match the term that would apply in an effectively competitive market for the period.

37. Second, DBP argues that shortening the regulatory period does not alter the risks faced by the firm. Based on Lally's arguments, with the one year update, the term should be based on one year. This is an entirely valid criticism, and the Authority has corrected its approach to address this. Lally's NPV=0 maths does not work otherwise. This is discussed in greater detail in the section below on the implications for debt.

38. Third, DBP suggests that the MRP would need to be estimated consistent with the term used for the risk free rate. The Authority does not agree with this point (see Chapter 11 – Market risk premium for the Authority's consideration of this issue.

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50 DBNGP (WA) Transmission Pty Ltd 2013, *ERA Draft Rate of Return Guidelines: DBP Response*, www.erawa.com.au, 23 September, p. 38.

51 Lally M. 2007, Rejoinder: Regulation and the Term of the Risk Free Rate: Implications of Corporate Debt, *Accounting Research Journal,* Volume 20, No.2, 2007, p. 87.

52 DBNGP (WA) Transmission Pty Ltd 2013, *ERA Draft Rate of Return Guidelines: DBP Response*, www.erawa.com.au, 23 September, p. 39.

The 2010 paper – accounting for refinancing risk

39. More recently, Lally (2010) considered the situation where the average debt term used by regulated businesses materially exceeds five years (that is, the term of the regulatory cycle), and where these firms use neither interest rate swaps nor credit default swaps to equate the longer term (say 10-year) debt with the regulated five year term of debt. In this scenario, the present value principle would be violated. This is because the regulator's allowed cost of debt would diverge from those actually incurred by the firms.[53]

40. In this 2010 paper for the Queensland Competition Authority (**QCA**), Lally notes that the reasoning adopted in his 2004 and 2007 papers ignores any consideration of "refinancing risk", the risk of exposure to unusual conditions in debt markets at the time of refinancing. This refinancing risk results in prudent firms adopting a staggered debt portfolio, with a proportion of total debt being refinanced each year. Lally notes that interest rate and credit default swaps could be used to hedge the staggered debt portfolio of the firm to the regulated term of debt (assumed to be five years), to ensure they are equal. With this in mind, Lally proposes 4 options with which to deal with refinancing risk.

41. The second option considered by Lally assumes that regulated firms borrow for 10 years, but utilise swap contracts to match the 5-year regulatory period.[54] Consequently, the regulator would award a cost of debt that would include: (i) a five-year risk free rate, (ii) annualised 10-year debt issuance costs, (iii) five-year debt risk premium; and (iv) the transaction costs involved in swap contracts. Lally notes that this approach will satisfy the NPV=0 principle if credit default swaps are available for the regulated entity.

42. Lally proposes a further scenario 3 to deal with a situation where credit default swaps are not available. In this situation, it is assumed that the regulated firm will borrow for a tenor of 10 years and use interest rate swaps to convert the ten-year risk-free rate to a five-year risk free rate. Given the difficulties with using credit default swaps to convert a 10-year debt risk premium to a 5-year one, Lally suggests the regulator should use: (i) the five-year risk-free rate, (ii) 10-year debt risk premium, (iii) annualised 10-year debt issuance costs; and (iv) the transaction costs involved with swap contracts. Whilst this would violate the NPV=0 principle, Lally suggests that this would be a slight deviation of approximately only 0.04% of the WACC per year.

43. The fourth scenario option assumes that both interest and credit default swaps are unavailable, and as a consequence the total cost of debt should be made up of: (i) the ten-year risk-free rate, (ii) ten-year debt risk premium; and (iii) annualised debt issuance costs across a 5-year regulation period.

44. Lally notes that in both scenario 3 and 4, the divergence from NPV=0 is likely to result in either a positive or negative Net Present Value. In his advice to QCA, Lally dismisses option 4 on the basis that it is unrealistic that the benchmark efficient firm

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53 Lally M. 2010, *The Appropriate Term for the Risk Free Rate and the Debt Margin,* Report for the Queensland Competition Authority*,* April, p. 14.

54 The first option provides a benchmark for comparison which meets the NPV=0 condition but which does not involve a staggered debt portfolio. It assumes that the benchmark efficient firm fully refinances its debt portfolio every regulatory control period. Lally suggests that the total cost of debt would therefore be made up of: (i) the five-year risk-free rate, (ii) five-year debt risk premium; and (iii) an annualised debt issuance cost of a five-yearly debt issue. Lally notes that this approach will satisfy the "NPV=0" but implicitly assumes that the incremental refinancing risk from using five-year debt as opposed to any alternative is inconsequential.

would not seek to hedge the mis-match between their borrowing term and the length of the regulatory cycle.

45. Lally does not advocate any given option in his advice, but outlines the conditions under which each scenario should be chosen. Lally suggests that a higher average term to maturity for debt is indicative of firms being significantly concerned with refinancing risk.

46. In the situation where the average term to maturity is significantly longer than 5 years, Lally advocates scenario 2 if credit default swaps are readily available and transaction costs are not significant. If transaction costs are significant, or credit default swaps are not readily available then Lally advocates the third option.

Davis's analysis

47. In his advice to the Australian Competition and Consumer Commission (**ACCC**), Davis advocates the use of a risk-free rate of return that matches the length of the regulatory period.[55] Davis outlines why it is wrong to consider the longer term life of the asset when considering the return on debt:[56]

> The argument that debt and real asset maturities should be matched is incorrect in that it confuses maturity with interest rate exposure considerations. The real assets involved in access pricing generate a future cash flow stream which is reset every five years (at regulatory determinations) in line with movements in market interest rates. Thus the duration of the real assets is five years or less.

48. Davis notes that regulated entities often assert that an efficient financing strategy involves an entity raising debt with a maturity close to the expected life of the asset or minimising transaction costs and risk when refinancing a debt portfolio. Davis suggests that this argument is invalid due to the ability of regulated entities to change the characteristics of debt instruments via the use of either floating rate debt or interest rate swaps.

49. GGT in its submission questions the Davis analysis and its conclusions. GGT refers to Davis' most recent paper developing the present value principle.[57] In particular, GGT suggests that the case of the regulated business borrowing short term, and the regulator using a one period cost of debt each period, shows that:[58]

> ...when the regulated business borrows with term to maturity of the debt the same as the regulatory period, and the regulator sets the cost of debt at rates consistent with this borrowing strategy, the equity investors receive their allowed return in each period. This seems to be the NPV = 0 principle invoked by the ERA.
>
> Once this result is established, the most interesting case is, in our view, the case where the regulated business uses long term fixed rate debt, and the regulator uses a two period cost of debt in period 1, and does not reset that cost in period 2. This is the case where the business borrows long term, and the regulator uses that long term borrowing cost to determine regulated revenue and prices regulatory period by regulatory period...

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55 Davis K 2003 *Risk Free Interest Rate and Equity and Debt Determination in the WACC, prepared for the ACCC,* pp. 11-12.

56 Davis K. 2010, *Determining Debt Costs in Access Pricing*, Appendix A of IPART 2011, Developing the approach to estimating the debt margin: Other industries: Draft Decision, www.ipart.nsw.gov.au, p. 2.

57 Davis K 2012, *The Debt Maturity Issue in Access Pricing*, www.kevindavis.com.au, Draft 3, September 2.

58 Goldfields Gas Transmission 2013, *Submission on the Economic Regulation Authority's Draft Rate of Return Guidelines*, www.erawa.com.au, 19 September, p. 32.

> When the regulated business borrows with term to maturity of the debt the same as the life of the regulated asset, and the regulator sets the cost of debt at rates consistent with this borrowing strategy, the equity investors receive their allowed return in each period. The ERA's NPV = 0 principle continues to apply. Davis, however, does not analyse this case in his paper. His analysis does not, therefore, allow the conclusion that term to maturity of bond used to estimate the risk free rate of return should correspond to the regulatory period.

50. GGT concludes that Davis' method of analysis can be used to show that if this is the case, and the regulator uses a rate of return consistent with the term to maturity of the service provider's debt, equity investors receive their allowed rates of return, such that the present value principle continues to apply.

51. The Authority considers that GGT's conclusion is theoretical because it assumes that debt instruments are available that equate to the life of the asset. But this is not commonly so; for example, the life of regulated assets can approach 70 years. Similar to Hall's critique of Lally noted above, it also assumes that the regulator sets the rate once at this rate, ex ante. These are clearly impractical approaches for a 70 year asset.

52. Given their interpretation, GGT is of the view that this means that the regulator should set the term of debt consistent with the term to maturity of the service provider's debt, say 10 years for argument's sake. But this is a flawed argument. To be consistent with the previous paragraph, and NPV=0, the requirement would be that the regulator only set the cost of debt once every 10 years. While this could be productively efficient (if there were no new investment), it would clearly be allocatively inefficient, as it would not be transmitting efficient prices associated with prevailing conditions to upstream and downstream users.

Implications

53. The implications for the term of the return on equity and the return on debt are discussed in what follows.

Return on equity

54. The Authority will adopt the Sharpe Lintner Capital Asset Pricing Model (**CAPM**) for the purpose of estimating the return on equity, as it is the only model considered relevant at the current time. The return on equity under the Sharpe Lintner CAPM is derived from the sum of an estimate of the risk free rate and an estimate of the risk premium estimated for the benchmark efficient entity, with the latter derived as a product of the estimated beta and the estimated market risk premium (**MRP**).

55. The estimates are forward looking.

56. The risk free rate would be based on the five year risk free rate 'on-the-day' prevailing at the start of the regulatory period.

57. The market risk premium would be estimated as a point within a range derived from:

- the historical MRP; and
- application of the Dividend Growth Model.

58. The first approach for the market risk premium above, the estimate, is derived as:

- the sample of historic observations of the total market return; from which
- the relevant estimate of the risk free rate would be netted off to give the market risk premium.

59. The Authority considers that these approaches would be consistent with the Lally/Davis NPV=0 principle.

60. DBP submits that:[59]

> The ERA has come out strongly in favour of a five-year term for both debt and equity, a conclusion which differs from the AER. Interestingly, both the author of the paper the ERA uses to support its position on the market risk premium (Damodaran, 2008) and the authors of the textbook it uses in its assessment of the Arbitrage Pricing Model (Pratt & Grabowski, 2010) have been used as references by the AER to argue that the return on equity, at least, ought to be set to match the long-term nature of the assets. It is interesting that two regulators could read the same literature and come to different conclusions.

61. In this context, Incenta provided a report to the Energy Networks Association on the term of the risk free rate for the cost of equity. Incenta considers that shortcomings in the Sharpe Lintner CAPM mean that the correct term for the risk free rate is indeterminate in theory:[60]

> ...the SL CAPM is a single period model, which assumes that an investment is made at the start of the period and liquidated (and consumed) at the end of the period, with the period being of undefined length. It is also implicit that both the life of all investments and the horizon of investors are the same (corresponding to the undefined period). In this model, the answer to the appropriate term of the risk free rate is obvious – indeed, if the risk free asset was a traded instrument, its term would match the undefined period. We observe that the SL CAPM clearly is not descriptive of reality. Investors do periodically re-evaluate portfolios and reinvest, and assets have a myriad of lives.

62. The question as to investors' horizons for investment is therefore an important consideration.

63. Incenta conducted a survey of 14 market practitioners, who all applied the 10 year risk free rate to estimate the cost of equity for regulated businesses. Incenta therefore argues that as the theory is indeterminate, but that market practitioners adopt a 10 year term, then a 10 year term should be adopted.

64. Similarly, SFG Consulting (**SFG**) found that as many as 94 per cent of a 2012/13 sample of 29 reports used the 10 year term for the risk free rate in the CAPM. All of the expert assessments used the CAPM, although some use an uplift factor to correct for perceived shortcomings in the CAPM.[61]

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59 DBNGP (WA) Transmission Pty Ltd 2013, *ERA Draft Rate of Return Guidelines: DBP Response*, www.erawa.com.au, 23 September, p. 36.

60 Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Attachment 14 (Incenta Economic Consulting 2013, Term of the risk free rate for the cost of equity), www.erawa.com.au, p. 7.

61 Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Attachment 4 (SFG Consulting 2013, Evidence on the required return on equity from independent expert reports), www.erawa.com.au, pp. 11 and 21.

65. Lally, in noting the importance of this consideration for the correct application of the CAPM, concludes that there is variation in investor horizons.[62] Lally quotes evidence that suggests that investors' horizons may be less than five years, based on data on the weighted 'average holding period' of equity shares.[63]

66. In the event that investors' horizons are less than the regulatory period, Lally considers that it is not inconsistent to use the five year term for the risk free rate in the first term of the CAPM. This is because successive applications of a short period risk free rate, up to the five years, would be equivalent in present value terms to using the five year rate.

67. Lally has considered that the MRP should be estimated with reference to the investors' horizons. Where this is less than five years, then Lally considers the shorter period should be used, even though five years is used on the left hand side. However, Davis considers that it is important that the term of the risk free rate used for the MRP and on the left hand side in the CAPM equation be the same.[64] More recently, Lally appears to have revised his views in this regard.[65]

68. Where investor horizons are deemed to be longer than five years, then Lally considers that there is a conflict between the NPV=0 requirement and the basis of the CAPM. Lally suggests that in this case the first term in the CAPM equation should be based on the five year risk free rate, as the NPV=0 condition should take precedence, but that the estimate of the MRP should be based on the longer term for the risk free rate.

69. The Authority considers that evidence for investors' horizons is inconclusive. Market practitioners often have an interest in 'talking up' investments, and market practitioners are not investors. Many investors only hold stocks for a much shorter period – as little as a year or two – consistent with the evidence provided by Lally. On this basis, a five year term would be consistent with a weighted average of investors' horizons.

70. Furthermore, the Authority considers that as the value of the regulatory asset base is assured at the end of the regulatory period, then investments in regulated assets may be considered to be a sequence of investments with a horizon of five years, in line with the view of Davis. As a corollary, the Authority considers that the use of the market risk premium in the CAPM suggests that the return on equity will err on the generous side, as it is based on a weighted average of assets which have significantly greater uncertainty attached to their future value than has the regulated asset base.

71. The Authority agrees with Lally that, where there are inconsistencies, then the present value principle is a key consideration, as it meets the requirements for economic efficiency in the NGR.

72. The Authority concludes that as the return on equity is reset every five years, using a five year term for the risk free rate is consistent with ensuring that investors in a regulated firm have reasonable opportunity to recover a return on their investments.

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62 Lally M. 2010, *The Appropriate Term for the Risk Free Rate and the Debt Margin,* Report for the Queensland Competition Authority*,* 27 April, p. 5.

63 Lally M. 2010, *The Appropriate Term for the Risk Free Rate and the Debt Margin,* Report for the Queensland Competition Authority*,* 27 April, p. 16.

64 Davis K. 2003, *Risk Free Interest rate and Equity and Debt Beta Determination in the WACC*, www.accc,gov.au, p. 10.

65 Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Attachment 14 (Incenta Economic Consulting 2013, Term of the risk free rate for the cost of equity), www.erawa.com.au, p. 19.

Basing the risk free rate on a 10 year term, as suggested by some stakeholders, could allow investors to earn extraordinary returns, which would not be in the long term interests of consumers.

73. Overall then, the Authority considers that a five year term for the risk free rate is the best approach for estimating the return on equity, in order to meet the allowed rate of return objective.

Return on debt

74. For the return on debt, the Authority will adopt the on-the-day approach to estimating the cost of debt, reflecting the prevailing conditions. The estimate would comprise the sum of the risk free rate and the debt risk premium.

75. For the risk free rate, the five year risk free rate is the relevant term, as the Authority proposes to update the estimate at the regulatory reset (see Chapter 7 – Risk free rate).[66] The five year term is consistent with the five year regulatory period for this component.

76. The Authority will update the debt risk premium annually. This annual reset could imply a one year term, in order to meet the present value principle. However, as hedging instruments – such as credit default swaps – are not readily available in Australia, firms cannot easily hedge this debt risk premium. Lally observes that where hedging is not available, it is reasonable to adopt the average term to maturity of the debt held by the benchmark efficient firm for estimating the debt risk premium (see paragraph 46 above). This recompenses the firm for the debt risk premium component, recognising efficient financing practices, and in particular, the need to stagger the term of debt to address refinancing risk.

77. The Authority's analysis of the debt profile of the benchmark efficient entity indicates that the term to maturity exceeds five years.[67]

78. As a result, in line with Lally's advice set out above at paragraph 46, the Authority considers that the appropriate term for the debt risk premium should be the term to maturity observed for the benchmark efficient entity through the bond yield approach. That term will fluctuate according to the average term to maturity of the sample in any year.

79. As Lally observes, this approach violates the present value principle. However, Lally's recent analysis suggests that the resulting deviation from NPV=0 would be small.[68]

80. The Authority notes that the bond yield approach is generous to the utility (but not to consumers). It is based on a sample of bonds with the same credit rating across the whole market. Yet infrastructure firms tend to be at the less risky end of the credit rating bands, so tend to have smaller debt risk premiums than the average within the band.

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66 In the event that a five year reset was adopted, then the term would be five years.

67 The term to maturity is observed through the sample of the bond yield approach. See Chapter 9 – Debt risk premium.

68 Lally M. 2010, *The Appropriate Term for the Risk Free Rate and the Debt Margin,* April, p. 11.

Appendix 3 Economic efficiency and the return on debt

1. When considering approaches to the cost of debt, the framework set out in Chapter 2 – The broad regulatory framework implies that any proposed approach needs to be evaluated within the three key dimensions:

   i) economic efficiency – does the proposed approach lead to efficient financing costs and economic efficiency; in particular, is it:

      1. an approach which retains incentives for the regulated firm to adopt efficient financing practices; and

      2. a good predictor for the actual cost of debt in the regulatory years, thereby providing effective incentives in order to promote economic efficiency;

   ii) reasonable opportunity – does the proposed approach result in a cost of debt that could be achieved in the market place by a firm that met all the characteristics of the benchmark; and

   iii) transactions costs – does the proposed approach minimise costs for both the regulator and the regulated firm with regard to the cost of debt?

2. This Appendix considers the performance of alternative approaches with regard to the economic efficiency dimension.

Alternative approaches for estimating the cost of debt

3. The Authority considers that an estimate based on a model of the cost of debt is likely to best achieve the allowed rate of return objective (see Chapter 6 – Return on debt). The Authority will base the cost of debt on two components, the risk free rate, and the risk premium over and above the risk free rate, plus an allowance for debt raising and hedging costs:

Cost of Debt = Risk Free Rate + Debt Risk Premium + Debt raising costs + Hedging costs

The prevailing on-the-day approach

4. The ‘on-the-day’ approach used by the Authority is derived as the sum of:

   i) the 5-year risk-free rate, averaged over 20 days just prior to the commencement of the regulatory period; and

   ii) an estimate of the debt risk premium based on the average of a sample of bonds from firms with similar risk characteristics to the benchmark efficient entity.

Portfolio approaches

5. Alternative approaches to estimating the cost of debt may be based on a 'portfolio approach', either:[69]

- the trailing average cost of debt – a long term average of historic outcomes on the overall cost of debt; or
- the hybrid approach – a base rate derived consistent with the on-the-day approach, plus a long term average of the debt risk premium.

Annual updating

6. A further consideration relates to whether to adopt a single estimate once every five years, at the regulatory reset, or to update the cost of debt estimate annually.

Prediction performance

7. In general, the best 'ex ante' predictor of the cost of debt in a future period is the on-the-day estimate made just prior to the future period. Analysis by the Authority supporting this contention is provided at Appendix 5 – The Diebold Mariano test:

- The best predictor for the average cost of debt over the whole of the access arrangement period is the on-the-day estimate that is made just prior to the commencement of the access arrangement.
- A better predictor of the future cost of debt may be developed by shortening the prediction period, utilising an on-the-day estimate that is updated just prior to each annual regulatory year. This reflects that the major driver of the return on debt is the underlying risk free rate, which is not a stationary series, but rather has the statistical property of a random walk (see Appendix 16 – Is the return on equity stable).

The marginal cost of debt for the regulated firm

8. The marginal cost of debt for the regulated firm is the regulated cost of debt. This may differ from its actual cost of debt.

9. The firm will apply the expected regulated rate of return to its operating and investment decisions, as this will be its opportunity cost of debt. With regard to investment, it is the regulated return on debt over the regulatory period and the regulated return expected over near future periods that will have greatest influence on the hurdle rate for investment for longer lived assets.[70]

10. The corollary is that if the firm's actual expected cost of debt at the time of the investment is below the expected regulated rate, then it would expect to receive an extraordinary return, and would have an incentive to over-invest, compared to the economically efficient outcome. On the other hand, if the firm's actual cost of debt at

[69] For more details on these alternative approaches, see SFG Consulting 2012, *Rule change proposals relating to the debt component of the regulated rate of return: Report for AEMC*, www.aemc.gov.au.

[70] The cost of new debt relating to any investment in a regulated year will be the firm's actual cost of debt. However, the return on debt will provide the revenue to cover that cost of debt. The regulated firms will make decisions based on the latter, as the regulated return on debt will determine whether the investment provides a normal profit to the firm (or not) in the first instance.

the time of the investment was above the regulated rate, then it would have an incentive to under-invest, compared to the economically efficient outcome.

Economic efficiency considerations

11. The Authority considers that effective incentives for economic efficiency will achieve outcomes similar to those observed in markets with effective competition, including:[71]

- efficient production;
- profits at levels just sufficient to encourage and reward investment, efficiency and innovation;
- prices that signal appropriate consumption decisions, clear markets, and enhance cyclical stability;
- output levels and product quality responsive to consumer demands, and which reward those firms which best deliver such responsiveness.

12. As it is a better predictor, the on-the-day approach will outperform the trailing average approach with regard to efficiency considerations. In what follows, its relative performance against each of these elements is considered, starting with dynamic efficiency.

Dynamic efficiency

13. Dynamic efficiency will be enhanced when firms make the ‘right’ investments that maximise returns to the firm and society over the longer term. The right investments will maximise the net present value over their life, based on a discount rate that reflects the opportunity cost of funds over that life. The prevailing cost of funds is a key component in that discount rate, and hence in ensuring that the right investment decisions are made.

14. As the on-the-day approach has been demonstrated to be a better ex ante predictor than the trailing average approach (see Appendix 5 – The Diebold Mariano test), it performs better with regard to this efficiency consideration. This is because the gap between a firm’s actual debt finance cost for a new investment and the prevailing debt finance cost is minimised. It is therefore more dynamically efficient.

Allocative efficiency

15. Allocative efficiency is achieved when the economy produces only those goods and services which are most valued by society. This occurs at the point where the marginal cost of producing a good or service just equals the willingness to pay for that good or service, which will be reflected in marginal revenue.

16. A divergence between actual debt costs and the allowed regulatory return on debt – where the latter is established at the start of the regulatory period (‘ex ante’) – would likely result in sub-optimal investment decisions by the regulated firm and by upstream and downstream users.

17. A service provider would be incentivised to over-invest in long term assets when the prevailing cost of new debt is lower than the regulated allowance, and to under-spend

71 See for example Scherer F. and Ross D. 1990, *Industrial Market Structure and Economic Performance*, Houghton Mifflin, Chapter 2.

when the opposite is true. This would occur regardless of whether the ex ante regulated allowance was derived from an 'on-the-day' or portfolio approach.

18. Users of the regulated firm's services – both upstream and downstream – make production decisions that are based on efficient prices for the regulated service. At any point in time, the capital used for producing the regulated firm's output is 'sunk', and therefore should not contribute to (variable) marginal costs of the user. To this extent, use of a regulated firm's service therefore should not depend on the cost of debt. However, users need to make efficient investment decisions for the future, and here it is the full cost of the network service input that is relevant, including the fixed as well as the variable costs. On this basis, the prevailing cost of debt is important for users' decision making, and for allocative efficiency.

19. However, as the on-the-day approach has been demonstrated to be a better ex ante predictor than the trailing average approach, it performs better with regard to this efficiency consideration. This is because the gap between a firm's actual debt finance cost for a new investment and the prevailing debt finance cost is minimised. It is therefore more allocatively efficient.

Productive efficiency

20. Generally, firms adopt a staggered debt portfolio as an efficient means to manage re-financing risk and the associated liquidity risk. Prudent management of re-financing risk lowers the cost of debt. A lower cost of debt is more productively efficient.

21. However, adopting a more staggered debt portfolio may increase mismatch timing risk, particularly where less than fully effective hedges are available. The resulting mismatch timing risk derives from having revenue based on an assumption of the cost of debt that differs from the cost of debt that the firm actually incurs. Increased mismatch timing risk may lead to a higher cost of debt, as lenders seek to account for the overall increased risk. As a consequence, there will be an optimal portfolio, which balances the increased mismatch timing risk with the reduced re-financing risk.

22. The prevailing cost of capital will also influence the decisions made by the regulated firm with regard to its use of factors of production. While investments in major capital assets owned by the firm are sunk in the short run, it may be possible to substitute capital for labour – at the margin – over the medium term. Appropriate pricing for the cost of capital will contribute to efficient decision making in this regard during the regulatory period. As noted above, the opportunity cost of capital of the regulated firm is the regulated cost of debt.

Re-financing risk

23. For the benchmark efficient entity, the current regulatory approach estimates the debt risk premium by estimating the weighted average spread to the risk free rate from a sample of observations of firms with the same credit rating as the benchmark. The resulting average credit spread reflects the debt risk premium of the sample.

24. The prime driver of credit spreads over the base interest rate, all other things being equal, is the expected value of loss.[72] The expected value of loss is the product of the expected probability of default, and the magnitude of the resulting potential loss. The

[72] The base rate may be either the Commonwealth Government Securities bond, or the swap rate.

credit spread for every entity will be different, as in addition to the broader macro and industry risk factors, there will be risk factors that are specific to the entity itself.[73]

25. It follows that the estimated debt risk premium will reflect the management of the re-financing risk by the comparable entities in their portfolios. That is to say, the observed average credit spread will reflect the cost of debt associated with the (sample) minimisation of the default risk. The corollary is that the estimate includes a risk margin for the expected 'average' value of default for the sample, which is the average amount of residual re-financing risk. It is efficient to trade off some re-financing risk against a reduced cost of debt. To completely eliminate it would be inefficient.

26. It also follows that the resulting observed cost of the debt risk premium for the benchmark efficient entity sample is 'around' that of an efficient finance structure. A regulated entity that has implemented an efficient financing structure, which minimises the costs associated with default risk, given the size of its borrowing requirement, is likely to have an equal or lower credit spread than the estimated average credit spread, all other things being equal. If a regulated firm was not managing re-financing risk at least as efficiently as the average, then it would likely have a higher credit spread.

27. Given that we are seeking a 'reasonable' estimate of the cost of debt over the access arrangement period, the sample of observations from the bond yield approach gives a 'reasonable' credit spread, which includes a margin for the efficient level of residual default risk. On this basis, the sample estimate will give a debt risk premium, which when added to the risk free rate, provides for a cost of debt which the efficient firm will have a reasonable opportunity to achieve.

Term to maturity of the estimate

28. Competition Economics Group (**CEG**) investigated the relevant term to maturity required for the benchmark term assumption by studying the debt strategies of utility businesses.[74] CEG provided evidence on the debt portfolios of utility/infrastructure businesses by focusing on the term at issuance of the portfolio.

29. CEG note that regulated energy companies in Australia and internationally have on average a term of debt issuance greater than 10 years. CEG estimate an average term at issuance of 17.5 years for electricity companies in Australia, and 14.9 years for gas companies. CEG also analyse the composition of utility company's debt portfolios between bonds and bank loans. CEG find that in Australia, regulated energy companies tend to hold 76% of their outstanding debt in the form of bonds and 24% in the form of loans. In addition CEG find that 65 per cent of outstanding debt is issued in terms of Australian dollars. CEG use this analysis to suggest that the cost of debt should be calculated with reference to a 10 year term to maturity, to align with the observed term at issuance of regulated utilities.

30. Energy Networks Association (**ENA**) submitted a report compiled by Price Waterhouse Coopers (**PwC**) regarding the benchmark term of debt assumption.[75] PwC compile empirical evidence regarding regulated infrastructure businesses

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[73] As noted by the Brattle Group, credit risk includes systematic and non-systematic risks (see Australian Pipeline Industry Association 2012, *Rate of Return Review*, www.erawa.com.au, Schedule 2, p. 68).

[74] Competition Economists Group 2013, *Debt strategies of utility businesses,* June 2013.

[75] Energy Networks Association 2013, *Benchmark term of debt assumption,* June 2013.

issuance term of debt from Australia, the UK and US. PwC provide the following evidence regarding the average term of debt:

- Australian energy network business have an average *issuance* term of 10.14 years;
- UK regulated energy and water transmission/distribution business the average term of *issuance* was 21.3 years;
- US regulated energy transmission/distribution business was found to have an average term of debt *issuance* of 18.9 years.

31. PwC conclude that Australian, UK and US business issue longer term debt in order to reduce re-financing risk. PwC conclude that as the average term of debt at issuance is 10.21 years for Australian network business, the appropriate benchmark debt term is 10 years in order to reduce the refinancing risk facing regulated entities.

32. However, the Authority is not persuaded by the above arguments that a term of 10-year risk-free rate should be used to reduce refinancing risk. While analysis has supported a term matching the length of the regulatory period (see Appendix 2 – The present value principle), the Authority is not aware of independent academic studies which objectively support matching a term consistent with the term at issuance of regulated entities debt.

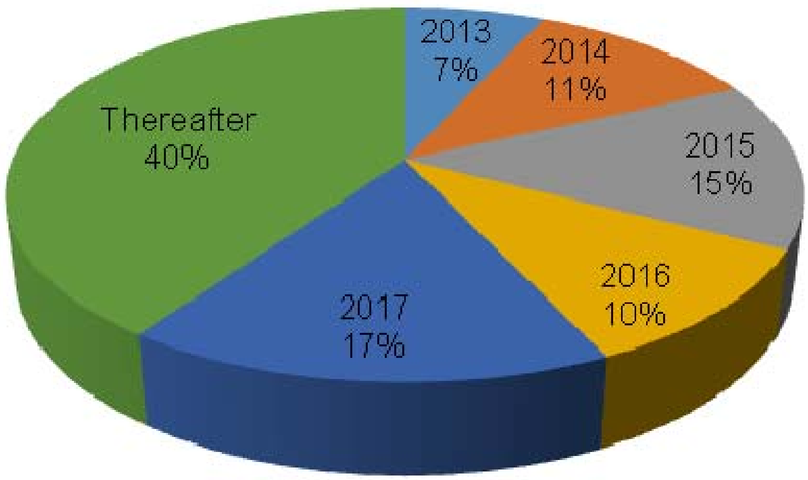
33. The Authority notes that the prior history of a bond does not determine the current market value for a bond, and therefore does not determine the current market value of a firm's debt. Therefore, the term to maturity at issuance is irrelevant for the pricing of a firm's debt, and consequently irrelevant for determining the refinancing risk present in regulated entities.

34. The Authority is aware that regulated utilities may not be able to completely hedge all financing or refinancing to ensure all costs are compensated in the year they arise. As such, in those years, the present value principle does not hold. However, future interest rates can move in any direction. The Authority is of the view that, over time, these under- and over-compensations will be cancelled out. As such, it is reasonable to assume that the present value principle does hold on average.

35. The Authority is of the view that a combination of various short-term debt (e.g. bank loans) and long-term debt (e.g. bonds) is required to ensure that businesses will not be exposed to liquidity issues in the short run, or to solvency concerns in the long run. This debt structure contributes to a reduction in the refinancing risk of the regulated entities. The debt structure of a particular business is expected to remain relatively constant across various periods.

36. The Authority has also conducted analysis of the debt profiles of Australian utilities as at March 2013 to investigate how regulated entities manage refinancing risk. S&P's industry report cards indicates that, as at December 2012, regulated entities stagger their debt portfolio. The Authority is of the view that the debt profiles of Australian rated utilities presented in S&P's industry report cards reflect the preferred debt structures of rated utilities and that refinancing risk is therefore adequately controlled for.

Figure 1 S&P's current debt profile for Australian rated utilities as at December 2012



Source: S&P's Industry Report Card 2012

37. The Authority considers that it is the average remaining term to maturity that determines the debt profile of a firm at a given time. That is, the yield required to service a firm's cost of debt is a function of the remaining term to maturity, and not the term to maturity at issuance. Investors will price bonds based on the coupons they are eligible to receive, the face value of the bond and the credit risk of the bond issuer. As a consequence, the Authority does not accept arguments for a longer term of the cost of debt is required.

38. To investigate this issue further, a sample of Australian gas and electricity network service providers (**NSPs**) bonds outstanding in March 2013 was sourced from Bloomberg. The sample includes bonds issued in domestic and foreign markets. The sample consists of 111 instruments. Table 2 presents the outcomes.

Table 2 Australian gas and electricity network service provider bonds as at March 2013

Company	Number of issuance
SPI Australia Assets	12
PowerCor Australia	5
SPI Electricity and Gas	18
ETSA Utilities Finance	5
APT Pipelines	20
DBNGP Finance Co	2
SP Powerassets	16
United Energy Distribution	4
DBNGP Finance Co	4
Energy Partnership Gas	2
CitiPower	2
Envestra	1
Envestra Limited	2
Jemena	8
Envestra Victoria	1
Singapore Power	1
Electranet	1
TXU Australia	3
SPI Electricity	4
Total	**111**

Source: Bloomberg

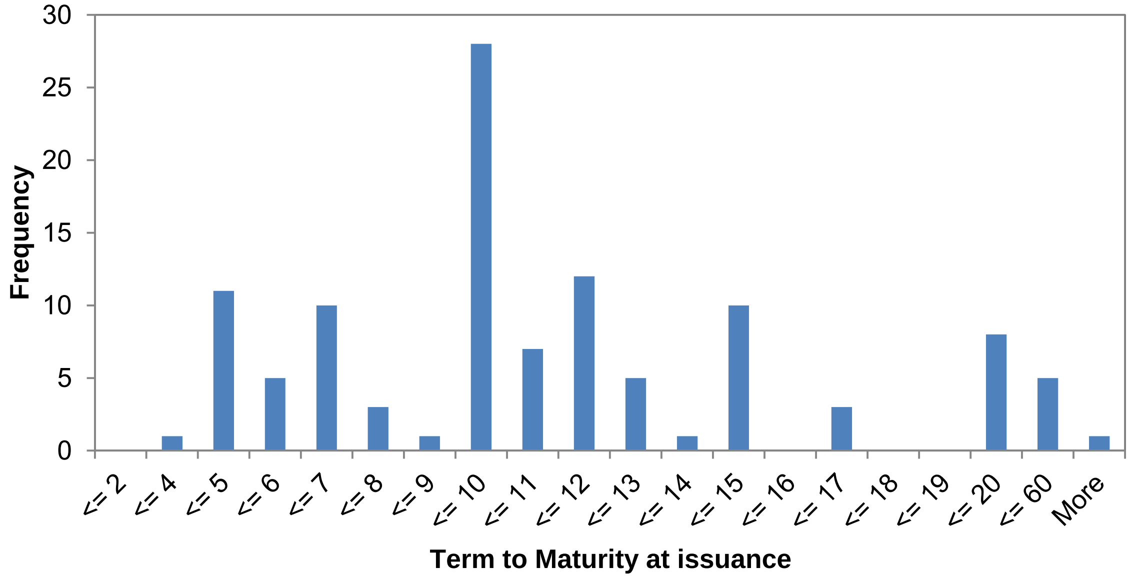
39. The average term to maturity for bonds at issuance was approximately 10 years while the average of the remaining term to maturity was approximately 5 years as presented in Figure 2 and Figure 3 below. Table 3 presents a summary of descriptive statistics for all Australian Electricity and Gas NSPs Bonds.

Table 3 Descriptive statistics – Australian electricity & gas NSPs bonds

	Term to Maturity at Issuance	Remaining Term to Maturity
Mean	11.5	6.0
Median	10.0	4.5
Mode	10.0	3.7
Amount-Issued Weighted Average	11.16	6.43

Source: Bloomberg & the Economic Regulation Authority's analysis

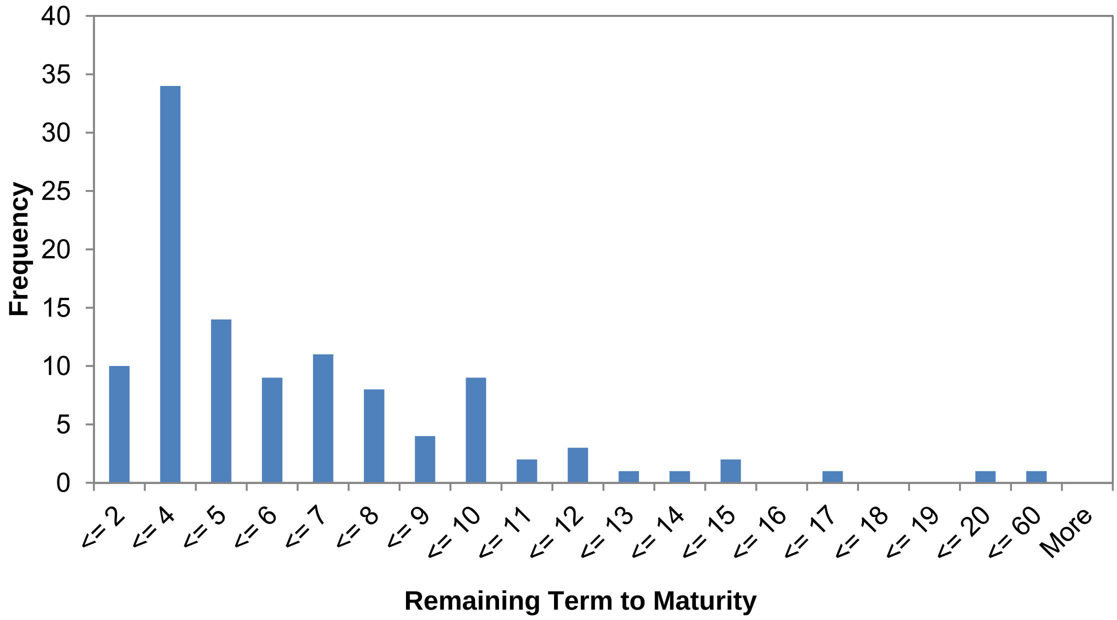
Figure 2 Terms to maturity at Issuance: Australian gas and electricity NSPs bonds as at 2013



Source: Bloomberg

40. The above analysis shows that overall, NSP's debt instrument's term to maturity at issuance tend to centralise around 10 to 11 years while the remaining term to maturity tends to centralise around 4 to 6 years. This outcome is consistent with what would be observed if an NSP issued 10 per cent of its debt every year with a maturity of 10 years; the average remaining term to maturity would be 5.5 years.

Figure 3 Remaining terms to maturity as at 2013: Australian gas and electricity NSPs bonds



Source: Bloomberg

41. The sample was then split into domestic and foreign issued bonds to examine any differences between the two markets. Table 4 shows that domestic issues had a longer term to maturity at issuance and the remaining term to maturity in comparison

with the entire sample of bonds issued in both domestic and foreign markets. The longer remaining term to maturity mainly reflects an unusually large and long issuance by APT Pipeline for $515 million over a term of 60 years in late 2012. Without this bond the remaining term to maturity in this sample has a mean of 5.6 years, median of 4.3 years and mode still of 7 years. The amount issued weighted average decreased substantially to 5.37 years. This is consistent with expected average term being 5.5 years.

Table 4 Australian electricity and gas NSPs bonds issued in domestic markets

	Term to Maturity at Issuance	Remaining Term to Maturity
Mean	10.8	6.8
Median	10.0	4.3
Mode	5.0	7.0
Amount-Issued Weighted Average	11.60	7.59

Source: Bloomberg & the Economic Regulation Authority's analysis

42. When the bonds at issuance in the international markets are considered, the mode in Table 5 shows that longer term bonds are the most common. Again, the results tend to centralise around 4 to 6 years.

Table 5 Australian electricity and gas NSPs bonds issued in foreign markets

	Term to Maturity at Issuance	Remaining Term to Maturity
Mean	11.9	5.5
Median	10.3	5.1
Mode	10.0	3.7
Amount-Issued Weighted Average	11	5

Source: Bloomberg & the Economic Regulation Authority's analysis

43. The Authority acknowledges that the above analysis presents a 'snap shot', not a complete picture of NSP debt profiles. The above results for remaining term to maturity however, are not inconsistent with the theoretical situation where a 5.5 year term to maturity is averaged by issuing 10 per cent of debt every year with a maturity of 10 years. The Authority considers that businesses can issue bonds at any time that is optimal for them. This will include consideration of refinancing risk, and should be independent of the regulatory regime. As such, the remaining time to maturity for bonds is relevant to determine the debt profile of a business and then the average cost of debt is determined accordingly, based on the current debt profile.

44. Taking account of the above analysis with regard to current debt profiles of Australian electricity and gas NSPs, the Authority does not believe that the presence of refinancing risk justifies extending the term assumption of the benchmark term of debt to that of the average issuance, as firms on average have a debt portfolio with terms that are significantly shorter.

1.1.1.1 Mismatch timing risk

45. The major issue for regulated firms would therefore appear to be the mismatch timing risk. A major criticism of the on-the-day approach is that firms are unable to match the resulting estimate used by the regulator to set the return on debt. The inability to match existing staggered debt costs to the regulated on-the-day rate arises because there are barriers in financial markets that preclude complete hedging. These barriers in large part arise due to a lack of adequate debt markets in Australia, of reasonable depth and liquidity.

46. Even where an actual difference in a regulated firm's actual cost of debt arises – as compared to the regulated cost of debt – the firm's net present value of its debt may still equal zero over the long run (the present value principle, NPV=0), provided that the average term of the firm's debt matches the term of the regulatory estimate (five years), all other things being equal (see Appendix 2 – The present value principle for a summary of evidence). However, with imperfect hedging, this outcome is less assured. Nevertheless, even with imperfect hedging, the over-statement of the cost of debt will be matched by under-statement of the cost of debt over the long term. It follows then that NPV=0 is likely to be maintained over the longer term.

47. Mismatch timing risk has a cost, in that it leads to increased volatility for cash flows to equity. This volatility would result in a higher β, all other things being equal, so would still be compensated for the regulated firm. To the extent that this volatility was reduced, such as by moving to some kind of portfolio trailing average approach, then historic observations of the β would need to be adjusted down, to account for the reduction of this mismatch timing risk.[76]

48. However, it is desirable that the efficient benchmark cost of debt reflects the actual opportunity costs, and not be hypothetical. To the extent that the benchmark firm cannot match the on-the-day estimate, due to financial market barriers, then there is a concern.

[76] SFG Consulting 2012, *Rule change proposals relating to the debt component of the regulated rate of return*, www.aemc.gov.au, p. 22.

In this context, the Authority notes that DBP consider that it is not 'the volatility of cash flows that matter for beta, but the covariance of cash flows with the market' (see DBNGP (WA) Transmission Pty Ltd 2013, *Submission to the ERA Benchmark Cost of Debt Secretariat Working Paper*, www.erawa.com.au, p. 18).

The Authority agrees with DBP's view that it is the covariance of cash flows with the market that matters for the estimate of beta.

However, it is accepted that the beta measures the covariance of the return on equity of the regulated firm with the variance of the market. As gearing increases, so too does the equity beta (through the levering of the asset beta), reflecting an increased exposure of equity to systematic risk. This occurs because increased debt will take an increased (invariant) proportion of the cash flows, all other things equal (including variance relating to the cost of debt), leaving a smaller but more variable proportion for equity.

For the purpose of exposition, it is now assumed that gearing is held constant. In the extremis, to the extent that the trailing average passed through the 'embedded' cost of the firm's debt, then the systematic variance of the cash flows relating to the cost of debt is significantly reduced. In this case, the Authority is of the view that mismatch pricing risk is reduced. As such, the resulting variation in cash flows to equity will be reduced, for any given level of leverage, as equity no longer has to absorb the unders and overs due to mismatch pricing on debt. The covariance of the returns on equity to the market will be reduced. It is argued that the beta will be lower in this case. For a further exposition of this, see SFG Consulting 2012, *Rule change proposals relating to the debt component of the regulated rate of return: Report for AEMC*, www.aemc.gov.au, p. 42.

1.1.1.2 Ability to reduce mismatch timing risk through hedging

49. The Authority engaged Chairmont Consulting to evaluate the degree to which a regulated firm may hedge its portfolio of debt to match the current on-the-day regulated rate, and the costs of doing so.[77]

50. Chairmont concluded that perfect hedging the on-the-day regulated rate is not possible:

- efficient firms stagger their debt issuance, typically issuing debt 'opportunistically' in a range of markets, as a means to manage re-financing and liquidity risk;
- this leads to mismatch timing risk, also known as re-pricing risk, which is associated with the constrained cost of debt set by the regulator through the on-the-day approach;
- regulated firms can hedge the on-the-day regulated base risk free rate for even very large amounts of debt through interest rate swaps, at low cost;
- however, there are no effective tools for hedging the debt risk premium in Australia – Credit Default Swaps provide one avenue but this market is narrow, reasonably illiquid, and there are no Credit Default Swaps available that are linked to the debt risk premium of the companies regulated by the Authority;
- therefore, a basis risk variation between the actual and benchmark cost of debt remains.

51. Chairmont's estimates of the basis point differential between a typical efficient portfolio and the on-the-day cost under plausible scenarios is:

- up to around 150 bps where no hedging is undertaken; and
- around 50 bps if hedging of the base swap rate is undertaken.

1.1.1.3 Is some residual level of basis risk efficient?

52. Chairmont note that a typical 'competitive' firm will seek to cost effectively remove any mismatch timing risk.[78] The base rate component could be hedged by purchasing exchange traded futures on Commonwealth Government Securities, or by undertaking interest rate swaps.[79] However, the competitive firm's debt risk premium cannot be hedged consistently, except by a few large firms of sufficient size for which there is a liquid corporate debt market. As a result, the competitive firm will inevitably face some mismatch timing risk on the debt risk premium component of its past debt issuances. Chairmont note:[80]

> Most companies regardless of the industry will face either some degree of Mismatch Interest Rate Risk or some risk of an interest rate increase on the expense side which has no offsetting counterpart on the revenue side.

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[77] Chairmont Consulting 2013, *Comparative Hedging Analysis*, www.erawa.com.au.

[78] This is the standard approach where the cost of finance is not a core business or profit centre. See Chairmont Consulting 2013, *Comparative Hedging Analysis*, www.erawa.com.au, p. 9.

[79] Ibid, p. 4.

[80] Ibid, p. 9.

53. The result is that some residual basis mismatch timing risk related to the debt risk premium for a regulated firm would be consistent with that faced by an unregulated firm operating in the economy:[81]

> It is noted that non-regulated companies in other industries are also likely to face some form of interest rate risk, because they do not have revenue items which equally offset changes in their debt funding costs. Some businesses are likely to face greater interest rate risk than regulated utilities and some are likely to face less. The special case of regulated energy entities arises because the revenue impact of interest rates is fixed each five years for that amount of time, whereas a non-regulated industry will typically face changing interest rate impacts continually across time.

54. Both the regulated firm and the competitive firm may manage the base rate timing risk through swaps, to greater or lesser degree.[82] To the extent that residual basis risk is similar, the regulator need not be concerned.

55. On the other hand, it may be observed that if the regulator set the cost of debt through a portfolio approach, then the regulated firm could have no residual mismatch timing risk, where it issued debt in equal tranches consistent with the periods of the trailing average. As the mismatch timing risk relates largely to the debt risk premium, then this would be the same irrespective of whether a pure trailing average or a hybrid portfolio was adopted.

56. Removing this mismatch timing risk from the regulated firm could artificially lower the cost of debt, all other things being equal, given that lenders consider all risks when setting the debt risk premium. This artificial lowering for the regulated firm, as compared to the market firm, would result in a distortion in financing costs between firms in the economy. This provides a further reason, in addition to the efficiency considerations, as to why the trailing average portfolio approach is less efficient than the on-the-day approach.

1.1.1.4 An optimum approach to setting the regulated cost of debt?

57. The 'once every five years' setting of the regulatory cost of debt under the current approach is an artificial constraint on regulated firms, which is not faced by competitive market players. This may increase the extent of the mismatch timing risk for the regulated firm, as compared to the competitive market firm. This difference occurs because the regulated debt risk premium is fixed every five years, but the competitive market debt risk premium may vary continuously.

58. A solution to the artificial constraint imposed by the once every five years setting of the regulated cost of debt could be to update the estimate of the cost of debt annually. The Authority engaged Chairmont Consulting to, among other things, evaluate approaches to setting the return on debt through the on-the-day approach. Chairmont Consulting concluded that annually updating the return on debt is preferred.[83]

59. The Authority considered two annual update options proposed by Chairmont Consultant:[84]

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[81] Chairmont Consulting 2013, *Comparative Hedging Analysis*, www.erawa.com.au, p. 15.

[82] Chairmont Consulting also note that hedging through swaps also hedges a portion of the debt risk premium, consistent with the spread between the risk free rate and the base swaps rate (see Chairmont Consulting 2013, *Comparative Hedging Analysis*, www.erawa.com.au, p. 14).

[83] Chairmont Consulting 2013, *Cost of Debt Comparative Analysis*, www.erawa.com.au, 27 November, p. 4.

[84] Chairmont Consulting 2013, *Cost of Debt Comparative Analysis*, www.erawa.com.au, 27 November, p. 4.

- a full annual update of the base rate and the debt risk premium components ('option B' in Chairmont's evaluation); and
- a partial annual update the debt risk premium, with the base rate set once every five years at the start of the regulatory period ('option C' in Chairmont's evaluation).

60. These options may be contrasted with the current approach, of resetting the components of the return on debt only at the start of the regulatory period, and then maintaining that return on debt for the duration of the regulatory period ('option A' in Chairmont's evaluation).

61. The Authority considers that the *efficiency* aspects of the allowed rate of return objective, and the objectives of the NGL more broadly, would be best met by adopting option B, for a full annual update of the risk free rate and the debt risk premium.

62. However, gas retailers have expressed concern at the resulting potential for network tariff volatility arising from annual updates, and a preference for stable tariffs. On this basis, gas retailers have expressed support for retaining the current approach of updating the cost of debt once every five years.[85] This preference has bearing on the consideration of the Authority with regard to the long term interests of consumers.

63. Therefore, the Authority has determined that it will continue to set the risk free rate once, at the start of the regulatory period. This will substantially dampen any changes arising from fluctuations in the cost of debt, at least within the regulatory period.

64. The Authority has therefore concluded that the allowed rate of return objective, and the objectives of the NGL more broadly, would be best met by adopting option C, for a partial annual update of the debt risk premium (see Chapter 6 – Return on debt).

[85] Wesfarmers Chemicals, Energy and Fertilisers 2013, Submission to the ERA Consultation Paper 'Guidelines for the Rate of Return for Gas Transmission and Distribution Networks', www.erawa.com.au, 19 November; Alinta Energy 2013, *Rate of Return Guidelines Review*, www.erawa.com.au, 19 November.

Appendix 4 Descriptions of companies used in the benchmark sample

Ticker	Industry Sector	Company Description (as at April 2013)
ENV AU Equity	Utilities	Envestra Limited operates natural gas distribution networks and transmission pipelines in South Australia, Queensland and the Northern Territory. The Company's networks distribute gas to households and businesses in Adelaide, Brisbane (north of Brisbane River), Alice Springs and various regional centers in South Australia and Queensland.
APA AU Equity	Energy	APA Group is a natural gas infrastructure company. The Company owns and or operates gas transmission and distribution assets whose pipelines span every state and territory in mainland Australia. APA Group also holds minority interests in energy infrastructure enterprises.
DUE AU Equity	Utilities	DUET Group invests in energy utility assets located in Australia and New Zealand. The Group's investment assets include gas pipelines and electricity distribution networks.
HDF AU Equity	Financial	Hastings Diversified Utilities Fund invests in utility infrastructure assets such as gas transmission and distribution assets, electricity generation, transmission and distribution assets, hydro and wind power generation assets and regulated and unregulated assets.
SPN AU Equity	Utilities	SP Ausnet owns and operates electricity transmission and electricity and gas distribution assets in Victoria, Australia.
SKI AU Equity	Utilities	Spark Infrastructure Group invests in utility infrastructure assets in Australia.

Source: Bloomberg

Appendix 5 The Diebold Mariano test

Updated analysis on the forecasting efficiency of an averaging period using the Diebold-Mariano test

1. The Authority has recently extended its analysis presenting the empirical evidence of the predictive power of various averaging periods – using the Diebold-Mariano test – that was set out in its 2012 Western Power decision.

2. In this updated analysis, two scenarios are considered:

   i) with annual updates where the risk free rate is updated each year for all of the 5 years over the regulatory period; and

   ii) without annual updates where the risk free rate is fixed for the whole 5 year regulatory period.

3. This analysis is in response to the proposal that the averaging period of a risk-free rate of 5 years, with annual updating, should be used to estimate a risk-free rate for the subsequent regulatory control period of 5 years. The key conclusions can be summarised as below.

4. First, when no annual update is used:

   - an averaging period of 20 trading days is superior to averaging periods of 5 and 10 years to predict the risk free rate for the regulatory control period over the subsequent 5 years; and
   - an averaging period of 60 trading days is still a superior forecast to averaging periods of 5 and 10 years for the risk free rate over the subsequent 5 years.

5. Second, when the annual update is used:

   - an averaging period of 20 trading days is again, superior to averaging periods of 5 and 10 years for the regulatory control period; and
   - an averaging period of 60 trading days is still a superior forecast to averaging periods of 5 and 10 years for the subsequent regulatory control period.

6. Third, the only instance where a longer term forecasting period is superior in the analysis is when an averaging period of 5 years with annual update is tested against an averaging period of 20 (or 60) trading days with no annual update. Only then is the predictive power of an averaging period of 5 years superior to that of a shorter averaging period. The Authority notes however, that this is not a "like-with-like" comparison.

7. Fourth, with a regulatory control period of 5 years, an averaging period of 60 trading days would still ensure that forecasting efficiency (or its predictive power) is statistically comparable to the more efficient short term forecasts. There is no statistical difference between an averaging period of 20 days and an averaging period of 60 days; that is, both averaging periods have the same forecasting power of the risk free rate for the subsequent regulatory control period of 5 years.

Considerations of the Authority

8. An explanation of some key concepts from basic econometric texts is given below in order to highlight where DBP's analysis requires augmentation so that more robust conclusions can be drawn from it.

Diebold- Mariano Test

9. The Diebold Mariano (**DM**) test was outlined in the 2012 Western Power third Access Arrangement.

10. It must be noted that the ERA now uses an absolute value loss function shown below as opposed to a squared value, as it has no reason to believe the forecast errors are quadratic.[86] All other details on the procedure are the same otherwise.

$$L(\varepsilon^{i}_{t+h|t}) = |[\varepsilon^{i}_{t+h|t}]|, \ i = 1,2 \qquad (2)$$

Stationarity

11. In order to better understand the issue a brief explanation of stationarity follows.

12. A series of observations on a variable X_t through time is 'covariance-stationary' (also referred to as weakly stationary or just stationary) if it has a finite mean and variance. That is, its mean and covariance are not dependent on the point in time they are observed.

13. The covariance however can be a function of the distance between two observations, X_t and X_{t-s} where the covariance is constant for all t given s, but can vary with a change in s, that is the distance between two points in time. It should be noted that when s is equal to zero the covariance is equal to variance.

14. The concept of stationarity is important in time series because data from the past is used to quantify relationships to inform future outcomes. If a series is not stationary this implies the future can differ fundamentally from the past. In the context of data if the mean and covariance is dependent on time the distribution of a time series variable can change over time.

15. This point is important in relation to the DM tests, because the behaviour of the forecast errors in the series are based on the past observations and if not stationary, may not say much, if anything about the future.

Integrated series

16. There are cases in which a non-stationary series X_t becomes stationary in its difference. That is the series $\Delta X_t = X_t - X_{t-1}$ becomes stationary. A typical example is stock prices which often have a tendency to 'jump' and 'meander' in an erratic manner, while the return which is calculated from the differences in the prices is typically more constrained in its movements and tend to test as stationary.

86 Enders. W, 2004, 'Applied Econometric Time Series', Second Edition, John Wiley & Sons, Inc. p. 86.

17. A series that is stationary in levels (not differenced) is integrated of order zero; I(0). A series that becomes stationary after it is differenced once (first difference) is known as being integrated of order one, that is I(1). If the series is stationary after being differenced twice it is integrated of order two and generalising if it is stationary after differencing d times it is integrated of order d; I(d).

$$X_t \sim I(d) \tag{3}$$

18. When considering two different time series the following property applies:

$$\text{If } X_t \sim I(d) \text{ and } Y_t \sim I(d), \text{ then } Z_t = (aX_t + bY_t) \sim I(d^*)$$

19. Where the case d* < d can arise if the series are co-integrated, that is the linear combination of a non-stationary series can become stationary, in a sense by ‘offsetting’ each others’ movements. The rule also implies that the linear combination of a stationary series is itself stationary.

Power of stationarity tests

20. It has long been recognised that tests for stationarity based on the hypothesis that the series contains a unit root (as explained in the Third Western Power Access Arrangement) are plagued by issues of lower power when faced with short samples.[87] Power refers to the probability of correctly rejecting the null hypothesis in the case that it is false. In the context of time series stationarity this concerns correctly rejecting the finding of a unit root; that is, a non-stationary series. More specifically the power of such tests increase with the time span of a series for any given sample size. For example, 30 observations spanning 4 years have more power than 30 observations spanning 1 year.

Empirical tests

21. Augmented Dickey Fuller **(ADF)** tests were carried out using Bloomberg data on the 10 year Commonwealth Government Bond Index. The data spans December 1969 to February 2013. After calculating the appropriate averages for the forecasts and realised value over the regulatory period and trimming each sample down to match the shortest (10 year series) a sample of 7456 daily observations was realised spanning July 1979 to February 2008.

22. The results from the tests on the forecast error series both with and without annual update are presented below.

[87] Frankel, J & Rose, A (1995), *A Panel Project on Purchasing Power Parity: Mean Reversion within and Between Countries*, NBER Working Paper Series, Working Paper No.5, p.1.

Table 6 Averaging period forecast errors

Error Series	test statistic	1 per cent	5 per cent	10 per cent	Outcome	Sample
No Annual Update						
10 Year	-2.108	-2.58	-1.95	-1.62	Stationary at 5 percent	7456
5 Year	-1.980	-2.58	-1.95	-1.62	Stationary at 5 percent	7456
60 Day	-3.534	-2.58	-1.95	-1.62	Stationary at 1 percent	7456
20 Day	-3.572	-2.58	-1.95	-1.62	Stationary at 1 percent	7456
Annual Update						
10 Year	-1.934	-2.58	-1.95	-1.62	Stationary at 10 percent	7456
5 Year	-2.030	-2.58	-1.95	-1.62	Stationary at 5 percent	7456
60 Day	-5.293	-2.58	-1.95	-1.62	Stationary at 1 percent	7456
20 Day	-7.291	-2.58	-1.95	-1.62	Stationary at 1 percent	7456

Source: Economic Regulation Authority's analysis

23. All series test to be stationary at either the 1; 5 or 10 per cent level critical value. This tends to indicate that the forecast errors in the past can inform the behaviour of forecast errors in future as there is no evidence that the mean and covariance change through time.

24. The DM test requires a loss differential to be calculated:

$$\bar{d} = \frac{1}{T}\sum_{i=1}^{T}\left[L(\varepsilon_{t+h|t}^{1}) - L(\varepsilon_{t+h|t}^{2})\right] \quad (4)$$

25. This is the difference between the absolute values of the 20 day averaging period forecast errors and absolute value of other averaging period forecast errors.

26. At this point it is worth recalling the preceding discussion on integrated series. A linear combination of stationary series will itself be stationary. The loss differential calculated on absolute values will therefore be stationary.

27. This is observed empirically in the results below, both for the series with and without annual update.

Table 7 Loss differential series ADF test: July 1979 - 2013

Error Series	Test statistic	1 per cent	5 per cent	10 per cent	Outcome [Stationary at]	Sample
No Annual Update						
10 Year	-3.092	-2.58	-1.95	-1.62	1 percent	7456
5 Year	-3.406	-2.58	-1.95	-1.62	1 percent	7456
60 Day	-16.289	-2.58	-1.95	-1.62	1 percent	7456
Annual Update						
10 Year	-1.768	-2.58	-1.95	-1.62	10 percent	7456
5 Year	-2.310	-2.58	-1.95	-1.62	5 percent	7456
60 Day	-17.064	-2.58	-1.95	-1.62	1 percent	7456

Source: Economic Regulation Authority's analysis

28. All loss differential series test as stationary at either 1, 5 or 10 per cent critical values.

Submissions

29. DBNGP Transmission (**DBP**) proposed that the Authority had made statistical errors when making use of the Diebold –Mariano (**DM**) to compare the forecasting efficiency of 20 day averages of the risk free rate of return vis-à-vis other averaging periods. This was on the basis that the forecast error series resulting from each of the averaging periods were not covariance-stationary when one is subtracted from the other to create the loss differential required when implementing the DM-test.

30. DBP used daily data on a 10 year Commonwealth Government Security from January 1995 to May 2013 to construct the error terms.

31. They noted that their sample spanned January 1995 to May 2013. Given that the 10 year trailing average consumes 10 years worth of observations from the starting date and that all series need to be of the same length in the DM test, DBP would have been left with a sample effectively starting from January 2005.

32. In addition, as DBP note 5 years worth of observations dating back from 2013 are also consumed to create the realised 5 year regulatory period average. In light of the above discussion on the power of stationarity tests, DBP's sample would have significantly less power than the sample used in the above analysis.

33. The data set in the above analysis was truncated to go back only as far as January 2005. This produced 817 observations. The above results are reproduced below based on this sample.

Table 8 Loss differential ADF tests: 2005 – 2013

Error Series	Test statistic	1 per cent	5 per cent	10 per cent	Outcome [Stationary at]	Sample
No Annual Update						
10 Year	-4.996	-3.96	-3.41	-3.12	1 percent	817
5 Year	-4.419	-3.96	-3.41	-3.12	1 percent	817
60 Day	-6.765	-2.58	-1.95	-1.62	1 percent	817
Annual Update						
10 Year	-3.136	-3.96	-3.41	-3.12	10 percent	817
5 Year	-3.335	-3.96	-3.41	-3.12	5 percent	817
60 Day	-4.428	-3.96	-3.41	-3.12	1 percent	817

Source: Economic Regulation Authority's analysis

34. The plots for the loss differential series based on the 10- and 5-year trailing average without annual update indicated a strong upward trend, likely a result of the rapidly decline in interest rates post 2008 that will cause the 10- and 5-year average period forecast errors to rapidly diverge from the 20 day forecast errors. As a result the 10 and 5 year ADF tests included a trend. The 20-60 day averaging period loss exhibited no drift or trend.

35. The plots for the loss differential for all series without annual update exhibited a downward trend. Accordingly, the ADF test for these included a trend.

36. Again, all tests indicate the loss differentials are stationary at either 1; 5 or 10 per cent, despite the low power of the test meaning this outcome would only if the result is robust.

Peer review

37. The Authority engaged Data Analysis Australia (**DAA**) to review its test data and conclusions from its application of the DM test.[88]

38. DAA concluded:

- the forecast errors had been correctly calculated;
- the tests for stationarity of the loss differentials were carried out in an appropriate manner;
- it is appropriate to use the 'R' statistical sofware's forecast package to carry out the DM test; and
- that the *dm.test* function was correctly applied.

39. DAA further concluded that in its view that on the basis of the DM test data:

- the 20 day averaging outperforms 5 year averaging and 10 year averaging; and

[88] Data Analysis Australia 2013, *Review of Risk Free Rate Calculation*, www.erawa.com.au, p. i.

- there is little evidence to favour 20 day averaging over 1 year averaging and there is some evidence that for the period since 1993 the 1 year averaging is superior; and
- the optimal amount of time included in the average is likely to be between 20 days and 1 year.

Conclusions

40. The ERA's loss differentials used in the DM tests are found to be stationary even when using samples based on a short time span such as those used by DBP. The difference between the ERA's results and DBP's are not explained by the use of a short time span, although DBP should note that the short time spans used in their tests are pre-disposed to not rejecting the hypothesis of a unit root (suggesting non-stationary series) given their low power.

41. Additionally, common unit root tests for stationarity such as the ADF are very sensitive to the specification of the test; that is whether a trend or intercept is included.

Other Issues on the forecasting efficiency of averaging periods

42. The Queensland Treasury Corporation (**QTC**) has for some time proposed the use of a 'trailing average approach' to estimating the cost of debt in cost of capital determinations for regulated entities. Specifically, they advocate the use of a 10-year trailing average, updated annually at the beginning of each regulatory year in the five-year regulatory control period.

43. The Authority currently advocates the use of the 'current' cost of debt as the most efficient forecast of the average cost of debt over the forward looking 5 year regulatory period. The rationale is based on the efficient market hypothesis which postulates that where rates follow a random walk, today's rate is the most 'efficient' forecaster of tomorrow's rate.

44. In order to determine whether this method is efficient the Diebold-Mariano tests of forecasting efficiency were used to test the predictive power of the 20-day average, the current averaging period, versus the 10-year trailing average forecast, proposed by QTC.

Background

45. The Diebold-Mariano test previously outlined in the Authority's averaging period analysis has been identified as an effective and objective test of forecasting efficiency.

Findings

Data

46. Bloomberg's data on the 10-year Commonwealth Government Security indices were used in the analysis as this provided the longest time series. The 20-day, 60-day and 10-year averaging periods were compared. For each of these averaging periods, two additional series were created: (1) the annually updated series at the beginning of the year; and (2) the fixed series without annual updates.

Annually updated series

47. The annually updated series updated the risk-free rate estimate at the beginning of each year over a 5-year period to reflect the assumption that 20 per cent of an entire debt portfolio is refinanced each year. This update was tested based on either the 20 days, or the 60 days or the 10 years prior to the relevant year of the regulatory control period. The average was then calculated for the 5 year period and compared to the observed average to derive an error forecast series which could be tested against a competing forecast's error series.

Fixed series

48. The fixed series only updated the forecast at the beginning of a 5-year period based on either the 20-days period, or the 60-days period or the 10-years period prior to a relevant regulatory control period. This average was then compared to the observed average of a historical risk-free rate for the 5-year period to derive an error series to be tested against the others.

49. The data covers the period from July 1979 to February 2008. Five years of data are lost from 2013 retrospectively, as the 5-year observed averages of a risk-free rate require the 5 years of data ahead. The data set comprised 7,460 observations.

Results

50. Two different scenarios were tested:

- Both the 20- (or the 60-) days period and the 10-year fixed series were tested against each other, to be named as *Scenario 1*.
- Both the 20- (or the 60-) days period and the 10-year annually updated series were tested against each other, to be named as *Scenario 2*.

Table 9 Diebold-Mariano test results for the 20-Day averaging versus the 10-Year Averaging Period

	Scenario 1	Scenario 2
Absolute Loss Function	-2.90	-3.11
Outcome:	Reject	Reject
20 Day Forecast is:	Superior	Superior

Source: Economic Regulation Authority's analysis

51. Results which have absolute values greater than 1.96 are statistically significant with 95 per cent confidence. Negative values indicate that the twenty day average is the superior forecast, whereas positive results indicate the opposite. The results in Table 9 indicate that, in both scenarios, the 20-day forecast is superior compared with the 10-year averaging period.

Table 10 Diebold-Mariano test results for the 60-Day averaging versus the 10-Year averaging period

	Scenario 1	Scenario 2
Absolute Loss Function	-2.92	-3.16
Outcome:	Reject	Reject
60 Day Forecast is:	Superior	Superior

Source: Economic Regulation Authority's analysis

52. Table 10 indicates that, in both scenarios, the 60-day forecast is superior to the 10-year averaging period. The same tests as above were conducted using a 5 year trailing average series in place of 10 years. The results are shown in Table 11 below.

Table 11 Diebold-Mariano test results for the 20-Day averaging versus the 5-Year averaging period

	Scenario 1	Scenario 2
Absolute Loss Function	-2.57	-2.46
Outcome:	Reject	Reject
20 Day Forecast is:	Superior	Superior

Source: Economic Regulation Authority's analysis

53. The findings are that the 20-day averaging period is superior to the 5-year trailing average in the two scenarios.

Table 12 Diebold-Mariano test results for the 60-Day averaging versus the 5-Year averaging period

	Scenario 1	Scenario 2
Absolute Loss Function	-2.66	-2.48
Outcome:	Reject	Reject
60 Day Forecast is:	Superior	Superior

Source: Economic Regulation Authority's analysis

54. Table 12 above indicates that the 60-day averaging period is superior to the 5-year trailing average in the two scenarios.

Concluding remarks

55. This Appendix has presented the empirical evidence in terms of the predictive power of various averaging periods using Diebold Mariano test. Both annual updates and no annual updates are considered. The key conclusions can be summarised as below.

- *First*, when no annual update is considered, an averaging period of the 20 trading days is superior to the averaging periods of 5 years and of 10 years for the regulatory control period of the subsequent 5 years.

- *Second*, when no annual update is considered, an averaging period of the 60 trading days is still superior to the averaging periods of 5 years and of 10 years for the regulatory control period of the subsequent 5 years. It is noted that the analysis only considered the averaging period that were different in approximately 10 ten increments instead of using many one day increments.
- *Third*, when the annual update is considered, an averaging period of 20 trading days is superior to the averaging periods of 5 years and of 10 years for the regulatory control period of the subsequent 5 years.
- *Fourth*, when the annual update is considered, an averaging period of 60 trading days is superior to the averaging periods of 5 years and of 10 years for the regulatory control period of the subsequent 5 years.
- *Fifth*, with the regulatory control period of 5 years, the averaging period of 60 trading days is the longest possible period to ensure that its forecasting efficiency (or its predictive power) is still statistically better than the averaging periods of either 5 years or 10 years in both cases: (i) annual updates; and (ii) no annual updates.[89] It is noted that, with the regulatory control period of 5 years, in terms of forecasting efficiency, there is no statistical difference between the averaging period of 20 days and the averaging period of 60 days (i.e. both averaging periods have the same forecasting power of the risk free rate for the subsequent regulatory control period of 5 years).

89 Averaging periods using a larger number of days were statistically inferior, possibly with the exception of a one year period

Appendix 6 Credit ratings of gas and electricity businesses, excluding government, 2008-2012

Industry	Company	2008	2009	2010	2011	2012
Gas	Alinta Network Holdings Pty Ltd/WA Network Holdings Pty Ltd/ATCO Gas Australia LP.	BBB	BBB-	BBB-	BBB-	BBB
	DBNGP Finance Co Pty Ltd	BBB	BBB-	BBB-	BBB-	**N/A**
	DBNGP Trust	BBB-	BBB-	BBB-	BBB-	BBB-
	Energy Partnership (Gas) Pty Ltd	BBB-	BBB-	BBB-	BBB-	BBB-
	Envestra Ltd	BBB-	BBB-	BBB-	BBB-	BBB-
	Envestra Victoria Pty Ltd	BBB-	BBB-	BBB-	**N/A**	**N/A**
	Gas Net Australia (Operations) Pty Ltd/APT pipelines Ltd	BBB	BBB	BBB	BBB	BBB
Gas & Electricity	SP AusNet Group	A-	A-	A-	A-	A-
	SPI Australia Holdings (Partnership) LP	A-	A-	**N/A**	**N/A**	**N/A**
	SPI Electricity & Gas Australia Holdings Pty Ltd	A-	A-	A-	**N/A**	**N/A**
	DUET Group	BBB-	BBB-	BBB-	BBB-	BBB-
	Alinta LGA Ltd/Jemena/SPI (Australia) Assets Pty Ltd.	A-	A-	A-	A-	A-
Electricity	The CitiPower Trust	A-	A-	A-	A-	A-
	ElectraNet Pty Ltd	BBB+	BBB+	BBB	BBB	BBB
	ETSA Utilities Finance Pty Ltd	A-	A-	A-	A-	A-
	Powercor Australia LLC	A-	A-	A-	A-	A-
	SPI Electricity Pty Ltd	A-	A-	**N/A**	**N/A**	**N/A**
	SPI PowerNet Pty Ltd	A-	A-	**N/A**	**N/A**	**N/A**
	United Energy Distribution Holdings Pty Ltd	BBB	BBB	BBB	BBB	BBB
	United Energy Distribution Pty Ltd	BBB	BBB	BBB	BBB	**N/A**
	Median Credit Rating	**BBB+**	**BBB+**	**BBB**	**BBB**	**BBB**

Source: *Economic Regulation Authority's analysis.*

Appendix 7 Credit ratings of gas and electricity businesses, excluding government and parent, 2008-2012

Industry	Company	2008	2009	2010	2011	2012
Gas	Alinta Network Holdings Pty Ltd/WA Network Holdings Pty Ltd/ATCO Gas Australia LP.	BBB	BBB-	BBB-	BBB-	BBB
	DBNGP Finance Co Pty Ltd	BBB	BBB-	BBB-	BBB-	**N/A**
	DBNGP Trust	BBB-	BBB-	BBB-	BBB-	BBB-
	Energy Partnership (Gas) Pty Ltd	BBB-	BBB-	BBB-	BBB-	BBB-
	Envestra Ltd	BBB-	BBB-	BBB-	BBB-	BBB-
	Envestra Victoria Pty Ltd	BBB-	BBB-	BBB-	**N/A**	**N/A**
Gas & Electricity	SP AusNet Group	A-	A-	A-	A-	A-
	SPI Australia Holdings (Partnership) LP	A-	A-	**N/A**	**N/A**	**N/A**
	SPI Electricity & Gas Australia Holdings Pty Ltd	A-	A-	A-	**N/A**	**N/A**
	Alinta LGA Ltd/Jemena/SPI (Australia) Assets Pty Ltd.	A-	A-	A-	A-	A-
Electricity	The CitiPower Trust	A-	A-	A-	A-	A-
	ElectraNet Pty Ltd	BBB+	BBB+	BBB	BBB	BBB
	ETSA Utilities Finance Pty Ltd	A-	A-	A-	A-	A-
	Powercor Australia LLC	A-	A-	A-	A-	A-
	SPI Electricity Pty Ltd	A-	A-	**N/A**	**N/A**	**N/A**
	SPI PowerNet Pty Ltd	A-	A-	**N/A**	**N/A**	**N/A**
	United Energy Distribution Holdings Pty Ltd	BBB	BBB	BBB	BBB	BBB
	United Energy Distribution Pty Ltd	BBB	BBB	BBB	BBB	**N/A**
	Median Credit Rating	**BBB+**	**BBB+**	**BBB**	**BBB**	**BBB**

Source: Economic Regulation Authority's analysis.

Appendix 8 Evaluation of models for the return on equity

1. The National Gas Rules (**NGR**) are explicit that the Authority needs to have regard to relevant estimation methods, financial models, market data and other evidence (NGR 87(5)(a)). The question then arises as to which of the possible alternative financial models meet this requirement, while also meeting the broader requirements of the National Gas Law, the National Gas Objective and the Revenue and Pricing Principles.

2. The Authority's primary considerations in assessing relevance are the objectives and requirements of the National Gas Law (**NGL**) and the NGR, with particular reference to the allowed rate of return objective under NGR 87(3).

3. In what follows, the Authority considers which models are 'relevant' for informing the return on equity, and which thus have potential to contribute to the achievement of the allowed rate of return objective, providing estimates that are commensurate with efficient financing costs.

4. Where it is required to exercise judgment with regard to its considerations, the Authority will outline its reasoning in terms of the criteria set out in Chapter 2.

Models of the return on equity

5. The standard regulatory implementation of the Capital Asset Pricing Model (**CAPM**) is known as the Sharpe-Lintner CAPM, after two of the original authors.

6. Other asset pricing models in the CAPM family build on the standard Sharpe-Lintner CAPM, including:

- the Black and Empirical CAPM;
- the Consumption CAPM; and
- the Inter-temporal CAPM.

7. There is also a broad range of other models which seek to estimate the return on equity, including:

- the Arbitrage Pricing Theory family of models;
- the Fama-French Three-Factor Model and its extensions;
- the Dividend Discount Model family (both single-stage and multi-stage);
- the Residual Income Model;
- Market Risk Premium approaches; and
- the Build-up Method.

8. In addition, there are approaches that are not based on modelling per se, but rather on available data from a range of comparators or analysts' reports. These include:

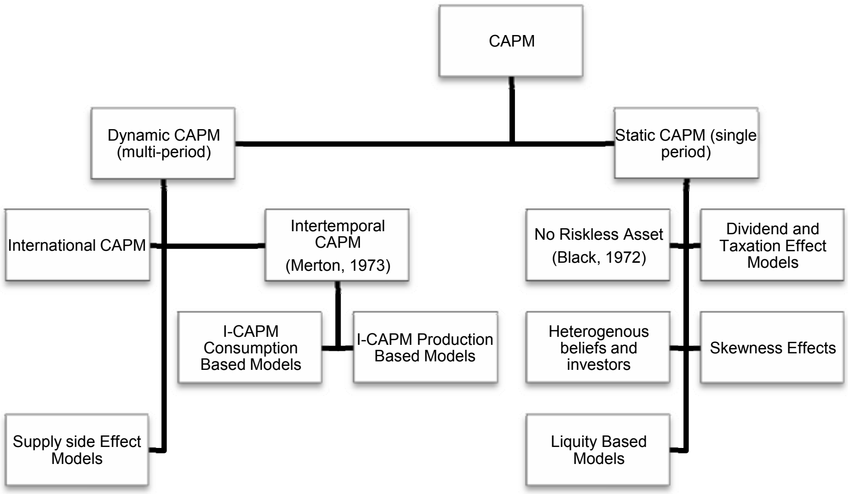
- estimated market returns on comparable businesses;
- brokers' reports and the Dividend Yield approach.

Sharpe Lintner CAPM

9. The Sharpe Lintner CAPM estimates the return on an asset by quantifying the 'risk premium' for the specific asset over and above the return to a risk free asset. The CAPM can be traced back to the first version developed in 1956, which became known as the Sharpe-Lintner CAPM.

10. The CAPM 'family' of models for the return on equity may be divided between static single period and dynamic multi-period models (Figure 4).

Figure 4 Summary of the CAPM literature



Source: McKenzie M. and Partington G. 2013, Risk, Asset Pricing and the WACC, Report to the AER, www.aer.gov.au, p. 24.

11. The Sharp-Lintner CAPM explains the expected return, in terms of the rate of return on a risk-free asset, and a premium for risk,

$$E_t\left(r_{i,t+1}\right) = r_{f,t} + \left(E_t\left(r_{M,t+1}\right) - r_{f,t}\right).\ \beta_{i,t} \qquad (5)$$

where

$E_t\left(r_{i,t+1}\right)$ is the expected return over the next period $(t+1)$ on any financial asset i at time t

$r_{f,t}$ is the return on the risk free asset which is equal to $E_t\left(r_{f,t+1}\right)$ at time t

$E_t\left(r_{M,t+1}\right)$ is the expected rate of return on a market portfolio of assets over the next period $t+1$ at time t

$\left(E_t\left(r_{M,t+1}\right) - r_{f,t}\right)$ represents the expected market risk premium (MRP) at time t over $t+1$

$\beta_{i,t}$ is the expected equity beta of asset i which is equal to $E_t(\beta_{i,t+1})$ and is defined as:

$\beta_i = \text{cov}(r_i, r_M)/\text{var}(r_M)$; and

$\left(E_t\left(r_{M,t+1}\right) - r_{f,t}\right).\beta_{i,t}$ is the premium for risk for holding the asset i.

12. The equity beta provides the key estimate of the risk associated with the underlying asset, as it measures the sensitivity of the returns for that asset to the systematic variation in the returns of the market as a whole. All other non-systematic risks associated with the underlying asset are assumed to be diversified away through the efficient market portfolio.

13. The Sharpe-Linter CAPM is based on the following assumptions:[90]

- Investors are risk averse and, when choosing among portfolios, only care about the mean and variance of their investment return. As a consequence, investors choose 'mean-variance efficient' portfolios.
- Investors agree on the joint probability distribution of asset returns, and this is the correct distribution of asset returns.
- Investors face no taxes or transaction costs.
- Borrowing and lending occur freely at the same risk free rate, which is the same for all investors and does not depend on the amount borrowed or lent.

14. Only the systematic risk of the asset enters the CAPM estimation process. The model considers that other, non-systematic risks are either diversified away, or included in the operating cash flows.

15. The greater the i) level of non-diversifiable risk of the asset, ii) the gearing of the firm, and iii) the risk free rate, the greater is the required or expected rate of return on equity estimated through the Sharpe Lintner CAPM. On this basis, the Sharpe Lintner CAPM is supported by 'a strong theoretical foundation'. The resulting estimates of the return on equity have the potential 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, and thus meet the allowed rate of return objective.[91]

16. The systematic risk of the overall market is captured in the market risk premium (MRP). The Authority is of the view that the MRP may vary in response to market conditions (for a detailed discussion of this issue, refer to Chapter 11 on the Market risk premium). The Authority considers that care is needed in estimating the MRP at

90 Fama E.F and French K.R (2004), 'The Capital Asset Pricing Model: Theory and Evidence' *Journal of Economic Perspectives* – Volume 18 Summer 2004.

91 Specifically, the Sharpe-Lintner CAPM is grounded in Markowitz's portfolio theory on the relationship between risk and return. This mean-variance theory provided the first rigorous measure of risk for investors and showed how one selects alternative assets to diversify and reduce the risk of a portfolio. It also derived a risk measure for individual securities within the context of an efficient portfolio. Based on this theory, Sharpe and several academicians extended the Markowitz's model into a general equilibrium asset pricing model that included an alternative risk measure for all risky assets (see for example, Reilly and Brown 2006, *Investment Analysis and Portfolio Management*, 8th Edition, p. 229).

By accounting for gearing in the equity beta, the Sharpe-Lintner CAPM is also consistent with Modigliani and Miller's propositions that i) a firm cannot change the total value of its securities just by splitting its cash flows into different streams, such as returns to debt and equity, and ii) the expected rate of return on equity of a levered firm increases in proportion to the debt-equity ratio (see, for example, Brealey R.A. and Myers S.C. 1996, *Principles of Corporate Finance, McGraw Hill*, p. 447).

any particular point in time, and will take account of prevailing conditions when determining this parameter (see Chapter 11 on Determining the return on equity).

17. The exposure of the underlying asset to the systematic risk of the overall market is quantified initially through the equity beta. As a final step, the equity beta is adjusted to reflect the level of gearing of the benchmark efficient entity. In this way, the equity beta thus takes account of the additional systematic risk that equity investors achieve through levering up the equity returns of the asset through debt.

18. Goldfields Gas Transmission (**GGT**) submitted that although the Sharpe Lintner CAPM could be expected to have a role to play in estimating the return on equity, it lacks explanatory power in an Australian context, implying that reliance on the Sharpe Lintner CAPM alone would not achieve the allowed rate of return objective.[92] The Authority notes in response that the explanatory power of the Sharpe Lintner CAPM – in terms of the R^2 value of individual firms – is low. However, the Authority considers that the Sharpe Lintner CAPM performs reasonably well as an explanator for the comparator portfolio. The residual, unexplained component of the return on equity relates to factors that are difficult to identify, robustly, in any model. This latter issue is considered in the section on the Fama French model below.

19. Dampier to Bunbury Pipeline (**DBP**) submitted that a failure to consider a wider range of models will cause significant problems, including:

- difficulties in estimating beta will lead to a large range, and there is nothing in the Sharpe Lintner CAPM theoretical framework which can indicate where the 'true' value of beta might lie;
- small sample issues, which necessarily means considering data from overseas, or else considering other asset pricing models or other market data which are not subject to the same estimation problems as the Sharpe Lintner CAPM.

20. However, the Authority notes that its estimates of beta are significant, and that the resulting range provides for a good representation of the beta of the benchmark efficient entity. In support of this view, the Authority notes that the estimates are consistent with those from similar firms in the United States, once adjusted for gearing (see Chapter 12 – Equity beta).

21. The Authority considers that the use of the 'on-the-day' risk free rate within the model, with a term equivalent to that of the regulatory period, provides an acceptable estimate of the prevailing return for the risk free portfolio.[93] The use of the prevailing rates for the cost of equity would be consistent with the Authority's preferred approach to estimating the cost of debt (see Chapter 6 – Return on debt and Appendix 2 – The present value principle).[94]

92 Goldfields Gas Transmission Pty Ltd 2013, *Submission on the Economic Regulation Authority's Draft Rate of Return Guidelines,* www.erawa.com.au, p. 42.

93 The Authority notes that a five year term for the risk free rate in the Sharpe Lintner CAPM would be consistent with the present value principle (see Appendix 2 – The present value principle).

94 The Authority notes that some experts adjust up risk free rate when applying the Sharpe Lintner CAPM. For example, SFG Consulting reported that some brokers apply an uplift for the risk free rate 'to reflect the longer term position' (see Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Report 4 (Use of Independent Expert Reports), www.erawa.com.au, 7 October, p. 15).

However, the Authority considers that this uplift is likely to reflect analyst's horizons which are longer than the five years of the regulatory period. The Authority does not consider such an adjustment is required in the regulatory setting. In particular, the Authority considers that the present value principle should apply:

22. In this way, the return on equity determined through the Sharpe Lintner CAPM takes account of prevailing risk free rates and fluctuations in the MRP. On this basis, the Authority considers that the CAPM is able to 'reflect changes in market conditions' and 'incorporate new information as it becomes available', which would be consistent with achieving the allowed rate of return objective.

23. There are many studies of the performance of the model, including within the Australian context. The Australian body of work provides confidence that the model performs consistently with outcomes in other jurisdictions. On these grounds, the model fits well with the Authority's preference to retain a domestic estimation approach which is 'supported by robust, transparent and replicable analysis'.

24. As noted by McKenzie and Partington, 'without doubt, the CAPM is the most widely used model for estimating the cost of equity in regulated companies'.[95] This widespread use reflects the model's simplicity and foundation in theory. Myers notes that the CAPM is simple and logical, and with careful application, tends 'to give estimates of the cost of equity that are sensible and reasonably stable over time'.[96] The Brattle Group note that 'the CAPM is a well-founded and commonly used model that relies primarily on readily available information'.[97]

25. However, the CAPM has been criticised on the grounds that:[98]

- empirical evaluation suggests that the Sharpe Lintner CAPM does not perform well in explaining the return on equity when tested with actual outcomes;
- the Sharpe Lintner CAPM model is not stable or may not be used in an internally consistent way, particularly when a prevailing cost of debt is used in conjunction with a long term estimate of the market risk premium;
- other models perform better in estimating the returns to equity;
- the model is based on the assumption that all investors optimally hold well diversified portfolios and therefore only care about systematic risks, whereas investor expectations about returns and investment opportunities are heterogeneous.

26. First, the view that the Sharpe Lintner CAPM performs poorly on empirical grounds reflects analysis, ex post, which indicates that the slope of the security market line is flatter than that predicted by the estimated CAPM equity beta. This suggests that actual returns on stocks with higher equity betas are systematically less than predicted by the CAPM, whereas actual returns on stocks with lower equity betas are systematically higher. Possible explanations for these empirical observations include that the CAPM omits important variables – that capture other dimensions of risk – or that the tests of performance are biased, or that the full 'portfolio of risky assets' open to investors is only partially captured in the equity market used as a proxy for that portfolio.

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prevailing rates for the five year term of the risk free rate are likely to be the best proxy for the risk free rate likely to apply over five year regulatory period.

95 McKenzie M. and Partington G. 2013, *Risk, Asset Pricing and the WACC*, DRAFT Report to the AER, provided as part of workshop materials, p. 24.

96 The Australian Pipeline Industry Association 2013, *Rate of Return Review*, www.erawa.gov.au, Schedule 1, p. 3.

97 The Australian Pipeline Industry Association 2013, *Rate of Return Review*, www.erawa.gov.au, Schedule 2, p. 19.

98 The Australian Pipeline Industry Association 2013, *Rate of Return Review*, www.erawa.gov.au, Schedule 2, p. 18. Similar points were also made in submissions on the draft guidelines by a number of stakeholders.

27. The Authority recognises that typical empirical applications of the Sharpe Lintner CAPM may under-estimate equity beta for low beta stocks, with the potential to lead to a downwards bias in the estimate of the return on equity. As a practical response, the Authority will take this into account when determining the point estimate of the equity beta for use in the Sharpe Lintner CAPM.[99] The Authority's approach in this regard is considered in greater detail in Chapter 10 – The return on equity.

28. Second, the Authority considers the stationarity of the historic components of the Sharpe Lintner CAPM in detail in Appendix 16 – Is return on equity stable. The Authority notes that its tests of the historic time series support the 'stationarity' of the return on equity, which suggests that the observed historic mean is stable, and that the return on equity is 'mean reverting' over time.

29. However, the risk free rate does not exhibit stationarity. Rather, it has the characteristics of a random walk. The best predictor for a random walk is its most recent estimate.

30. Similar tests provide mixed evidence for 'stationarity' for the MRP, which suggest that annual fluctuations in the MRP may not be mean reverting, and that an estimate for the future that is based on the historic estimate of the mean of the MRP may be biased. In consequence, the Authority will use a range of evidence on expectations for the MRP, including the historic mean, in order to assess the value of the MRP looking forward.

31. Third, the Authority is open to considering other models which have merit in explaining the return on equity in the Australian setting, provided that the results are relevant to informing the allowed rate of return objective. The performance of these other models with regard to the allowed rate of return objective is considered below.

32. Fourth, there is an extensive literature which considers the influence of investors' preferences on their investment choices, and potential resulting violations of the mean-variance assumptions underpinning the CAPM.[100] However, even where the CAPM's assumptions are violated, the Authority is aware of evidence that shows that the CAPM nevertheless provides a close approximation for the choices made by investors.[101] More recently, behavioural economics and prospect theory have advanced the understanding of decision making under uncertainty, and provide further support for the CAPM. As summarised by Levy:[102]

> ...when diversification is allowed (e.g. financial assets), the two paradigms, prospect theory and the mean-variance efficiency analysis, yield almost the same efficient frontier, and when a riskless asset is added, these two paradigms yield the same frontier; therefore, the CAPM is also intact.

33. In summary, the Authority considers that the Sharpe Lintner CAPM remains a key tool for evaluating the return on equity. The model aligns with theory. It is also the most empirically stable model of the return on equity within an Australian context.[103] Together, these outcomes lead the Authority to consider that the Sharpe Lintner

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[99] The Authority notes that the closer the equity beta is to one, the less the potential bias.

[100] The term preferences here relates to investors' expected utility.

[101] Levy, H 2012, *The Capital Asset Pricing Model in the 21st Century*, Cambridge University Press, p. 116.

[102] Levy, H 2012, *The Capital Asset Pricing Model in the 21st Century*, Cambridge University Press, p. 374.

[103] The Authority recognises that limited data sets can create issues for robust estimation, particularly with regard to estimation of the benchmark equity beta. However, the Authority considers that it will be able to manage the resulting uncertainty in a transparent and reasonable manner, that would be consistent with the allowed rate of return objective.

CAPM is fit for purpose. On this basis, the Authority judges that the Sharpe Lintner CAPM model is relevant in terms of estimating the return on equity for the purposes of meeting the allowed rate of return objective.

Other models of the CAPM family

34. The range of other models in the CAPM family include:

- the Black and Empirical CAPM;
- the Consumption CAPM; and
- the Inter-temporal CAPM.

The Black and Empirical CAPM

35. The Black CAPM was developed as a response to the ex post empirical assessment of the performance of the Sharpe-Lintner CAPM, and its resulting perceived shortcomings, particularly the 'low beta' bias referred to above at paragraph 23. The Black CAPM belongs to the Empirical CAPM family of models, which adjust the parameters of the Sharpe-Lintner CAPM to align better with the ex post outcomes that are observed.

36. The Black CAPM does not assume the existence of a single risk free rate asset and does not assume the availability of unrestricted borrowing and lending.

37. In Black's derivation, the return on a portfolio of assets for which the return is uncorrelated with the return on the market portfolio – known as the zero-beta portfolio – acts as the equivalent of the risk free return. The Black CAPM specification assumes that the expected return of a zero beta portfolio, $E[r_z]$ falls in the range between the lending and borrowing rate of return, $\mathrm{r}_l < E[r_z] < \mathrm{r}_b$.

38. To estimate the cost of equity, the Black CAPM requires a risk free rate, an estimate of the zero-beta premium, an equity beta and a market risk premium. Except for the zero-beta premium, all other parameters are the same as those used in the Sharpe-Lintner CAPM.[104] The Black CAPM can be stated as follows:

$$E[r_j] - E[r_z] = \beta_j [E(r_m) - E(r_z)], \qquad \mathrm{r}_l < E[r_z] < \mathrm{r}_b \tag{6}$$

where

$E[r_z]$ is the expected return of a "zero beta" portfolio, estimated from data on buying and short selling risk-free assets

$E(r_m)$ is the expected return of the market portfolio

r_l is the lending rate of return

[104] The Authority considers that the Black CAPM has a similar theoretical basis as the Sharpe Lintner CAPM. However, the Black model substitutes one assumption from the Sharpe Lintner CAPM (investors can borrow and lend unlimited amounts at the risk free rate) with another assumption (the existence of a zero-beta portfolio). Both assumptions have been criticised as being unrealistic.

r_b is the borrowing rate of return.

39. Closely aligned to the Black CAPM, models which seek to empirically estimate the return on equity are known as the Empirical CAPM. These models take the general form:

$$E(r_j) = r_f + \alpha + \beta_j . (MRP - \alpha) \quad (7)$$

where

α is a constant which adjusts the standard CAPM risk return line (or Security Market Line).

40. The Authority notes that the use of less restrictive models than the CAPM – which have more parameters – can tend to reduce potential bias, but at the expense of precision. In this regard, NERA Economic Consulting (NERA) notes that:[105,106]

> In principle, one may be willing to trade off bias for precision. In practice, though, one may wish to demonstrate that a trade-off will convey benefits. Demonstrating that there will be benefits from trading off bias for precision may be difficult.

41. The difficulty for estimating the Black CAPM is developing robust estimates of the return on the zero beta portfolio.

42. In the Australian context, NERA Consulting (**NERA**) has presented estimates derived from the Black CAPM, both for Dampier to Bunbury Natural Gas Pipeline and most recently, for Envestra.[107]

43. The Authority considered NERA's proposal provided by Dampier to Bunbury Pipeline (**DBP**) at length as part of its determination for its decision on the Dampier to Bunbury Natural Gas Pipeline access arrangement.[108] The Authority concluded that the Black CAPM was not widely used in Australia, and did not produce reliable estimates within an Australian context.

44. In the report for Envestra, NERA submitted a range for the mean return to a zero-beta asset of between 6.99 and 8.15 per cent per year.[109] NERA suggest that the empirical version of the Black CAPM better explains the cross section of mean returns to Australian stocks than does the Sharpe-Lintner CAPM, that the zero-beta estimates may be based on historic data, and that the Black CAPM will provide a better estimate of the return to the zero beta portfolio than the Sharpe-Lintner CAPM.

105 See for example Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Report 1 'Review of Cost of Equity Models', www.erawa.com.au, 7 October, p. ii.

106 The CAPM is highly restricted because it captures all of the relative risk in a single parameter, the beta.

107 See NERA Economic Consulting 2011, *Estimating the Required Rate of Return on Equity for a Gas Transmission Pipeline: an Update for DBNGP*, www.erawa.com.au and NERA Economic Consulting 2012, *The Black CAPM: A report for APA Group, Envestra, Multinet & SP AusNet*, www.aer.gov.au.

108 Economic Regulation Authority 2011, *Final Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline*, www.erawa.com.au, p. 156.

109 NERA Economic Consulting 2012, *The Black CAPM: A report for APA Group, Envestra, Multinet & SP AusNet*, www.aer.gov.au, p iv.

45. McKenzie and Partington, in their critique of the NERA estimates developed for Envestra, considered that the NERA arguments for use of the Black CAPM unconvincing, and:[110]

- the estimates imply that the return on equity is a constant across shares and through time, which is implausible, not consistent with theory, nor reflective of prevailing market conditions;
- estimates of the magnitude of the zero beta return are not robust, and further, large differences in the value are possible given the estimation approach, such that any estimate should be viewed with great caution;
- there are unresolved issues relating to the standard error of the zero beta estimates, which is important as this is the basis for concluding whether the estimated zero beta returns have any magnitude at all;
- there are internal inconsistencies in the empirical estimates and the final values adopted in the model to estimate the return on equity; and
- there is no link to theory, without which 'all we have is a regression... [which] boils down to being a constant and that constant is simply an estimate of the average return on the market'.[111]

46. NERA have, in response, argued that:[112]

- first, it is not that the return on equity is constant across shares and time, rather that beta is not calculated with the full portfolio of risky assets, missing other sources of risk;
- second, issues of sensitivity relating to the estimate of the zero beta return are of little concern;
- third, the extent to which the standard errors overstate the precision is likely to be small;
- fourth, the estimates are robust.

47. This is a highly technical debate. Of most concern to the Authority is the inference from NERA's modelling that the zero beta portfolio has a return that is consistent with the MRP, leaving no room for variation in returns across stocks based on relative risk. The Authority considers that it is difficult to reconcile this result with either the theoretical underpinnings of portfolio theory, or actual observed outcomes in the market.[113]

48. As a related point, the Authority remains of the view that implementation of the Black model has practical difficulties in terms of developing robust estimates of the zero-beta premium. The Authority prefers the transparency of the risk free rate, for which

110 McKenzie M. and Partington G. 2012, *Review of NERA Report on the Black CAPM*, www.aer.gov.au.

111 Ibid, p. 6.

112 Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Report 2 (Estimates of the Zero-Beta Premium), www.erawa.com.au, 7 October, p. 24.

113 The Authority notes that NERA present evidence of the equity risk premium for a range of beta portfolios in Australia, based on historical data, to suggest that the CAPM equity beta cannot be relied upon for estimating the return on equity (see Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Report 2 (Black CAPM zero beta estimates), www.erawa.com.au, 7 October, p. 15). Yet the evidence presented could be interpreted as being consistent with the CAPM, apart from stock portfolios with equity betas of 0.6 or below. The figure could also be taken to suggest that the use of the CAPM within an Australian context may have less 'low beta' bias for some low beta stocks than suggested in other empirical studies.

observable proxies are readily available. As such, the Authority considers that the Sharpe Lintner CAPM provides for a preferable CAPM modelling approach as compared to the Black CAPM at the current time.

49. Therefore, the Authority considers that without some new development of the model in terms of its empirical performance, the Black CAPM cannot be relied on to achieve the rate of return objective, and hence is not relevant at the current time. This view is based on a judgment that the Black CAPM model has shortcomings in terms of being 'fit for purpose' and 'implemented in accordance with best practice', particularly as it is unlikely to provide a robust basis for estimating the return on equity in the Australian context.

50. Nevertheless, as noted above, 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 Lintner 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.

Inter-temporal CAPM

51. Merton suggested that the Sharp-Lintner CAPM and the Black CAPM have theoretical shortcomings given their grounding within the mean-variance framework.[114] Merton then derived a general form of the asset pricing relationship, using a standard model of inter-temporal choice from microeconomic theory. By doing so, Merton also dropped the assumption of a single time period as adopted in both the Sharp-Lintner CAPM and the Black CAPM.[115]

52. Merton's Inter-temporal CAPM incorporates inter-temporal conditioning variables for the return on the asset, in the form of a range of future state variables that are priced:[116]

> In the I-CAPM, however, investors are also concerned with the opportunities they will have to invest (or consume) the payoff. These opportunities vary with future state variables, which capture expectations about income, consumption and investment opportunities. Equilibrium in this model suggests that investors expected returns will reflect not only market risk, but also compensation for bearing the risk of unfavourable shifts in the investment opportunity set.

53. The Inter-temporal CAPM relates changes in the return on the asset to changes in inter-temporal state variables. The betas in the model are estimated as the covariance of the portfolio returns with the variance in the state variables.

54. Formally, Merton's theory of inter-temporal choice presents that:

$$P_t = E_t(m_{t+1}; x_{t+1}) \quad (8)$$

where

P_t is the equilibrium asset price at time t;

114 Robert Merton (1973), "An Inter-temporal Capital Asset Pricing Model", *Econometrica,* 4(15), pp. 867-887.

115 DBNGP Revised Access Arrangement Proposal Submission, pp. 15-16.

116 McKenzie M. and Partington G. 2013, *Risk, Asset Pricing and the WACC*, DRAFT Report to the AER, www.aer.gov.au, p. 24.

x_{t+1} is the uncertain payoff on the asset at time $t+1$; and

m_{t+1} is the stochastic discount factor which is determined by the ratio of the marginal utility of goods and services consumption tomorrow and the marginal utility of goods and services consumption today.

55. McKenzie and Partington describe a simple form of the Inter-temporal CAPM, which builds on the standard form of the single factor CAPM to add a single additional factor that covaries negatively with the risk free rate:[117]

$$E(r_i) = r_f + \delta_1[E(r_m) - r_f] + \delta_2[E(r_n) - r_f] \quad (9)$$

where

r_n is the instantaneous return on an asset displaying perfect negative correlation to r_f;

δ_1 and δ_2 are weights given by:

$\delta_1 = \frac{\beta_{im} - \beta_{in}\beta_{nm}}{1-\rho_{nm}^2}$ and $\delta_1 = \frac{\beta_{in} - \beta_{im}\beta_{nm}}{1-\rho_{nm}^2}$ and

$\beta_{ik} = \frac{Cov(r_i, r^k)}{Var(r^k)}$ where K indexes the factors.

56. Recently, NERA proposed to the Australian Energy Regulator (**AER**) a regime switching model based on the Inter-temporal CAPM, which relates estimates of the market risk premium to states of stock market volatility, in particular the probability that it is in a state above or below the long run unconditional mean. However, a review of the model for the AER by McKenzie and Partington concluded that some aspects of the results are implausible and that 'the NERA (2012) model does not provide a good model of volatility'.[118] The AER noted that the use of a Markov chain to govern the transition from one state to another does not provide a good fit of the data, and given the stochastic nature of the states, implies that there is uncertainty in the estimates determining the current state.[119] In consequence, the AER placed limited emphasis on the regime switching model in estimating the value of the market risk premium,

57. The Inter-temporal CAPM model has not found widespread use or acceptance. McKenzie and Partington state that:[120]

> The main problem with operationalising the I-CAPM is that it is not easy to identify the state variables that affect expected returns. ...In terms of the regulatory use of the I-CAPM, to the best of our knowledge, there has not been a regulatory body that has relied on this version of the CAPM to estimate the cost of capital.

117 McKenzie M. and Partington G. 2013, *Risk, Asset Pricing and the WACC*, DRAFT Report to the AER, www.aer.gov.au, p. 28.

118 McKenzie M. and Partington G. 2012, *Review of Regime Switching Framework and Critique of Survey Evidence*, www.aer.gov.au, p. 5. In particular, McKenzie and Partington use evidence from a study by Brailsford, Handley and Mahareshwan, which indicates that there is no compelling reason for the two regimes adopted by NERA, and that a greater number of regimes could be justifiable (p. 20).

119 Australian Energy Regulator 2013, *APA GasNet final decision*, Appendix B, www.aer.gov.au, p. 20.

120 McKenzie M. and Partington G. 2013, Risk, Asset Pricing and the WACC, DRAFT Report to the AER, provided as part of workshop materials, p. 29.

58. The Authority notes that the Inter-temporal CAPM has not been used to estimate expected asset returns in Australia. Without further empirical development for the Australian context, the model would appear to have shortcomings with regard to reliability. On this basis, the Authority considers that Inter-temporal CAPM family of models cannot be relied on to achieve the rate of return objective, and hence are not relevant at the current time. This view reflects the Authority's concerns that these models are not 'fit for purpose' or able to be 'implemented in accordance with best practice' at the current time.

Consumption CAPM

59. The Consumption CAPM is a form of the Inter-temporal model in which the state variable is the utility of aggregate consumption over time. Other potential state variables in the Inter-temporal model include income and investment opportunities, as well as measures of stock market volatility.

60. The Consumption CAPM assumes that investors maximise a lifetime utility function and there exists a capital market that allows consumers to smooth consumption over different periods, the return of assets may be linearly related to the growth rate in aggregate consumption.[121] As such, consumers are concerned not just with their wealth, but also 'the risk of changes in reinvestment opportunities over time'. The beta in this version of the CAPM measures the covariance of the underlying asset to the variance of aggregate consumption.[122]

61. Based on this approach, the Consumption CAPM relates the return on the security to movements in aggregate consumption, through the covariance of the return on the security with that the variance in aggregate consumption. This can be formally expressed as:

$$E[R_{i,t}] = \alpha + \beta_i C_t \qquad (10)$$

where

C_t is the growth rate in aggregate consumption per capita at time t;

$E[R_{i,t}]$ is the expected rate of return of asset i in period t; and

β_i is the sensitivity of the rate of return of asset i to changes in consumption per capita, $\beta_i = \frac{Cov(R_{i,t}, C_t)}{Var(C_t)}$.

62. Breeden, Gibbons and Litzenberger (1989) argued that this model is difficult to utilise in practice due to the difficulty in estimating consumption.[123] In addition, these authors

121 Elton E.J, Gruber M.J, Brown S.J & Goetzmann W.N (20xx), *Modern Portfolio Theory and Investment Analysis*

122 McKenzie M. and Partington G. 2013, Risk, Asset Pricing and the WACC, DRAFT Report to the AER, provided as part of workshop materials, p. 22.

123 Breeden D.T, Gibbons M.R and Litzenberger R.H(1989), Empirical Tests of the Consumption-Oriented CAPM, *The Journal Of Finance*, Vol XLIV.

consider that the consumption-based CAPM has been shown to have poor performance relative to the standard CAPM.

63. The Brattle Group refer to the Ahern model as a version of the consumption CAPM developed explicitly to estimate the cost of equity for regulated entities. The estimate of the return for the firm is based on conditional volatility with regard to the stochastic discount factor, which is the aggregate consumption inter-temporal marginal rate of substitution.[124] However, the Brattle Group also note:[125]

> The model has been presented in some U.S. regulatory jurisdictions but regulatory decisions based on the model are either still pending or it is not clear how the regulator used the information.

64. The Brattle Group considers that the Consumption CAPM allows for empirical evaluation, but also note that the results are sensitive to prevailing economic conditions and the models have not been implemented outside of the US market setting.[126]

65. There appear to have been no Australian studies based on the model.

66. Overall, the Authority considers that the consumption-based CAPM, like the Inter-temporal CAPM, has not been used to estimate expected asset returns in Australia. Without further empirical development for the Australian context, the consumption-based CAPM would appear to have shortcomings with regard to reliability. On this basis, the Authority considers that these models cannot be relied on to achieve the rate of return objective, and hence are not relevant at the current time. This view reflects the Authority's concerns that these models are not 'fit for purpose' or able to be 'implemented in accordance with best practice' at the current time.

The Fama French Model

67. The development of the Fama-French Three-factor model (**FFM**) was a response to empirical studies assessing the performance of the CAPM. The FFM identifies three sources of undiversifiable risk:

- The excess return to the market portfolio (the market risk premium, MRP).
- The value or growth risk premium, high minus low (**HML**) – the premium earned by HML book value shares. In this asset pricing model, high-value firms have a high ratio between book value of equity and market value of equity whereas the opposite is true for low-value firms (also known as growth shares). HML is a risk premium associated with the returns earned by firms with high book-to market values of equity. It has been observed that firms with high book-to-market values (known as value stocks) tend to have higher realised returns than those of firms with low book-

124 McKenzie and Partington discuss Stochastic Discount Factor (**SDF**) models as a type of meta asset pricing approach – where the value of the financial asset equals the expected value of the product of the payoff on the asset and the Stochastic Discount Factor (McKenzie M. and Partington G. 2013, *Risk, Asset Pricing and the WACC,* DRAFT Report to the AER, provided as part of workshop materials, p. 19 and p. 41):

> The basic intuition of the model is that both cash flows and discount rates may vary according to future states of the world.

The Sharpe-Lintner CAPM may be configured within the context of the SDF, as may intertemporal models such as the Consumption CAPM and the Intertemporal CAPM.

125 The Australian Pipeline Industry Association 2013, *Rate of Return Review*, www.erawa.gov.au, Schedule 2, p. 23.

126 The Australian Pipeline Industry Association 2013, *Rate of Return Review*, www.erawa.gov.au, Schedule 2, p. 24.

to-market values (known as growth stocks). The FFM considers that the higher realised return of stocks with high book-to-market values represents a risk factor that investors cannot diversify, and as a consequence, the HML risk premium is a compensation for investors incurring this risk; and

- The size risk premium, small minus big (**SMB**) – the premium earned by SMB shares. Small (big) firms have small (big) total capitalisation (i.e. equity at market value). SMB is a risk premium associated with the differential in returns earned by small market capitalisation firms in comparison with large capitalisation firms. The FFM is built on the observed empirical evidence that small market capitalisation firms tend to earn a higher return than firms with larger market capitalisations. It is assumed that this is due to smaller market capitalisation firms being riskier than larger market cap firms. As a consequence, the FFM contains a risk premium in compensation for investors incurring this form of risk.

68. The return on equity for the firm estimated by the FFM is defined as follows:

$$E(r_j) = r_f + \left(E\left(r_M\right) - r_f\right).\, \beta_m + HML\,.\, h_j + SMB\,.\, s_j \qquad (11)$$

where

$E(r_j)$ is the expected return of stock j;

r_f is the risk free rate;

b_j is the covariance sensitivity of stock j to variance in the market portfolio, as per the CAPM;

$\left(E\left(r_M\right) - r_f\right)$ is a risk premium associated with the risk of aggregate market fluctuations, which represents the systematic risk, as per the CAPM;

h_j is the covariance sensitivity of stock j to changes in the High minus Low portfolio;

HML is a risk premium associated with the differential in returns earned by firms with high and low book-to-market values of equity;

s_j is the sensitivity of stock j to changes in the Small minus Big portfolio; and

SMB is a risk premium associated with the differential in returns earned by small market capitalisation firms and large capitalisation firms.

69. The FFM states that small firms and firms with high book-to-market ratios require additional returns to compensate investors for these additional risks. Accordingly, large firms and firms with a low book-to-market ratio have less risk and therefore investors require a lower rate of return.

70. A further version of the model is the Zero-beta Fama-French Model, which is a combination of selected elements from both the Black CAPM and the FFM in which a zero-beta portfolio return (r_z) from Black CAPM is used instead of the risk-free rate of return from Fama-French CAPM.

$$E(r_j) = r_z + \left(E\left(r_M\right) - r_z\right).\,\beta_m + HML\,.\,h_j + SMB\,.\,s_j \qquad (12)$$

71. There is no theoretical foundation that explains the choice of factors in the FFM, the exact form of the variables used, or reasons why these are common factors in returns.[127] This may be contrasted with the other versions of the CAPM, which are explicitly supported by theory.

72. The FFM was proposed by Dampier to Bunbury Pipeline as part of its proposal to the Economic Regulation Authority for the 2011 - 2015 Dampier to Bunbury Natural Gas Pipeline access arrangement, and also to the Australian Energy Regulator by Jemena for its most recent NSW Gas Networks proposal. [128,129] Both proposals drew on work by NERA. In both cases, the estimates from the FFM were not considered relevant.

73. To inform the FFM in an Australian context, NERA submitted that a 2008 study by O'Brien, Brailsford and Gaunt found similar results to those from the US with a time series of Australian data.[130] The Authority notes that Brailsford, Gaunt and O'Brien have recently updated their work. Their 2012 study observes that prior Australian research has suffered from limited datasets, resulting in mixed and weak results compared to US studies.[131] For their 2012 study, Brailsford, Gaunt and O'Brien utilised a new and specially constructed dataset that provides coverage of over 98 per cent of listed Australian firms over the 25-year period of 1982-2006.

74. McKenzie and Partington consider that the 2012 Brailsford, Gaunt and O'Brien study provides support for the FFM model in the Australian context, particularly with respect to the book to market factor.[132] However, similar to a study by Faff in 2004, there was a negative risk premium for the size factor, although statistically it was not significantly different from zero.[133]

75. More recently, NERA reviewed the evidence relating to the FFM in an Australian context. NERA concluded that, similar to the Sharpe Lintner CAPM, the Fama-French model is likely to provide a downwardly biased estimate of the return that the market requires on a low-market-beta stock, but that[134]

> ... the Fama-French model is likely to provide an unbiased estimate of the return required on a stock that has a market beta of one and that is a value, growth, small-cap or large-cap stock. The Fama-French model, though, because it contains more parameters than the SL CAPM, will produce less precise estimates than the SL CAPM.

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127 Ibid.

128 Dampier Bunbury Pipeline Pty Ltd 2010, *Revised Access Arrangement Proposal Submission: Supporting document from NERA – The required rate of returns on equity for a gas transmission pipeline*, pp. 21-24.

129 Australian Energy Regulator 2010, *Final Decision, Jemena Gas Networks: Access arrangement proposal for the NSW gas networks*, 1 July 2010 – 30 June 2015, pp. 170-171.

130 O'Brien, Michael, Tim Brailsford and Clive Gaunt, Size and book-to-market factors in Australia, Table 3, Electronic copy available at: http://ssrn.com/abstract=1206542.

131 Brailsford T, Gaunt C and O'Brien M.A (2012), 'Size and book-to-market factors in Australia', *Australian Journal of Management* 37(2) 261-281 Aug 2012.

132 McKenzie M. and Partington G. 2013, *Risk, Asset Pricing and the WACC*, DRAFT Report to the AER, provided as part of workshop materials, p. 33.

133 Faff R. 2004, A simple test of the Fama and French model using daily data: Australian evidence, *Applied Financial Economics*, 14, pp. 83 - 92.

134 Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Report 1 'Review of Cost of Equity Models', www.erawa.com.au, 7 October, p. ii.

76. Given evidence that regulated firms are generally low beta stocks, it is not clear the degree to which the other FFM factors affect the resulting bias of the estimates.

77. Consistent with its decision on the 2011 - 2015 Dampier to Bunbury Natural Gas Pipeline access arrangement, the Authority remains of the view that the variation in FFM risk premia and inconsistent FFM factor coefficients factors are of concern. On this basis, it would be unreasonable to conclude that the additional FFM risk factors are present in the market for funds and provide a robust, transparent and replicable means to determine the rate of return on equity. Furthermore, as noted above, the Authority has significant concerns with models which mine ex post data without underlying theoretical support. The Authority agrees with McKenzie and Partington when they say:[135]

> In summary, the Fama and French three factor model provides no clear guidance on exactly what are the risk factors that are priced. There are also some somewhat arbitrary choices that must be made in measuring the factor risk premiums as the return to the spread portfolios.[136] Furthermore the empirical evidence suggests ambiguity about the magnitude of the premiums and even their sign. Despite these issues, the Fama and French three factor model has been used as a method to estimate the cost of equity. However, to do so requires significant effort in estimating factor risk premiums and factor loadings with no clear evidence that an improved estimate of the cost of capital results relative to the simpler CAPM.

78. Davis provides the following view: [137]

> The Fama-French factors can be constructed for the Australian equity market, making implementation of this model feasible. However, the results of studies attempting to implement a Fama-French model for Australia have had mixed results, and my opinion based on examining these studies is that there is not strong evidence to support its use.

79. Overall, the Authority has significant concerns as to the robustness of the FFM model specification and its results, particularly as the model is not 'based on a strong theoretical foundation'. The Authority's view is that the model is not 'fit for purpose' or able to be 'implemented in accordance with best practice' at the current time. On this basis, the Authority considers that the model cannot be relied on to achieve the rate of return objective, and hence is not relevant at the current time.

Arbitrage pricing theory

80. Arbitrage Pricing Theory (**APT**) was developed as an alternative to the CAPM. A key difference in the APT is that, unlike the CAPM, risk aversion and normality of returns is not assumed.[138] Rather, returns are related to a set of factors, which measure the stock's covariance with each risk factor at any point in time, similar to the CAPM, assuming that:[139]

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[135] McKenzie M. and Partington G. 2013, *Risk, Asset Pricing and the WACC*, DRAFT Report to the AER, provided as part of workshop materials, p. 35.

[136] One procedure is to take the top 30 percent of the firms and bottom 30 percent of firms. For example, the difference in returns to a portfolio of the bottom 30 percent of firms by book to market and the top 30 percent by book to market gives the return to the book to market factor, but other choices would be just as valid.

[137] Davis K. 2011, *Cost of Equity Issues: A Report for the AER*, www.aer.gov.au, p. 13.

[138] Levy, H 2012, *The Capital Asset Pricing Model in the 21st Century*, Cambridge University Press, p. 180.

[139] APT differs from the CAPM in not having assumptions of investor risk aversion or normality of returns. However, the zero beta CAPM can be derived as a special case of the APT (see Levy, H 2012, *The Capital Asset Pricing Model in the 21st Century*, Cambridge University Press, p. 183).

- the returns are generated by some specific process that is captured in the factors;
- investors hold a portfolio of numerous assets, some of which may be in a short position.

81. The APT assumes that if deviations from the equilibrium occur, an arbitrage profit becomes available, and this may be used to increase holdings in long positions.[140]

82. Formally, the APT replaces the mean variance structure used to develop the CAPM by assuming that the expected return of a stock is linearly related to a set of n risk factors as follows:[141]

$$E[r_i] = R_f + \sum_{j=1}^{n} b_{i,j} RP_j \qquad (13)$$

where

$E[r_i]$ is the expected rate of return on stock i;

R_f is the risk free rate;

RP_j is the risk premium associated with risk factor j; and

$b_{i,j}$ is the sensitivity of stock i to risk factor j.

83. Intuitively, this model assumes that investors require compensation for being exposed to a variety of risk factors. It is noted that the model does not specify a theoretical basis for the risk factors. However, most parameterisations of the APT utilise risk factors that are related to the state of the economy, such as the debt risk premium, level of inflation and the change in gross national product.[142]

84. It has been argued that APT is theoretically superior to CAPM in that it allows for several systematic factors to influence stock returns.[143] In addition, some research suggests that multivariate APT models explain expected rates of return better than the Sharp-Lintner CAPM.[144] However, choice of risk factors is not straightforward:[145]

> Unfortunately, extant asset pricing models do not provide a consensus on what the systematic risk factors are...

85. Furthermore, implementing the APT can be difficult in that n risk premiums need to be estimated, whereas the CAPM requires only one, the market risk premium. In addition, n sensitivities have to be calculated as opposed to CAPM which requires only one, the beta. Additionally, as there is no general consensus about which

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140 Levy, H 2012, *The Capital Asset Pricing Model in the 21st Century*, Cambridge University Press, p. 180.

141 Pratt, S.P & Grabowski, R.J 2010, *Cost of Capital Applications and Examples, Fourth Edition.* John Wiley & Sons p. 352.

142 Ibid

143 Brigham E.F & Ehrhardt M.C(2008), *Financial Management: Theory and Practice.* Thomson Learning Inc p. 267.

144 Pratt, S.P & Grabowski, R.J (2010), *Cost of Capital Applications and Examples, Fourth Edition.* John Wiley & Sons p. 353.

145 McKenzie M. and Partington G. 2013, *Risk, Asset Pricing and the WACC*, DRAFT Report to the AER, provided as part of workshop materials, p. 6.

variables to include in the APT; the model is seen as being vulnerable to data mining, as well as been sensitive to the variables chosen.[146]

86. To the Authority's knowledge, the APT model has not been proposed before in the Australian regulatory context.

87. Overall, the Authority considers that the APT has not been used for estimating expected asset returns in Australia. Without further empirical support in the Australian context, the model would appear to have shortcomings with regard to reliability. On this basis, the Authority considers that the model cannot be relied on to achieve the rate of return objective, and hence is not relevant at the current time. This view reflects the Authority's concerns that the model is not 'fit for purpose' or able to be 'implemented in accordance with best practice' at the current time. In addition, the Authority has concerns as to the robustness of the model specification and its results, particularly as the model is not 'based on a strong theoretical foundation'.

Dividend growth models

88. Dividend Growth Models (**DGM**) seek to estimate the internal rate of return which equates the present value of the expected stream of future returns with the present value of the underlying asset value.[147] Future returns may include dividends, retained earnings or other cash flows. Share repurchases and capital contributions such as dividend reinvestment plans need to be excluded. Importantly, account needs to be taken of implicit tax cash flows, which will depend on the specific taxation treatment.

89. DGM are based on an 'implied' return on equity, and are therefore not supported by any theoretical underpinning as to what risk factors are priced in the return. DGM do not identify the risks which investors bear in exchange for the expected future return, although McKenzie and Partington note that in the DGM:[148]

> ...the only stochastic variable is the expected dividend. While the dividend growth rate is usually written as a fixed parameter in the model, the reality is that the growth rate is uncertain and this translates into ongoing uncertainty of the magnitude of the dividend through time. Thus, the risk that is recognised in the DGM, and therefore presumably driving the required return, is uncertainty over future cash flows in the form of dividends.
>
> This is consistent with asset pricing models where uncertainty over future cash flows is the key risk.

90. DGM may be based on either a single stage constant growth or multi-stage growth model to estimate the internal rate of return.

91. The single stage DGM, or Gordon growth model, calculates the return on equity by treating dividends as a perpetuity. The dividends are assumed to grow at a constant periodical rate and expressed as a proportion of the current share price in order to calculate a dividend yield. This yield is augmented with the growth rate to arrive at the estimated return on equity:

146 Pratt, S.P & Grabowski, R.J (2010), *Cost of Capital Applications and Examples, Fourth Edition.* John Wiley & Sons p. 354.

147 DGM also known as 'Dividend Discount Models' (**DDM**).

148 McKenzie M. and Partington G. 2013, *Risk, Asset Pricing and the WACC*, DRAFT Report to the AER, provided as part of workshop materials, p. 38.

$$r_s = \frac{D_0(1+g)}{P} + g \qquad (14)$$

where

r_s is the return on the security;

D_0 is the dividend;

g is the expected growth rate in the dividend; and

P is value of the underlying asset.

92. The estimates of the growth rate in dividends into the future, the 'g', is a key to estimating the return on equity in the DGM.

93. The multistage DGM does not assume a constant growth rate and instead forecasts dividends at varying rates of growth for the near term before they eventually reach a terminal growth rate. A price is determined for the equity once the terminal growth rate is reached which is then discounted along with the various dividends in the periods in which they occur using the general present value formula. The discount rate that equates these cash flows to the current share price is the estimated return on equity. It is common for the DGM model to be used in this way by regulators in the United States.[149]

94. In either version of the model, the results are very sensitive to the inputs, and hence to the modeller's discretion. In this context, it may not always be clear what implicit framework is driving the assumptions relating to the inputs for the model, particularly relating to the dividends:[150]

> To implement the DDM it is necessary to specify one or more growth rates and to determine whether (i) dividends accurately reflect cash flow to shareholders, (ii) the horizon over which to apply each growth rate if using a multi-stage model, and (iii) the exact determination of the initial stock price. In most applications, the choice of growth rate is the most controversial part of the DDM implementation and the determination of the stock price is the least controversial.

95. In this context, the Authority notes that forecasts of dividends, particularly for the near term, tend to be based on analysts' estimates, such as from brokers' reports. The Authority considers that brokers' estimates may have potential to provide relevant information, particularly in terms of the parameters used in modelling, such as the market risk premium. In some cases, brokers' estimates may also provide relevant information for the overall return on equity of the regulated firm. However, particular care is needed in interpreting such information (see Appendix 29 – 'Other material to inform rate of return' for more detail of the Authority's consideration in this regard).[151]

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149 The Australian Pipeline Industry Association 2013, *Rate of Return Review*, www.erawa.gov.au, Schedule 2, p. 29.

150 The Australian Pipeline Industry Association 2013, *Rate of Return Review*, www.erawa.gov.au, Schedule 2, p. 28.

151 Such information is only likely to be relevant where it is supported by transparent analysis, implemented in accordance with best practice. In particular, account needs to be made for the term of the estimate, to ensure that it is consistent with the regulatory period, otherwise the economic efficiency requirements of the NGL and NGR will be violated.

96. The Authority notes that the cash flows for the regulated business are established by the regulator through the building block approach. Thus there may be an element of circularity, to the extent that dividends growth – which are based on the expected return on equity – are used to inform the expected return on equity.[152]

97. When it comes to valuing the assets, the analyst will use the share price. However, there may be inconsistencies in the estimate of the share price and the associated estimate of the dividend. It is not clear whether bias related to dividend cash flows will necessarily be related to views on the asset value or the target price.[153]

98. The Authority is not aware of use of the DGM by Australian regulators to estimate the cost of equity for regulated firms. The AER, for example, has in the past rejected the use of the DGM approach, noting a number of shortcomings, including among other things that it is sensitive to inputs, tends to produce an extremely wide range of estimates, and has at times produced unacceptable results.[154]

99. In the Draft Guidelines, the Authority noted that it had significant concerns where DGM estimates were based on analyst inputs, which may preclude the approach being fit for purpose. However, the Authority considers that DGM estimates may provide relevant information with regard to the market risk premium (MRP), for the purpose of providing this input to the Sharpe Lintner CAPM.

100. This view reflects that the use of the DGM estimates of the MRP may be more robust than those for individual firms or industries. This is particularly the case where the estimate of the MRP is informed by theory, and also historic data on the long term potential for overall market returns to equity. The Authority considers how this market-wide information from the DGM may be used in Chapter 11 – Market Risk Premium.

101. However, the Authority is not convinced that DGM estimates can be relied upon for individual equities, and hence for estimating the return on equity to the benchmark firm. The concerns relating to these estimates remain that the DGM needs to be forward looking to be valid, and hence requires analyst's inputs. Given the models sensitivity to inputs, then where the range of companies is small and where less-than-transparent analyst's views are key, then the potential for circularity and highly variable results is high. As noted by the Brattle Group:[155]

> As for other evidence such as expert reports and investment reports, the merits of the derived estimates are highly dependent upon the quality of the reports and the purpose for which the estimates were derived. We caution against placing weights on estimates where the purpose for their derivation is not known, and against placing substantial weight on estimates that were derived for purposes other than to provide an independent assessment of the cost of equity. For example, estimates derived for accounting purposes, stock recommendations, etc. may not be suitable for other uses.

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152 A further issue relates to the possibility that there may significant amounts of non-regulated assets in the business represented by the cash flows. Other issues relating to the cash flows include the importance of capturing all cash flows, particularly implicit cash flows relating to tax.

153 For a summary of work on broker bias, see SFG Consulting 2010, *The required return on equity commensurate with current conditions in the market for funds, Report prepared for WA Gas Networks*, www.erawa.com.au, p. 18. With regard to this report, the Authority notes that it does not consider that using broker target stock prices will necessarily offset broker bias with regard to dividend cash flows. SFG Consulting make this claim but provide no supporting evidence. It is not clear to the Authority as to whether the bias applies equally to dividends or target stock price. It is possible that the bias applies only to dividends, and hence the return on equity.

154 Australian Energy Regulator 2013, *Access arrangement final decision: SPI Networks (Gas) Pty Ltd 2013 – 2017,* Part 2 Attachments, www.aer.gov.au, pp. 101 – 103.

155 Australian Pipeline Industry Association 2012, *Rate of Return Review*, www.erawa.com.au, 13 March, p. 42.

102. Overall, the Authority is not convinced that the DGM family can be relied on to achieve the allowed rate of return objective for the benchmark efficient entity, and hence considers that the DGM is not relevant at the current time. This view reflects the Authority's concerns that the method is not able to be 'implemented in accordance with best practice', particularly as it may be founded on subjective views, rather than being informed by 'a strong theoretical foundation'. The approach would appear to have shortcomings with regard to being 'fit for purpose' at the current time. Nevertheless, the Authority considers that the DGM may provide relevant information for the determination of the MRP.

Residual income model

103. The Residual Income Model (**RIM**) may be used to estimate the value of a company, by summing the invested capital – taken from the historic book value – plus the discounted present value of estimated 'residual income'. Residual income is estimated as the excess of the company's earnings over its cost of capital.

104. The Residual Income Model in many respects is an identical framework to the DGM approach, with the difference being use of gross cash flows (earnings and cost of capital) rather than net cash flows (dividends).[156] For this reason, the analysis relating to the DGM above is equally applicable to the Residual Income Model, and vice versa.

105. A recent proposal based on the RIM was that considered by the Authority in 2010 as part of its decision on the Western Australian Gas Networks (**WAGN**) access arrangement. The estimate was developed by SFG Consulting (**SFG**).[157]

106. The residual income model, used by SFG in its submission, is as follows:

$$V_0 = BVPS_0 + \sum_{t=1}^{T} \frac{(ROE_t - r_e)\ .\ BVPS_{t-1}}{(1+r_e)^t} + \frac{(ROE_t - r_e)\ .\ BVPS_{T-1}\ .\ (1+\text{g})}{(\text{r}_e - \text{g})\ .\ (1+r_e)^T} \qquad (15)$$

where

V_0 is the estimated value per share;

$BVPS_0$ is the current book value per share;

r_e is the cost of equity;

g is the perpetual growth;

T is the length of the forecast period; and

$BVPS_t = BVPS_{t-1} + EPS_t - DPS_t$

where

156 Lundholm R. and O'Keefe T. 2001, Reconciling value estimates from the discounted cash flow model and the residual income model, *Contemporary Account Research*, 18 (2), pp. 311 – 335 quoted in SFG 2010, *The required return on equity commensurate with current conditions in the market for funds*, Report for WA Gas Networks, www.erawa.com.au, p. 15.

157 SFG Consulting 2010, *The required return on equity commensurate with current conditions in the market for funds, Report prepared for WA Gas Networks*, www.erawa.com.au.

DPS_t is estimated as the historical dividend payout ratio multiplied by EPS_t.

107. SFG's approach is that three parameters in its model are simultaneously estimated, including a perpetual growth (g); the long-term return on book equity (ROE_T) and the cost of equity (r_e).

108. SFG applied the above model to a set of comparable firms, as in the approach using the brokers' research reports. Two data sets were used to estimate the cost of equity: (i) analyst forecasts from the I/B/E/S/ database;[158] and (ii) brokers' research reports.[159]

109. However, regarding the second approach used in SFG's report, the Authority concluded that there were significant issues associated with SFG's analysis.[160] Based on those concerns, the Authority did not approve the use of brokers' research reports and the RIM as proposed by SFG to estimate the cost of equity for WAGN.

110. A recent report for Ofgem rejected putting weight on the Residual Income Model, on the grounds that:[161]

> It is not as widely used in practice and relies heavily on the quality of accounting information, which can lead to mis-estimation of the implied cost of equity. This is particularly true for companies which have significant intangible assets or assets recorded at cost on the balance sheet which do not reflect market values.

111. Overall, similar to the DGM, the Authority is not convinced the model can be relied on to achieve the allowed rate of return objective, and hence is not relevant at the current time. This view reflects the Authority's concerns that the method is not able to be 'implemented in accordance with best practice', particularly as it may be founded on subjective views, which are not necessarily informed by a 'theoretical foundation'. Without further development, the approach would appear to have shortcomings with regard to being 'fit for purpose' at the current time.

Risk premium

112. The Risk Premium approach typically uses the historical spread between returns from entities in the same industry – based on either accounting conventions or stocks – and the return from a given debt instrument to estimate a premium. This estimated risk premium then acts as a margin added to returns observed on the debt instrument.

113. As such, the model represents a simplified version of the Sharpe Lintner CAPM:

$$r_e = r_d + RP \qquad (16)$$

where

158 The Institutional Brokers Estimate System (I/B/E/S) is a unique service which monitors the earnings estimates on companies of interest to institutional investors. The I/B/E/S database currently covers over 18,000 companies in 60 countries. It provides to a discriminating client base of 2,000 of the world's top institutional money managers. More than 850 firms contribute data to I/B/E/S, from the largest global houses to regional and local brokers, with US data back to 1976 and international data back to 1987.

159 For more detail on the broker reports, refer to paragraph 125 below.

160 Economic Regulation Authority 2011, *Final Decision on WA Gas Networks Pty Ltd proposed revised access arrangement for the Mid-West and South-West Gas Distribution Systems*, www.erawa.com.au, p 100.

161 FTI Consulting 2012, *Cost of capital study for the RIIO-T1 and GD1 price controls*, www.ofgem.co.uk, p. 11.

r_e = return on equity;

r_d = return a selected debt instrument; and

RP = estimated risk premium.

114. As such, the results should be similar to the CAPM, if the model inputs are well specified. However, the Brattle Group observe in this context:[162]

> There are many versions of this model depending on the choice of the debt instrument, r_d , and the estimation of the risk premium. It is important to note here that the risk premium approach, while a generalized form of the CAPM, does not have the same level of theoretical support as the standard CAPM. This is because the return on the selected debt instrument used is not necessarily equal to the risk-free rate, and the estimated risk premium used is not explicitly based upon the product of the market beta and the MRP.

115. The Authority notes that the model is not related to specific risk factors, and hence lacks a strong theoretical foundation. In this context, the Brattle Group observe that it is common for analysts to rely on DGM models when determining the risk premium in forward looking versions of the model.[163] For this reason, the Authority has reservations about the use of the model in an Australian context, for the reasons outlined above in regard to the DGM.

116. Overall, the Authority is not convinced the model can be relied on to achieve the allowed rate of return objective, and hence is not relevant at the current time. This view reflects the Authority's concerns that the method is not able to be 'implemented in accordance with best practice', particularly as it may be founded on subjective views, rather than being 'based on a strong theoretical foundation'. Without further development, the approach would appear to have shortcomings with regard to being 'fit for purpose' at the current time.

Build-up method

117. The cost of equity in the Build-up is calculated as a sum of the risk free rate, market risk premium, firm size premium, industry premium and premiums for any other factors that capture specific risks:

$$r_e = r_f + RP + FS + I + \sum F_i \qquad (17)$$

where

r_e is the return on equity;

r_f is the Risk-Free Rate;

RP is the Market Risk Premium;

FS is the Firm Size Premium;

162 Australian Pipeline Industry Association 2012, *Rate of Return Review*, www.erawa.com.au, Schedule 2, p. 33.

163 Australian Pipeline Industry Association 2012, *Rate of Return Review*, www.erawa.com.au, Schedule 2, p. 34.

I is the Industry Premium; and

$\sum F_i$ is the premiums for other potential factors.

118. The model is used by Ibbotson to estimate returns to equity for selected stocks.[164]

119. The Authority notes that the Build-up Method has characteristics in common with both the Empirical CAPM and Arbitrage Pricing Theory. As such, the Authority has similar reservations about the Build-up Method as with these models, considering that it:

- is not grounded in theory;
- 'mines' ex post data; and
- is subjective, depending on the choice of premia and the method for determining those premia.

120. The Authority considers that this family of models cannot be relied on to achieve the allowed rate of return objective, and hence are not relevant at the current time. This view reflects the Authority's concerns that the method is not able to be 'implemented in accordance with best practice', particularly as it is not 'based on a strong theoretical foundation'. Without further development, the approach would appear to have shortcomings with regard to being 'fit for purpose' at the current time.

Comparable earnings

121. The Comparable Earnings method involves assessing returns based on those for a group of comparable companies. This is done for a sample of companies over a specified time period to average out fluctuations and company specific factors. Risk adjustments are then made to account for differences between the comparable entities and the company analysed.

122. The Brattle Group note that the Comparable Earnings approach requires comparison with firms that are not regulated, to avoid circularity problems. Adjusting for risk characteristics then becomes an important element in the analysis, which is usually based on the subjective view of the analyst.[165] The Brattle Group note a number of significant issues with regard to the Comparable Earnings approach:[166]

> A major issue is whether realized book returns are a good proxy for the returns that investors expect going forward. From a statistical perspective, the realized accounting return on book equity for any given period is the realization of a single outcome of a distribution, whereas the expected return represents the probability-weighted average of all possible outcomes of the distribution. These two figures can differ substantially. In addition, there are practical problems with the implementation of this model because financial reporting occurs with a lag, which during times of change can mean that the results are out of date.

123. The approach provides for a simple check. However, the Authority notes that the evidence on comparable investments is generally inconclusive regarding the return investors expect and there may be limited evidence to suggest that these returns are sufficiently comparable to the regulated utilities.

164 Australian Pipeline Industry Association 2012, *Rate of Return Review*, www.erawa.com.au, Schedule 2, p. 36.

165 Australian Pipeline Industry Association 2012, *Rate of Return Review*, www.erawa.com.au, Schedule 2, p. 37.

166 Australian Pipeline Industry Association 2012, *Rate of Return Review*, www.erawa.com.au, Schedule 2, p. 38.

124. Overall, the Authority considers that this approach cannot be relied on to achieve the allowed rate of return objective, and hence is not relevant at the current time. This view reflects the Authority's concerns that the method is not able to be 'implemented in accordance with best practice', particularly as it is not 'based on a strong theoretical foundation'. Without further development, the approach would appear to have shortcomings with regard to being 'fit for purpose' at the current time.

The dividend yield approach

125. The Dividend Yield approach, which is often used in brokers' reports, is similar to the Comparable Earnings method, except that it uses regulated firms as comparators. The Dividend Yield approach – and brokers' reports more broadly – were considered by the Authority in 2010 as part of its decisions on the Western Australian Gas Networks (**WAGN**) and Dampier Bunbury Natural Gas Pipeline access arrangements. An estimate based on the method was developed by SFG Consulting.[167]

126. First, SFG submitted that the expected return on equity available to investors has three possible components: (i) dividends; (ii) capital gains; and (iii) dividend imputation credits.

127. In the case of WAGN, SFG Consulting used research reports from various brokers to estimate the average dividend yield for a sample of firms which were considered comparable to WAGN.[168] This was added to estimates of capital gains and the benefits from dividend imputation credits to derive an overall return on equity for the comparable firms.

128. However, while forecasters have been reluctant to evaluate their own performances, there exists evidence to suggest that the record of economic forecasting is not encouraging.[169] Additionally, the estimate of the cost of equity using the brokers' research reports involves at least three forecasts (dividend yield, inflation and GDP growth). The Authority is of the view that all series used as inputs for the brokers' forecasts exhibit a relatively high degree of volatility. As a result, the error of these estimates compounds for the estimate of the cost of equity.

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167 See for example, SFG Consulting 2010, *The required return on equity commensurate with current conditions in the market for funds, Report prepared for WA Gas Networks*, www.erawa.com.au.

168 The sample of comparable firms included a sample of firms which are considered comparable to DBP, including APA Group (APA), Hastings Diversified Utilities Fund (HDF), Envestra (ENV), Spark Infrastructure (SKI), SP Ausnet (SPN), and DUET Group (DUE).Broking houses include Macquarie Bank, UBS, Wilson HTM, Morgan Stanley, Credit Suisse, Ballieu Research, Goldman Sachs JBWere, JP Morgan, RBS Morgans, Merrill Lynch.

169 For example, see Fildes, R. and Makridakis, S. (1995). The impact of empirical accuracy studies on time series analysis and forecasting, *International Statistical Review,* 63, 3, 289-308; and Hendry, D. and Clements, M. (2003). Economic forecasting: some lessons from recent research, *Economic Modelling,* 20, 301-329.

129. SFG Consulting claimed that:

- estimating the cost of equity using the Dividend Yield technique does not require any other input assumptions other than the brokers' estimates of the dividend yield;[170] and
- even if an individual analyst does suffer from an optimism bias, the same bias is present in his or her forecasts and target price and, as such, using the earnings forecasts of equity analysts is appropriate to estimate the cost of equity.[171]

130. The Authority considers that the first argument by SFG Consulting runs counter to the fact that Dividend Yield approaches are based on analysts' views with regards to dividend cash flows and stock prices. As noted at paragraphs 95 to 97 above, these estimates are sensitive to input assumptions, and may vary significantly across equity analysts and across time.

131. With regard to the second argument, the Authority does not consider that using broker target stock prices will necessarily offset broker bias with regard to dividend cash flows (refer to footnote 153). SFG Consulting makes this claim but provides no supporting evidence. It is not clear to the Authority as to whether the bias applies equally to dividends or target stock price. It is possible that the bias applies only to dividends, and hence to the return on equity.

132. Given its concerns with regard to brokers' research, the Authority is of the view that it is generally inappropriate to use brokers' reports or the Dividend Yield approach to derive an estimated cost of equity. The Authority considers that such approaches cannot be relied on to achieve the allowed rate of return objective, and hence are not relevant at the current time. This view reflects the Authority's concerns with regard to the transparency and reproducibility of the broker analysis, which suggests that such an approach is not able to be 'implemented in accordance with best practice'. These approaches would appear to have shortcomings with regard to being 'fit for purpose' at the current time.

133. However, the Authority considers that elements of some brokers' estimates, and associated dividend yield approaches, may have potential to provide relevant information, particularly in terms of the parameters used in modelling, such as the market risk premium (see Appendix 29 – Other material to inform the rate of return for more detail of this consideration). In some cases, some brokers' estimates may also provide relevant information for the overall return on equity of the regulated firm.[172]

Conclusion

134. The conclusion from the assessment above leads the Authority to consider that only the Sharpe Lintner CAPM model is relevant for informing the Authority's estimation of the return on equity, at the current time.

[170] SFG Consulting 2011, *The required return on equity commensurate with prevailing conditions in the market for funds: Response to Draft Decision*, Report prepared for DBP, www.erawa.com.au, p. 19.

[171] SFG Consulting 2010, *The required return on equity commensurate with current conditions in the market for funds: Response to BHP Billiton submission*, Report prepared for DBP, www.erawa.com.au, pp. 3-4.

[172] Appendix 29 concludes that care is needed in interpreting such information. Such information is only likely to be relevant where it is supported by transparent analysis, implemented in accordance with best practice. In particular, the term of the information needs to be consistent with the regulatory period, otherwise the economic efficiency requirements of the NGL and NGR will be violated.

135. The Authority proposes to give some weight to relevant outputs from the DGM when estimating the Market Risk Premium for the Sharpe Lintner CAPM. In particular, estimates from the DGM will be used to inform the point estimate of the Market Risk Premium from within its estimated range, which will be used within the Sharpe Lintner CAPM.

136. Other models and approaches are considered to be not relevant within the Australian context at the current time, at least without some new developments in terms of the theoretical foundations or in the empirical evidence.

137. The Authority does not expect it likely that there would be significant new developments over the course of the life of these Guidelines and expects to be able to rely on these Guidelines in making its decisions over the next three years. However, the Authority recognises that further development of models or empirical support may arise at some future point, that might make them relevant. In this event, the Authority would review its position.

Appendix 9 Modern portfolio theory

1. Modern portfolio theory (**MPT**) seeks to determine how a rational investor will allocate capital between various securities. By combining stocks in a portfolio, the MPT demonstrates that investors can achieve superior levels of expected return by taking on a given level of risk than that which could be achieved by holding individual stocks. In addition, this MPT theory also assumes that investors can borrow and lend their capital at the risk free rate. In this context, the MPT theory presents that an optimal portfolio exists, to be called the market portfolio, which maximises the expected return per unit of risk. Investors then determine the proportion of capital they allocate between a risk-free asset, which is risk-free, and the optimal market portfolio, which is risky, through their preference for risk.

2. Formally, an investor is presented with a universe of assets that are assumed to be random variables in which to allocate their capital. That is, each assets value in the future is uncertain and only probability statements can be made about the likelihood of their future value or return. Modern portfolio theory determines how a rational investor will allocate their capital in the face of this uncertainty. The uncertainty is quantified by the variance of the probability distribution[173], while its expected return is the mean value of the probability distribution. The variance is an estimate of the likely divergence from the expected return of an asset and is therefore seen as a measure of risk. Risk can also be expressed in terms of the standard deviation of expected returns. Note that in this initial stage, every asset is assumed to have some level of risk. Let X_i represent the i^{th} asset, $U = \{X_1, X_2, ...X_n\}$ be the universe of n assets, R_i be the return of the i^{th} asset (assumed to be a random variable), $R_i \sim f_i(x)$ be the assumed probability distribution of returns for the i^{th} asset. The expected return of X_i is thus $E[R_i]$ and its risk is the variance of return, $Var[R_i] = \sigma_i^2$. Each stock is therefore assumed to have a probability distribution, with the mean of the distribution determining the expected return of the stock and the variance of the probability distribution determining the level of risk. In addition, each stock is assumed to be related to all others via the correlation coefficient between itself and the other stocks in the portfolio. That is, the correlation in returns between assets R_i, R_j is $-1 \le \rho_{i,j} \le 1$. The correlation coefficient measures the degree of the relationship between R_i, R_j. The portfolio choices of an investor can be represented by the proportion of their capital they chose to allocate to each asset in the universe U. Therefore, let w_i be the proportion of capital allocated to asset X_i. It follows that $0 \le w_i \le 1$ and $\sum_{i=1}^{n} w_i = 1$.

3. Given the above framework, the expected return and risk of a portfolio of assets derived from universe U for given proportions $w_1, w_2, ..., w_n$ can be calculated. The expected return of a portfolio, $E[R]$, is a weighted average of its component securities, using the proportion of capital invested in the security as follows[174]:

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173 The variance of a continuous random variable, X, with probability density function f(x) is given by: $Var(X) = \sigma^2 = \int_{-\infty}^{\infty} (x - E[X])^2 f(x)dx$, with it's expected return, $E[X]) = \int_{-\infty}^{\infty} x.f(x)dx$.

174 Sharp, W.F (1985), *Investments Third Edition,* Prentice-Hall, New Jearsey, p121

$$E[R] = \sum_{i=1}^{n} w_i E[R_i] \qquad (18)$$

4. Note that the equation above states the portfolios expected return is a function only of the proportions invested in each security and its corresponding expected return. The variance of the portfolio can be defined as the likely divergence from the expected return of the portfolio, represented in the equation above.

5. The variance of this portfolio, σ_p^2, of assets can be summarised as below:[175]

$$\sigma_p^2 = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{j \neq i}^{n} w_i w_j \sigma_i \sigma_j \rho_{ij} \qquad (19)$$

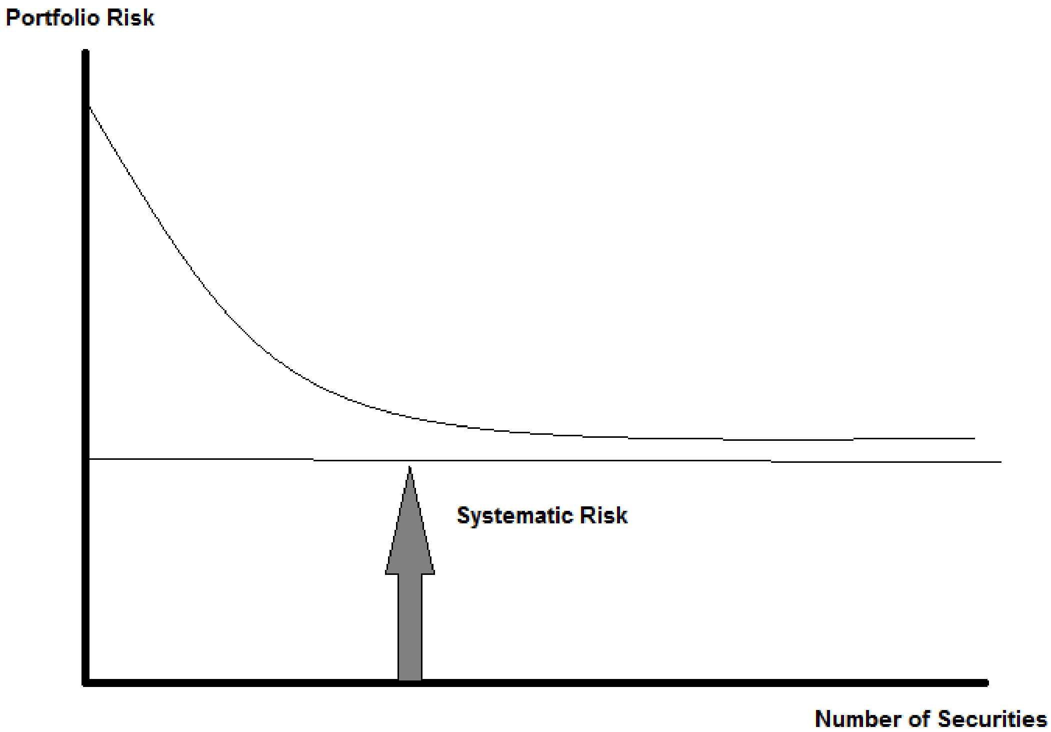
6. Here the variance of the portfolio is a function of the variance of component securities and the correlation between component securities. It can be shown that if $\rho_{i,j} \neq 1$ for all securities, investors can reduce their exposure to risk by holding a portfolio of assets. That is, the risk of holding a portfolio of stocks ,σ_p^2, is less than the risk of any of the component securities, σ_i.[176] This is diversification; the holding of multiple securities reduces an investor's exposure to risk, as diversification reduces variability in the return of the portfolio as a whole. Diversification reduces risk as a consequence of the fact that different stocks are not perfectly correlated and as a consequence stocks will not move in unison. It can be shown that as the amount of stocks in the portfolio increases, the portfolio approaches the average covariance between component securities.[177] This average covariance cannot be diversified away, as common stocks will always move together in response to common risks. The risk that remains after diversification is known as market risk or systematic risk, and represents risk that is faced by all firms in the economy. Figure 5 demonstrates the impact of diversification on a portfolio of securities:

[175] Ibid, p. 129.

[176] Myers. S.C. and Brealey, R.A *Principles of Corporate Finance 7th Edition,* McGraw- Hill , 2003, p. 171.

[177] Ibid, p. 172.

Figure 5 Diversification



7. Therefore, investors can choose their desired level of expected return and risk by altering the proportion of their capital they allocate between securities, $w_1, w_2, ..., w_n$. An investor's preference for risk and return therefore determines how they construct their portfolios.

8. Each investor is assumed to have a utility function with assigns a value to each possible combination of risk and return, with the value of the utility function representing the investor's preference.[178] This assumed utility function assigns higher values to combinations of risk and return that have higher expected rates of return for a given level of risk, and higher values to combinations that have the same expected rates of return but lower levels of risk. This implies that investors are risk averse when determining their capital allocation, preferring a higher expected return and less risk. As a consequence, modern portfolio theory seeks to determine the maximum value of this utility function, with the portfolio that maximises a given investors utility function being the optimal portfolio for the investor. Lintner (1965) notes that these indifference curves are complex and non-linear.[179]

9. A "frontier" of possible portfolio expected returns and variances can be developed by varying the choice of portfolio weights $w_1, w_2, ..., w_n$. [180] This frontier shows all possible combinations of risk and return. Given that investors prefer more expected return and less risk, it makes sense to only consider the "efficient frontier", those combinations with a minimum variance for a given expected return or a maximum expected return for a given variance. An investor will therefore allocate their capital to the point on the efficient frontier that maximises their utility function. This implies that

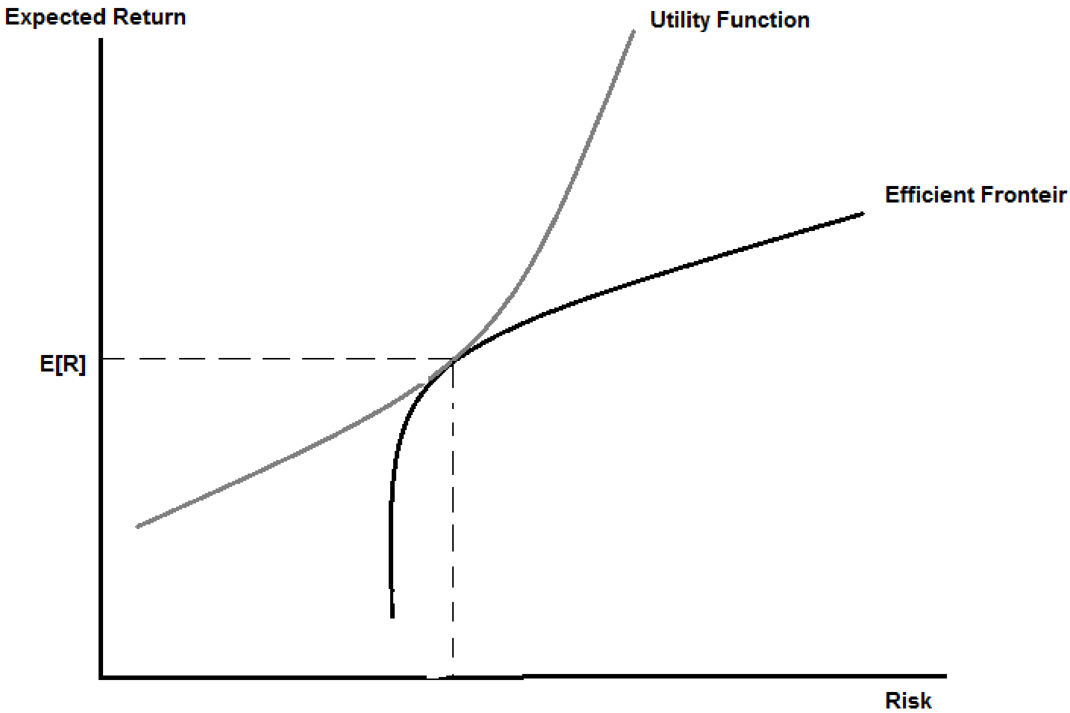
178 Lintner .J, 'The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets', *The Review of Economics and Statistics,* Vol. 47. No.1 (Feb, 1965), pp. 13-37.

179 Ibid.

180 Markowitz, H. "Portfolio Selection", *The Journal of Finance,* Vol. 7, No.1 (March 1952).

investors seek to maximise their expected return per unit of risk, and choose their level of risk and thus expected return based on their own personal preference for risk. This situation is depicted in Figure 6 below:

Figure 6 Portfolio Selection with No Risk Free Asset



10. This model was developed on the assumption that all assets in the universe have some degree of risk. This model is extended further by allowing for the existence of a risk-free asset. That is, an asset that has zero variance. In this context, capital can be allocated to the risk-free asset such as Commonwealth government securities, together with a portfolio of stocks. If we treat a risky portfolio on the efficient frontier as a single asset, with expected return $E[R_r]$ and variance σ_r^2, and a risk free asset with expected return r_f and variance 0 and allocate capital between both assets, w_r [181] and w_{rf} [182] we have:

$$\begin{aligned} &E[R_p] \\ &= w_r E[R_r] + w_{rf} r_f \\ &= w_r E[R_r] + (1 - w_r) r_f \\ &= r_f + w_r (E[R_r] - r_f) \end{aligned} \qquad (20)$$

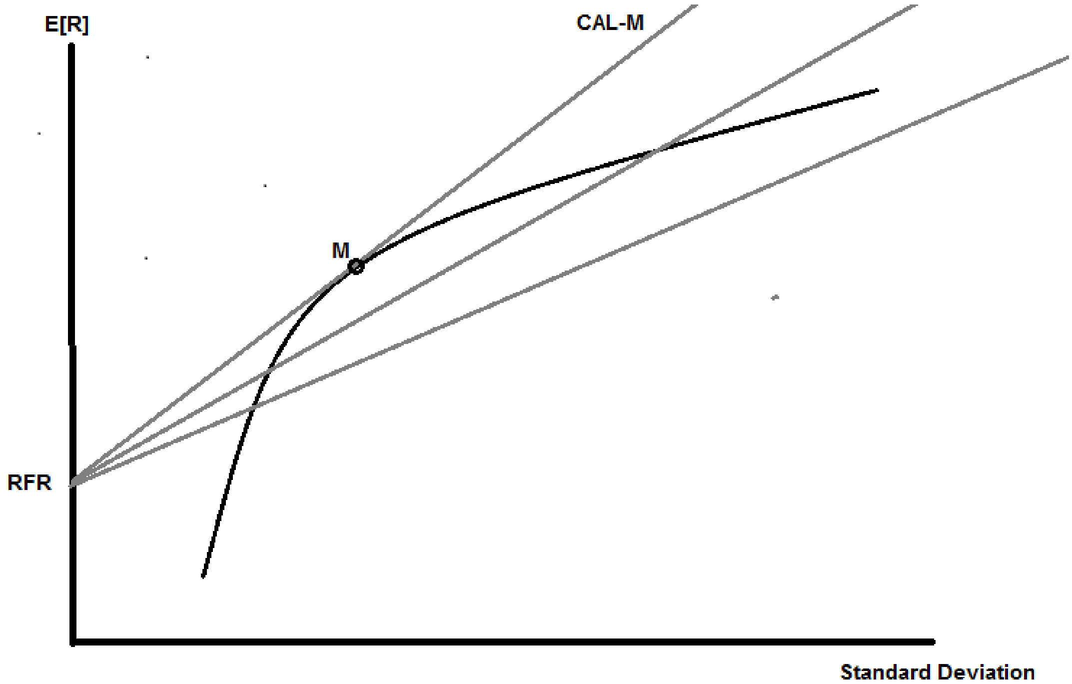
$$\sigma_p^2 = w_r^2 \sigma_r^2 \qquad (21)$$

[181] Proportion of capital invested in the risky portfolio.

[182] Proportion of capital invested in the risk free asset.

11. Intuitively, equation $E[R_p]$ and σ_p^2 imply that when a risky security or portfolio is combined with a risk free asset, the risk and return is proportional to the amount invested in the risky component. [183] Note that equation $E[R_p]$ and σ_p^2 imply investors are able to borrow funds at the risk free rate, which occurs if $w_r > 1$. Graphically, this relationship implies that an investor can obtain any risk-return combination along the straight line between a risk free asset and a given portfolio of risky assets, by varying w_r and w_{rf} . This relationship is shown below in is referred to as the Capital Allocation Line (**CAL**). With the addition of the risk free asset, it can be shown that an optimal portfolio of stocks exist, which combined with a risk free asset has a superior expected return per unit of risk. Figure 7 below shows various CAL for various risky portfolios, with portfolio M clearly being superior to all other portfolios:

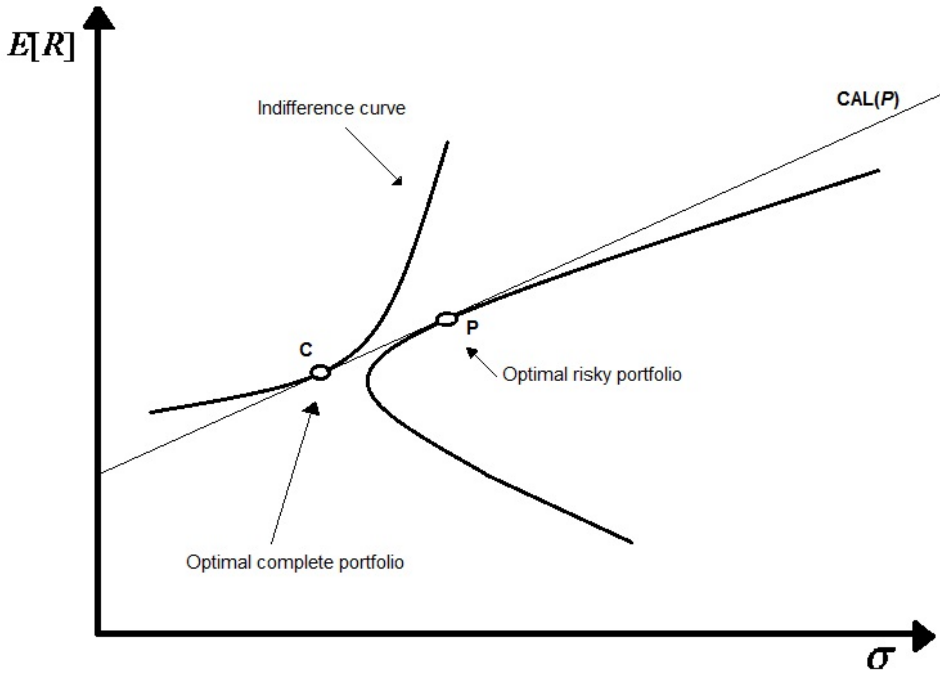
Figure 7 Portfolio possibilities with Risk Free Asset



12. By allocating capital between the risk-free asset and this optimal portfolio, the superior expected return per unit of risk ratio can be preserved. The investors desired level of risk can be achieved via this mechanism. As a consequence, all rational investors who seek to maximise the expected return per unit of risk will choose to hold a proportion of their capital in this optimal portfolio, and the remaining proportion in the risk free asset. By choosing the proportions of capital allocated between the optimal portfolio and risk-free asset, the desired level of risk can be achieved that maximises expected return, as determined by the investors utility function.

183 Sharp, W.F (1985), *Investments Third Edition,* Prentice-Hall, New Jersey, p. 135.

Figure 8 Capital market line



13. As presented in Figure 8, the allocation of capital between the optimal risky portfolio, P, and the risk-free asset is shown above in the capital market line (**CML**). Point P represents the optimal portfolio that maximises the expected return per unit of risk. Given that the CML dominates the efficient frontier of risky assets, investors are able to achieve superior risk return combinations by investing in both the risk-free asset and the optimal portfolio. The choice of portfolio is determined by the investor's indifference curve, which represents the risk-return combinations that give the investor the same level of utility as calculated by their utility function. A rational investor will attain the highest indifference curve possible, representing the highest level of utility possible from investing. Therefore, an investor will allocate their capital at point C above, where the highest possible indifference curve is tangent to the capital market line.

14. The optimal portfolio is known as the market portfolio as this portfolio must contain all risky assets. Given that diversification reduces the unsystematic risk of the portfolio, only systematic risk remains in a diversified portfolio. It is assumed that diversification is costless, and as a consequence, return is only achieved by bearing systematic risk. The optimal portfolio will therefore only compensate investors for bearing systematic risk, as unsystematic risk is costless to diversify away. As systematic risk is market risk, the fully diversified portfolio will contain only macroeconomic risks, and as a consequence investors will only earn a return for bearing macroeconomic risks.

15. The expected return of the risk-free asset corresponds to an asset having a beta of zero because a risk-free asset faces no systematic risk. The return of the market portfolio as a whole corresponds to a beta of 1, as by definition the market portfolio is the benchmark for systematic risk. Assuming that the return of an individual asset is linearly related to its β, these 2 points can be used to construct the Security Market Line (**SML**) as follows:

$$SML : E[R_i] = R_f + \beta_i (E[R_m] - R_f) \qquad (22)$$

where

$E[R_i]$ is the expected return of security i;

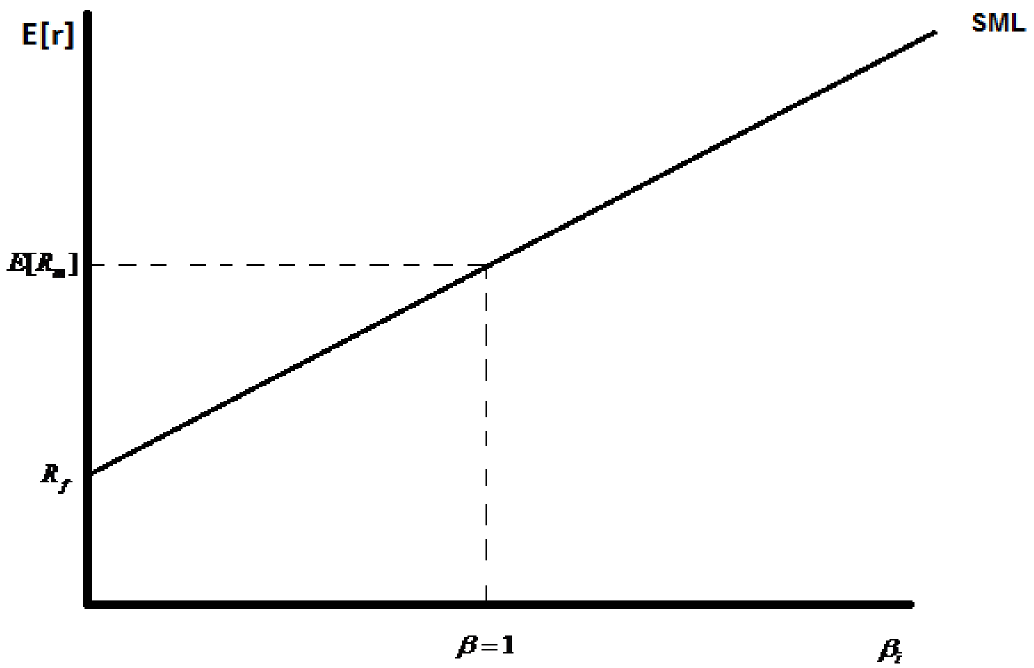
R_f is the risk free rate of return;

β_i is a measure of the systematic risk present in security i;and

$E[R_m]$ is the expected market return.

16. The difference between the expected return for security i and a risk-free rate of return, $E[R_m]-R_f$, is generally referred to as the market risk premium (**MRP**). The MRP represents the premium investors earn over and above the risk-free rate of return for bearing systematic risk. This situation can be represented graphically showing the relationship between a securities expected return $E[R_i]$ and a security β. As a result, the intercept represents the risk-free rate of return, whilst the slope of the SML is the market risk premium. The SML representation in Figure 9 is also known as the Sharpe-Lintner CAPM.

Figure 9 Security market line



17. The CAPM can be derived from the above modern portfolio theory framework. The traditional "Sharp-Linter CAPM" is derived from the following assumptions:[184]

- Investors are price takers.
- All investors invest for one holding period (myopic behaviour).
- Investments are limited to publically traded assets, and they all capable of investing/borrowing at the risk free rate.
- Investors pay no taxes or have any transaction costs.

184 Bodie. Z, Kane.A and Marcus A.J 1999, *Investments fourth edition,* Irwin/McGraw-Hill, p 251

- All investors are rational mean-variance optimizers, ie rely on the above modern portfolio theory framework.
- All investors have identical estimates of the probability distribution of asset returns (Homogeneous expectations).

18. In order to derive the CAPM relationship, consider an investor who has 100% of his capital allocated in the market portfolio (earning an expected return, $E[R_m]$ for given variance σ_m^2), and increases his position by an infinitesimal amount, δ which the investors finances by borrowing at the risk free rate, r_f.[185] In this situation, the new portfolio has an expected return and variance of:

$$E[R_m]+\delta(E[R_m]-r_f) \quad (23)$$

$$\sigma_p^2=\sigma_M^2+(2\delta+\delta^2)\sigma_M^2 \quad (24)$$

19. The incremental change in expected return and variance is:

$$\Delta E[R_p]=\delta(E[R_m]-r_f) \quad (25)$$

$$\Delta\sigma_p^2=(2\delta)\sigma_M^2 \quad (26)$$[186]

20. Dividing the equation above by its preceding one we can derive an "incremental risk premium" which is referred to as the marginal price of risk as follows:

$$\frac{\Delta E[R_p]}{\Delta\sigma_p^2}=\frac{(E[R_m]-r_f)}{2\sigma_M^2} \quad (27)$$

21. Similarly, consider an investor who instead invests the increment δ, in an asset X_i. The incremental return and incremental variance in this case is as follows:

$$\Delta E[R_p]=\delta(E[R_i]-r_f) \quad (28)$$

$$\Delta\sigma_p^2=(2\delta)\,\mathrm{Cov}(R_i,R_m) \quad (29)$$

185 Ibid, p257

186 The square of an infinitesimal quantity, δ^2, is assumed to be zero.

22. In this situation, the marginal increase in risk due to asset X_i (marginal price of risk) is:

$$\frac{\Delta E[R_p]}{\Delta \sigma_p^2} = \frac{(E[R_i] - r_f)}{2\,\mathrm{Cov}(R_i, R_m)} \tag{30}$$

23. For equilibrium to occur in capital markets, the marginal price of risk due the addition of asset X_i must equal the marginal price of risk due to the addition of the market portfolio (i.e. equation 28 must equal equation 29). If this was false, investors can invest in asset X_i to earn superior returns per unit of risk. Therefore, equation the marginal price of risk due to asset X_i and that due to the market portfolio results in:

$$\frac{(E[R_i] - r_f)}{2\,\mathrm{Cov}(R_i, R_m)} = \frac{(E[R_m] - r_f)}{2\sigma_M^2} \tag{31}$$

24. Solving equation (31) for $E[R_i]$ results in:

$$E[R_i] = r_f + \frac{\mathrm{Cov}(R_i, R_m)}{\sigma_M^2}[E[R_m] - r_f] \tag{32}$$

25. By defining $\beta_i = \frac{\mathrm{Cov}(R_i, R_m)}{\sigma_m^2}$ we have the Sharp-Lintner CAPM:

$$E[R_i] = r_f + \beta_i[E[R_m] - r_f] \tag{33}$$

26. From the above analysis, the return of an individual security is related to the covariance the security has with the returns of the market portfolio. As investors earn no return for bearing unsystematic risk, it follows that the return of an individual security will be related to the degree of systematic risk inherent in the security. The covariance between the market portfolio and the individual security represents the degree of systematic risk presented in the individual security. The sensitivity between a security and the market is referred to as a beta, β and this beta represents the degree of systematic risk presented in a security.

Appendix 10 Flight to quality in the Australian financial market: empirical evidence

Literature review

1. Academic studies have shown considerable empirical evidence in support of a 'flight-to-quality', shown by a negative correlation between the equities markets and bond markets during times of uncertainty within equities markets around the world.

2. Chordia, Sarkar and Subrahmanyam examined the impact of financial crises, monetary policy and mutual fund flows on financial market liquidity over 17 June 1991 to 31 December 1998. The authors observed that financial crises, such as the Asian Financial Crisis (from 1 October to 31 December 1997) and the Russian Default Crisis (from 6 July to 31 December 1998) are accompanied by a decrease in fund flows to equity funds and an increase in flows to the American Government bond funds, resulting in higher bond market liquidity. The authors concluded that this evidence supports a "flight-to-quality" during times of financial uncertainty.[187]

3. Gulko tested the hypothesis that the stock-bond correlation is positive before equity market crashes and negative in the aftermath. The author examined daily returns of the Standard and Poor's (**S&P**) 500 Index and the on-the-run United States (US) Treasuries, the most frequently traded bonds, over 1946 – 2000. A short run event study around equity market crashes was constructed. The author defined equity market crashes as where the S&P 500 index decreased by more than five per cent in a single trading day. The author reported a statistically significant positive correlation between equities and bonds for the ten trading day period before crashes, which reversed in the period spanning two days before crashes until ten days after. The author interpreted this as evidence supporting a 'decoupling' between the two markets as investors flee to the relative safety offered by American Government Bonds.[188]

4. Li examined the correlation between daily observed returns on equity and long-term government bonds over the period from 1958 to 2001 for the G-7 nations, including France, Germany, Italy, Japan, The United Kingdom, US and Canada. Equity indices are value-weighed broad market indices whereas the long-term bond indices are used to represent the benchmark government bond indices. A perfect correlation of one (either positive or negative) means that if the market for equity (bond) moves a given amount in a given direction, the market for bond (equity) will also move in perfect synchronisation. The author observed that the degree of correlation between the two markets was ranged from 0.2 to 0.3, meaning that movements in the stock market were mirrored in the bond markets to a degree of 20 per cent to 30 per cent.[189]

5. Illmanen examined the yearly correlation between the US stock market, approximated by the S&P 500 Index, and the bond market, approximated by the 20-year Treasury bonds over December 1926 to December 2001. The author reported that while the correlation between the two tends to be positive, there are periods of negative correlations, 1929 – 1932, 1956 – 1965 and 1998 – 2001. The author interpreted this as evidence of a 'decoupling' between the two markets in times of uncertainty.[190]

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[187] Chordia T, Sarkar A & Subrahmayam A, 2001, Common Determinants of Bond and Stock Market Liquidity: The Impact of Financial Crises, Monetary Policy, and Mutual Fund Flows, working paper.

[188] Gulko L, 2002, Decoupling, *The Journal of Portfolio Management*, Vol 28, No. 3. pp. 59-66.

[189] Li L, 2002, Macroeconomic Factors and the Correlation of Stock and Bond Returns, Yale ICF Working paper No. 02-46.

[190] Illmanen A, 2003, Stock-Bond Correlations, *The Journal of Fixed Income*, Vol 13, No. 2, pp. 55 – 66.

6. Dopfel examined the monthly stock and bond index correlation in the United States over January 1976 to December 2002. Equity returns were based on the S&P 500 Index and bonds from the Lehman Brothers Aggregate Bond Index. The author observed that while the correlation was positive on average, there were four years when a negative correlation between the two markets was observed, including 1987, 1998, 2001 and 2002. The author interpreted this as evidence in support of a decoupling of the two markets in times of crisis as investors seek a flight-to-quality from equities markets into bond markets.[191]

7. Connolly, Stivers and Sun examined whether equity market uncertainty, approximated by volatility, affects equity and bond market correlation. The authors examined daily equity data over 1988 to 2000 using the Chicago Board Options Exchange (**CBOE**) Volatility Index, calculated from the implied volatility of S&P 100 index options. Bond data was taken from 10 year and 30 year US Treasury bond yields. The authors observed that in periods where volatility is low, equities and bonds display a positive and reliable correlation. However, the correlation reverses when volatility is high. The authors also observed that bond returns and changes in volatility are positively related, suggesting that investors rebalance their portfolio towards bonds in times of high equity market uncertainty.[192]

8. Baur and Lucey examined the existence of a “flight-to-quality” phenomenon within European and American markets over 30 November 1995 to 30 November 2005. The authors used daily returns from Morgan Stanley Capital International (**MSCI**) stock and bond indexes MSCI Bond indexes represent total sovereign returns for bonds with maturities greater than ten years. The authors observe a negative correlation for transitory periods around market crises including the October 1997 equities market crashes, the Russian crisis in June 1998, the introduction of the Euro in January 1999 and 2002, the 2001 September 11 terrorist attacks and the beginning of the war in Iraq in March 2003. The authors observe changes in the magnitude of the correlation of as much as 0.6 within a period as short as 20 trading days and interpreted this as evidence that equity and bond markets can decouple quickly.[193]

9. Kim, Moshirian and Wu observed a consistent role of stock market uncertainty in many European markets. The authors used implied volatilities from the CBOE Volatility Index and Germany’s DAX Equity Index as a proxy for uncertainty in equities markets. Total daily return on the government bond indexes for bonds with maturities greater than ten years from 2 March 1994 to 19 September 2003 were used. The finding from the study is that the stock and bond market integration has trended downwards towards zero and even into negative territory in most European markets. This observation is consistent with findings from other studies which provide evidence supporting the validity of a flight-to-quality phenomenon.[194]

10. In conclusion, the above literature reviewed is in consensus of evidence of a positive correlation between equity and bond markets. However, during times of crisis or uncertainty within equities markets, the two markets ‘decouple’, resulting in a negative correlation as investors seek the liquid and safer assets within the bond market.

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[191] Dopfel F, 2003, Asset Allocation in a Lower Stock-Bond Correlation Environment, *The Journal of Portfolio Management*, Vol 30, No. 1. pp. 25-38.

[192] Connolly, R, Stivers, C & Sun, L. (2005). Stock Market Uncertainty and the Stock-Bond Relation, *The Journal of Financial and Quantitative Analysis*, Vol 40, No. 1, pp. 161-194.

[193] Baur D & Lucey B, 2009, Flight-to-quality or Contagion? An Empirical Analysis of Stock-Bond correlations, *Journal of Financial Stability*, Vol 5, No. 4. pp. 339-352.

[194] Kim SJ, Moshirian F & Wu E, 2006, Evolution of International Stock and Bond Market Integration: Influence of the European Monetary Union, *Journal of Banking and Finance*, 30:5, pp.1507-1534.

11. Dungey, McKenzie and Tambakis (2009) specified a threshold auto-regression conditional heteroskedasticity model (**TARCH**) to test for sign bias in the effect of negative return shocks in emerging stock markets on US Treasury bond yield volatility. They proposed that negative shocks in the returns from developing equity markets should lead to significant positive volatility responses in US Treasury bond yields. They developed specifications to test the hypothesis for a range of maturities in US Treasury bonds, corresponding to a range of emerging equity markets. Their results tended to find evidence in support of their proposition in all but the longest dated US Treasury debt instruments in their study. These findings supported their theoretical model of a flight-to-quality between emerging stock markets and US Treasury bonds.[195]

Methodology

12. The most common methodology in the flight-to-quality literature is to investigate whether there is a negative relationship between government bond prices and equity returns in order to find evidence of funds moving rapidly from a domestic equity market into domestic Government bonds.

13. The following model is specified:

$$\%\Delta BY_t = \alpha + \beta_0 R_{m,t} + \varepsilon_t \tag{34}$$

14. The dependent variable $\%\Delta BY_t$ is the per cent change in bond yields from day t-1 to day t that is from the day before to the day after. The pricing convention in the Australian market for Treasury bonds is in yields. Negative values of $\%\Delta BY_t$ therefore indicate an increase in the bond's price.

15. The intercept α represents the average difference between daily yield changes and equity market returns. Although it is reported, it is not of any interest in the context of this study.

16. The independent variable $R_{m,t}$ is the return on the domestic equity market between day t-1 and day t. A negative value of $R_{m,t}$ implies a fall in the equity market index between yesterday and today.

17. Following Gulko's methodology, a crash day is defined as a day where the market index loses five percent or more of its value.[196]

18. Equation (34) is estimated three times:

- once for observations falling in the event window. The event window is as starting two days before this day and finishes ten days after this day. If another crash occurs between the crash day and day ten after the crash, day ten is reset to occur ten days after the latest crash;

[195] Dungey M, McKenzie M & Tambakis D, 2009, Flight-to-Quality and Asymmetric Volatility Responses in US Treasuries, *Global Finance Journal*, No. 19, pp. 252-267.

[196] Gulko L, 2002, Decoupling, *The Journal of Portfolio Management*, Vol 28, No. 3. p 60

- once for observations falling in the prologue. The prologue is defined is defined as ten days before the event window; and
- once for the epilogue (the period after the event window) is defined as the ten days after.

19. The event window is defined as starting two days before this crash day and finishes ten days after this crash day. If another crash occurs between the crash day and day ten after the crash, day ten is reset to occur ten days after the latest crash. The prologue is the period before the event window while epilogue is the period after the event window.

20. Gulko's study used changes in bond prices (as opposed to yields) in equation (34) which represents changes in yields. The implication of this difference is that the sign of Gulko's β will be inverse to the sign of β as presented in (34). Gulko's study found that β is significantly positive during prologue and epilogue, but significantly negative during the crash window. The findings of Gulko's paper concluded that stock-bond correlation switches sign from positive to negative during stock market crashes with high probability. Since β in (34) is inversely related to Gulko's β, our hypothesis is formulated inversely. Accordingly, the following hypothesis to test for flight-to-quality responses in the Australian equity market and Government Treasuries is:

Hypothesis (iii)

In equation (34), β is significantly negative during the prologue and epilogue, but significantly positive during the crash window.

Data

21. The All Ordinaries (non-accumulation) price and 10-year Australian Commonwealth Government bond yield indices were sourced from Bloomberg. Each observation represents the last trading day closing observation available. The full set of daily observations covers the period from 30 September 1983 to 25 January 2013.

22. Daily bond yield changes were calculated using the continuous[197] daily percentage change:

$$\%\Delta BY_t = \ln\left(\frac{y_t}{y_{t-1}}\right) \tag{35}$$

where

y_t is the last closing yield available on trading day t.

23. Daily market returns (ie the daily percent change in price) are calculated as:

[197] Continuous per cent changes are preferred in regression analysis due to their symmetrical properties in in creases and decreases.

$$R_{m,t} = \ln\left(\frac{p_t}{p_{t-1}}\right) \quad (36)$$

where

p_t is the last closing index price available on trading day t.

24. Table 13 shows that across the whole period of 7,650 observations on average, daily market returns were positive at 0.025 per cent (prices tended to increase each day), where as bond yields tended to decline over the same period (- 0.019 per cent).

25. The largest negative daily market return was around 29 per cent, whereas the largest daily gain was only around 6 per cent. Bond yields are more symmetric in their extremes with daily change maximum and minimums being in the order of -7.5 and 7.5 percent respectively.

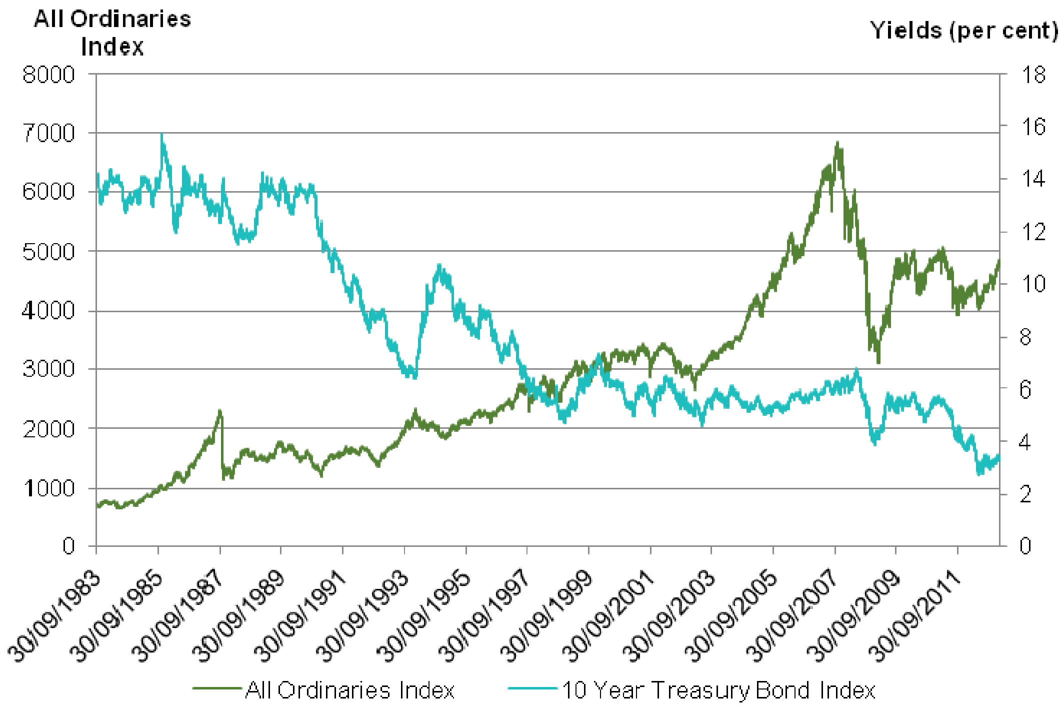
Table 13 Descriptive statistics - full data set: September 1983 to January 2013

	Market Return	Bond Yield Change
Mean	0.025%	-0.019%
Mean t-statistic	2.21	-1.51
Median	0.028%	0.000%
Mode	0.000%	0.000%
Standard Deviation	0.989%	1.100%
Range	34.830%	15.038%
Minimum	-28.761%	-7.398%
Maximum	6.069%	7.640%
Sum	191%	-145%
Count	7650	7650

Source: Economic Regulation Authority's analysis

26. The behaviour of the changes in the series is reflected in the market index and bond yield trends plotted in Figure 10. Over the entire period, the All Ordinaries index has trended up while bond yields have trended down.

Figure 10 Australian stock market and treasury bond index trends: September 1983 to January 2013



27. As per Gulko's study, three subsets of data were extracted from the full set consisting of:

- the crash period;
- prologue period (period before the crash); and
- epilogue (period after the crash).

28. A crash is defined as any day where the index loses more than 5 per cent of its value. The crash period is defined as that day, the two days before that day and ten days after that day making a crash period thirteen days long, provided another crash did not occur within the crash period. If another crash did occur within a crash period, then the period is extended to include another ten days after that crash and so forth.

29. The prologue period is defined as the ten days before a crash period while the epilogue is defined as ten days after the crash period.

30. The dates corresponding to the crash are outlined in Table 14 below:

Table 14 Australian equity market crash dates and descriptions

Date	All Ordinaries Index	10 Year Treasury Bond Yield Index	Market Return	Bond Yield Change	Event
20/10/1987	1549	13.75	-28.76%	4.46%	1987 Wall Street Crash
23/10/1987	1514	13.3	-7.30%	0.00%	
26/10/1987	1415	13.1	-6.78%	-1.52%	
27/10/1987	1317	13.5	-7.20%	3.01%	
29/10/1987	1284	14	-7.82%	2.53%	
4/11/1987	1290	13.65	-5.63%	0.00%	
16/10/1989	1601	14.002	-8.44%	0.00%	United Airlines Leveraged Buy Out Failure
28/10/1997	2299	6.045	-7.45%	4.22%	Asian Financial Crisis
17/04/2000	2920	6.098	-5.85%	-1.51%	'Dot Com' Bubble
22/01/2008	5222	5.872	-7.54%	-2.62%	Global Financial Crisis
8/10/2008	4370	4.931	-5.09%	-2.58%	
10/10/2008	3940	5.139	-8.55%	0.98%	
16/10/2008	3988	5.248	-6.89%	-2.35%	
13/11/2008	3672	4.909	-5.59%	-3.50%	

Source: Bloomberg and Economic Regulation Authority's analysis

31. October 1987 witnessed one of the most spectacular stock market crashes on record as stock exchanges worldwide recorded some of the largest one day declines in history. While there is no consensus to its cause, some factors considered to contribute to the cause include widespread contagion, a lack of liquidity and an extended period of overvaluation in stock prices prior to the crash.

32. The October 1989 crash was triggered by the breakdown of the United Airlines leveraged buyout. The breakdown of the United Airlines buyout triggered a collapse in the junk bond market as the announcement that the buyout group could not secure the requisite amount of debt financing caused widespread contagion as investors withdrew their money from the equity and bond markets.

33. The October 1997 crash was triggered by the Asian Financial Crisis which saw large currency depreciations and defaults in many Asian countries. The crisis started in Thailand with the collapse of their sovereign currency, which triggered widespread depreciations in currencies, equities markets and asset price across most of the Southeast Asian nations.

34. The April 2000 crash was triggered by the popping of the 'dot com' bubble, a speculative bubble in internet stocks within the NASDAQ from 1995 to 2000. The bubble was characterised by overvaluations and irrational exuberance towards internet based stocks which was started by rapidly increasing stock prices, overconfidence and widely available venture capital for internet based stocks.

35. The 2008 stock market crash was caused by the onset of the 2008 Global Financial Crisis. This crisis was triggered a combination of the United States subprime mortgage crisis, the effect of which was spread worldwide by securitisation causing a liquidity crisis in the credit market. This eventually caused the bankruptcy of many major financial institutions, such as Lehman Brothers, Fannie Mae, Freddie Mac and Bear Stearns.

36. Descriptive statistics for the 108 observations falling in the crash periods are outlined in Table 15 below. Daily market returns in this period are significantly negative on average as expected, while daily changes in bond yields are also negative on average, although these changes appear not to be significantly different from zero as indicated by the mean t-statistic, median change and sum of changes. The major changes in stock returns (minimum of bond yields (minimum of-7.398 per cent and maximum of 7.640 per cent) and bond yields (minimum of -28.761 and maximum of 6.069 per cent) from the full data set are incorporated within the crash period set.

Table 15 Australian equity market crash period data set

	Market Return	Bond Yield Change
Mean	-0.879%	-0.067%
Mean t-statistic	-2.11	-0.35
Median	-0.256%	0.000%
Mode	0.000%	0.000%
Standard Deviation	4.322%	1.971%
Range	34.830%	15.038%
Minimum	-28.761%	-7.398%
Maximum	6.069%	7.640%
Sum	-95%	-7%
Count	108	108

Source: Bloomberg and Economic Regulation Authority's analysis

37. Prior to the crash, descriptive statistics (see Table 16) based on the 70 observations show that the average change in both series are of the same sign, but not of a large magnitude. The ranges and volatility of these series (as shown by the standard deviation) appear to be more closely aligned than during the crash period above.

Table 16 Descriptive statistics - prologue data set

	Market Return	Bond Yield Change
Mean	-0.182%	-0.099%
Mean t-statistic	-0.92	-0.54
Median	-0.234%	0.000%
Mode	NA	0.000%
Standard Deviation	1.651%	1.524%
Range	9.059%	9.448%
Minimum	-4.391%	-4.848%
Maximum	4.668%	4.600%
Sum	-13%	-7%
Count	70	70

Source: Bloomberg and Economic Regulation Authority's analysis

38. In the period after the crash, descriptive statistics in Table 17 below show a similar situation to that in prologue. The average change in both series is of the same sign, but not of a large magnitude while the ranges and standard deviations are more aligned than those in the crash.

Table 17 Descriptive statistics - epilogue data set

	Market Return	Bond Yield Change
Mean	-0.186%	-0.145%
Mean t-statistic	-0.88	-0.80
Median	-0.192%	0.000%
Mode	NA	0.000%
Standard Deviation	1.777%	1.520%
Range	10.259%	8.773%
Minimum	-5.592%	-4.438%
Maximum	4.668%	4.335%
Sum	-13%	-10%
Count	70	70

Source: Bloomberg and Economic Regulation Authority's analysis

39. The overall picture from these statistics is that daily changes in bond yields tend to respond mildly to crashes in the stock market, but these changes appear to behave in a comparable way to stocks returns.

Results

40. Equation (34) was run on the full data set and the subsets, prologue, crash and epilogue to test Hypothesis (i). Results are shown in Table 18. The three components of the hypothesis are rejected:

- The beta regression coefficient in the prologue subset is significantly *positive* – the hypothesis requires it to be significantly *negative*.
- Beta is not significantly different from zero during in the crash subset – the hypothesis requires it to be significantly positive.
- Beta in the epilogue is significantly *positive*

  – the hypothesis requires it to be significantly *negative.*

Table 18 Regression results

Period	Beta	p-value	R-square	Observations
Full Set	0.0789	0.0000	0.0050	7,650
Prologue	0.4614	0.0000	0.2499	70
Crash	-0.0040	0.9277	0.0001	108
Epilogue	0.4315	0.0000	0.2545	70

Source: Bloomberg and Economic Regulation Authority's analysis

41. The full data set estimate is positive and significant at 1 per cent. This indicates that over the whole period, bond yields tend to change in the same direction as stock prices. Another interpretation is that bond prices tend to change in the opposite direction of stock prices over the whole period. This relationship appears to move closer towards a one to one co-movement during the prologue, disappears entirely during the crash and returns toward a one to one co-movement after the crash.

Conclusion

42. The 'flight-to-quality' hypothesis as formulated by Gulko is rejected in the Australian Market.

43. The results from this study suggest that, in general, there tends to be some positive co-movement between stock prices and Treasury bond yields in Australia. In the days before a crash, it appears that the co-movement is more direct between the two markets, but this co-movement completely breaks down during the days that closely surround a crash. In the epilogue, similar co-movement between the markets appears to return.

44. Gulko's analysis was carried out on the US market. The US is perceived as a 'safe haven' thus it may experience net capital inflows from the rest of the world into its safest assets.[198] Post 1987, the US Treasury bonds became the safe investment of choice over gold.[199] Conversely, Australia is a very small market without the reputation of the US as a safe haven during times of heightened uncertainty. A possible explanation for the above results is that the 'flight-to-quality' effect may see funds leaving the Australian market destined for investment in markets that are perceived as safe. Dungey, McKenzie and Tambakis' 2009 study found this to be the case between emerging equity markets and the US Treasury bond market.[200]

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198 Caballero and Kurlat, October 2008, Flight-to-quality and Bailouts: Policy Remarks and a Literature Review, Massachusetts Institute of Technology Department of Economics Working Paper 08-21, p.1.

199 Gulko, 2002, Decoupling, The Journal of Portfolio Management, Vol 28, No. 3, pp.59-66.

200 Dungey M, McKenzie M & Tambakis D, 2009, Flight-to-Quality and Asymmetric Volatility Responses in US Treasuries, *Global Finance Journal*, No. 19, pp. 252-267.

Appendix 11 Co-integration between Commonwealth Government bond yields and the cash rates

Introduction

1. On the advice of their consultants, regulated business submitted that a required rate of return on the regulatory decisions should be stable over time. The implication of this view is that an reduction in the risk free rate will be offset by a relative increase in the Market Risk Premium (**MRP**), leaving the return on equity unchanged when the Sharpe-Lintner CAPM is adopted. In an econometric sense, this implication means that the risk free rate and the MRP should be co-integrated.

2. In a separate empirical study, the Authority failed to find empirical evidence to support the view that the Commonwealth Government Security (**CGS**) yields and the MRP are co-integrated. It is in contrast with claims made by regulated businesses. In this brief empirical test, the Authority has conducted the co-integration test between the CGS observed yields and the cash rates.

3. A stationary series is a series that tends to revert to a long run mean and variance. It is noted that two or more series that are non-stationary (i.e. they tends to follow a random walk when they are observed in isolation) may be linearly combined by adding or subtracting from each other to form a stationary series. The movements of the series in isolation may appear to be erratic but the differences between them may not be the case because the series may be 'anchored' to one another. Such a series is said to be co-integrated.

4. Co-integration does not necessarily mean correlation. In the shorter term, the series may move independently with each other. However, in the longer term, these series will tend to converge as if they were 'elastically tethered' together to prevent them from drifting too far apart.

5. The co-integration test is adopted to test the relationship between the overnight cash rate and the CGS bond yields. While the former series is typically fixed for periods of one month or more, the latter series moves frequently to reflect the market demand and supply forces.

6. The following equation is specified:

$$\varepsilon_t = CR_t - \phi Yield_{i,t} \qquad (37)$$

where

t is the day in which the observation is observed;

i is the term to maturity of the Treasury, in this case, 5- or 10-year terms;

CR is the overnight cash rate on day *t*;

Yield is the corresponding CGS bond yield on day *t*; and

ϕ is the co-integrating coefficient (*phi*).

7. It is argued that if the cash rates and the Treasury bond yields series are co-integrated, the series ε_t will be known as being stationary.

8. The two-step Engel-Granger Augmented Dickey Fuller test for co-integration is carried out as follows.

- *First*, the series ε_t is created by running the following regression for both *i* equal to 5- and 10- year terms

$$CR_t = \alpha + \phi Yield_{i,t} + \varepsilon_t \qquad (38)$$

where

α is a constantly observed difference between the overnight cash rate and the CGS bonds yields.

- *Second*, this step involves using the Augmented Dickey-Fuller test on residual series ε_t to test hypothesis (i) as stated below.

Hypothesis (i)

The series are non-stationary - that is they have a unit root.

9. Rejection of Hypothesis (i) suggests the two series are co-integrated and are bound together.

Data

10. The daily closing (trading day) annualised bid yield (*Yield*) on the 5- and 10-year Australian Government Bonds and the Reserve Bank of Australia's overnight cash rate were sourced from Bloomberg. The last available price[201] is used for each trading day observed on all data series. The data is outlined in Table 19 below.

Table 19 Cash rate and bond yield raw data: October 1983 to April 2013

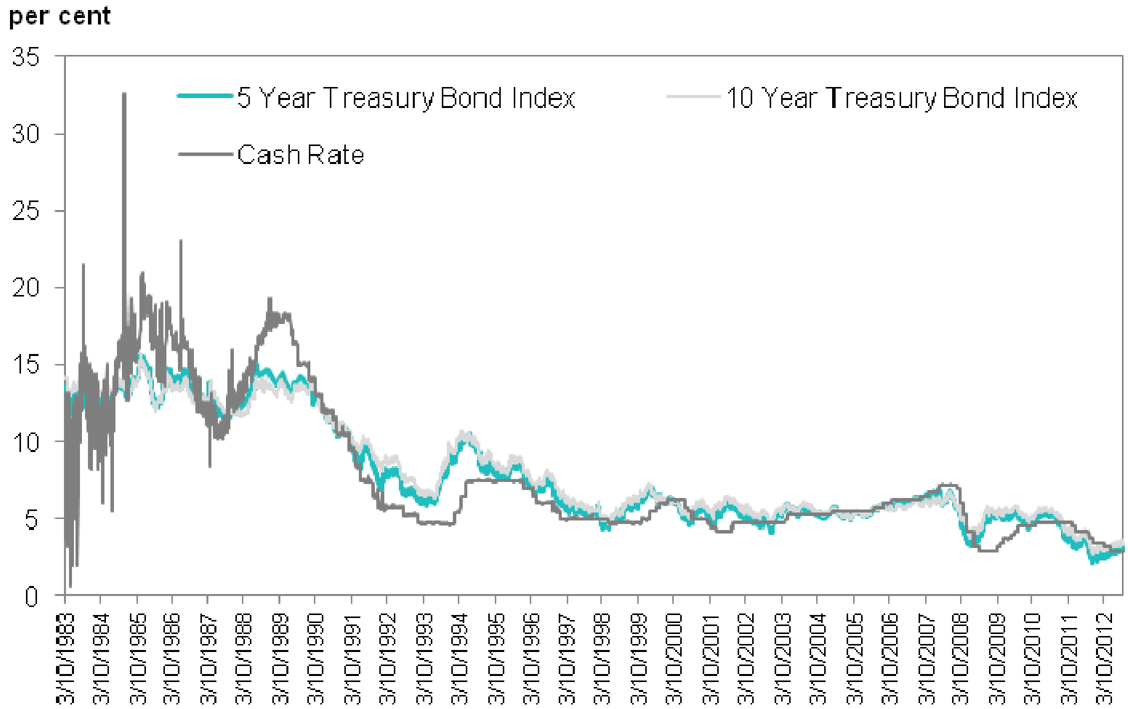
Description	Ticker	Observations
10 Year Australian Government Bond	GACGB10	7500
5 Year Australian Government Bond	GACGB5	7025
Australian Overnight Cash Rate	RBACOR	7380

Source: Bloomberg

11. The yields of the CGS bonds and the Reserve Bank of Australia's (RBA) overnight cash rate are plotted below in Figure 11 to illustrate the relationship over the period.

[201] Bloomberg field 'PX_LAST'.

Figure 11 Overnight cash rate vs. 5 and 10 year bloomberg treasury bond index



Source: Bloomberg

Results

12. The Augmented Dickey-Fuller unit root tests were carried out on the series ε_t estimated from (38). The results are presented in Table 20 and Table 21 below.

Table 20 Yield series regression results

Regression	Observations	Intercept (alpha)	Yield Coefficient (phi)	R-Squared
10-Year Series	6946	-1.1315	1.0723	0.7893
p-value		0.0000	0.0000	
5- Year Series	6946	-0.9001	1.0789	0.8348
p-value		0.0000	0.0000	

Source: Economic Regulation Authority's analysis

13. The co-integrating coefficients on the CGS yields show that both CGS bond indices move similarly (1.07 for the 10-year and 1.08 for the 5-year series) with the cash rates. The results imply that the CGS yields move around one for one with the cash rate.

14. The intercept (alpha) on the 10-year series regression indicates that there is approximately 1.13 per cent premium over the cash rate on the 10-year bond and 0.9

per cent premium over the cash rate on the 5-year bond. This appears to be consistent with the intuition that a 10-year bond yields should provide a higher liquidity premium than a 5-year one.

Table 21 Augmented Dickey-Fuller unit root tests: no trend or drift

Series	Observations	Test Statistic	Critical Value			Stationary
			1%	5%	10%	
10 Year Series	6946	-2.0925	-2.58	-1.95	-1.62	Yes
5 Year Series	6946	-1.9483	-2.58	-1.95	-1.62	Yes[202]

Source: Economic Regulation Authority's analysis

15. Absolute values of the test statistic greater than absolute critical values in Table 21 indicate rejection of the unit root hypothesis suggesting that the series ε_t are stationary. This suggests that both bond yields and the cash rate series are co-integrated.

Conclusion

16. Engel–Granger co-integration tests indicate that the overnight cash rate and 5-year and 10-year CGS bond yields series are co-integrated. The Authority is of the view that it is reasonable to assume that monetary policy acts independently of bond yields, given its informal (post 1993) and formal primary objective of targeting inflation. The CGS bond yields, however, are determined by markets which consider many macroeconomic variables including the RBA's overnight cash rates in the economy. From this perspective, it would be difficult to think of a scenario in which the causality runs from the CGS bond yields to the overnight cash rate (i.e. the CGS bond yields cause the RBA's cash rates).

17. This view, together with the above test results, tend to support the prevalence of the effect of the overnight cash rate on the CGS bond yields, given the strongly significant co-integrating coefficients of 1.07 to 1.08 which indicate an approximately one for one movement between the two series.

[202] At 10 per cent, on border at 5 per cent.

Appendix 12 Co-integration between the equity risk premium and the risk-free rate of return

Methodology

1. A single time series such as the yields on a bond may move in such a way that it does not revert to any long run mean or long run level of volatility. In the language of time series analysis, such a series is known as *non-stationary*. The implication is that the most recent observation in the series is the best predictor of tomorrow's value.

2. Two or more time series that exhibit such trends can at times have a stochastic trend in common - often exhibited over long periods of time. It can be the case that a linear combination of the two series produces a new stationary series, that is, one that tends to revert to some long run average and long run level of volatility. This implies that an equilibrium relationship exists between the series. Two series that exhibit such a characteristic are referred to as *co-integrated*.

3. In the case of the market returns and the risk free rate in the Capital Asset Pricing Model (**CAPM**), the two series are tested to confirm whether or not they are co-integrated, in the sense that they share some long run stochastic trend. Intuitively, the risk free rate is not expected to rise above the market returns for an extended period of time. Conversely, the market returns is not expected to stay below the risk free rate for an extended period of time. One would expect a tendency for correction over the long run where the returns to investing in the market are sufficiently higher than risk free rate to compensate for the risks inherent in equity investment.

4. The following series is constructed:

$$\varepsilon_t = R_{m,t} - \phi Yield_t \qquad (39)$$

where

$R_{m,t}$ is the market return, $Yield_t$ is the corresponding bond yield on day t.

5. The initial assumption is that phi (ϕ) is equal to one.

6. Series (39) is tested for stationarity using the Dickey-Fuller Generalised Least Squares (**GLS**) test. The following hypothesis is tested:

Hypothesis (i)

The series are non-stationary - that is they have a unit root.

7. Additionally, tests are carried out to relax the assumption that ϕ is equal to one using the two step Engel-Granger Augmented Dickey Fuller test for co-integration.

8. The first step involves running the following regressions:

$$R_{m,t} = \alpha + \phi Yield_t + \varepsilon_t \tag{40}$$

$$ERP_{m,t} = \alpha + \phi Yield_t + e_t \tag{41}$$

9. The second step involves using the Augmented Dickey-Fuller test on residual series ε_t and e_t to test hypothesis (i).

Data

10. The daily (trading day) annualised bid yield (Yield) on 5-year and 10-year Australian Government Bonds and daily closing price for the All Ordinaries accumulation index were sourced from Bloomberg. The last available price[203] is used for each trading day observation on all data series. The data is outlined in Table 22 below.

Table 22 Market index and bond yield raw data: acquired January 2013

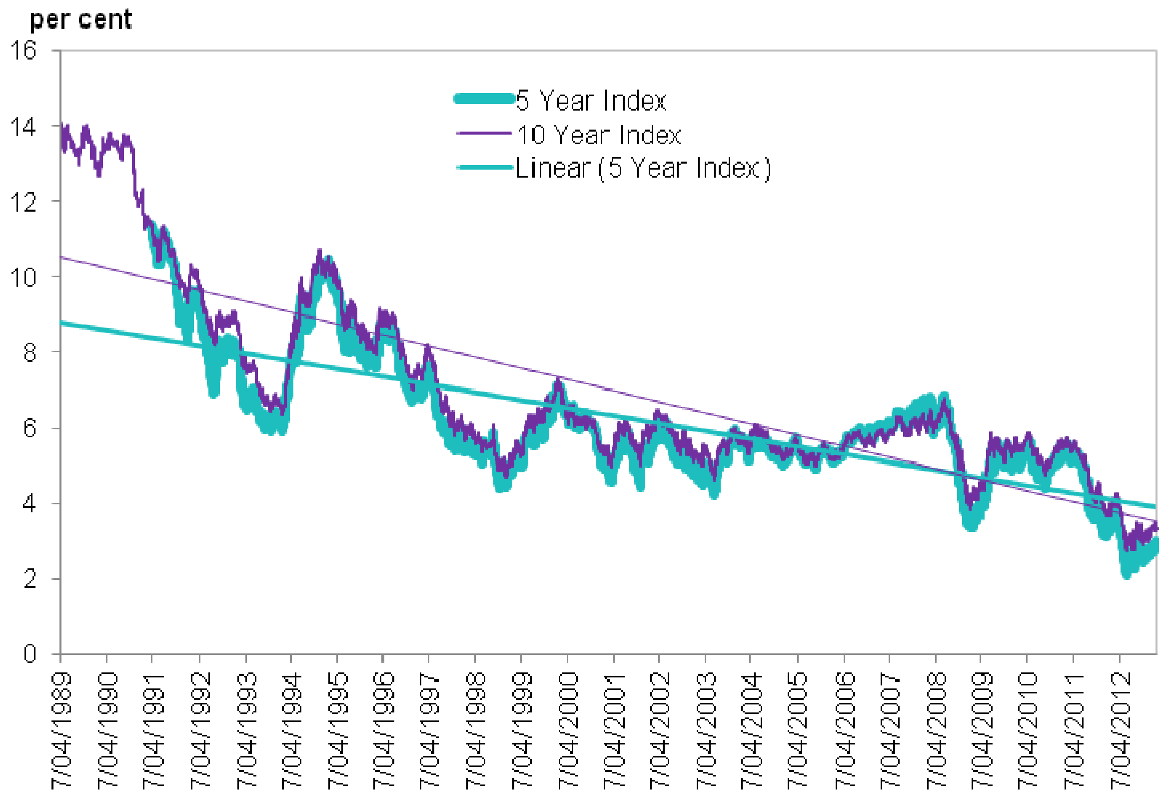
Description	Ticker	Source	From	To	Observations
10 Year Australian Government Bond	GACGB10	Bloomberg	7/04/1989	23/01/2013	7,195
5 Year Australian Government Bond	GACGB5	Bloomberg	19/03/1991	23/01/2013	6,688
All Ordinaries Accumulation Index	ASA30	Bloomberg	7/04/1989	23/01/2013	7,195

Source: Bloomberg

11. The yields of government bonds are plotted below in Figure 12 to illustrate the trends over time.

203 Bloomberg field 'PX_LAST'.

Figure 12 Australian Commonwealth Government bond index series 5 year versus 10 Year 1989 to 2013



Source: Bloomberg and Economic Regulation Authority's analysis

12. Market returns were constructed for a 5-year and 10-year holding period by taking the natural log of the last closing price for 5 calendar years (or 10 for 10 year period) in the future divided by the present day's closing price. This continuous return is annualised by dividing by 5 for 5-year holding period (or 10 for 10-year holding period).

$$R_{m,t} = \ln\left(\frac{P_{t+5\,years}}{P_t}\right)/5 \tag{42}$$

where

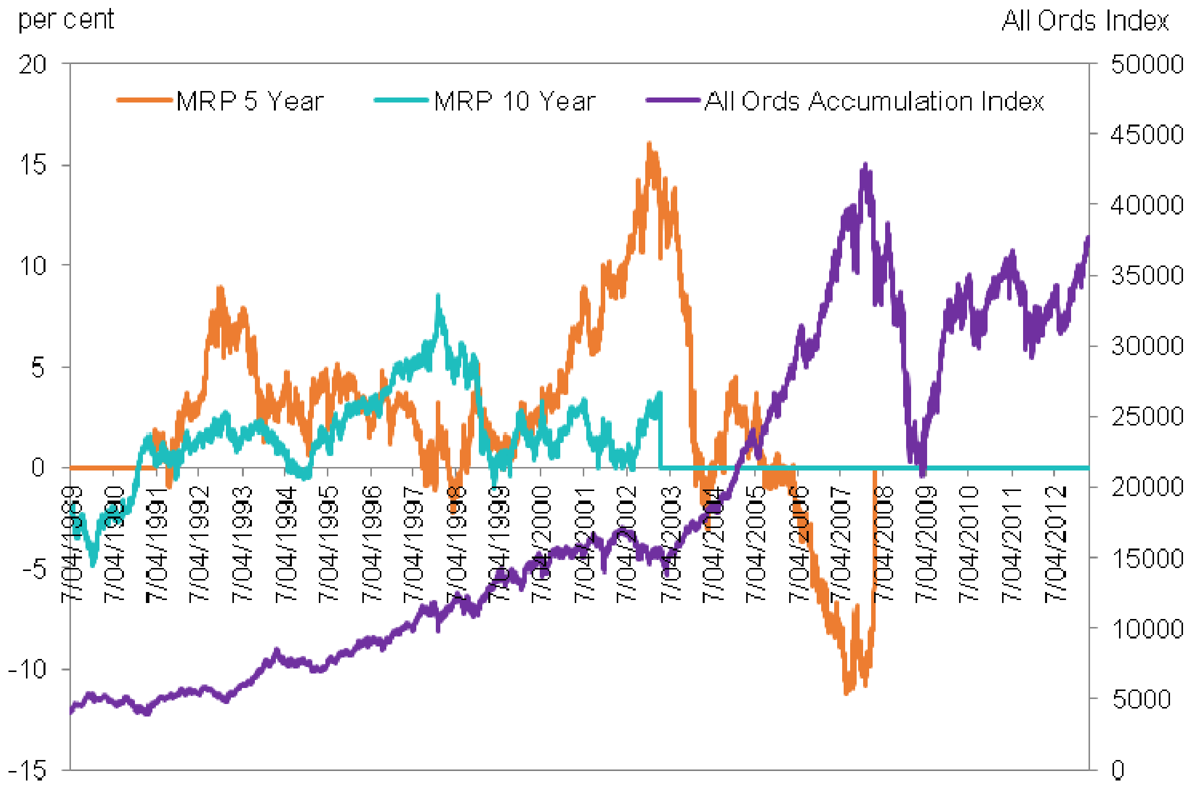
P_t is the last available daily closing price on day t.

13. The equity risk premium is calculated by subtracting the present day's yield from the present day's return calculated in (42). This is done for both the 5 and 10 year series.

$$\text{ERP}_t = \ln\left(\frac{P_{t+5\,years}}{P_t}\right)/5 - \text{Yield}_t \tag{43}$$

14. The resultant series from (43) for 5-year holding period and 10-year holding period is illustrated in Figure 13.

Figure 13 Equity Risk Premium - holding period of 5 Years versus 10 Years - 1989 to 2013



Source: Economic Regulation Authority's analysis

Results

15. The Dickey-Fuller GLS unit root tests were carried on the series constructed from (43) assuming ϕ equal to one for both the 5-year and 10-year series. The results are shown in Table 23 below.

Table 23 Dickey-Fuller GLS unit root tests: no trend or drift - ϕ = 1

Series	Observations	Test Statistic	Critical Value			Stationary
			1%	5%	10%	
5-Year Series	4,861	-1.3680	-2.57	-1.94	-1.62	No
10-Year Series	3,601	-0.7200	-2.57	-1.94	-1.62	No

Source: Economic Regulation Authority's analysis

16. The hypothesis that the series have a unit root cannot be rejected even at the 10 per cent level of significance. This suggests that in the 5-year and 10-year series, the market return and bond yield are *not* co-integrated. This conclusion implies that there

is *no* long run equilibrium relationship between the two series observed over the period in which these observations are taken.

17. Before running regression (42) and (43) to test the residuals, Augmented Dickey-Fuller tests were carried out to determine whether the risk free rate and the market return series alone were stationary. A trend was included in the test on the basis of the distinct declining trend exhibited over the periods in which all series were observed. The results are presented in Table 24.

Table 24 Augmented Dickey-Fuller tests on market returns and bond yield series with trend

Series	Observations	Test Statistic	Critical Value			Stationary
		(tau)	1%	5%	10%	
5 Year Bond Yield Index	4861	-2.8053	-3.96	-3.41	-3.12	No
5 Year Market Returns	4861	-1.9297	-3.96	-3.41	-3.12	No
10 Year Bond Index	3601	-2.0686	-3.96	-3.41	-3.12	No
10 Year Market Returns	3601	-2.2897	-3.96	-3.41	-3.12	No

Source: Economic Regulation Authority's analysis

18. All of the tests do not reject the hypothesis of a having a unit root as demonstrated by the low values of the test statistics relative to the critical values in absolute terms.

19. Augmented Dickey-Fuller unit root tests were carried out on the residual series ε_t and e_t from regression (42) and (43) with the results presented in Table 25 below.

Table 25 Augmented Dickey-Fuller unit root tests: no trend or drift - ϕ unconstrained

Series	Observations	Test Statistic	Critical Value			Stationary
(Regression)		(tau)	1%	5%	10%	
5 Year Series (2)	4,861	-1.3424	-2.58	-1.95	-1.62	No
5 Year Series (3)	4,861	-1.3424	-2.58	-1.95	-1.62	No
10 Year Series (2)	3,601	-2.2600	-2.58	-1.95	-1.62	Yes
10 Year Series (3)	3,601	-2.2660	-2.58	-1.95	-1.62	Yes

Source: Economic Regulation Authority's analysis

20. Again, the 5-year series did not reject the hypothesis of no unit root as shown by the value of the test statistic being lower than even the value 10 per cent critical value in absolute terms.

21. The 10-year series however, rejected the hypothesis of a unit root at the 5 per cent level of significance. This suggests that the 10 year risk free rate and market returns/risk premium are co-integrated with the implication that a long term equilibrium relationship exists between them.

22. The regression results for (42) and (43) on the 10 year series are shown in Table 26.

Table 26 10-Year yield series regression (42) and (43) results

Regression	Observations	Intercept (alpha)	Yield Coefficient (phi)	R-Squared
10 Year Series (2)	3,601	6.3702	0.4222	0.2896
p-value		0.0000	0.0000	
10 Year Series (3)	3,601	6.3702	-0.5778	0.4329
p-value		0.0000	0.0000	

Source: Economic Regulation Authority's analysis

23. The intercept for both cases is highly significant at 6.37 per cent annualised return. The yield coefficient ϕ (known as the co-integrating coefficient) indicates a positive relationship between returns and the risk free rate. The sign of this result is intuitively appealing, given we expect that market returns consist of some premium over the risk free rate; market returns tend to rise when the risk free rate rises and vice versa. There is no obvious reason in practice however, why the coefficient should not equal one. Conversely, ϕ indicates a negative relationship between the market risk premium and risk free rate series.

24. These coefficients should be interpreted with caution. In addition to the nonsensical value of ϕ in (43) generally, these Ordinary Least Squares (**OLS**) estimates have a non-normal distribution meaning inference based on the student distribution can be misleading. While dynamic OLS estimates can resolve this latter issue, one would expect to see a value of one on the yield coefficient in regression (43).

Conclusion

25. There is no evidence to support a co-integrating relationship between the 5-year bond yield series and market return/risk premium series. Statistically, there appears to be a co-integrating relationship between the 10-year bond yield series and the corresponding market return/risk premium series when the co-integrating coefficient (ϕ) is not constrained to one. One must exercise caution in accepting the conclusion in the unconstrained analysis given the estimate for the coefficient on bond yields regressed against market returns is much less than one. From economic theory, common sense is relied up when carrying out co-integration tests. The estimate of -0.5778 for the co-integrating coefficient ϕ does not make economic sense because the ERP is considered as the market return less the *entire* risk free rate not *some proportion* of it.[204]

[204] Stock J and Watson, 2007, Introduction to Econometrics, Pearson Education, Boston MA, p. 661.

Appendix 13 The equity risk premium and the risk-free rate: Granger Causality test

Methodology

1. The Granger causality test assumes that changes in variable X cause changes in variable Y based purely on precedence within a time series. If there is a relationship between changes in X and Y, and X *precedes* Y then X *Granger causes* Y based on the assumption that the future cannot predict the past. That is, if event A occurs before event B it is possible event A causes event B, but not vice versa. A commonly cited example of Granger causality which highlights the downfall of this assumption is that Christmas card sales precede Christmas, therefore Christmas card sales Granger cause Christmas.

$$\Delta \text{Yield}_t = \sum_{i=1}^{n} \alpha_i \Delta \text{ERP}_{t-i} + \sum_{i=1}^{n} \beta_i \Delta \text{Yield}_{t-j} + \varepsilon_{1t} \quad (44)$$

$$\Delta \text{ERP}_t = \sum_{i=1}^{n} \lambda_i \Delta \text{ERP}_{t-i} + \sum_{i=1}^{n} \delta_i \Delta \text{Yield}_{t-j} + \varepsilon_{2t} \quad (45)$$

2. In the context of bond yields (**Yield**) and the equity risk premium[205] (**ERP**), equations (44) and (45) are regressed to determine whether (in aggregate) the coefficients on the lagged values of the respective variables are statistically different from zero. That is, the following hypotheses are tested:

Hypothesis (ii)

$$\alpha_1 = \alpha_2 = ... = \alpha_n = 0 \quad (46)$$

$$\delta_1 = \delta_2 = ... = \delta_n = 0 \quad (47)$$

3. An assumption is made on the number of lags to include in the regression (i.e. what *n* should be equal in (46) and (47). For example, if the data is daily and returns are only significantly affected by changes in yield from the previous day, in this case, the lag will only be one. If the ERP will be significantly affected by changes in yield on each day over the past business week, then the lag will be five to capture the five previous days.

- If the null hypothesis (44) is rejected, that is alpha is statistically different from zero, changes in the ERP Granger cause changes in Yield.

205 The equity return premium is the difference between the observed daily return and observed daily bond yield change, as opposed to the market risk premium which is the difference between the *expected* return and the bond yield over a longer time horizon.

- If the null hypothesis (45) is rejected, that is delta is statistically different from zero, changes in Yield Granger cause the ERP.
- Rejecting both null hypotheses is evidence of feedback or bilateral Granger causality, that is both variables Granger cause each other.
- Failure to reject both null hypotheses suggests that the variables are independent.

Data

4. To test for Granger causality between changes in bond yields and changes in the market risk premium, the same raw series in Table 22 was used. The data is outlined in Table 22 above.

5. For this study, the 5-year and 10-year daily yield series were differenced by the previous day's observation as shown in (48).

$$\Delta \text{Yield}_t = \text{Yield}_t \text{-Yield}_{t\text{-1 } day} \tag{48}$$

6. The same was done for the market return outlined in (42) to create (49):

$$\Delta R_{m,t} = R_{m,t} \text{ - } R_{m,\ t\text{-1 } day} \tag{49}$$

7. These are the daily changes in returns (not prices).

8. The equity risk premium series outlined in (43) was also differenced to derive (50):

$$\Delta E\text{RP}_t = E\text{RP}_t \text{-ERP}_{t\text{-1 } day} \tag{50}$$

Note:

- These are the daily changes in the ERP (*not returns*).
- The series (48) through to (50) are created for both 5 and 10 year holding periods. These series form the data required for the Granger Causality Test.
- The test requires that both series are stationary and so augmented Dickey-Fuller tests are carried out on the differenced series to ensure this is the case.

9. Both series exhibit an absolute value of the t-statistic greater than the absolute value of the critical value and thus reject the null hypothesis of a unit root at the one percent level of significance. This implies that the series are stationary and suitable to use in the test as presented in Table 27 below.

Table 27 Augmented Dickey Fuller unit root tests of daily changes: no trend or drift

Series	Test Statistic (tau)	Critical Value (1%)	Stationary
∆Yield (5 year)	-60.3947	-2.58	Yes
∆Yield (10 year)	-63.4847	-2.58	Yes
∆ERP (5 year)	-49.6625	-2.58	Yes
∆ERP (10 year)	-44.6409	-2.58	Yes

Source: Economic Regulation Authority's analysis

Results

10. The Granger causality test function of the MSBVAR package in R was used to test the relationships between the daily changes in the ERP and bond yields. The Akaike information criterion was used to determine the appropriate number of lags. The results are shown in Table 28.

Table 28 Granger Causality test results: ERP and yield differenced series – lag 1

Test	F-Statistic	P-Value	Significant (at 5%)	Observations
∆ERP predicts ∆Yield (5 year)	2.2987	0.1295	No	4,860
∆ERP predicts ∆Yield (10 year)	0.0002	0.9892	No	3,599
∆Yield predicts ∆ERP (5 year)	6.9745	0.0083	Yes	4,860
∆Yield predicts ∆ERP (10 year)	9.1912	0.0024	Yes	3,599

Source: Economic Regulation Authority's analysis

11. The null hypothesis (46) is rejected at the five percent level of significance for both the 5-year and 10-year series. This suggests that changes in the ERP do not have any predictive content with respect to changes in the Yield.

12. The null hypothesis (47) is not rejected at the five percent level of significance for both the 5-year and 10-year series. This suggests that changes in the Yield do contain predictive content with respect to changes in the ERP.

13. The same test was carried out directly on change in Return series (49) in place of the change in the ERP. The results are shown in Table 29.

Table 29 Granger Causality test results: return and yield differenced series – lag 1

Test	F-Statistic	P-Value	Significant (at 5%)	Observations
∆Return predicts ∆Yield (5 year)	2.2987	0.1295	No	4,860
∆Return predicts ∆Yield (10 year)	0.0002	0.9892	No	3,599
∆Yield predicts ∆Return (5 year)	2.9669	0.085	No	4,860
∆Yield predicts ∆Return (10 year)	0.0223	0.8812	No	3,599

Source: Economic Regulation Authority's analysis

14. The tests of null hypothesis (46) are virtually identical when using the differenced return series - still suggesting that changes in the ERP do not have any predictive content with respect to changes in the Yield.

15. However, the test of hypothesis (47) rejects the null hypothesis that changes in the Yield do contain predictive content with respect to changes in the Return for both the 5 and 10 year series.

Conclusion

16. The Granger causality test suggests that changes in Australian Government bond yields Granger cause (as opposed to cause) changes in the equity risk premium approximated by returns on the All Ordinaries Index less bond yields, but not vice versa.

17. Bond yields and market returns appear to contain no predictive content with respect to each other when a holding period approach is taken to ensure market returns are matched with the yield to maturity holding period.

18. Tests to ensure the error terms are uncorrelated can be conducted as an additional test to ensure the results are robust.

Appendix 14 Relationship between the risk free rate, market risk premium and the return on equity: academic evidence

McKenzie and Partington

1. McKenzie and Partington reviewed and presented the following evidence on a relationship between a risk-free rate of return and the market risk premium.

2. Breen, Glosten and Jagannathan (1989) provided empirical evidence of a negative correlation between the nominal government yield and future nominal excess returns [an approximation of the market risk premium (**MRP**)] on the market. The study was based on US data. McKenzie and Partington noted that the regressions used in this study had low explanatory power. Although low explanatory power is usual for equations that predict returns, in the case of the Breen et. al.'s study, it meant that most of the excess returns were represented by random variation. Higher returns following low interest rates in the study were not a consequence of an increased MRP, but rather higher than expected equity returns.[206]

3. Theoretical papers supporting a negative relationship between the risk-free rate and MRP include Campbell and Cochrane (1999), Lettau and Ludvigson (2001), Li (2001), Bansal and Yaron (2004) and Bhamra, Kuehn and Strebulaev (2010). These papers are based on consumption models and generally support the finding that people become more risk averse in recessions which leads to higher expected equity returns.

4. Theoretical literature supporting a negative relationship based on modelling time variability in risk parameters included Menzly, Santos and Veronesi (2004), Bekaert, Engstrom and Xing (2009), Guvenen (2009), Verdlhan (2010) and Jouini and Napp (2011).

5. Empirical literature supporting a negative relationship includes the following studies:

   - Harvey (1989) concluded that US equity risk premiums are higher during low points of the business cycle than high points. These findings were also confirmed by Li (2001).
   - Ang and Bekaert (2007) argued that the negative relationship and predictability is mainly a short-horizon rather (around one year) than a long horizon phenomenon.
   - Henkel, Martin and Nardari (2011) found that the market risk premium is higher in a range of countries during recessions.

6. Evidence against a negative relationship is found in the following empirical literature:

   - Bekaert, Hoerva and Scheicher (2009) found no evidence of a negative relationship between short term interest rates and the equity risk premium using US and German financial instrument data.
   - Damodoran (2012) highlights that in corporate finance and asset valuation the equity risk premium is assumed to be unrelated to the level of interest rates.
   - McKenzie and Partington calculated twelve month rolling correlations between the 10 year Commonwealth Government Security yield and Australian market dividend yield over the period January 1973 to December 2012. For 55 per cent of the sample the correlations were positive while for

206 McKenzie and Partington (2012) "Supplementary Report on the MRP", February 2012, p. 9.

the remainder the relationship was negative. This formed evidence against claims of a negative relationship between the risk-free rate and MRP in Australia.

- Li (2007) used a consumption based model to show that counter cyclical variation in risk aversion results in a pro cyclical conditional risk premium.
- Kim and Lee (2008) found that investors become more risk averse during economic upswings.
- An empirical study was undertaken by Damodoran (2012) who found a positive relationship between equity risk premiums and interest rates.
- Amromin and Sharpe (2012) found that when macroeconomic conditions are more expansionary, investors had a tendency to expect higher returns and lower volatility and that their portfolios had a greater proportion of equities under these circumstances.
- Greenwood and Shleifer (2013) provides evidence showing that investors expectations are highly positively correlated with past stock returns and current price level.
- Graham and Harvey (2005) also found positive correlation between expected equity risk premiums and real interest rates.
- De Paoli and Zabczyk (2009) carried out modelling to show that the MRP can be either pro or counter cyclical.

Conclusions on the relationship between the risk-free rate and MRP

7. After reviewing the range of literature, McKenzie and Partington concluded that it is entirely possible that the relationship between the risk-free rate and MRP could be either pro- or counter cyclical and that the relationship ship itself may even oscillate over time.

Professor Stephen Wright's advice

8. Professor Stephen Wright has recently provided advice to the Australian Energy Regulator (**AER**) in relation to the cost of equity in its recent regulatory decisions.[207] Wright was asked to provide expert advice to the following questions:

   i) "Is the AER's methodology for estimating the cost of equity in these decisions consistent with the approach adopted by the UK regulator, Ofgem and UK appeals body, the Competition Commission (CC)?

   ii) "In light of the UK regulatory approach, is the AER's approach to estimating the cost of equity for the Distributors and APA GasNet likely to result in a rate of return that satisfies the requirements of Rule 87(1) of the National Gas Rules that:

   > *"The rate of return on capital is to be commensurate with prevailing conditions in the market for funds and the risks involved in providing reference services"*

9. Wright was also asked to explain if the UK regulatory approach is likely to be relevant within the Australian context.

[207] Wright S (2012) *Review of Risk Free Rate and Cost of Equity Estimates: A Comparison of UK Approaches with the AER*, University of London.

10. Wright concludes in relation to question (1) that the AER has been noticeably different to the approach adopted by UK regulators. Wright notes that both UK regulators, Ofgem and CC have worked on an assumption of a constant real market cost of equity. This is in contrast to the AER which assume a constant MRP and a market-based risk-free rate. In addition, Wright notes that both Ofgem and CC have departed from the use of market estimates of the risk free rate, mainly due to the use of Quantitative Easing from the Bank of England placing downward pressure on the rate of return.[208] However, Wright places a relatively small emphasis on this point relative to the first point.

11. Wright notes that the UK approach of assuming a constant return on equity is based on the Mason, Miles and Wright 2003 cost of capital study.[209] This study notes that the CAPM equation can be rearranged as follows:

$$E(R_i) = E(R_m) + (\beta_i - 1)MRP \tag{51}$$

12. Mason et al note that the expected market return, $E(R_m)$, can be decomposed as follows:

$$R_m = E(R_m) + \varepsilon \tag{52}$$

13. Where ε is the error made from deviations of the actual return from the expected return. They conclude that these errors should average out to be close to zero over the longer term, and as a consequence the average realised aggregate return provides an estimate of the expected market return ($E(R_m)$) in equation (51). This study also provided various academic evidence that the realised real stock market returns have been stable over long historical samples and from a wide range of markets.[210] As a consequence, they conclude that the $E(R_m)$ should also be stable over long historical samples and a wide range of markets.

14. The Mason, Miles and Wright study note that the risk free rate is not stable over any horizon. As a consequence, given the relative stability of $E(R_m)$ relative to the risk free rate, the Authors conclude that there has been a historical tendency for the MRP to have offsetting movements with the risk free rate. Wright notes that this is the source of inconsistency between the AER and UK regulators.

15. With regard to the second question, Wright notes that both the real market cost of equity and the MRP are inherently unobservable.[211] However, regulators must commit themselves to a particular set of assumptions in order to calculate regulated rates of return. Wright argues that the assumption regulators should use is one of a constant real market return, based on the evidence outlined above. Wright concludes that whatever assumption is made regarding the risk-free rate, the MRP must move one to

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208 Ibid, p. 9.

209 Mason, R., Miles, D and Wright S (2003), *A Study into certain aspects of the cost of capital for regulated utilities in the UK,* Smithers & Co Ltd report to a consortium of UK regulators.

210 Siegel, J, *Stocks for the Long Run,* McGraw-Hill and Dimson, E ,Marsh, P and Staunton, M (2001), *Triumph of the Optimists* Princeton University Press.

211 Wright S (2012) *Review of Risk Free Rate and Cost of Equity Estimates: A Comparison of UK Approaches with the AER*, University of London, p. 2.

one in the opposite direction, having an offsetting effect. As a consequence of this, Wright believes the AER has made an error in assuming that the MRP is a constant value as this contradicts the core assumption of a stable return to equity.

16. Wright believes that this is extremely inappropriate in an Australian context, presenting evidence that Australian corporations are currently experiencing high levels of profits. Wright states that "...with returns which are currently almost certainly above their assumed costs of equity".[212] Wright presents evidence from the Reserve Bank of Australia (**RBA**) which shows that corporate savings rate is extremely high relative to previous historical levels, which he believes supports the conclusion of high returns to equity. This evidence conflicts with the AER's approach of assuming a constant MRP, as falling real interest rates have resulted in a reduction in the awarded return on equity.

17. Wright presents indirect evidence to support his assertion of a negative correlation between the MRP and risk free rate. Wright notes that the risk free rate is determined by the following factors: a) inflationary vs recessionary risks in that country[213] and b) risk-free rates in other countries. Wright notes that in a small open economy like Australia, the main determinant of interest rates are likely overseas interest rates. He asserts that "Thus risk-free rates are also low in Australia, but because the global economy is depressed, rather than the Australian economy".

18. With respect to the MRP, Wright notes that any asset model that seeks to explain risk premiums should apply equally across all asset classes. In particular, risk premia from bonds should in principle convey information about risk premia of another asset class (such as equity). Wright notes a second characteristic of asset pricing models is that it should reflect two factors: the quantity of systematic risk and the market price of this risk. Wright believes that although volatility has been reduced since the Global Financial Crisis (**GFC**), the market price of risk has shown "greater persistence over time". Wright believes that this higher price of risk is due to an increase in risk aversion.

19. Wright notes that Ludvigson and Ng have produced evidence that suggests risk premiums on government bonds have displayed counter cyclical patterns.[214] In particular, there is a strong tendency for risk premia to increase during recessions. Wright cites the well known Elton, Gruber, Agrawal and Mann (2001) study that finds strong evidence of an inverse relationship between the Debt Risk Premium and the risk free rate in corporate bonds.[215] Wright concludes that given the necessary link between the risk premiums across asset classes and the strong evidence for an inverse relationship in bonds, an inverse relationship between the risk free rate and the MRP must also exist.

20. Wright suggests that given capital markets are highly integrated, the cost of capital faced by Australian companies is set in the international capital market. As a consequence Wright believes that the evidence presented above, as well as the practice of overseas regulators is highly relevant for Australian regulators.

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[212] Ibid, p. 13.

[213] *This refers to the central banks tendency to use monetary policy as a means to stabilise the business cycle.*

[214] Ludvigson, S and Ng, S, "Macro Factors in Bond Risk Premia" , *Review of Financial Studies,* 2009, pp. 5027-5067.

[215] Elton, E , Gruber, M, Agawal,D and Mann, C (2001) "Explaining the Rate Spread on Corporate Bonds", *Journal of Finance* LVI, pp. 247-278.

Appendix 15 The Authority's dividend growth model estimates of the market risk premium

Theoretical models

1. In order to estimate the "implied market risk premium" (**MRP**) using the dividend growth model (**DGM**), two key assumptions are made: (i) the future forecast dividends of the index as a whole; and (ii) future dividend growth rates. The present value of these forecast dividend streams is equalised to the observed price of the index, and the implied return on equity is the required discount rate that achieves this equality. The implied MRP is then calculated by subtracting the current risk-free rate from the implied return on equity obtained from the DGM.

2. In the draft rate of return guideline, on the advice of Professor Lally, the Australian Energy Regulator (**AER**) implemented a two-stage DGM in order to estimate a return on equity.[216] In the traditional two-stage DGM, dividend forecasts are initially made based on an initial "growth phase", before falling to a lower rate of long term growth (the terminal phase). In the AER's implementation of the DGM, the initial growth phase comprises of three forecast dividends reported by Bloomberg, with future dividends assumed to grow at a long-term growth rate g after the final forecast dividend from Bloomberg.

3. The AER also utilised an "imputation factor" to reflect the value franking credits contributing to the return on equity an investor receives. The estimated net dividend is multiplied by this imputation factor in order to yield the gross dividend value.

$$IF = 1 + (\theta . f . \frac{t_c}{1 - t_c}) \qquad (53)$$

where

θ is the market value of franking credits;

f is the proportion of franked dividends;

t_c is the corporate tax rate.

4. The AER estimated the rate of a long-term real dividend growth by estimating the expected growth rate of real Gross Domestic Product (**GDP**), which is 3 per cent per year based on Lally's estimation. However, the adjustment factor was also utilised by the AER based on Lally's advice. Professor Lally was of the view that the long-term growth rate of real GDP is expected to be higher than the long-term growth rate of a real dividend. Lally's view is supported by a study by Bernstein and Arnott[217] who argued that, due to 'the net creation of shares', a deduction must be made from the expected growth rate of real GDP in order to estimate accurately the long-term growth

216 Australian Energy Regulator, *Explanatory statement draft rate of return guideline*, *August 2013,* p. 220.

217 William Bernstein and Robert Arnott, 'Earnings Growth: The Two Percent Dilution', *Financial Analysts Journal,* October 2003, pp. 47-55.

rate of the real dividend. Lally considered that a deduction of between 0.5,1.0 and 1.5 per cent is appropriate. As a result, the long-term growth rate of real dividend falls within the range between 1.5 per cent and 2.5 per cent per year.

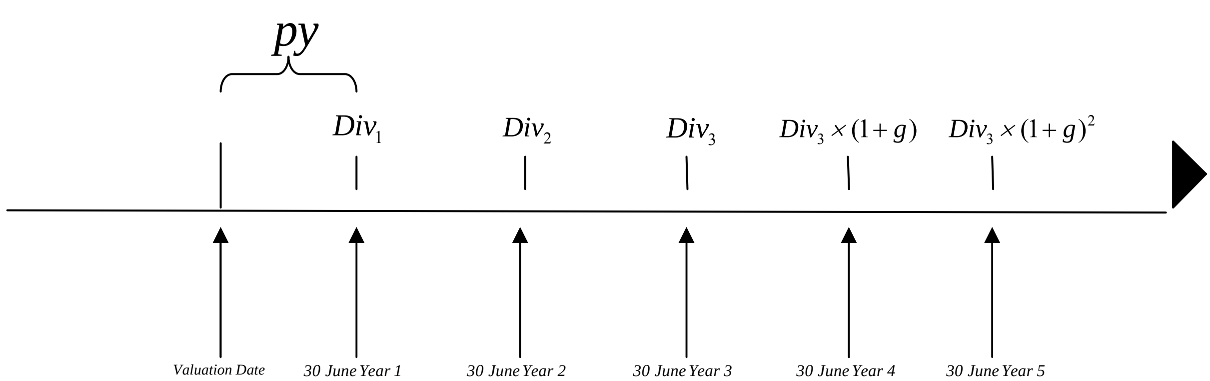
5. The nominal growth rate of dividend, g, is now estimated using the midpoint of the Reserve Bank of Australia's (**RBA**) inflation target of 2-3 per cent, which is 2.5 per cent per year.

$$g = 100.\,((1 + E[\textit{real dividend growth}]).\,(1+\pi^{e}) - 1) \tag{54}$$

6. The AER used the S&P/ASX 200 index as the market proxy, and utilised forecasts available in Bloomberg which provides forecasted net dividends[218] per share for three financial years in advance. These forecasted dividends are used in the first stage of the DGM model. It is unclear from the AER's analysis when these forecast dividends are assumed to be paid.

7. In the Authority's analysis, the forecasted dividends are assumed to be paid at the end of the financial year (30 June each year). A "partial first-year adjustment" is utilised in order to account for valuation dates that do not coincide with the start of the financial year, as suggested by Pratt and Grabowski.[219] This proposed adjustment impacts the first forecast dividend only. Taking into account this partial first-year adjustment, the cash flow is multiplied by the number of months from the valuation date until 30 June of Year 1, as presented in the first right-hand term in illustration below.

8. The final assumed cash flows of the ERA's model can be summarised as follows:



9. The estimated return on equity (r_e) therefore satisfies the following equation:

$$P_0 = \frac{Div_1.\,IF.\,py}{(1+r_e)^{py}} + \frac{Div_2.\,IF}{(1+r_e)^{py+1}} + \frac{Div_3.\,IF}{(1+r_e)^{py+2}} + \frac{\dfrac{Div_3.\,IF.(1+g)}{(r_e - g)}}{(1+r_e)^{py+2}} \tag{55}$$

218 Net dividends do not reflect the benefit received in the form of franking credits, which contribute to the return on equity investors receive.

219 Pratt and Grabowski, *Cost of Capital: Applications and Examples,* pp. 36-40.

where

P_0 is the value of the index at the valuation date;

py is the number of months from the valuation date untill 30 June of Year 1, expressed as a decimal;

Div_1 is the nominal forecast dividend for the current financial year from Bloomberg;

Div_2 is the nominal forecast dividend for the next financial year from Bloomberg;

Div_3 is the nominal forecast dividend for the financial year two years in advance from Bloomberg;

g is the estimated nominal growth rate of dividend;

I.F is the imputation factor.

10. The Authority has adopted the AER's approach to estimate the MRP using the DGM. Bloomberg has reported historical forecast dividends for the ASX 200 Index for the current financial year and for the next two financial years. Bloomberg's historical forecast dividends can be traced back to June 2006. This data allows us to calculate a retrospective implied return on equity on the Australian financial market. This estimate was done on a monthly basis from June 2006 until August 2013 when this analysis was conducted. The implied MRP was then calculated by subtracting the 5-year risk-free rate from the implied return on equity.

11. In order to implement the DGM, assumptions must be made regarding two inputs: (i) the market value of franking credits (θ); and (ii) the long-term real rate of dividend growth (which is assumed to be between 1.5 per cent and 2.5 per cent in this analysis). The expected inflation rate π^e of 2.5 per cent, and the franking proportion of f = 75 per cent are not controversial and as such, they are assumed to be constant in the application of the DGM.

12. Using various assumptions in relation to the estimates of theta (a market value of imputation credits) and a real dividend growth, the implied MRP derived from the DGM is presented in Table 30 below. The implied MRP estimated from the DGM falls within the range 4.68 per cent and 6.62 per cent for the period from 30 June 2008 to 31 August 2013. In addition, as at 30 August 2013, the implied MRP falls with the range of 6.11 per cent and 8.01 per cent.

Table 30 Implied MRP from the dividend growth models

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Assumed value of theta	1	0.7	0.55	0.35	0.55	0.55	0.35
Assumed value of real dividend growth	2.50%	2.50%	2.50%	2.50%	2.00%	1.50%	1.50%
Average value return on equity (30/06/2006 to 31/08/2013)	11.35%	10.90%	10.66%	10.36%	10.19%	9.72%	9.41%
Average value of implied market risk premium (30/06/2006 to 31/08/2013)	6.62%	6.16%	5.93%	5.63%	5.46%	4.99%	4.68%
Implied Market Risk Premium as at 30 August 2013	8.01%	7.57%	7.35%	7.06%	6.88%	6.41%	6.11%

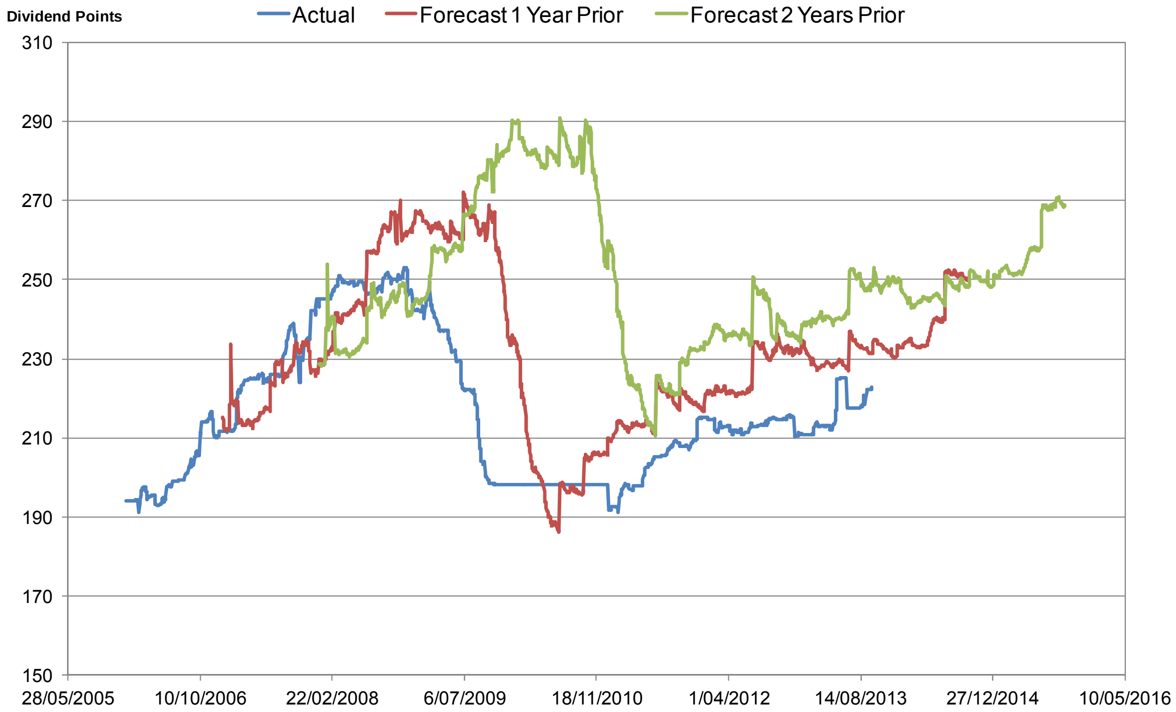
Source:Economic Regulation Authority's analysis

13. However, as noted in the Draft Guidelines, the Authority is of the view that estimates of dividend forecasts are subjective. In addition, the Authority considers that evidence exists to support the view that a systematic bias exists in analyst forecasts of future dividends.[220] In particular, evidence was provided suggesting that economic forecasting has a poor performance record.[221] In order to examine this relative bias within the specific context of dividend forecasts reported by Bloomberg, the Authority has plotted the dividend forecasts against the observed (actual) values of dividends as reported by Bloomberg, as presented in Figure 14.

220 Economic Regulation Authority, *Explanatory Statement for the Draft Rate of Return Guidelines,* 6 August 2013 p. 159.

221 See Fildes, R. and Makridakis, S. (1995). The impact of empirical accuracy studies on time series analysis and forecasting, *International Statistical Review,* 63, 3, 289-308; and Hendry, D. And Clements, M. (2003). Economic forecasting: some lessons from recent research, *Economic Modelling,* 20, pp. 301-329.

Figure 14 Forecasted dividends and observed dividends of the ASX200 index



Source:Bloomberg and Economic Regulation Authority's analysis

14. An estimated average percentage bias for the 1-year and the 2-year forecast is as follows:

$$bias = \frac{\sum_{i=1}^{n} \frac{forecastdividend_i - actualdividend_i}{actualdividend_i}}{n}.100 \qquad (56)$$

15. The Authority notes that an average bias of 5.6 per cent in the 1-year dividend forecast, and a 15.9 per cent in the 2-year dividend forecast over the period are found. The Authority is of the view that a part of these significant biases can be explained by the slow reaction from equity analysts to update their forecasts in response to new information, for example during the GFC.

16. The Authority has now re-estimated the implied MRP using the same approach with the above biases removed. That is the Authority has reduced the forecast dividends reported by Bloomberg by subtracting the estimates of these biases from the forecast dividends. The updated estimates of the implied MRP are presented Scenarios 1 to 7 were then reproduced using these bias adjusted forecast dividends. The results are presented in Table 31 below.

Table 31 The implied MRP from the dividend growth models – biases removed

	Scenario 8	Scenario 9	Scenario 10	Scenario 11	Scenario 12	Scenario 13	Scenario 14
Assumed value of theta	1	0.7	0.55	0.35	0.55	0.55	0.35
Assumed value of real dividend growth	2.50%	2.50%	2.50%	2.50%	2.00%	1.50%	1.50%
Average value return on equity (30/06/2006 to 31/08/2013)	10.41%	10.01%	9.82%	9.56%	9.34%	8.87%	8.60%
Average value of implied market risk premium (30/06/2006 to 31/08/2013)	5.68%	5.29%	5.09%	4.86%	4.61%	4.13%	3.87%
Implied Market Risk Premium as at 30 August 2013	7.11%	6.73%	6.54%	6.29%	6.07%	5.59%	5.34%

Source:Bloomberg and Economic Regulation Authority's analysis

17. For the Scenarios 8 to 14, the implied MRP estimated from the DGM falls within the range 3.87 and 5.68 per cent (compared to 4.68 per cent and 6.62 per cent under Scenarios 1 to 7 as presented in Table 30 for the period from 30 June 2008 to 31 August 2013. In addition, as at 30 August 2013, the implied MRP falls with the range of 5.34 and 7.11 per cent (compared with 6.11 per cent and 8.01 per cent under Scenarios 1 to 7).

18. The Authority notes the sensitivity of the estimates of the implied MRP. For the purpose of an estimate of a forward looking MRP, the Authority is of the view that an implied MRP estimated at a specific day is not appropriate to be used as a proxy for a forward looking MRP over the next 5 years. As such, the Authority considers that it is more appropriate to use the implied MRP estimated for a period of time. For example, for the Authority's own estimate of the implied MRP using the DGM, the period covers from 30 June 2008 to 31 August 2013. In this period, the implied MRP falls within the range of a rounded 4 per cent (under Scenarios 8 to 14) and 6.5 per cent (under Scenarios 1 to 7).

Figure 15 Return on equity & MRP using dividend growth model, Scenario 1

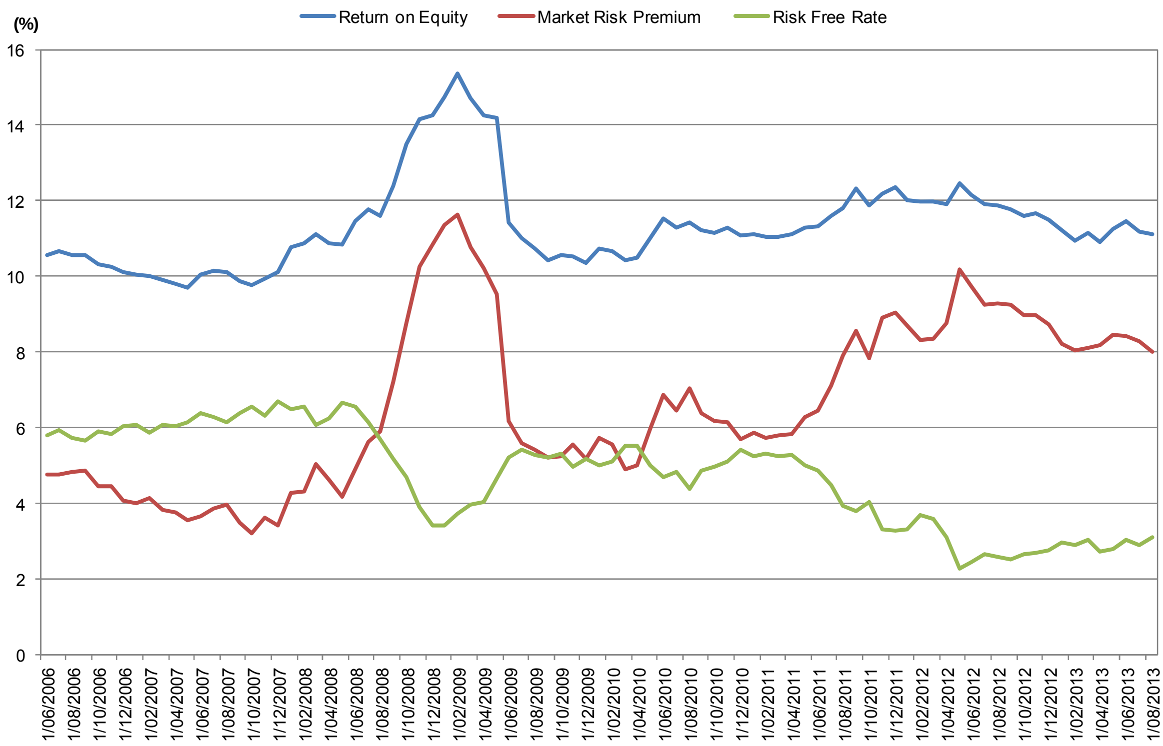


Figure 16 Return on equity & MRP using dividend growth model, Scenario 2

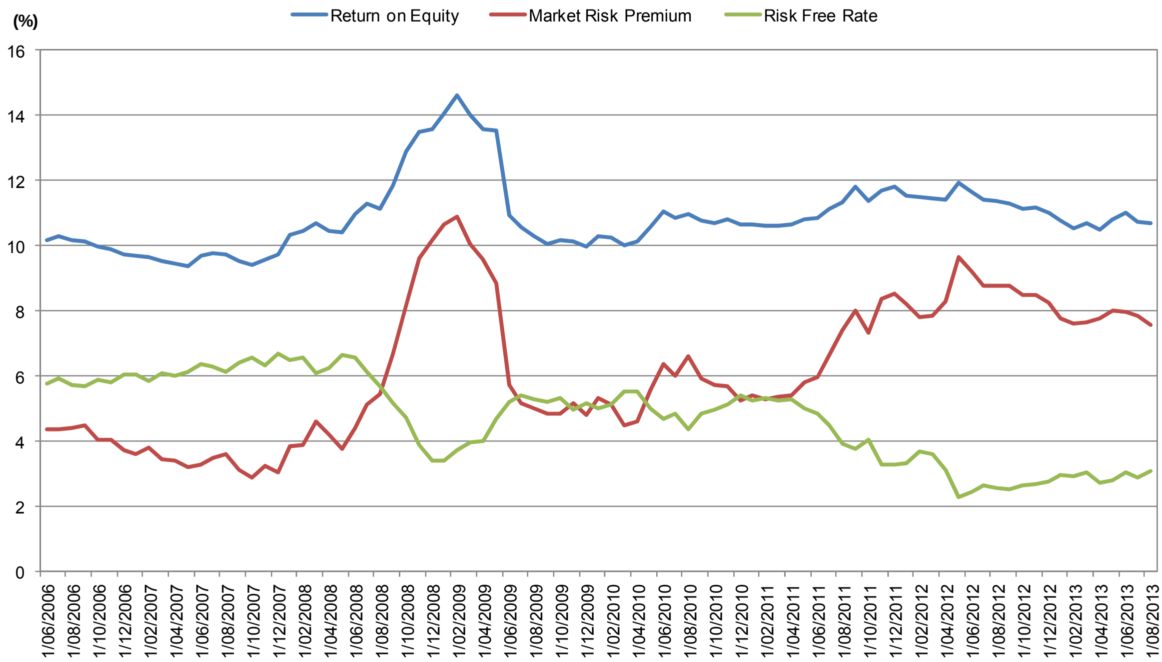


Figure 17 Return on equity & MRP using dividend growth model, Scenario 3

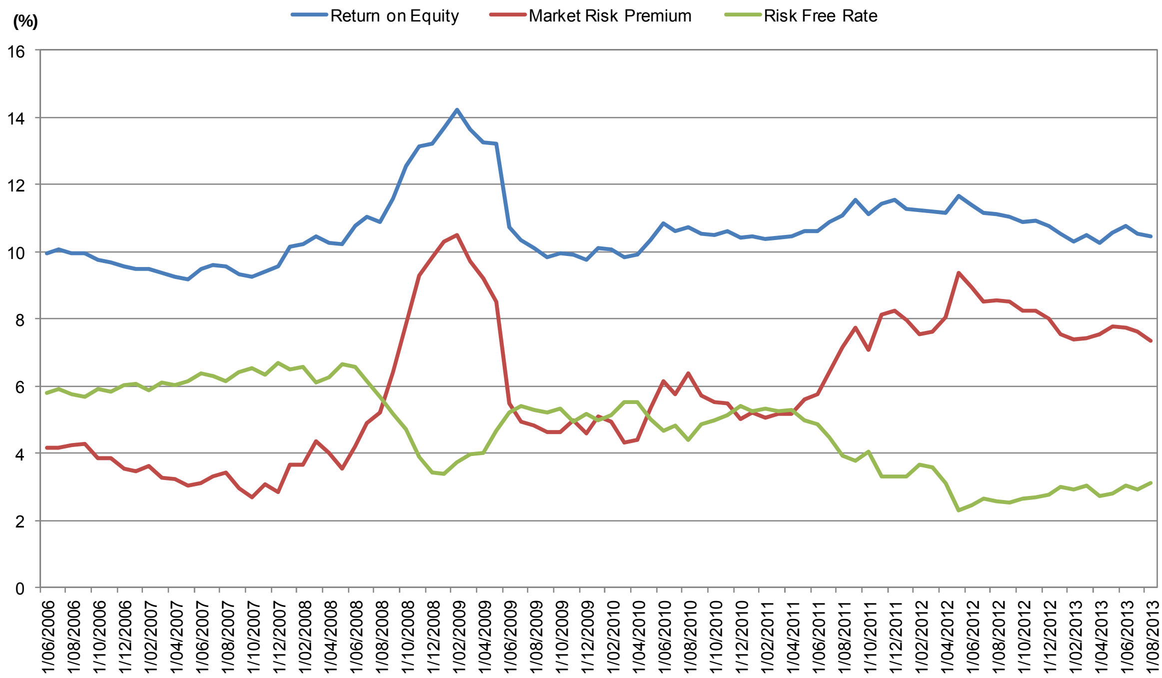


Figure 18 Return on equity & MRP using dividend growth model, Scenario 4

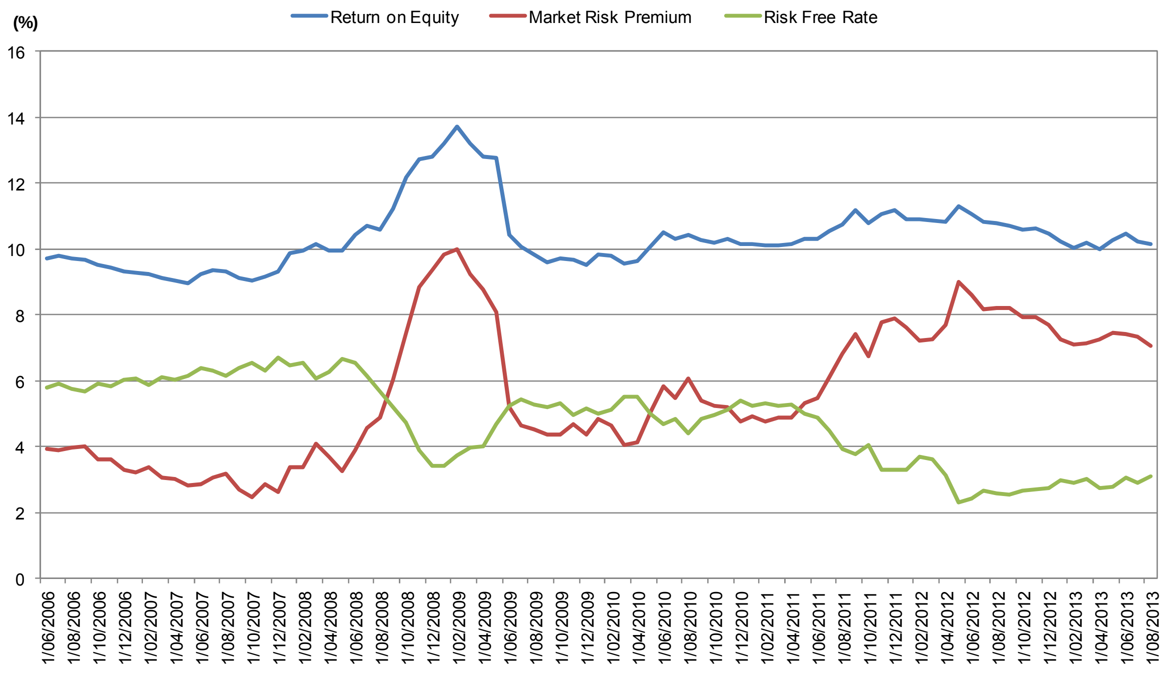


Figure 19 Return on equity & MRP using dividend growth model, Scenario 5

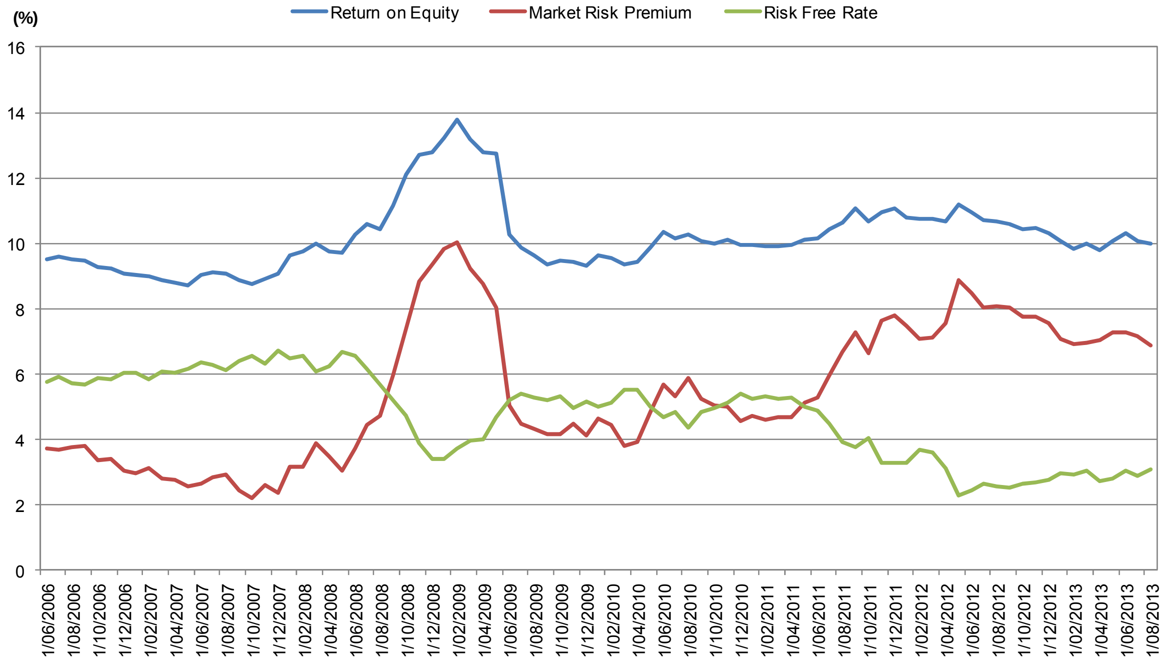


Figure 20 Return on equity & MRP using dividend growth model, Scenario 6

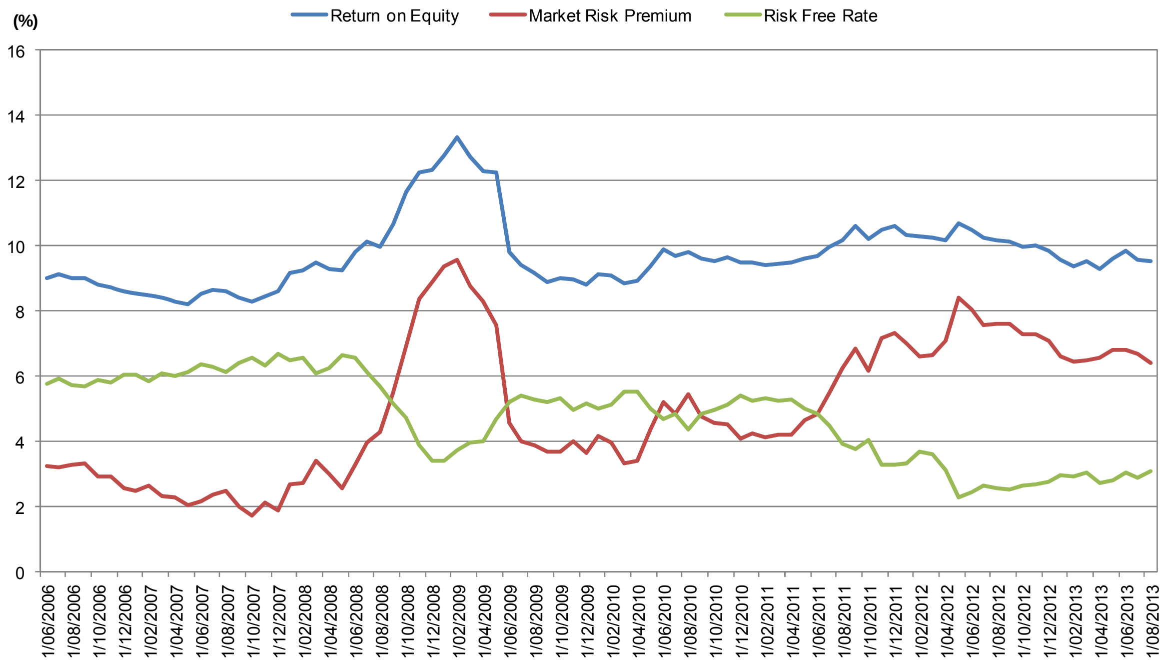


Figure 21 Return on equity & MRP using dividend growth model, Scenario 7

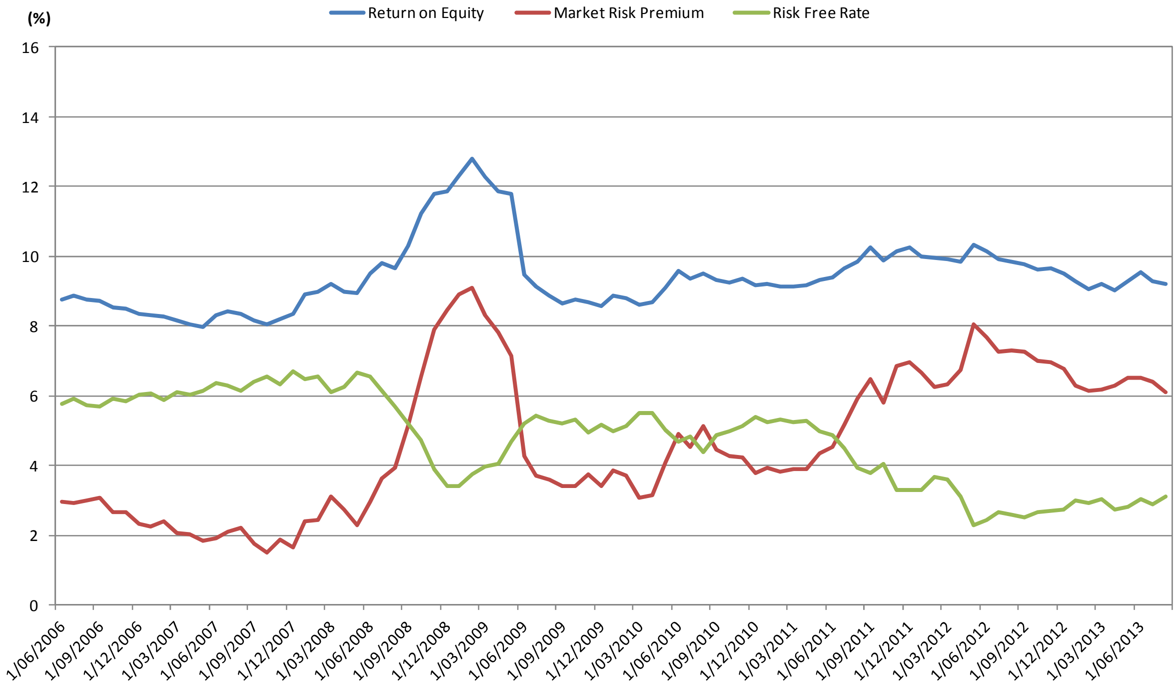


Figure 22 Return on equity & MRP using dividend growth model, Scenario 8

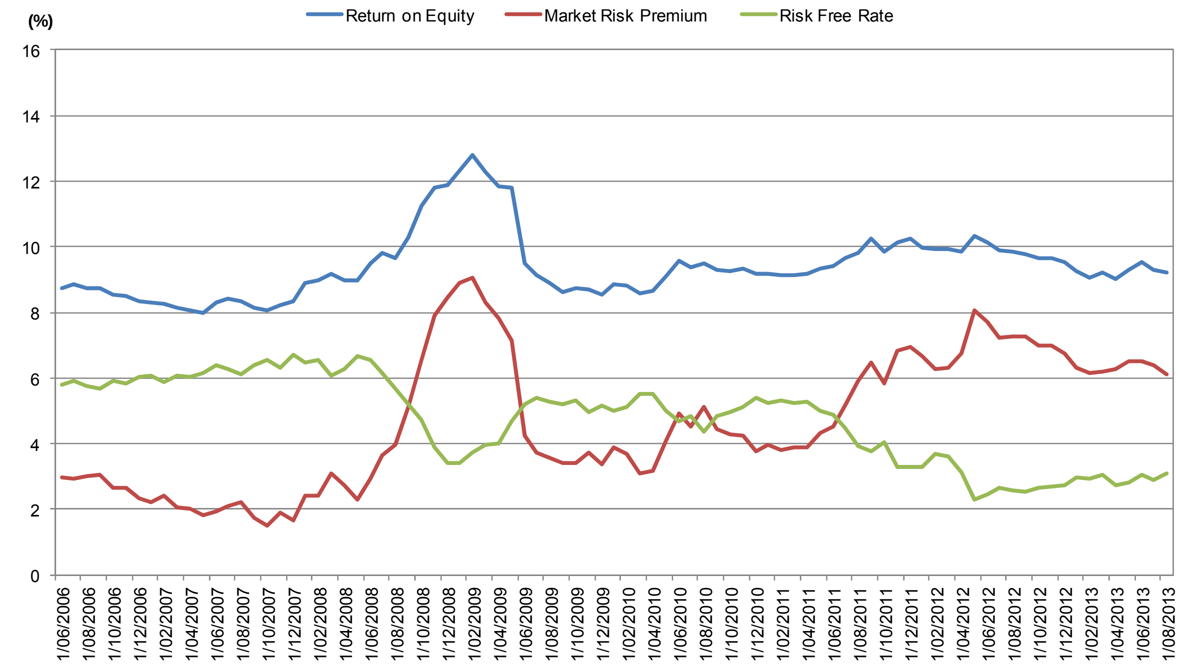


Figure 23 Return on equity & MRP using dividend growth model, Scenario 9

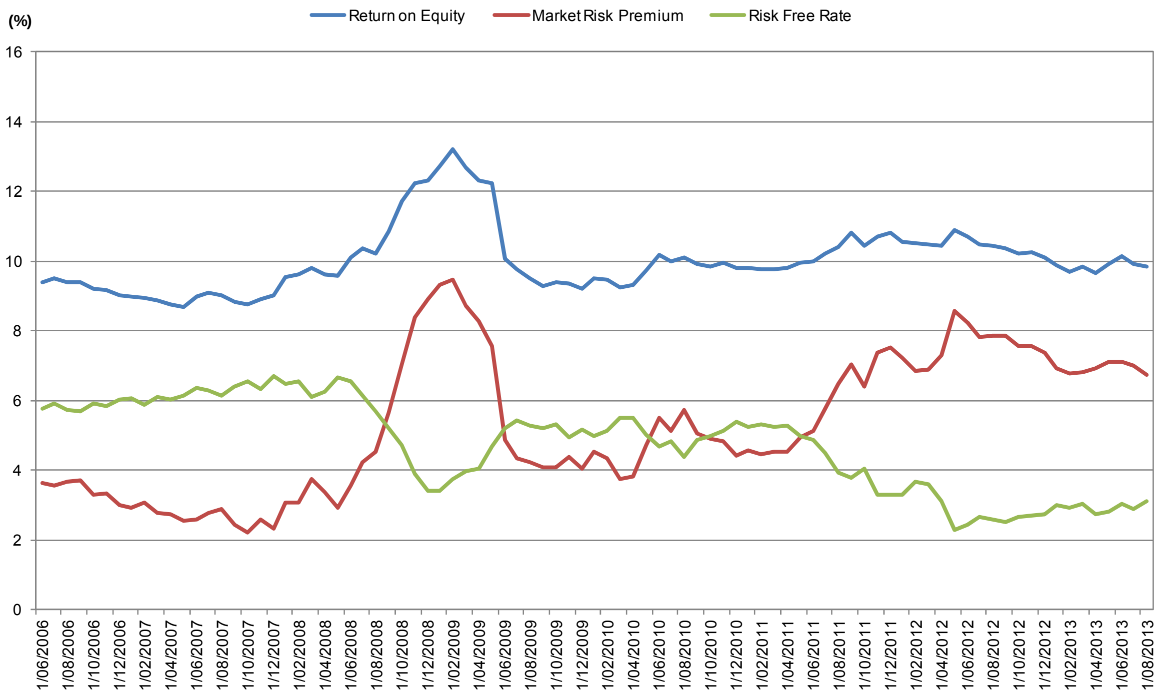


Figure 24 Return on equity & MRP using dividend growth model, Scenario 10

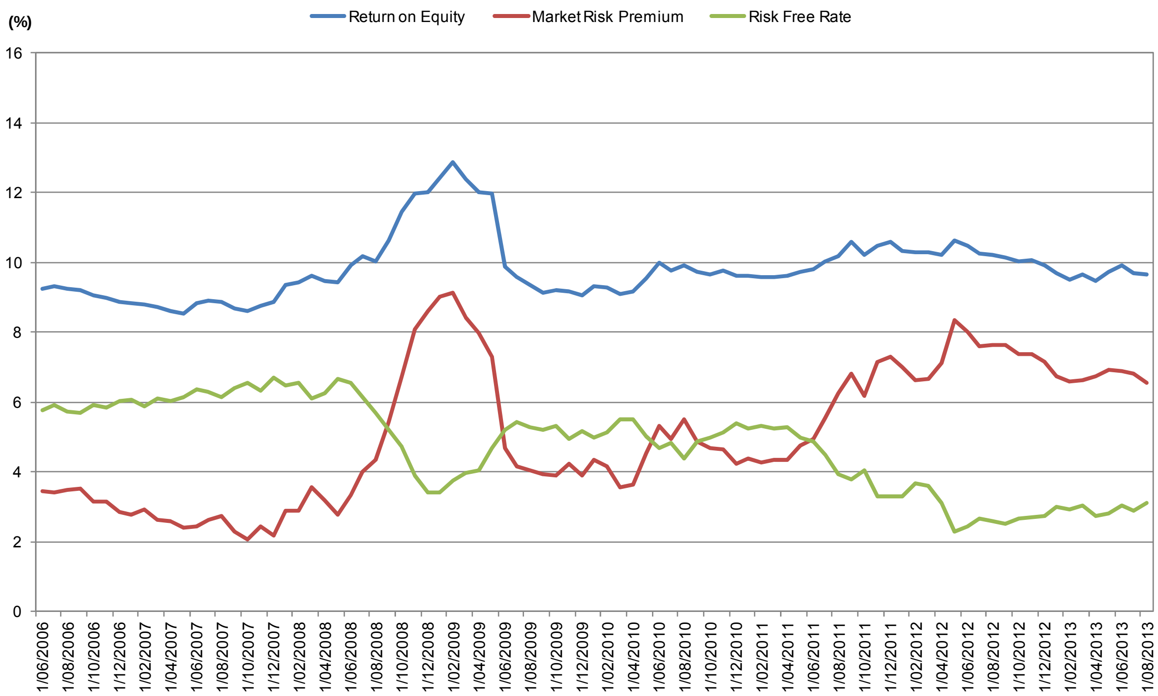


Figure 25 Return on equity & MRP using dividend growth model, Scenario 11

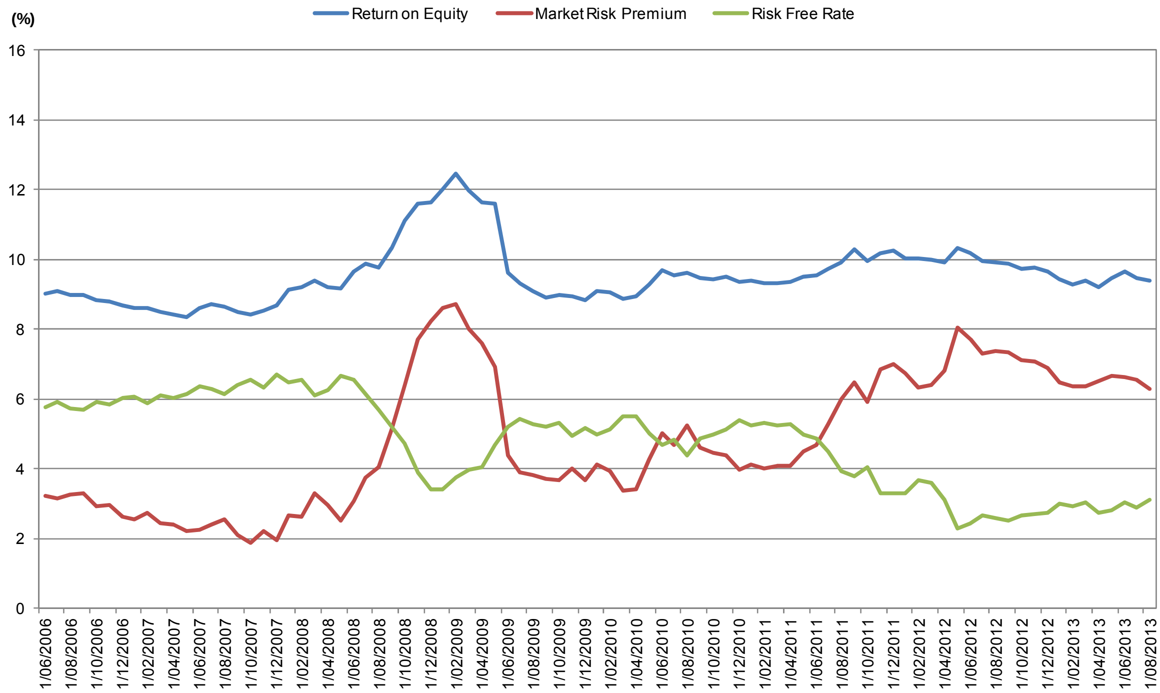


Figure 26 Return on equity & MRP using dividend growth model, Scenario 12

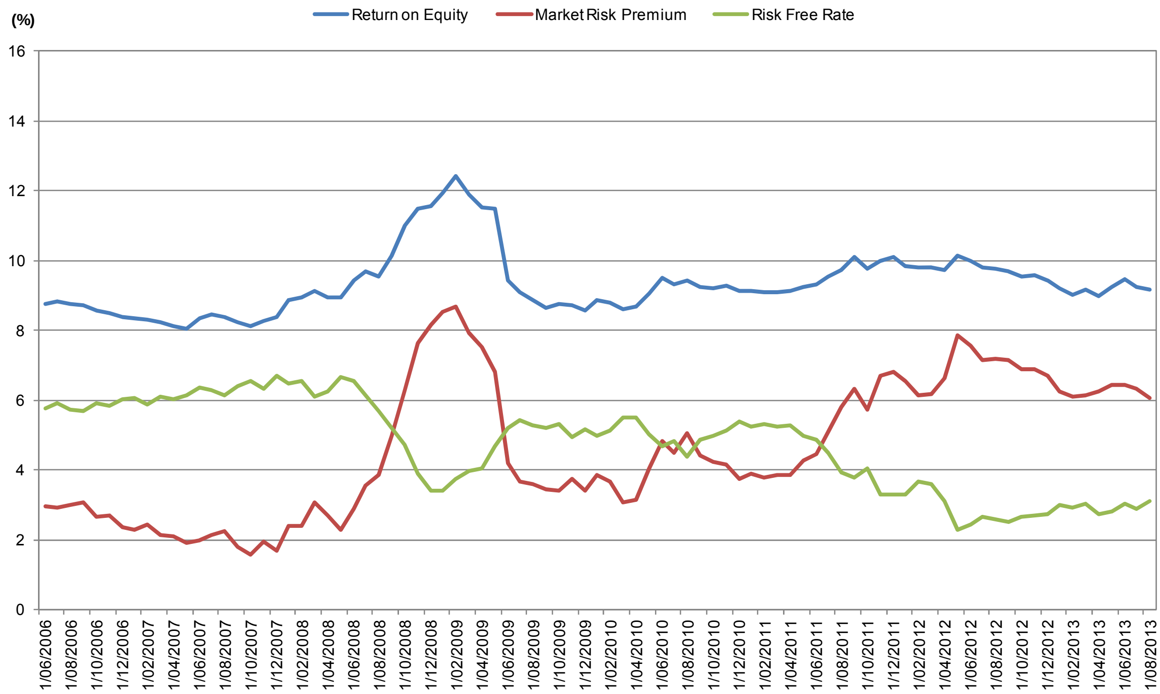


Figure 27 Return on equity & MRP using dividend growth model, Scenario 13

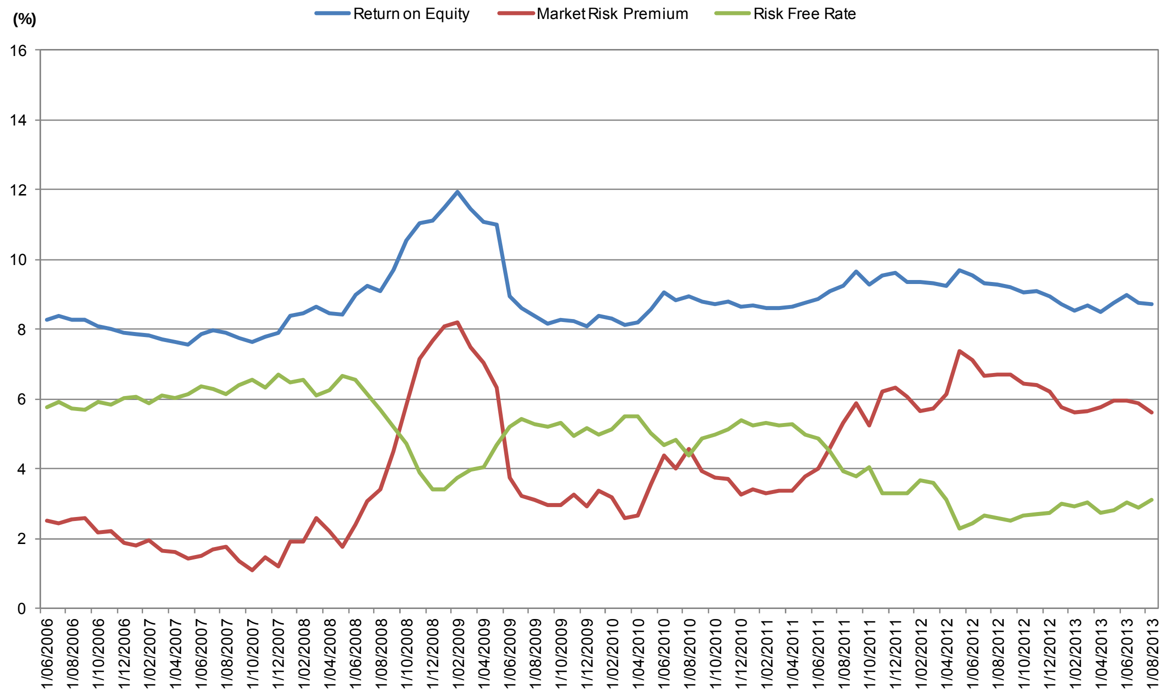


Figure 28 Return on equity & MRP using dividend growth model, Scenario 14

Appendix 16 Is the return on equity stable?

Introduction

1. The Economic Regulation Authority (**ERA**) has previously conducted studies using Bloomberg data in an attempt to ascertain whether specific series have a tendency to be anchored to a long-run mean and a level of volatility. In the language of time series econometrics, this was an attempt to determine whether each series was stationary and whether some combination of the series was cointegrated.

2. Studies based on overseas data such as Siegel (1998); Smithers and Co (2003); and Wright (2012) present evidence to suggest that the return on equity is more stable than the market risk premium (**MRP**).[222] Some of these qualify the results observing that the real return on equity is stable.

3. This analysis attempts to determine whether conclusions on the return on equity and risk free rate in the Australian financial market are comparable to the above studies. Australian data using a term series of 128 years has been employed.

Important concepts

Long run averages may be poor forecasts

4. A single time series such as the yields on a bond may move in such a way that it does not revert to any long run mean or level of volatility. Such a series is known as non-stationary.[223] The implication is that the use of a long run average will perform very poorly as a future forecast compared the current value of the series.

Unpredictable series may be predictable when combined with another series

5. Two or more time series that exhibit non-stationary trends can at times have a random 'offsetting' trend in common. Such cases are usually observed over long periods of time. It can be the case that a linear combination of the two series produces a new stationary series. That is, one that tends to revert to some long run mean and a level of volatility. This implies that an equilibrium relationship exists between the two series. Two series that exhibit such a characteristic are referred to as cointegrated. The implication is that the two series cannot drift infinitely far apart. This implies that one series can tell us something about future movements of the other series.

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222 Smithers and Co (2003) *A Study into Certain Aspects of the Cost of Capital for Regulated Utilities in the UK*, February, p.49; Siegel, J (1998) *Stocks for the Long Run*, McGraw-Hill Second Edition; and Wright S (2012) *Review of Risk Free Rate and Cost of Equity Estimates: A Comparison of UK Approaches with the AER*, University of London.

223 In order to better understand the issue, a brief explanation of stationarity is as follows. A series of observations on a variable X_t through time is 'covariance-stationary' (also referred to as weakly stationary or just stationary) if it has a finite mean and variance. That is, its mean and covariance are not dependent on the point in time they are observed. The covariance however can be a function of the distance between two observations, X_t and X_{t-s} where the covariance is constant for all t given s, but can vary with a change in s. in other words, change with the distance between two points in time. It should be noted that when s is equal to zero the covariance is equal to variance. The concept of stationarity is important in time series because data from the past is used to quantify relationships to inform future outcomes. If a series is not stationary, this implies the future can differ fundamentally from the past. In the context of data, if the mean and covariance are dependent on time, the distribution of a time series variable can change over time. This point is important in relation long run average values or point estimates of time series (such as the MRP). Averages and point estimates are based on past observations and if not stationary, may not say much, if anything about the future.

*Cointegration test using Dickey-Fuller generalised least squares (**GLS**)*

6. The following series is constructed:

$$\varepsilon_t = R_{m,t} - \phi Yield_t \qquad (57)$$

7. Where $R_{m,t}$ is the market return, $Yield_t$ is the corresponding bond yield at time t. The initial assumption is that ϕ (the cointegrating coefficient) is equal to one.

8. The ε_t series is tested for stationarity using the Dickey-Fuller GLS test. The following hypothesis is tested:

Hypothesis (i)-

The series is non-stationary - this means that it has a unit root.

Engel-Granger two-step cointegration test

9. Additionally, tests are carried out to relax the assumption that ϕ is equal to one using the two-step Engel-Granger Augmented Dickey Fuller test for cointegration.

10. The first step involves running the following regressions:

$$R_{m,t} = \alpha + \phi Yield_t + e_t \qquad (58)$$

11. The second step involves using the Augmented Dickey-Fuller test on residual series e_t to test hypothesis (i).

Integrated series

12. There are cases in which a non-stationary series X_t becomes stationary in its difference. This means that the series $\Delta X_t = X_t - X_{t-1}$ becomes stationary. A typical example is stock prices which often have a tendency to 'jump' and 'meander' in an erratic manner, while the return which is calculated from the differences in the prices is typically more constrained in its movements and tend to test as stationary.

13. A series that is stationary in levels (not in difference) is integrated of order zero; I(0). A series that becomes stationary after it is differenced once (first difference) is known as being integrated of order one, that is I(1). If the series is stationary after being differenced twice, it is integrated of order two. As a general case, if the series is stationary after differencing d times, it is then said that the series is integrated of order d; I(d).

14. When considering two different time series, the following properties apply:

$$\text{If } X_t \sim I(0) \text{ and } Y_t \sim I(1), \text{ then } Z_t = (X_t + Y_t) \sim I(1) \tag{59}$$

15. The rule also implies that the sum of a stationary and non-stationary series is non-stationary.

Power of stationarity tests

16. It has long been recognised that tests for stationarity based on the hypothesis that the series contains a unit root are plagued by issues of lower power when short samples of data are used.[224] Power in this context refers to the probability of correctly rejecting the null hypothesis in the case that it is false. In the context of time series stationarity, this concerns correctly rejecting the finding of a unit root, that is a non-stationary series.

17. More specifically, the power of such tests increases with the time span of a series for any given sample size. For example, 30 observations spanning 4 years have more power than 30 observations spanning 1 year. From this perspective, the time series provided by Brailsford, Handley and Maheswaran (2012) are superior to those used in the ERA's previous tests.[225] Bloomberg data in the previous tests contain a greater number of observations taken at a greater sampling frequency (i.e. daily) than the Brailsford et al data. However, the Brailsford et. al data covers a far greater span of time, taking annual observations dating back to 1883.

Data

18. The returns data presented in Brailsford, Handley and Maheswaran (2012) for the stock accumulation index, government bills, bonds and inflation were used in this analysis.[226] Their data will be referred to as **BHM** in this study for convenience. BHM provided the methodology used in Handley's 2012 advice to the Australian Energy Regulator in estimating the Market Risk Premium.[227]

19. The data are reported on an annual basis with 128 calendar year worth of observations spanning January 1883 to December 2010. This data series is comprised of data from a variety of different sources which is discussed in turn below.

Stock Accumulation Index

20. The stock accumulation index from 1882 to 1936 consists of the Commercial and Industrial index. From 1936 to 1979, the Sydney All Ordinary share price index was used. The All Ordinaries Accumulation Index during 1980-2010 was sourced from the Australian Stock Exchange. Returns were calculated on a discrete basis.

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224 Frankel, J & Rose, A (1995), *A Panel Project on Purchasing Power Parity: Mean Reversion within and Between Countries*, NBER Working Paper Series, Working Paper No.5, p. 1.

225 Brailsford, T, Handley, J & Maheswaran K, (2012) The *Historical Equity Risk Premium in Australia: Post-GFC and 128 years of Data*, Accounting and Finance (52). pp. 237-247.

226 Ibid

227 Handley, J (2012), *An Estimate of the Historical Equity Risk Premium for the Period 1883 to 2011*, Final report prepared for the Australian Energy Regulator, April 2012.

Bond Returns

21. This series was based on the redemption yield on New South Wales securities trading on the London capital market up until 1913. From 1914 to 1925, the data is comprised of the yields from Commonwealth and State government securities maturing in 4 or more years trading on the Sydney Stock Exchange. For 1926 to 1940, bond returns is calculated as the average redemption yield on a fully taxed security maturing in 10 or more years.

22. The theoretical redemption yield on fully taxed security maturing in 12 years was used from 1941 to 1947. In 1948 through to 1958, the data was made up of theoretical yield on government securities that are taxed and maturing in 10 or more years.

23. Bond returns in 1959 to 1973 are based on the theoretical yield on 10 year rebatable bonds. The yield on non-rebatable 10 year treasury bonds are used from 1974 to 2005. Bond returns are based on 10 year Commonwealth Government treasury bond yields sourced from the Reserve Bank of Australia (**RBA**) over 2006 and 2010.

Bill Returns

24. Before 1895, the bill returns data consisted of 3 month deposit and discount rates offered by Australian trading banks at the end of December each year. From 1895 to 1919, the 3 month mid–point deposit rate was used. Details of the series from 1920 to 1936 were not published.

25. The theoretical yield on two year rebatable bonds was sourced from the RBA Statistical Bulletin used from 1937 to 1959. Yield data on 3 month securities/Treasury notes were also sourced from the RBA Bulletin from 1959 to 1975. For 1976 to 2001 the yield data was sourced from the RBA Occasional Paper no. 10.

26. Bill returns are based on 90 day bank accepted bills over 2002 to 2008 and 3 month Treasury notes over 2009 to 2010. The data were obtained from the RBA.

Table 32 Summary of statistics

	Stock Accumulation Index	Bills	Bonds
Mean	0.118	0.053	0.057
Standard Error	0.015	0.003	0.003
Median	0.117	0.045	0.049
Mode	0.177	0.036	0.038
Standard Deviation	0.167	0.032	0.029
Sample Variance	0.028	0.001	0.001
Kurtosis (excess)	-1.592	1.507	-0.866
Skewness	0.114	2.154	1.717
Range	1.070	0.153	0.120
Minimum	-0.433	0.020	0.030
Maximum	0.637	0.173	0.150

Source: The Economic Regulation Authority's analysis

27. Table 32 presents the summary statistics of returns for the various series. The mean stock return over the period, from 1883 and 2010, was 11.8 per cent. This is statistically significant given the standard error 1.5 per cent. The skewness was positive indicating a slightly higher probability of positive returns, but generally the distribution is symmetric. This is also mirrored in the maximum being higher than the minimum.

28. Bill and bond returns averaged around 5.3 to 5.7 per cent and were not statistically different from each other given the 0.3 per cent standard error. Both bill and bond returns are highly positively skewed as expected due to always being positive.

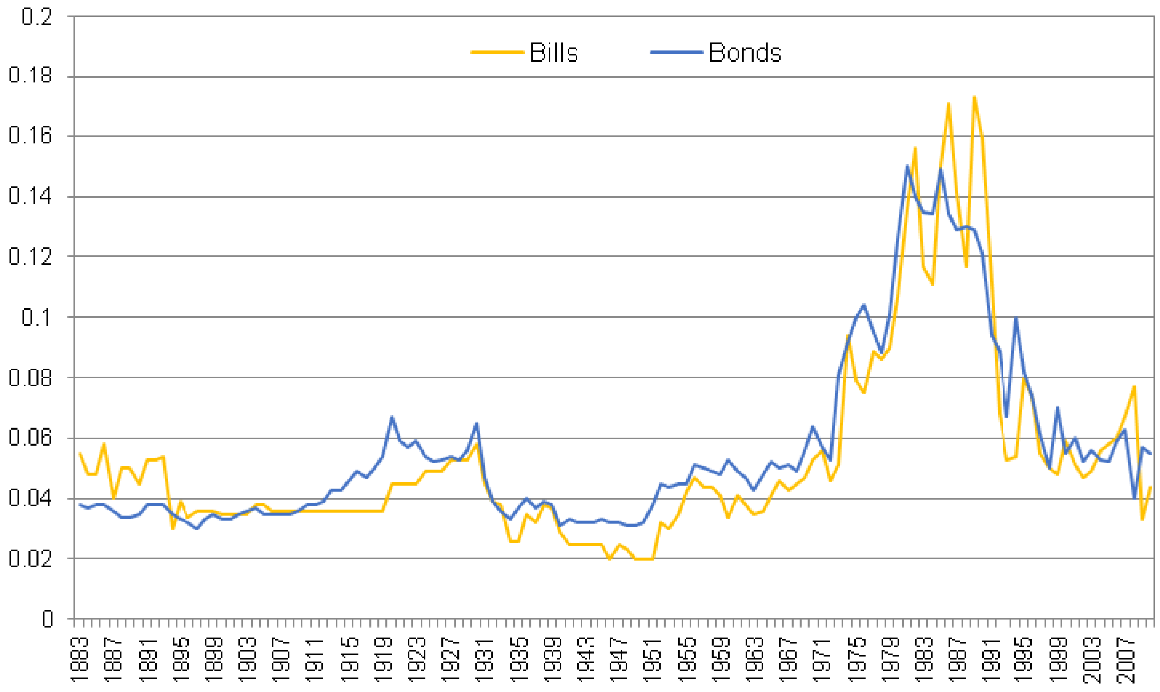
29. A striking feature of the data is the shape of the distribution with respect to kurtosis. Both stock returns and bonds have negative excess kurtosis indicating a relatively high probability of extreme values. Bills however have positive excess kurtosis which tends to indicate a more normal (relatively speaking) distribution of the series. This may indicate greater instability in the stock return and bond series.

Results

Is the risk-free rate mean-reverting?

30. A visual inspection of the Brailsford et al's bond and bill rates in Figure 29 indicates both periods of stability and instability with no distinct trend up or down. The series appears to be returning to the level seen prior to 1951. The data are not characteristic of a stationary series which have a time independent mean and variance.

Figure 29 Australian bill and bond series 5 Year versus 10 Year 1883 to 2010



Source: The Economic Regulation Authority's analysis

31. Table 33 shows that both series are non-stationary with the implication that they are not mean reverting. The augmented Dickey Fuller test statistic has an absolute value lower than the critical value for bills and bonds (1.27 and 0.54 are less than 1.95). This indicates a failure to reject the null-hypothesis of a unit root at the 5 per cent significance level.

32. As a robustness check, the Dickey Fuller GLS test was also carried out. This test has better performance for small samples and has higher power.[228] Again the results fail to reject the null-hypothesis of a unit root for both bills and bonds at 5 per cent significance (1.87 and 1.26 are lower than 1.94). This confirms the results of the augmented Dickey Fuller test.

Table 33 Tests for stationarity on Brailsford (2012) bill and bond yield series

	Augmented Dickey Fuller Test Statistic	5% Critical Value	Result	Dickey-Fuller GLS Test Statistic	5% Critical Value	Result
Bills	-1.27	-1.95	Non-Stationary	-1.87	-1.94	Non-Stationary
Bonds	-0.54	-1.95	Non-Stationary	-1.26	-1.94	Non-Stationary

Source: The Economic Regulation Authority's analysis

33. The non-stationarity of the series may be a result of structural changes over time. There are distinct regimes in the history of Australian government interest rates which may have a bearing on the stationarity of the series.

228 Elliott, Graham, Rothenberg, Thomas J., and James H. Stock. Efficient Tests for an Autoregressive Unit Root. *Econometrica*, 64:4, 1996, 813-836.

34. Up until August 1982, the Australian Government issued bonds through a 'tap' method where the applicable interest rate was set by the authorities leaving investors to determine the volumes demanded.[229] The daily yield observations in this period are characterised by extremely low day-to-day variability.

35. A tender system was adopted in August 1982 where investors competitively bid for the stock of Treasury Bonds. However, the market initially suffered from illiquidity with secondary market prices moving sharply until around July 1989. From mid-1993, the primary objective of monetary policy was to target inflation.[230] The setting of the underlying cash rate, has a significant effect on bond yields. It is possible that these regime changes and or the transitioning between them have contributed to the non-stationary/unpredictable nature of government interest rates.

Is the return on equity mean-reverting?

36. Table 34 below presents evidence that the return on equity is mean reverting. This is an implication of the series being tested as stationary. The same tests that were carried out on the bill and bond returns were carried out on the stock accumulation index which represent for a return on equity. The absolute value of the test statistic is greater than the 5 per cent critical value for both tests (5.63 is greater than 1.95 and 2.07 is greater than 1.94). This indicates a rejection of the null-hypothesis of a unit root which, in turn, indicates that the series is stationary.

Table 34 Tests for stationarity on Brailsford (2012) stock accumulation index return series

	Stock Accumulation Index Returns
Augmented Dickey Fuller Test Statistic	-5.63
5% Critical Value	-1.95
Result	Stationary
Dickey-Fuller GLS Test Statistic	-2.07
5% Critical Value	-1.94
Result	Stationary

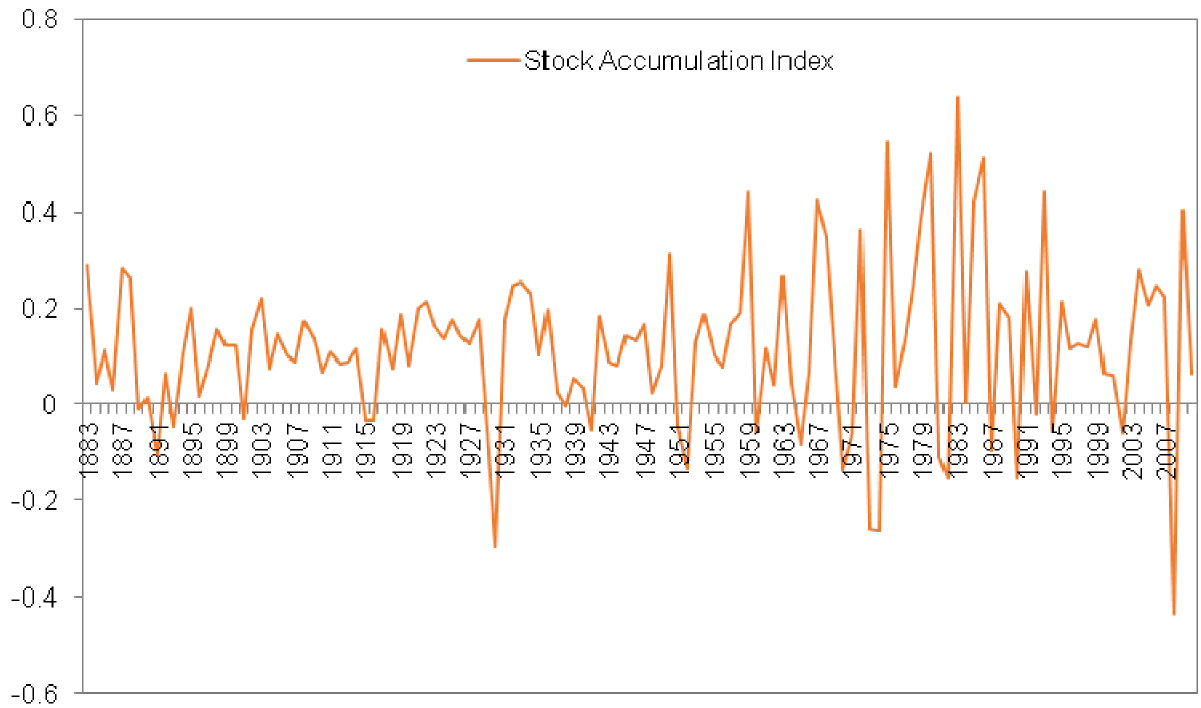
Source: The Economic Regulation Authority's analysis

37. It is important to note that stationarity does not imply a constant or stable rate. Figure 30 shows that while the stock return series is stationary, it is certainly not constant or stable. The stock returns fluctuate wildly around a mean of 11.78 per cent, more so after 1959.

229 http://www.aofm.gov.au/content/publications/speeches/2000-03-28-1/speechtoadb_paper.asp
http://www.aofm.gov.au/content/publications/reports/AnnualReports/2010-2011/html/05_Feature_Article.asp

230 http://www.rba.gov.au/publications/bulletin/1999/may/pdf/bu-0599-2.pdf

Figure 30 Brailsford et al (2012) stock accumulation index 1883 to 2010



Source: The Economic Regulation Authority's analysis

Is there a relationship between the risk-free rate and return on equity?

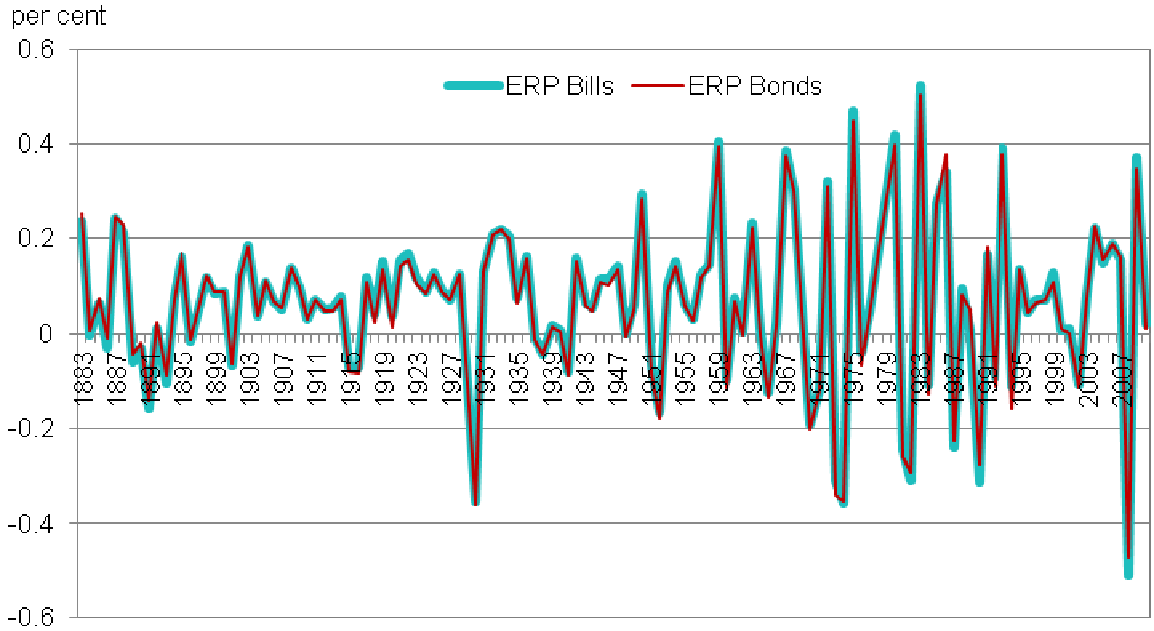
38. Tests for a relationship between the risk-free rate and return on equity reveal mixed results, although there appears to be more evidence in favour of no relationship.

39. The MRP is not directly observable from the prices of individual assets whereas the market returns or risk free rates are. A constant or stable MRP implies that the return on equity is strongly positively correlated with the risk-free rate. However, the Pearson correlation coefficient between the return on equity and risk free rate is 0.076 using bills and 0.1213 using bonds which indicates virtually no or very little correlation.

40. Absence of correlation does not imply that there is no relationship between the series. It could be the case that the series move in their own uncorrelated ways, but have limits on how far they drift apart, that is, they could be cointegrated.

41. Two types of cointegration tests were carried out to determine whether the series were cointegrated. The first test assumes the cointegrating coefficient is equal to one. In other words, the MRP is calculated by subtracting the risk free rate from the return on equity. The MRP is then tested using the Dickey Fuller GLS test. The equity risk premium (**ERP** used as a proxy for the MRP in this study) is shown in Figure 31 below.

Figure 31 Equity Risk Premium based on stock returns, bills and bonds



42. The series appears to fluctuate around a mean of 6 per cent before 1959, but exhibits wildly varying volatility thereafter. Potentially, there is also a shift in the mean. More formal tests are required to provide information on whether the series has a time varying mean or variance (ie non-stationary).

43. Table 35 shows that the MRP series is stationary for bills. For bonds, however, the test results are on the threshold of acceptance/rejection of non-stationarity. This implies that MRP is mean reverting (for bills) and that the risk free rate and return on equity are cointegrated for bills. However, these conclusions cannot be drawn when the risk-free rates are proxied by the returns on bonds.

Table 35 Cointegration tests between the return on equity and risk free rate using the MRP

	Dickey-Fuller GLS Test	5% Critical Value	Result
MRP based on Bills	-2.17	-1.94	Stationary
MRP based on Bonds	-1.94	-1.94	Stationary

Source: The Economic Regulation Authority's analysis

44. This result is counter to the theory that the sum of stationary and non-stationary series is itself non-stationary.[231] As previously presented, stock returns being tested as stationary while the risk-free rate tested as non-stationary.

45. In addition the Engel-Granger cointegration two-step test was carried out to cross-check the results. The stock market returns were regressed against the bill and bond returns. The results are shown in Table 36 below.

231 Gujarati (2003), *Basic Econometrics,* Fourth Edition McGraw Hill Education, New York, p. 805.

Table 36 Cointegrating coefficient regressions – bills and bonds

	Cointegrating Coefficient	t-statistic
Regression based on Bills	0.4022	0.3928
Regression based on Bonds	0.6900	0.1722

Source: The Economic Regulation Authority's analysis

46. The cointegrating coefficients in the regression are not statistically different from zero, indicating no cointegrating relationship between the two series. This is because both of the t-statistics for the cointegrating coefficients are significantly lower than 2. The hypothesis that the cointegrating coefficient is different from zero cannot be rejected on the basis of these low test statistics.

47. The second step of the test involves testing the residuals from the above regressions for stationarity. This is not necessary because the initial regression in the first part of the test fail to show any relationship to begin with. That is, the cointegrating coefficient is not statistically different from zero.

Conclusion

48. The findings in the previous sections indicate the following:

    i) That the risk-free rate is non-stationary and the return on equity is stationary. These findings imply that there is no cointegrating relationship between the risk-free rate and return on equity. This is because in time series, a non-stationary series combined with a stationary series is non-stationary - the ERP is then essentially a linear combination of a stationary and non-stationary series implying that the ERP is non-stationary.

    ii) The Dickey Fuller GLS tests suggest the ERP is stationary (only marginally so for bonds).

    iii) The Engel-Granger two-step cointegration tests do not show any relationship between the risk free rate and return on equity. Additionally, there is a very weak correlation between the risk free rate and return on equity.

49. Overall, on the basis of i) and iii), the empirical evidence indicates that there is no statistically reliable relationship between the risk free rate of return and the return on equity. There is therefore, no convincing evidence of mean reversion in the ERP. The return on equity however, does appear to be mean reverting and thus more predictable.

Appendix 17 Econometric techniques for estimating equity beta

Ordinary Least Squares

Introduction

1. The equity beta is typically estimated using ordinary least squares (**OLS**) where the sum of squared residuals are minimised to estimate the parameters α_i and β_i:

$$Min\sum_{t=1}^{T}\varepsilon_{i,t}^2 = Min\sum_{t=1}^{T}(r_{i,t}-\hat{r}_{i,t})^2 = Min\sum_{t=1}^{T}(r_{i,t}-\hat{\alpha}_t-\hat{\beta}_t r_{m,t})^2 \quad (60)$$

where

$\widehat{r}_{i,t}$, $\widehat{\alpha}_\iota$ and $\widehat{\beta}_\iota$ are OLS estimates of r_{it}, α_i and β_i.

Failure of OLS in financial data due to presence of outliers

2. Regression analysis involves fitting a model to observed data. The traditional linear model relates the dependent, or 'response', variable y_i to independent variables $x_{i1}, x_{i2},..., x_{ip}$ for $i = 1,...........n$ such that:

$$y_i = \beta_1 x_{i,1} + \beta_2 x_{i,2} + ... + \beta_p x_{i,p} + \varepsilon_i \quad (61)$$

where

$\beta_1, \beta_2,..., \beta_p$ is the coefficients of the model[232]; and

ε_i is a random disturbance term.

3. Given a set of observed data, a regression estimator is chosen to estimate the unknown parameters $\beta_1, \beta_2,..., \beta_p$, resulting in estimated values $\widehat{\beta_1}, \widehat{\beta_2},..., \widehat{\beta_p}$. From this fitted values of a response variable can be calculated as follows, $\widehat{y_i} = \widehat{\beta_1} x_{i,1} + \widehat{\beta_2} x_{i,2} + ... + \widehat{\beta_p} x_{i,p}$, which has the interpretation of been the predicted value produced by the estimated model, given observed values of the independent variables.

4. This model is commonly be expressed in matrix notation, expressing n observations of the k^{th} variable as $\mathbf{x_k}$, $k = 1,..., p$, and assemble these data in an n x K data matrix, X . Let $\mathbf{y}$ be the n observations, $y_1,..., y_n$ and let $\boldsymbol{\varepsilon}$ be the column vector containing the *n* disturbances. The entire model can now be represented in vector form as:

232 It is generally assumed that $x_{i,1}$ =1 for all i, so that β_1 corresponds to the intercept of the regression model.

$$\boldsymbol{y} = \boldsymbol{x}_1\beta_1 + \ldots + \boldsymbol{x}_p\beta_p + \boldsymbol{\varepsilon} \tag{62}$$

5. Which can be expressed in matrix notation is:

$$\boldsymbol{y} = X\boldsymbol{\beta} + \boldsymbol{\varepsilon} \tag{63}$$

6. The most popular choice of regression estimator is the Ordinary Least Squares **(OLS)** estimator. In order to perform OLS, the following is assumed:[233]

- Full Rank: No exact linear relationship between any of the independent variables in the model.
- $E[\varepsilon_i \mid X] = 0$, which implies that the expected value of the disturbance at observation i is not a function of any of the independent variables in the sample
- Each disturbance has the same variance, $Var[\varepsilon_i] = \sigma^2$ and is independent of every other disturbance, $\varepsilon_i \perp \varepsilon_j$
- Each disturbance is a random variable following a normal distribution $\varepsilon_i \sim N(0, \sigma^2)$
- The least squares fit of a straight line consists of finding $\widehat{\beta}_1, \widehat{\beta}_2, \ldots, \widehat{\beta}_p$ such that the residuals,

$$r_i = y_i - (\widehat{\beta}_1 x_{i,1} + \widehat{\beta}_2 x_{i,2} + \ldots + \widehat{\beta}_p x_{i,p}) \tag{64}$$

Satisfy

$$Min(\sum_{i=1}^{n} r_i^2) \tag{65}$$

- In matrix notation, the OLS estimate satisfying the above is given by:

$$\beta_{LS} = (X'X)^{-1} X'y \tag{66}$$

7. If the observed data satisfies assumptions 1-4, it can be shown that OLS is the Best Linear Unbiased Estimator **(BLUE)**, implying that OLS is the best choice if these assumptions are met. That is, out of the class of linear and unbiased estimators, OLS

[233] Greene, W.H. (2003). *Econometric analysis, 5th edition*. Upper Saddle River, NJ: Prentice Hall.

has the lowest variance (and thus highest efficiency). It is generally understood that the assumptions (1 to 4) are an approximation for reality. In particular, the normality assumption holds only approximately in describing the majority of observed errors, particularly in an economics and financial context. A common reason for the failure of the normality assumption is a small proportion of errors being distinct from the rest of the errors. These observations are referred to as outliers and they can have a large influence on the estimator. Another failure of the normal assumption occurs if the distribution of errors has "heavier" tails than those of a normal distribution. Intuitively this can be understood as errors being large in magnitude, or more "extreme" than that predicted by the normal distribution.

8. It is often assumed by practitioners that small departures from assumptions will not reduce the optimal properties of the OLS estimator. In particular, small deviations from assumptions I to IV will cause the OLS to be extremely sensitive to changes in the sample. Observations that are quite far from the majority of the data can dramatically affect the OLS estimate. For this reason, it is prudent to consider the use of other econometric techniques that estimate a linear trend in data. Robust statistical procedures are a reaction to the violation of assumptions used in traditional statistical analysis. Robustness can be described as 'insensitivity to small deviations from the assumptions made'.[234]

Least Absolute Deviations

9. It is well known that outliers can bias the estimates of equity beta. The manual removal of such outliers is not appropriate because the removal may introduce subjectivity into the estimate given the presence of outliers. Henry's advice to the AER in 2009 was that the Least Absolute Deviations (**LAD**) method should be used to reduce the impact of outlier observations. The impact of outliers in the sample can be measure by comparing the estimates of equity beta from the OLS and the LAD methods. LAD regression minimises the sum of the absolute value (as opposed to the squared value) of the residuals. This regression can be expressed mathematically as follows:

$$Min\sum_{t=1}^{T}|\varepsilon_{i,t}| = Min\sum_{t=1}^{T}|r_{i,t} - \hat{r}_{i,t}| = Min\sum_{t=1}^{T}|r_{i,t} - \hat{\alpha}_t - \hat{\beta}_t r_{m,t}| \quad (67)$$

where

$\tilde{r}_{i,t}$, $\tilde{\alpha}_i$ and $\tilde{\beta}_i$ are LAD estimates of r_{it}, α_i and β_i.

The MM methodology

Introduction

10. A central concept of robust statistics is the breakdown point of an estimator; the smallest fraction of contamination that can cause the estimator to "break down" and no longer represent the trend in the bulk of the data.[235] The breakdown point of the

[234] Huber, P.J. (1996). *Robust Statistical Procedures.* Second edition. Philadelphia: SIAM.

[235] Ibid.

OLS estimator is 0%, as just one data point can cause the estimator to “break down”.[236] Yohai (1987) defines the breakdown point as “The finite sample breakdown-point measures the maximum fraction of outliers which a given sample may contain without spoiling the estimate completely”.[237] A trade-off between the breakdown point and statistical efficiency of a MM estimator exists - a high a breakdown point can be achieved by a reduction in statistical efficiency; or conversely, a higher statistical efficiency can result from a lower breakdown point.

11. The statistical efficiency of an estimator is defined as the ratio of its minimum possible variance to its actual variance. It is desirable for an estimator to have an efficiency ratio close to 1, as this ensures the estimator for the target parameter has the lowest variance possible. Note that the concept of statistical efficiency assumes a normal distribution of the errors, which is likely to be invalid in situations where a robust estimator is required. It is however desirable for an estimator to have as higher breakdown point and statistical efficiency as possible. The MM estimator introduced by Yohai (1987)[238] has a breakdown point of 50 per cent, and a high statistical efficiency of 95 per cent.

The MM methodology

12. In order to understand MM regression, the concept of M and S regression must first be developed.

M Robust Regression

Recall that OLS minimises the following:

$$Min(\sum_{i=1}^{n} r_i^2) \quad (68)$$

where

$$r_i = y_i - (\widehat{\beta_1} x_{i,1} + \widehat{\beta_2} x_{i,2} + ... + \widehat{\beta_p} x_{i,p}) \quad (69)$$

13. Given that the residuals are a function of the estimated regression coefficients, $\widehat{\beta_1}, \widehat{\beta_2}, ..., \widehat{\beta_p}$, this can be expressed as:

$$Min(\sum_{i=1}^{n} r_i(\hat{\boldsymbol{\beta}})^2) \quad (70)$$

236 Yohai, V.J. (*1987*), High Breakdown-Point and High Efficiency Robust Estimates for Regression, *The Annals of Statistics, Vol.15, No.2.*

237 Ibid.

238 Yohai, V.J. (*1987*), High Breakdown-Point and High Efficiency Robust Estimates for Regression, *The Annals of Statistics, Vol.15, No.2.*

14. By letting $\rho(x) = x^2$ this can be expressed as:

$$Min\sum_{i=1}^{n} \rho\,(\,r_i(\hat{\beta})) \tag{71}$$

15. M estimators generalise OLS by choosing a different function, ρ, which is a continuous, symmetric function with a minimum value at 0. The function is chosen that "down-weights" the larger residuals, as opposed to OLS, as $\rho(x) = x^2$ gives increasing weight to larger residuals. ρ is generally referred to as the objective function. The objective function is chosen through how the resulting estimator down-weights the larger residuals. Therefore, M robust regression can be seen as a form of "weighted regression", with the weights determined by the objective function and the size of the residuals, r_i. In general, the objective function is chosen in order to assign less weight to outlying observations, as opposed to OLS which assigns increasing weight.[239]

16. Before proceeding with the above, M-estimators require an adjustment to take into account that the above will not be *scale equivalent.*[240] This problem is solved by standardising the residuals in (69) by an estimate of their scale, s. M-estimators therefore minimise the following:

$$Min\sum_{i=1}^{n} \rho\left(\frac{r_i(\hat{\beta})}{\hat{\sigma}}\right) \tag{72}$$

17. Note that OLS does not require the adjustment in (72), as for OLS:

$$Min\sum_{i=1}^{n} \rho\left(\frac{r_i(\hat{\beta})}{\hat{\sigma}}\right) = Min\sum_{i=1}^{n}\left(\frac{r_i(\hat{\beta})}{\hat{\sigma}}\right)^2 = \frac{Min\sum_{i=1}^{n}\left(r_i(\hat{\beta})\right)^2}{\hat{\sigma}^2} \tag{73}$$

18. Therefore, OLS does not require a scale adjustment as minimising (68) is equivalent to minimising (71). Given that the objective function is generally piecewise[241], this is not the case for M robust regression. The most popular choice for estimating $\hat{\sigma}$ is the "*rescaled **MAD***" (median absolute deviation) estimate, where:[242]

$$\hat{\sigma} = 1.4826(\text{MAD}) \tag{74}$$

239 Maronna, R.; D. Martin and V. Yohai (2006). *Robust Statistics: Theory and Methods*. Wiley. p. 28.

240 The scale parameter measures the statistical dispersion of a probability distribution, ie for the Normal distribution $N(\mu,\sigma^2)$ the scale parameter is σ.

241 A function that is made up of different sub-functions, each sub function defined over different domains.

242 Andersen, R. (2008). *Modern Methods For Robust Regression.* Thousand Oakes: SAGE Publications.

where

$$\text{MAD} = \text{median}|r_i|$$

19. In order to minimise equation (72), the partial derivatives with respect to the parameters are calculated and set to 0 as follows:

$$\frac{\partial}{\partial \beta_i}\sum_{i=1}^{n}\rho\left(\frac{r_i(\widehat{\beta})}{\widehat{\sigma}}\right)=0$$
$$-\frac{1}{\widehat{\sigma}}\sum_{i=1}^{n}x_i\rho'\left(\frac{r_i(\widehat{\beta})}{\widehat{\sigma}}\right)=0 \qquad (75)$$
$$\sum_{i=1}^{n}x_i\psi\left(\frac{r_i(\widehat{\beta})}{\widehat{\sigma}}\right)=0$$

where

$\psi(u)=\frac{\partial\rho}{\partial u}$ is referred to as the "score function".

20. Equation (75) does not have a closed form solution, therefore algorithms which employ iterative solutions are used to estimate the required parameters, $\widehat{\beta}_1, \widehat{\beta}_2, ..., \widehat{\beta}_p$.

21. M-estimators are highly efficient; being 95% as efficient as OLS when the assumptions of OLS are achieved. In situations where there is a heavy-tailed error distribution and non-constant error variance, M estimators are *more* efficient than OLS.[243] M estimators are generally not employed as robust regression estimators in practice due to their lack of robustness to leverage points.[244] Therefore, in this situation M estimators have a breakdown point of 0%. They, however, provide an important starting point to other forms of more resistant regression.

S-Estimator regression

22. S-estimators are a reaction to the vulnerability of M estimators. S estimators seek to minimise a measure of the dispersion of the residuals. The dispersion of the residuals, s, is defined as the solution to the following:

$$\frac{1}{n}\sum_{i=1}^{n}\rho\left(\frac{r_i(\widehat{\beta})}{s}\right)=K \qquad (76)$$

243 Ibid.

244 A leverage point is an outlier in one of the explanatory variables, $x_{i1}, x_{i2}, ..., x_{ip}$ as opposed to response variable, y_i.

where

K is a constant, and the objective function ρ satisfies the following conditions:

1) ρ *is symmetric and continuously differentiable, and* $\rho(0)=0$

2) $\exists a$ s.t ρ is strictly increasing on [0,a] and constant on [a,∞)

3) $\frac{K}{\rho(a)}=\frac{1}{2}$

23. An S-estimator is therefore defined as the parameters, $\widehat{\beta}_1,\widehat{\beta}_2,...,\widehat{\beta}_p$ that results in the *s* defined in (76) as being minimal. Formally, *s* is a function of the residuals, $r_i(\widehat{\boldsymbol{\beta}})$ and therefore s is chosen as follows:

$$\arg\min_{\beta} s(r_1(\widehat{\boldsymbol{\beta}}),r_2(\widehat{\boldsymbol{\beta}}),...,r_n(\widehat{\boldsymbol{\beta}})) \tag{77}$$

24. If conditions (1-3) are satisfied, the S-estimator has a breakdown point of 50 per cent. Unfortunately, S-estimators suffer from low statistical efficiency. It is for this reason that S-estimators are not used in practice as a robust regression estimator.

MM-Estimator

25. MM estimators are designed to have a simultaneously high breakdown point and high statistical efficiency. The MM-estimator is computed in 3 stages, combining elements of both the M-estimator and S-estimator:[245]

Stage 1:
An initial estimate of $\boldsymbol{\beta}$ is calculated, using the S-estimator (Equation 77), denoted as $\widetilde{\boldsymbol{\beta}}$. Using this estimator, a set of residuals is calculated as:

$$r_i(\widetilde{\boldsymbol{\beta}})=y_i-(\widetilde{\beta}_1x_{i,1}+\widetilde{\beta}_2x_{i,2}+...+\widetilde{\beta}_px_{i,p}) \tag{78}$$

Stage 2:
Using these residuals, an "M-estimate of scale" is calculated using (79) as follows:

$$\frac{1}{n}\sum_{i=1}^{n}\rho_0\left(\frac{r_i(\widetilde{\boldsymbol{\beta}})}{s_n}\right)=K \tag{79}$$

Therefore,

[245] Yohai, V.J. (*1987*), High Breakdown-Point and High Efficiency Robust Estimates for Regression, *The Annals of Statistics, Vol.15, No.2.*

$$s_n = s(r_1(\tilde{\beta}), r_2(\tilde{\beta}), ..., r_n(\tilde{\beta})) \quad (80)$$

Stage 3:

An M estimator (equation 72) is than calculated using s_n as the estimate of scale.

$$\underset{\beta}{Min} \sum_{i=1}^{n} \rho_1 \left(\frac{r_i(\hat{\beta})}{s_n} \right) \quad (81)$$

The objective function, ρ_1 must satisfy the following constraints:

- ρ_1 is symmetric and continuously differentiable, $\rho_1(0)=0$.
- $\exists a$ s.t ρ is strictly increasing on [0,a] and constant on [a,∞)
- $\rho_1(u) \leq \rho_0(u)$
- $\sum_{i=1}^{n} \rho_1 \left(\frac{r_i(\hat{\beta})}{s_n} \right) \leq \sum_{i=1}^{n} \rho_1 \left(\frac{r_i(\tilde{\beta})}{s_n} \right)$

$\hat{\beta}$ is the MM estimator. Given that the MM estimator has no closed form, an iterative solution to $\hat{\beta}$ is calculated using the following:

$$\sum_{i=1}^{n} x_{i,j} \psi_1 \left(\frac{r_i(\hat{\beta})}{s_n} \right) = 0 \qquad j=1,........p \quad (82)$$

where

$$\psi_1(u) = \frac{\partial \rho_1(u)}{\partial u}.$$

26. In practice, the objective functions used for ρ_0 and ρ_1 is the Tukey bisquare objective function.[246] The R software package implements this as its standard choice for MM regression. In this circumstance, the MM estimator will have a breakdown point of 50%, and a relative statistical efficiency of 95 per cent. Given the high breakdown point and high statistical efficiency of MM regression, it offers the best choice for robust regression currently available.

246 The Tukey Bi-square function is defined as : $\rho(u) = \begin{cases} \frac{u^2}{2} - \frac{u^4}{2a^2} + \frac{u^6}{6a^4} & \text{if } |u| \leq a \\ \frac{a^2}{6} & \text{if } |u| > a \end{cases}$

27. It is noted by Maronna and Yohai (2010)[247] that the theoretical properties of the MM estimator are based on asymptotic distributions and large sample theory. As a consequence, the practical performance of an MM estimator may be inferior to its theoretical properties for small samples.

The Theil-Sen methodology

28. The Theil-Sen Estimator is an alternative robust, nonparametric estimator proposed by Theil (1950) and Sen (1968). The Theil-Sen estimator is only applicable in univariate regression, i.e regression of the form: $y_i = \alpha + \beta x_{i,1}$. For each pair of possible points in a data sample, the slope is calculated and then ranked. The Theil-Sen estimator of the slope is than calculated as the *median* of these slopes. Formally this can be expressed as:

$$\beta_{TS} = median\{\beta_{ij}\}$$

$$\beta_{TS} = median\{\beta_{ij} \mid \beta_{ij} = \frac{y_j - y_i}{x_j - x_i}, x_i \neq x_j, 1 \leq i < j \leq n\} \qquad (83)$$

where

β_{ij} is the slope between point i and point j; and

$$\alpha_{TS} = median\{y_i - \beta_{TS} x_i\}.$$

29. It is noted by Sen(1968)[248] that the OLS estimator, can itself be expressed as a linear function of the slopes between two points. Sen states that the OLS estimator can be expressed as follows:

$$\beta_{OLS} = \sum_{i=1}^{n} \sum_{j=1}^{n} (x_j - x_i)^2 \beta_{i,j} \qquad (84)$$

30. Given that OLS is thus just a weighted average of $\beta_{i,j}$, the slope between each possible point, it follows that both the Theil-Sen estimator and OLS are both functions of $\beta_{i,j}$. Therefore as the median is more robust to outliers than a weighted average, it follows that the Theil-Sen estimate is more robust to outliers than the OLS estimator.

31. The Theil-Sen estimator is an unbiased, scale equivalent estimator of the true parameter to be estimated, β.[249] The Theil-Sen estimator has a breakdown point of 29%,[250] which holds even for relatively small samples. In addition, the regression is

[247] Maronna, R. A. And V.J Yohai (2010). 'Correcting MM estimates for "fat" data sets.' *Computational Statistics and Data Analysis,* Vol.54, No. 12, pp. 3168-3173.

[248] Sen, P.K (1968). 'Estimates of the Regression Coefficient Based on Kendall's Tau.' *Journal of the American Statistical Association,* Vol.63, No. 324 pp. 1379-1389.

[249] Ibid.

[250] Wilcox, R.R (2001) *Fundamentals of Modern Statistical Methods.* Springer.

valid even when both the dependent and independent variable are random variables (as is the case in a financial context), unlike OLS.[251] In addition, the Theil-Sen estimator has a high statistical efficiency, implying that OLS offers only a slight advantage in circumstances where the errors are normally distributed. It has been shown that in the presence of heteroscedasticity, the Theil Sen estimator gives far more accurate results than OLS.[252]

32. Given the predominance of outliers in financial data, it is generally surprising that the Theil-Sen estimator is not more widely used in estimating the beta coefficient.[253] The lack of popularity of the Theil-Sen estimator may be explained by the computational power needed in order to calculate it. Given a dataset of size n, the Theil-Sen estimator requires $\frac{(N)(N-1)}{2}$ different slopes to be calculated. Therefore, before the advent of high computing power, the Theil-Sen estimator was beyond the reach of practitioners.

251 Sen, P.K (1968). 'Estimates of the Regression Coefficient Based on Kendall's Tau.' *Journal of the American Statistical Association,* Vol.63, No. 324 pp. 1379-1389.

252 Ibid.

253 Fabozzi, F.J(2013) *Encyclopedia of Financial Models,* Wiley Publications.

Appendix 18 Descriptions of companies in the equity beta sample

Ticker	Industry Sector	Company Description (as at April 2013)
ENV AU Equity	Utilities	Envestra Limited operates natural gas distribution networks and transmission pipelines in South Australia, Queensland and the Northern Territory. The Company's networks distribute gas to households and businesses in Adelaide, Brisbane (north of Brisbane River), Alice Springs and various regional centers in South Australia and Queensland.
APA AU Equity	Energy	APA Group is a natural gas infrastructure company. The Company owns and or operates gas transmission and distribution assets whose pipelines span every state and territory in mainland Australia. APA Group also holds minority interests in energy infrastructure enterprises.
DUE AU Equity	Utilities	DUET Group invests in energy utility assets located in Australia and New Zealand. The Group's investment assets include gas pipelines and electricity distribution networks.
HDF AU Equity	Financial	Hastings Diversified Utilities Fund invests in utility infrastructure assets such as gas transmission and distribution assets, electricity generation, transmission and distribution assets, hydro and wind power generation assets and regulated and unregulated assets.
SPN AU Equity	Utilities	SP Ausnet owns and operates electricity transmission and electricity and gas distribution assets in Victoria, Australia.
SKI AU Equity	Utilities	Spark Infrastructure Group invests in utility infrastructure assets in Australia.

Source: Bloomberg

Appendix 19 Adjustments to Bloomberg’s reporting of data

1. The Bloomberg terminal offers the ability to adjust reported stock prices for events such as stock splits, to keep prices movements comparable to the historical series. For example, if a two-for-one stock split occurs, a share in a particular company that was value at $50, holding all other factors constant, is now valued at $25. To maintain comparability to the past data, an adjustment can be made.

2. In the data set using historical pricing, adjustments were made to reflect company equity policy such as spin-offs, stock splits/consolidations, stock dividend/bonus, rights offerings/entitlement. Similarly, the price may drop as a result of dividend payouts which take many forms.

3. The last price was adjusted for all normal and abnormal cash dividend types except omitted, discontinued, deferred or cancelled.

4. Normal dividend adjustments included those dividends made for regular cash, interim, first interim, second interim, third interim, fourth interim, income, estimated partnership distribution, interest on capital, distribution and prorated dividends.

5. Abnormal dividend adjustments were made for special cash, liquidation, capital gains, long-term capital gains, short-term capital gains, memorial, return of capital, rights redemption, miscellaneous, return premium, preferred rights redemption, proceeds/rights, proceeds/shares and proceeds/warrants.

6. Bloomberg offers the ability to make adjustments for changes in volume; however, no such adjustments were made to the series used in this analysis.

Appendix 20 De-levering and Re-levering factors

1. Since the sample used in this analysis consists of many utilities with differing gearing levels, a de-levered/re-levered factor is needed. The average level of gearing $\bar{G}$ is calculated as the average level of the book value of net debt $\bar{D}$ as a proportion of the value of the firm represented by the sum of the book value of net debt $\bar{D}$ and market value of equity $\bar{E}$. The average gearing level is presented in equation (85) below:

$$\bar{G} = \frac{\bar{D}}{\bar{D} + \bar{E}} \quad (85)$$

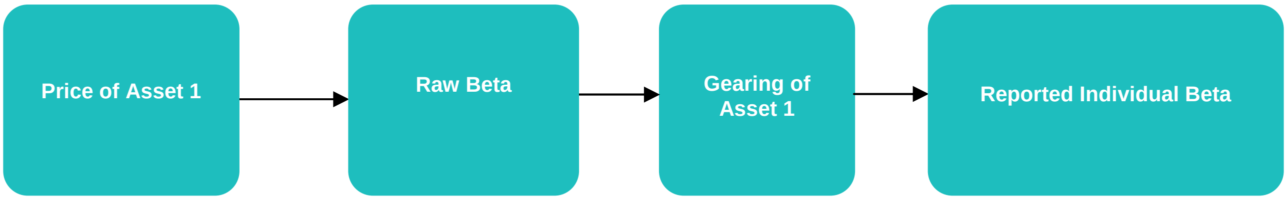
2. Australian economic regulators have assumed the benchmark gearing level of 60 per cent debt and 40 per cent equity in their regulatory decisions.[254] As such, the conventional approach to calculate the re-levering factor, which will be applied to raw beta estimates from the regression, is calculated using:

$$\omega = \frac{1 - \bar{G}}{1 - 0.6} \quad (86)$$

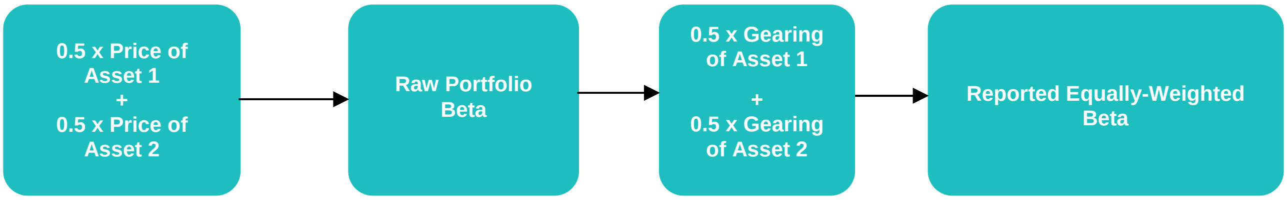
[254] Australian Energy Regulator (2008), "Explanatory Statement: Electricity transmission and distribution network service providers Review of the weighted average cost of capital (WACC) parameters" p.14.

Appendix 21 Portfolio construction

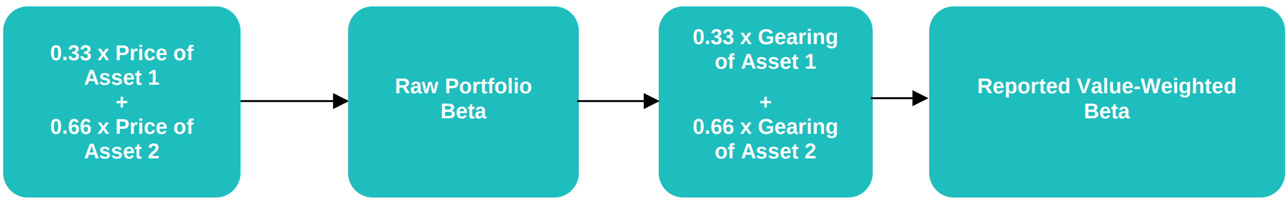
Individual Equity Betas



Equal Weighted Portfolio Equity Betas



Value Weighted Portfolio Equity Betas



1. The above diagrams give a stylised explanation of the differences between the individual, equal weighted and value weighted portfolio betas.

2. The individual's raw equity betas are estimated based on the individual equity's price. The gearing for the company in question is then applied to the raw beta through a 'de-levering/re-levering formula' to create the equity beta that is reported in this study.

3. The equal weighted portfolio raw equity betas are estimated based on an equally weighted price of each individual equity, for example if there are two equities each will receive a weight of 50 per cent, three equities, a weight of 33.33 per cent and so on. The gearing for the company is then calculated as an equally weighted average using the same weighting and then applied to the raw portfolio beta through a 'de-levering/re-levering formula' to create the reported equity beta.

4. The value weighted portfolio raw equity betas are similar, but instead based on weights reflecting their relative market capitalisation within the portfolio. If the total market capitalisation was $1b with asset one's capitalisation equal to $333.33m and assets two's capitalisation equal to $666.66m the first asset will receive a weight of 0.33 while the second a weight of 0.66. The gearing for the company is then calculated as a weighted average using this same weighting and then applied to the raw portfolio beta (again through a 'de-levering/re-levering formula') to create the reported equity beta

.

Appendix 22 Assumptions regarding OLS

1. In order to verify whether or not the assumptions underlying Ordinary Least Squares (**OLS**) regressions are violated in relation to the estimates of equity beta, the Authority has conducted various hypothesis tests designed to test the normality assumption. Regressions for each firm were run over the period between 19 April 2008 and 19 April 2013. The residuals were extracted from the OLS beta estimated over the period so that tests could be carried out to determine their distribution. Jarque-Bera tests were carried out to test the null hypothesis of the error series following a normal distribution – an assumption underlying OLS regression.[255] The Jarque-Bera test statistic is a goodness-of-fit test analysing the skewness and kurtosis present within residual data. A p-value of less than 0.05 strongly rejects the hypothesis of residuals following a normal distribution, indicating that there is substantial statistical evidence that OLS regression is inappropriate. The Jarque-Bera tests were carried out using the R software package, using the library tseries and function jarque.bera.test().[256]

2. The Anderson-Darling, Cramer-von Mises, Watson, Kolmogorov-Smirnov and Kuiper tests were carried out on the residuals data to determine whether the errors follow a Laplace distribution. These tests are outlined in Puig and Stephens (2000).[257] Each of these tests has a null hypothesis that the error distribution follows a Laplace distribution. Therefore, rejecting the null hypothesis is equivalent to rejecting the hypothesis that the errors have a Laplace distribution. Evidence of a Laplace distribution of the errors will suggest that Least Absolute Devaition (**LAD**) estimation is the most appropriate regression technique for analysing equity beta data, contrary to the views of SFG consulting and Competition Economics Group.[258] [259] The Laplace tests were carried out using the R software package, using the library lawstat and function laplace test.[260]

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255 Jarque C.M and Bera A.K "A Test for Normality of Observations and Regression Residuals" *International Statistical Review Vol. 55, No.2 (Aug 1987), pp. 163-172.*

256 *Documentation available at: http://127.0.0.1:18027/library/tseries/html/jarque.bera.test.html.*

257 Puig.P and Stephens M.A "Tests of Fit for the Laplace Distribution, with Applications", *Technometrics Vol. 42, No.4 (Nov, 2000), pp.417-424.*

258 SFG Consulting, *Beta estimation: Considerations for the Economic Regulation Authority,* 19 September 2013.

259 Competition Economists Group, *Regression estimates of equity beta,* September 2013.

260 *Documentation available at: http://127.0.0.1:29726/library/lawstat/html/laplace.test.html.*

Table 37 Distribution tests for individual companies' OLS regression errors

	5% Critical Values	APA	DUE	ENV	HDF	SKI	SPN
Jarque Bera Test p-value		0	0	0	0	0	0
Outcome				***Violates OLS Assumption***			
Anderson-Darling Test Statistic	0.983	0.3878	0.4925	0.2784	1.7325	0.6086	0.5167
Cramer-von Mises Test Statistic	0.144	0.0561	0.0647	0.0314	0.2760	0.0807	0.0699
Watson Test Statistic	0.084	0.0501	0.0615	0.0282	0.2363	0.0672	0.0503
Kolmogorov-Smirnov Test Staistic	0.918	0.6426	0.7408	0.4528	1.1716	0.7488	0.6880
Kuiper Test Statistic	1.324	1.2007	1.3091	0.7713	1.7868	1.1935	1.0906
Anderson-Darling Outcome		Do Not Reject	Do Not Reject	Do Not Reject	Reject	Do Not Reject	Do Not Reject
Cramer-Von Mises Outcome		Do Not Reject	Do Not Reject	Do Not Reject	Reject	Do Not Reject	Do Not Reject
Watson Outcome		Do Not Reject	Do Not Reject	Do Not Reject	Reject	Do Not Reject	Do Not Reject
Kolmogorov-Smirnov Outcome		Do Not Reject	Do Not Reject	Do Not Reject	Reject	Do Not Reject	Do Not Reject
Kuiper Outcome		Do Not Reject	Do Not Reject	Do Not Reject	Reject	Do Not Reject	Do Not Reject
Overall Outcome		**LAD well suited**	**LAD well suited**	**LAD well suited**	**LAD not suited**	**LAD well suited**	**LAD well suited**

Source: Economic Regulation Authority's analysis

3. shows that the hypothesis "the errors follow a normal distribution" is strongly rejected for all companies in the sample, except for Hastings Diversified Utility Fund (HDF). The assumption underlying OLS is therefore strongly rejected, and therefore other regression techniques are necessary to estimate equity beta. The overall outcome shows considerable evidence that estimated errors for all firms follow a Laplace distribution. HDF is the only exception.

4. The analysis conducted above for individual firm equity betas was also carried out on equal weighted portfolio estimates to determine the appropriateness of both OLS and LAD regression. The results are presented in Table 38.

Table 38 Distribution tests for equally weighted portfolio OLS regression errors

	5% Critical Values	Equal Weight Portfolio 0	Equal Weight Portfolio 1	Equal Weight Portfolio 2	Equal Weight Portfolio 3	Equal Weight Portfolio 4
Jarque Bera Test p-value		0	0	0	0	0
Outcome				***Violates OLS Assumption***		
Anderson-Darling	0.983	1.3267	0.9153	0.9655	0.7288	0.5083
Cramer-von Mises	0.144	0.1884	0.1372	0.1443	0.0978	0.0506
Watson	0.084	0.1844	0.1358	0.0900	0.0731	0.0506
Kolmogorov-Smirnov	0.918	1.0043	0.8650	0.8603	0.8088	0.6147
Kuiper	1.324	1.7870	1.7092	1.1576	1.2232	1.1911
Anderson-Darling Outcome		Reject	Do Not Reject	Do Not Reject	Do Not Reject	Do Not Reject
Cramer-Von Mises Outcome		Reject	Do Not Reject	Reject	Do Not Reject	Do Not Reject
Watson Outcome		Reject	Reject	Reject	Do Not Reject	Do Not Reject
Kolmogorov-Smirnov Outcome		Reject	Do Not Reject	Do Not Reject	Do Not Reject	Do Not Reject
Kuiper Outcome		Reject	Reject	Do Not Reject	Do Not Reject	Do Not Reject
Overall Outcome		**LAD not suited**	**LAD possibly suited**	**LAD possibly suited**	**LAD well suited**	**LAD well suited**

Source: Economic Regulation Authority's analysis

5. The Jarque Bera p-values reject the hypothesis of normal distribution again for all equally weighted portfolios. This suggests that OLS regression is not appropriate for equal weighted portfolio beta estimation. The various tests present evidence of Laplace distribution for equal weight Portfolios 1 to 4. The LAD estimator is not necessarily suited to regression of equally weighted Portfolio 0.

6. In addition, the analysis has also been conducted for value weighted portfolio estimates to determine the appropriateness of both OLS and LAD regression. The results are presented in Table 39.

Table 39 Distribution tests for value weighted portfolio OLS regression errors

	5% Critical Values	Value Weighted Portfolio 0	Value Weighted Portfolio 1	Value Weighted Portfolio 2	Value Weighted Portfolio 3	Value Weighted Portfolio 4
Jarque Bera Test p-value		0	0	0	0	0
Outcome				***Violates OLS Assumption***		
Anderson-Darling	0.983	1.0248	0.7395	0.4476	0.6101	0.4288
Cramer-von Mises	0.144	0.1302	0.0958	0.0478	0.0717	0.0583
Watson	0.084	0.1220	0.0922	0.0429	0.0493	0.0583
Kolmogorov-Smirnov	0.918	1.0216	0.7589	0.5663	0.8176	0.6170
Kuiper	1.324	1.9311	1.5071	0.9357	1.2121	1.1515
Anderson-Darling Outcome		Reject	Do Not Reject	Do Not Reject	Do Not Reject	Do Not Reject
Cramer-Von Mises Outcome		Do Not Reject	Do Not Reject	Do Not Reject	Do Not Reject	Do Not Reject
Watson Outcome		Reject	Reject	Do Not Reject	Do Not Reject	Do Not Reject
Kolmogorov-Smirnov Outcome		Reject	Do Not Reject	Do Not Reject	Do Not Reject	Do Not Reject
Kuiper Outcome		Reject	Reject	Do Not Reject	Do Not Reject	Do Not Reject
Overall Outcome		**LAD not necessarily suited**	**LAD possibly suited**	**LAD well suited**	**LAD well suited**	**LAD well suited**

Source: Economic Regulation Authority's analysis

8. In conclusion, the Authority notes that the Jarque Bera p-values reject the hypothesis of normal distribution for all equally-weighted and value-weighted portfolios. This suggests that OLS regression is not appropriate for any portfolio's beta estimation. The various tests present evidence of Laplace distribution for equally weighted Portfolios 1 to Portfolio 4. The LAD estimator is not necessarily suited to regression of equally-weighted or value-weighted Portfolio 0.

9. The Authority considers that the above analysis presents compelling evidence indicating that relying solely on OLS regression is not appropriate for the purposes of equity beta estimation. The optimal properties of OLS regression only exist if regression errors follow a normal distribution. As a consequence, the Authority is justified in utilising alternative regression techniques, in addition to OLS to inform its judgment on equity beta.

Appendix 23 Equity beta estimates using bootstrapping

1. Bootstrapping refers to a form of statistical inference by estimating the sampling distribution of a statistic by re-sampling the data at hand.[261] Traditional statistics involves drawing a random sample of observations from a population $\boldsymbol{P} = \{x_1, x_2 ..., x_n\}$, and using a randomly generated sample from $\boldsymbol{P}$, $S = \{X_1, X_2 ..., X_n\}$ with each element having probability distribution $\boldsymbol{X}_i \sim \boldsymbol{f(x)}$, to infer characteristics of some aspect of this probability distribution.[262] That is, suppose the quantity of interest, θ, has some relationship, t, with the population as follows: $\theta = t(\boldsymbol{P})$. Given that we do not usually have access to the entire population, we cannot specify the probability distribution exactly and therefore rely on the observations drawn from the probability distribution to estimate the statistic of interest as follows: $\hat{\theta} = t(\boldsymbol{S})$.[263] We refer to $\hat{\theta}$ as an estimate of the quantity of interest θ. Given that $\boldsymbol{S}$ is itself a random variable (with each observation having a probability density function $\boldsymbol{X}_i \sim \boldsymbol{f(x)}$), and $\hat{\theta}$ simply a function of $\boldsymbol{S}$, it follows that $\hat{\theta}$ will itself be a random variable. The sampling distribution of $\hat{\theta}$ refers to the probability distribution of the estimated quantity $\hat{\theta}$. Given that the probability distribution, $\boldsymbol{X}_i \sim \boldsymbol{f(x)}$, is unknown traditional statistics assumes a parametric form of $\boldsymbol{f(x)}$, and then uses this to derive the sampling distribution of $\hat{\theta}$. This is a very strong assumption, which can result in the sampling distribution being seriously inaccurate if the assumption is wrong. In addition, deriving the probability distribution of the sampling statistic may be mathematically impossible, given the complexity in both the underlying probability distribution $\boldsymbol{f(x)}$ and the function t.

2. The bootstrap is a nonparametric technique that does not require an assumption of the parametric form of $\boldsymbol{f(x)}$. Instead it allows for an estimate of the sampling distribution of $\hat{\theta}$ by re-sampling numerous times from the original sample $\boldsymbol{S}$. The essential idea of bootstrapping is as follows:

   - A sample of size n is drawn from the observed sample, with replacement, resulting in a bootstrap sample $\boldsymbol{S}_1^*$;
   - This is done $\boldsymbol{B}$ times, resulting in $\boldsymbol{B}$ bootstrap samples $\boldsymbol{S}_1^*, \boldsymbol{S}_2^*, ... \boldsymbol{S}_B^*$;
   - For each bootstrap sample, we calculate $\hat{\theta}_i = t(S_i)$, resulting in $\hat{\theta}_1, \hat{\theta}_2, ..., \hat{\theta}_B$ estimates of θ;
   - The sampling distribution of $\hat{\theta}$ is therefore approximated by $\hat{\theta}_1, \hat{\theta}_2, ..., \hat{\theta}_B$ around the original estimate of $\hat{\theta}$.

261 Fox J (2002), An R and S-PLUS Companion to Applied Regression, Appendix p1. Sage Publishing.

262 The probability distribution $\boldsymbol{X}_i \sim \boldsymbol{f(x)}$ describes the probability of drawing a certain value/values from the population $\boldsymbol{P}$.

263 Note that this assumes the statistic is based on the "plug-in principle". It can be shown that bootstrapping is robust to more complicated statistics that are not based on the plug-in principle, See: Efron. B , Tibshirani R.J , 1993, An Introduction to the Bootstrap, Chapman and Hall Chapter 8.

3. Bootstrapping is useful as it allows practitioners to estimate the statistical accuracy of an estimator, given the observed data set. Typically a statistical practitioner is interested in two measures of statistical accuracy, the standard error and bias of an estimate. The bias of an estimator is defined as the difference between the expected value of an estimator, $E[\hat{\theta}]\hat{\theta}$, and the true value of the parameter, θ as follows: $bias = E[\hat{\theta}] - \theta$. It is desirable for a statistical estimator to have no bias, i.e $E[\hat{\theta}] = \theta$. Given that $E[\hat{\theta}]$ cannot be calculated unless the sampling distribution of $\hat{\theta}$ is known, and θ is unobservable the bias of an estimator can be estimated using a bootstrap procedure. Efron (1979) defines the bootstrap estimate of bias as follows:[264]

$$\widehat{bias}_B = \frac{\sum_{i=1}^{B} \hat{\theta}^*(S_i)}{B} - \hat{\theta}(S) \quad (87)$$

4. Intuitively equation (87) states that an estimate of the bias of an estimator can be obtained by averaging the values of an estimator obtained via the bootstrap procedure ($\frac{\sum_{i=1}^{B} \hat{\theta}^*(S_i)}{B}$), and subtracting the value of the estimator obtained by using the original sample S ($\hat{\theta}(S)$).

5. The bootstrap can also be used to measure the variability of a given estimator. The standard deviation of the sampling distribution, referred to as the standard error is a measure by which a practitioner can estimate the accuracy of an estimated quantity. A small standard error is desirable as this ensures the sampling distribution is clustered around the true population value θ (assuming a nil or negligible bias). Efron (1979) proposed the following for estimating the standard error of an estimator:[265]

$$\widehat{se}_B = \sqrt{\frac{(\sum_{i=1}^{B} [\hat{\theta}^*(S_i) - \hat{\theta}^*(.))^2}{B-1}} \quad (88)$$

where

$$\hat{\theta}^*(.) = \frac{\sum_{i=1}^{B} \hat{\theta}^*(S_i)}{B}$$

6. Intuitively equation (88) calculates the standard error of an estimator $\hat{\theta}$ by calculating the standard deviation using each bootstrap sample and the mean of the bootstrap samples. Therefore, it is desirable for each regression estimator to have a bias of 0, in addition to having a low standard error.

[264] Efron. B , Tibshirani R.J , 1993, *An Introduction to the Bootstrap,* Chapman and Hall, p 130.

[265] Efron. B , Tibshirani R.J , 1993, *An Introduction to the Bootstrap,* Chapman and Hall, p 170.

7. Efron and Tibshirani (1993) discuss methods of generating accurate confidence intervals using the bootstrap.[266] In particular, the percentile interval approach is a non-parametric method that allows practitioners to estimate the α percentile of the sampling distribution of $\hat{\theta}$. The estimate of the α percentile is denoted $\hat{\theta}_B^{(\alpha)}$ and is calculated by creating an ordered list of all bootstrap samples $\hat{\theta}_1, \hat{\theta}_2, ..., \hat{\theta}_B$, and choosing the $\alpha.B$ value from the ordered list. For example, if 10,000 Bootstrap replications were generated and we are interested in the 5% percentile, i.e. B=10,000 and α =.05, the 500th ordered value is chosen as the estimate $\hat{\theta}_{10,000}^{(0.05)}$. The $1-2\alpha$ percentile interval is generated using the following:

$$[\hat{\theta}_B^{(\alpha)}, \hat{\theta}_B^{(1-\alpha)}] \tag{89}$$

8. For example, the 95 per cent confidence interval is given by taking the lower endpoint as the 2.5%, $\hat{\theta}_B^{(0.025)}$ and the upper endpoint as the 97.5% percentile as $\hat{\theta}_B^{(.975)}$.

9. With respect to the equity beta calculation, the random variable of interest is the joint distribution of the return of asset i at time t, $r_{i,t}$, and the return of the market, $r_{m,t}$. This can be represented as the random vector $X_t \sim < r_{i,t}, r_{m,t} >$, with the random vector having joint probability distribution $X_t \sim f(r_{i,t}, r_{m,t})$. It is assumed that the relationship between the return of the market, r_m and the return of asset i, r_i are related via the Sharp-Linter CAPM as follows[267]:

$$r_{i,t} = \alpha_i + \beta_i r_{m,t} + \varepsilon_{i,t} \tag{90}$$

where

α_i is the return due to factors unrelated to market movements;
β_i is the sensitivity of asset i to changes in the market;
$\varepsilon_{i,t}$ is an error term.

10. The parameter of interest is β_i. Each β_i is estimated by observing observations $S = \{X_1, X_2, ..., X_n\}$ of the random vector $X_t \sim < r_{i,t}, r_{m,t} >$. Regression techniques are then employed using (90) to arrive at an estimate of β_i, $\widehat{\beta}_i$. Implicit in this estimate is that the probability distribution of $X_t \sim < r_{i,t}, r_{m,t} >$, is independently and identically

266 Ibid.

267 Henry O. *Estimating Beta, Submitted to ACCC 23 April 2009,* p2.

distributed, and that the probability density functions is a stationary process over the 5 year period. No assumption is made regarding the parametric form of the distribution of returns, $X_t \sim f(r_{i,t}, r_{m,t})$. The Authority believes that the assumption of independently and identically distributed returns will hold as a consequence of the Efficient Market Hypothesis. Therefore, the returns observed in the market will not be dependent and the bootstrap approach will be valid.

11. If equation (90) satisfies the following conditions, then the Best Linear Unbiased Estimator (BLUE) for equation (90) would be the Ordinary Least Squares estimator by the Gauss-Markov Theorem.[268]

$$E[\varepsilon_i] = 0$$
$$Var[\varepsilon_i] = \sigma^2$$
$$Cov[\varepsilon_i, \varepsilon_j] = 0 \text{ if } i \neq j$$
$$\varepsilon_i \sim N(0, \sigma^2)$$

12. In this scenario, (and σ^2 is known), the sampling distribution of $\widehat{\beta}_i$ will have the following distribution:[269]

$$\widehat{\beta}_i \sim N(\beta_i, \frac{\sigma^2}{\sum_{i=1}^{n}(r_m - \overline{r_m})^2}) \quad (91)$$

13. However, given the violation of the regression assumptions, outlined in , the Authority has employed 3 additional regression estimators, the LAD, MM and Theil-Sen estimators. This is a consequence of the assumptions underlying OLS failing to hold, requiring estimators that are robust to deviations from traditional statistical assumptions (As described in Appendix 22). It is not a result of preferring “Outlier-resistant regression techniques” over OLS as suggested by SFG.[270] Using the notation of $\hat{\theta} = t(S)$ above, where t is the particular regression procedure employed, we have the following relationship between the observed sample and beta estimates:

$$\hat{\beta}_{i,OLS} = t_{OLS}(S), \quad \hat{\beta}_{i,LAD} = t_{LAD}(S), \quad \hat{\beta}_{i,MM} = t_{MM}(S), \quad \hat{\beta}_{i,TS} = t_{TS}(S) \quad (92)$$

14. Equation (92) states formally that each beta estimate is arrived at by applying a particular regression estimator to the sample S. It is desirable to derive the sampling

268 Hill R.C , Griffiths W.E, Lim G.C , 2008, *Principles of Econometrics* , p 32.

269 Ibid, p 33.

270 SFG Consulting, *Beta estimation: Considerations for the Economic Regulation Authority,* 19 September 2013, p 3.

distribution for each beta estimate, as this allows for a comparison of the accuracy of each estimate. However, as the probability distribution of each observation $X_t \sim f(r_{i,t}, r_{m,t})$ is unknown, in addition to the complexity of the regression estimators, the sampling distributions of $\beta_{i,OLS}$, $\beta_{i,LAD}$, $\beta_{i,MM}$ and $\beta_{i,TS}$ are also unknown and unlikely to follow (91) (as assumed by SFG Consulting). As a consequence, bootstrapping is required in order to estimate the sampling distribution for $\beta_{i,OLS}$, $\beta_{i,LAD}$, $\beta_{i,MM}$ and $\beta_{i,TS}$. The sampling distribution for each beta estimate is desirable as it allows the Authority to compare the accuracy of each estimate across regression technique and company estimated, as well as computing theoretical quantities such as the median and confidence intervals without strict parametric assumptions. The sampling distribution has the interpretation of being the sampling distribution of the beta estimate using a specific regression technique, over the 5 year period estimated. Equation (87) allows the Authority to infer if any systematic biases exist when applying the four different regression estimators to equity beta. In addition, if the assumptions were violated it is likely that a systematic bias would be evident across all estimated betas, as this would indicate a significant structural change has occurred during the 5 year estimation period with respect to beta.

15. The Authority has used the "bootstrapping pairs" approach described in Efron & Tibshirani (1993) as it is robust to heteroscedasticity, and allows for comparison across different regression procedures employed without the need for assumptions concerning the regression coefficients.[271] The Authority has applied the bootstrapping pairs technique to the data used in the Draft Guidelines, with B=10,000 and n=260 as follows:

- A sample of size n is drawn, with equal probability, from the observed sample $S = \{X_1, X_2, ..., X_n\}$, where $X_t \sim < r_{i,t}, r_{m,t} >$,with replacement, resulting in a bootstrap sample $\boldsymbol{S}_1^*$;
- This is done $\boldsymbol{B}$ times, resulting in $\boldsymbol{B}$ bootstrap samples $\boldsymbol{S}_1^*, \boldsymbol{S}_2^*, ...\boldsymbol{S}_B^*$;
- For each bootstrap sample, we calculate:

$$\hat{\beta}_{i,OLS} = t_{OLS}(\boldsymbol{S}_i^*), \quad \hat{\beta}_{i,LAD} = t_{LAD}(\boldsymbol{S}_i^*), \quad \hat{\beta}_{i,MM} = t_{MM}(\boldsymbol{S}_i^*), \quad \hat{\beta}_{i,TS} = t_{TS}(\boldsymbol{S}_i^*)$$

- The sampling distribution of each beta estimate is approximated by the relevant bootstrap estimates.

271 Efron B. and Tibshirani R.J. 1993, *An Introduction to the Bootstrap,* Chapman and Hall, p 113.

Appendix 24 Histograms of bootstrap distributions

Figure 32 Bootstrap estimates of APA using OLS regression

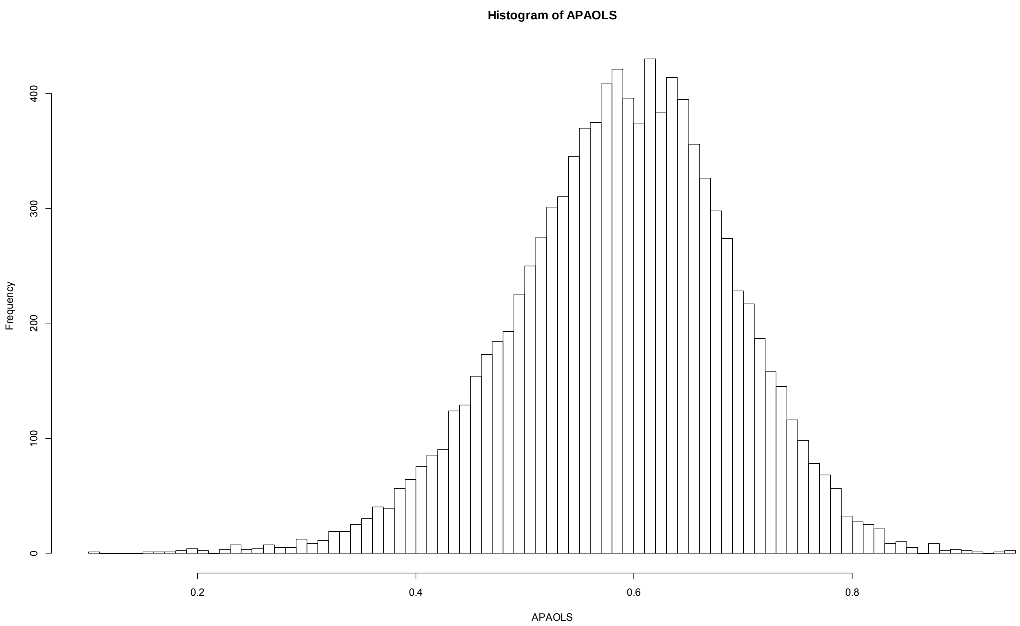


Figure 33 Bootstrap estimates of APA using LAD regression

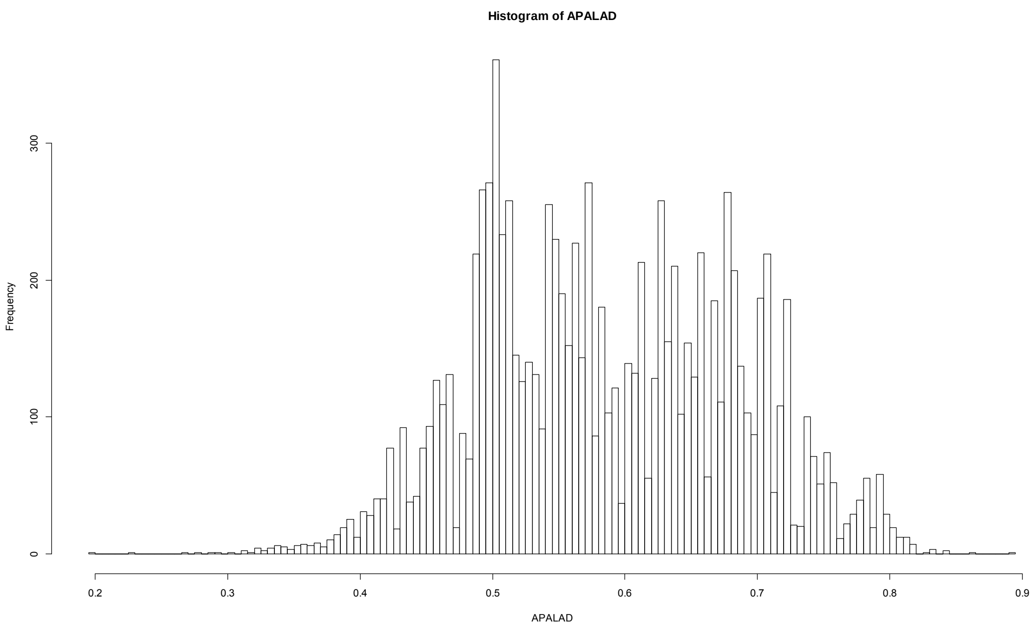


Figure 34 Bootstrap estimates of APA using MM regression

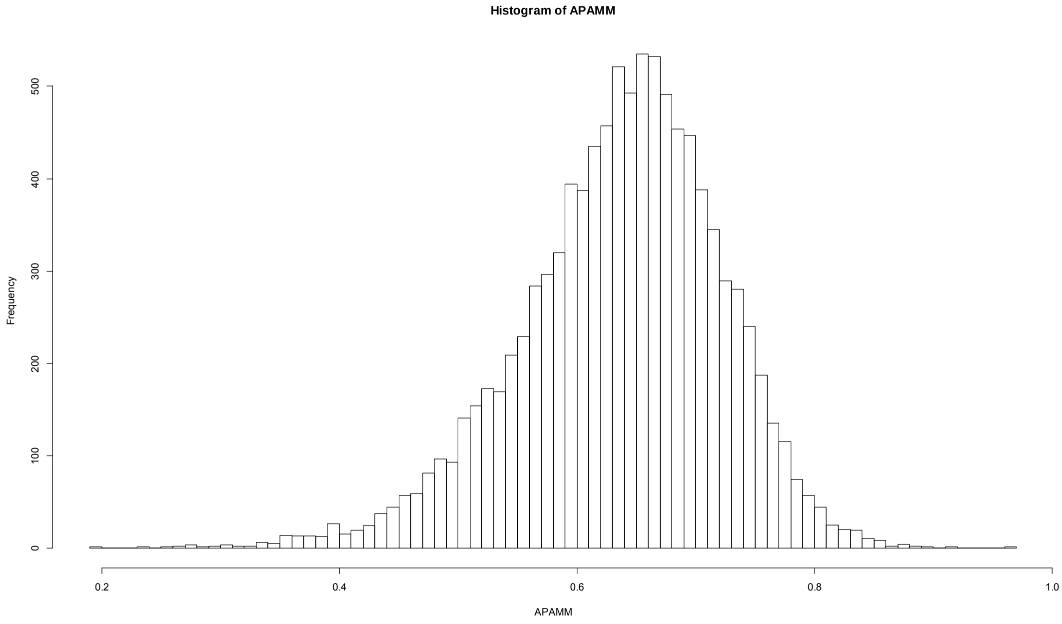


Figure 35 Bootstrap estimates of APA using TS regression

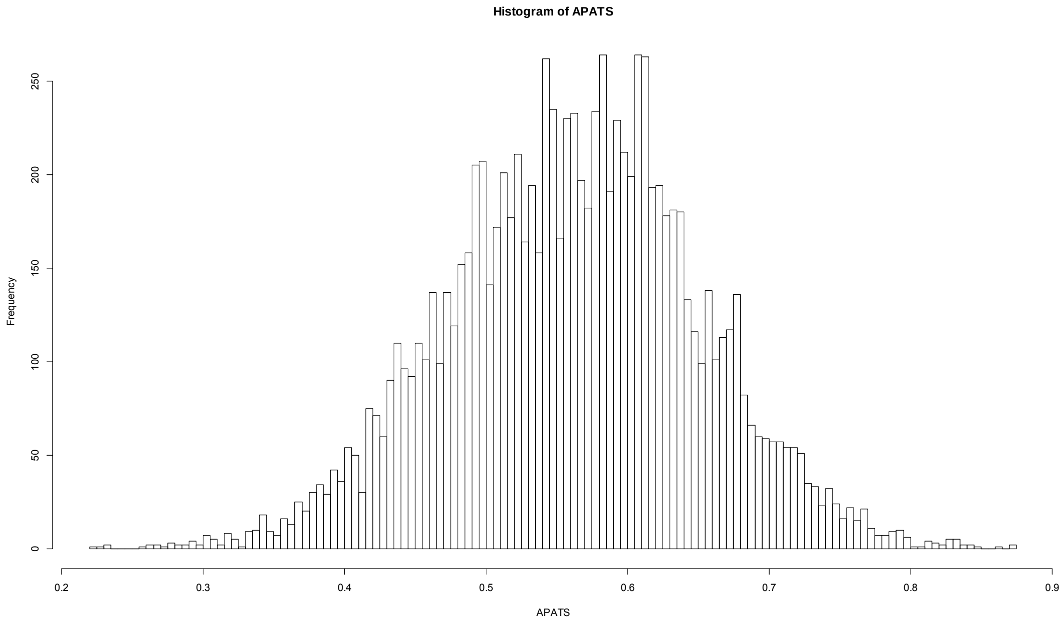


Figure 36 Bootstrap estimates of DUE using OLS regression

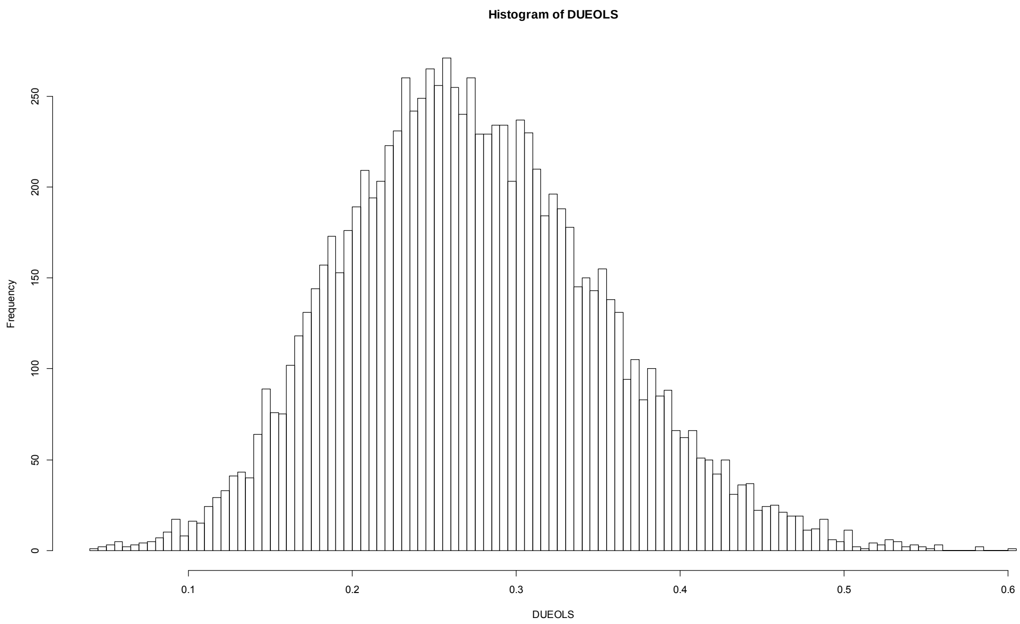


Figure 37 Bootstrap estimates of DUE using LAD regression

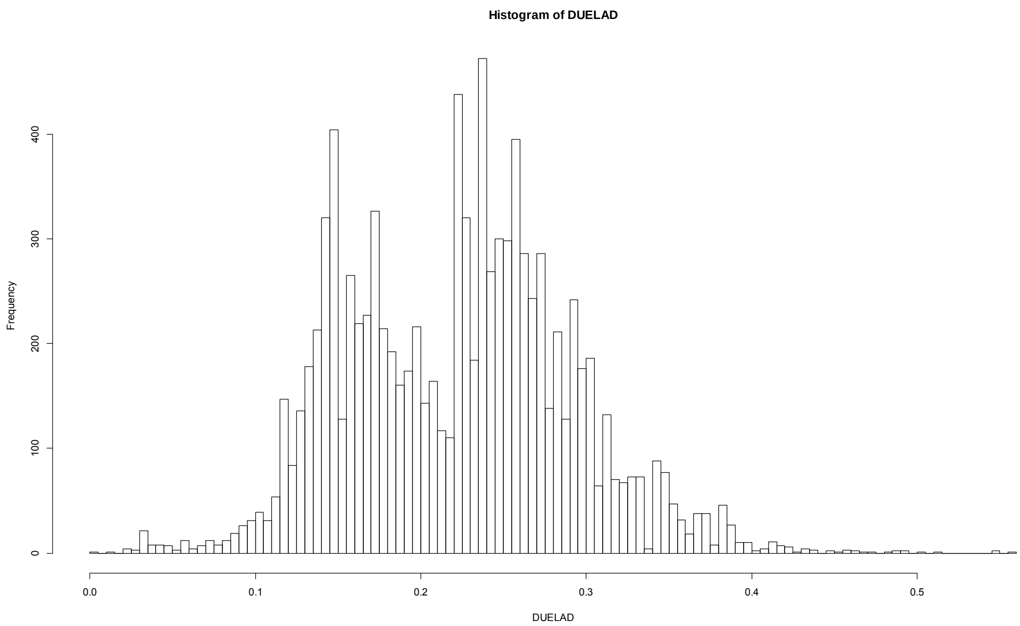


Figure 38 Bootstrap estimates of DUE using MM regression

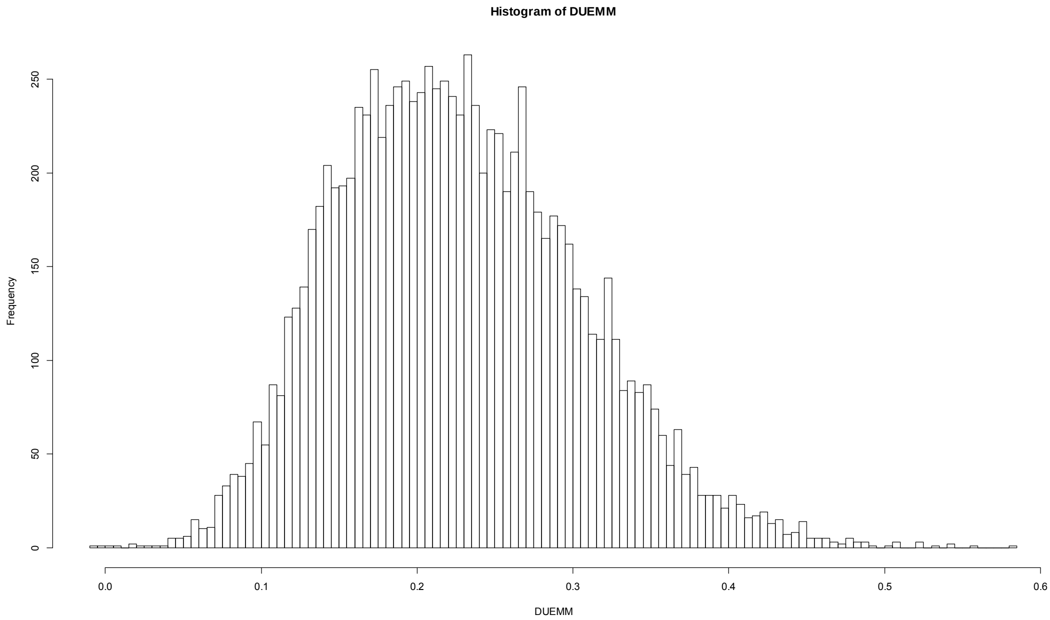


Figure 39 Bootstrap estimates of DUE using TS regression

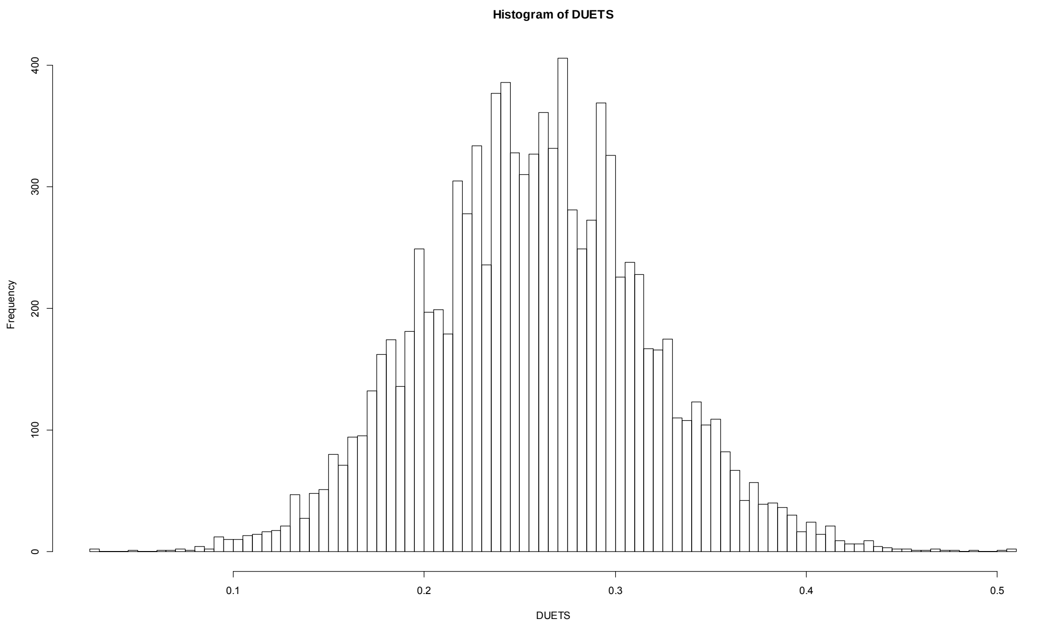


Figure 40 Bootstrap estimates of ENV using OLS regression

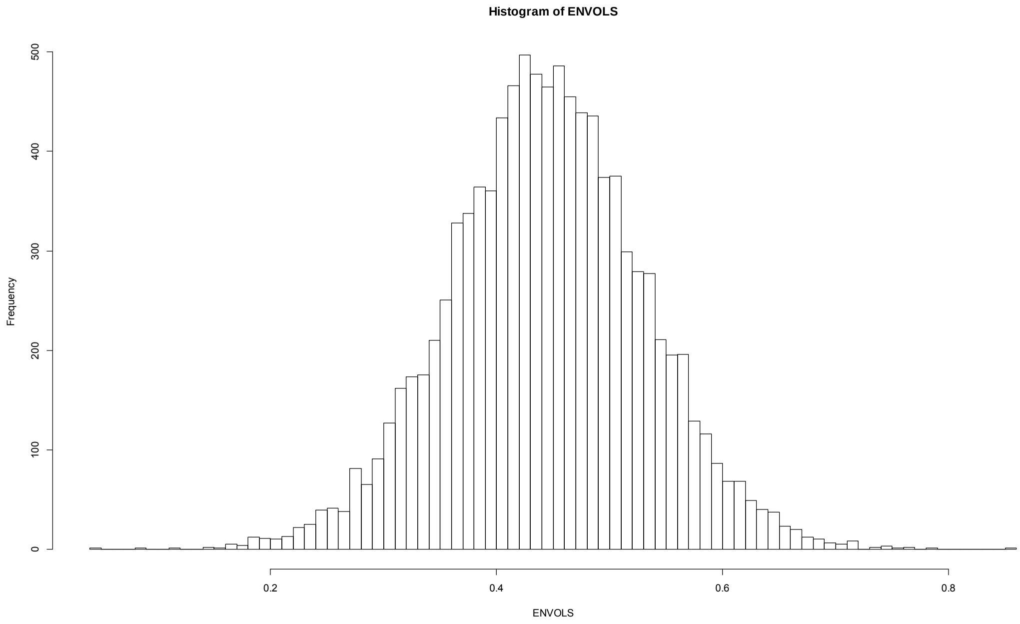


Figure 41 Bootstrap estimates of ENV using LAD regression

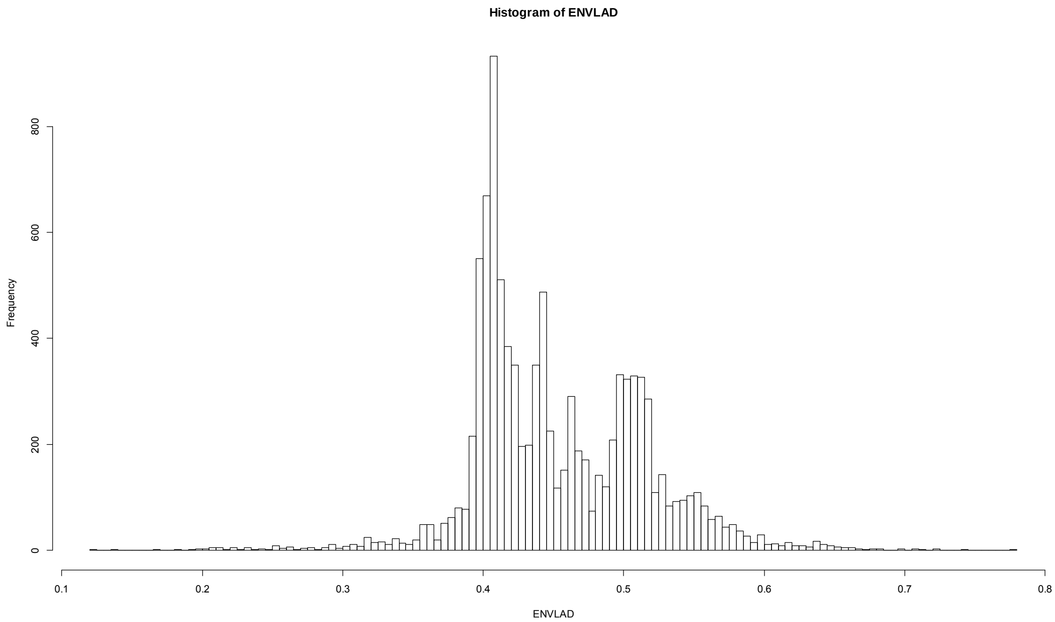


Figure 42 Bootstrap estimates of ENV using MM regression

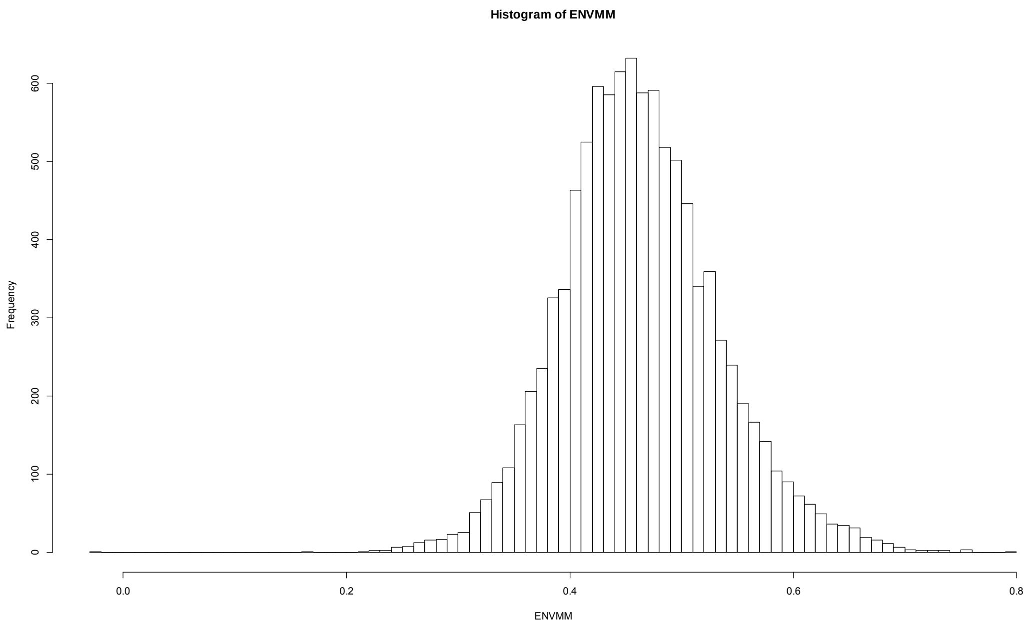


Figure 43 Bootstrap estimates of ENV using TS regression

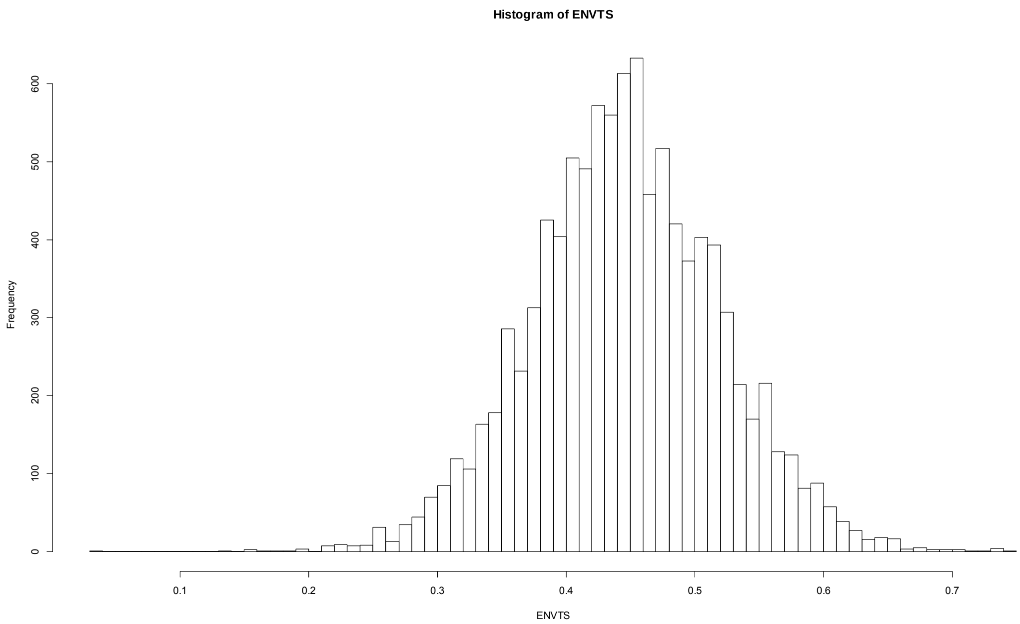


Figure 44 Bootstrap estimates of HDF using OLS regression

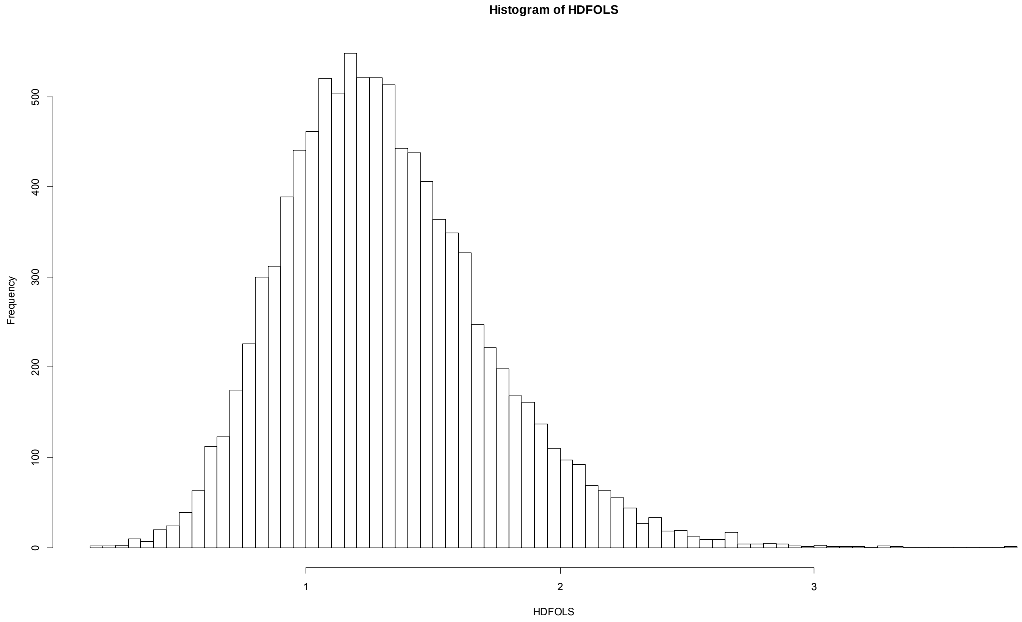


Figure 45 Bootstrap estimates of HDF using LAD regression

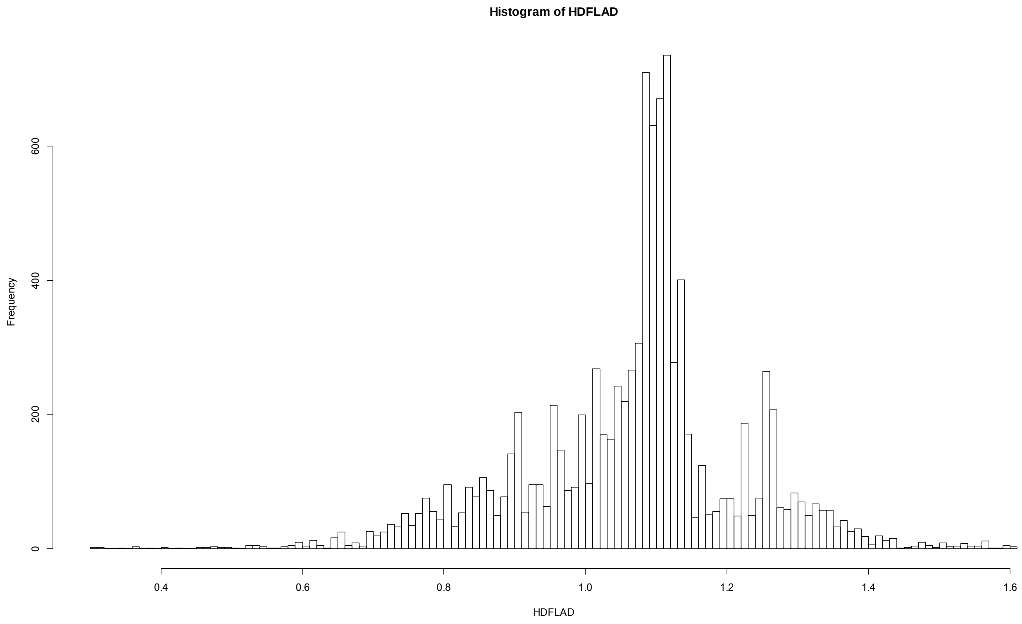


Figure 46 Bootstrap estimates of HDF using MM regression

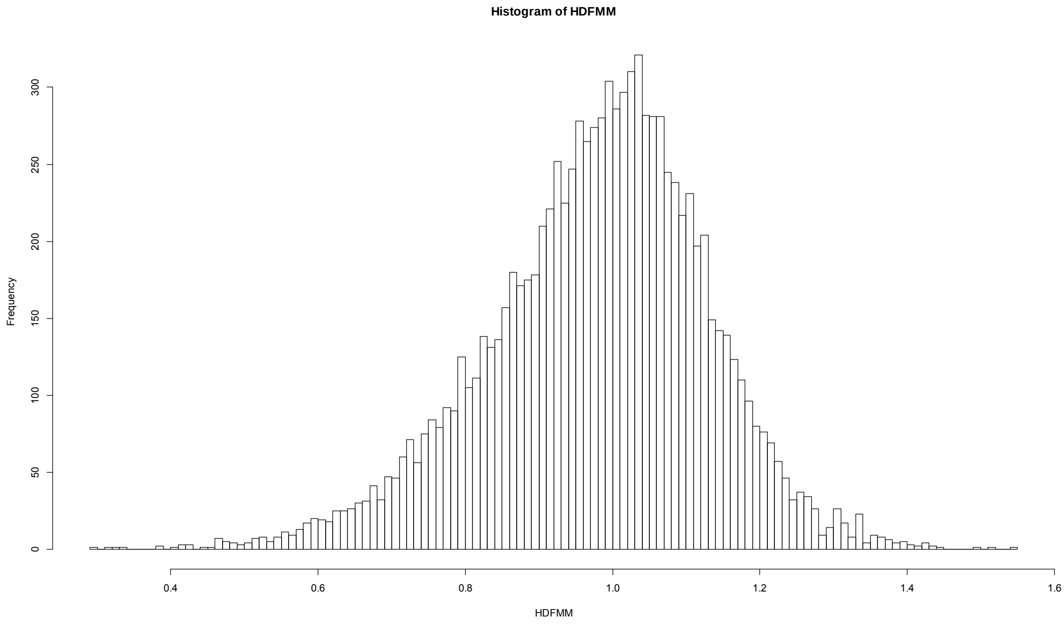


Figure 47 Bootstrap estimates of HDF using TS regression

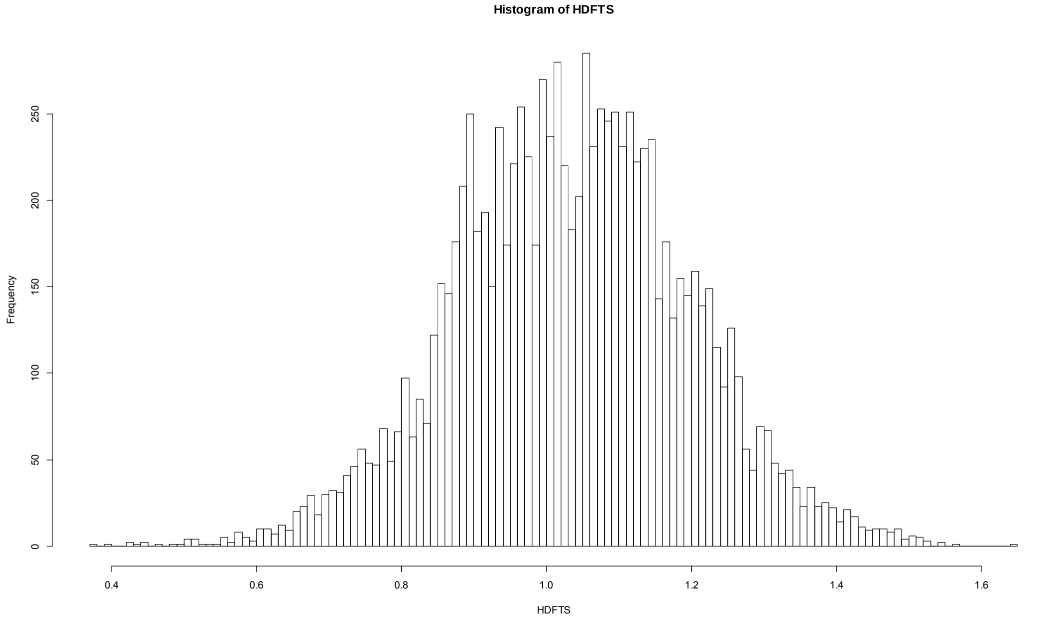


Figure 48 Bootstrap estimates of SKI using OLS regression

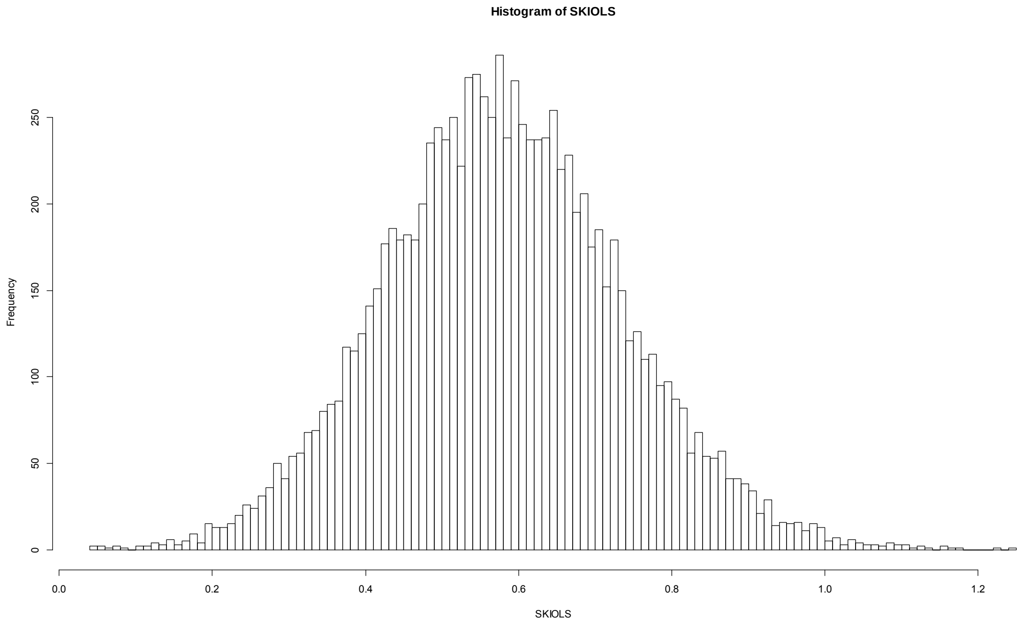


Figure 49 Bootstrap estimates of SKI using LAD regression

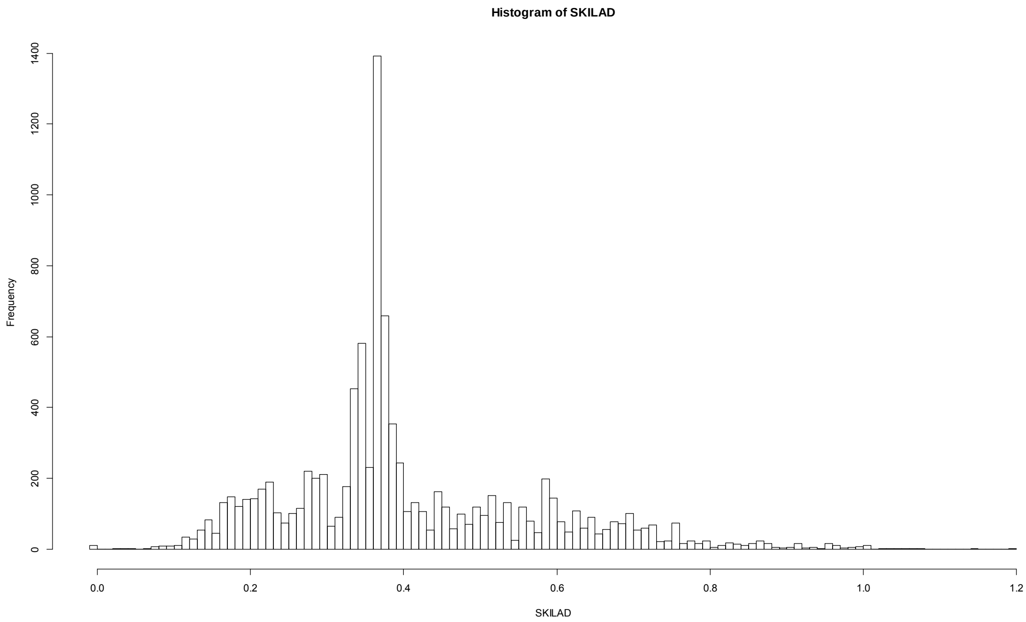


Figure 50 Bootstrap estimates of SKI using MM regression

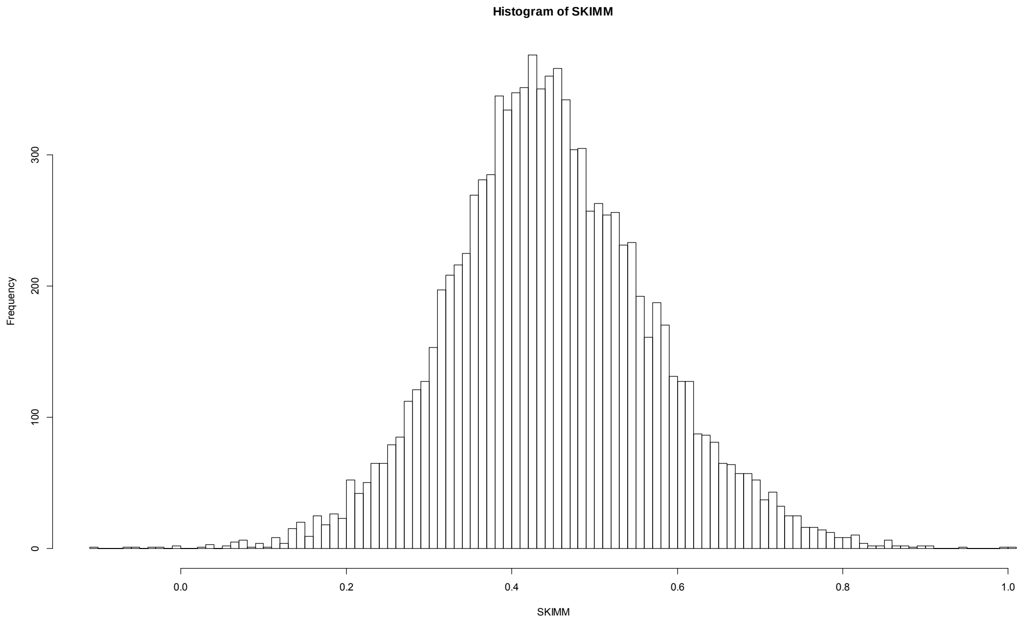


Figure 51 Bootstrap estimates of SKI using TS regression

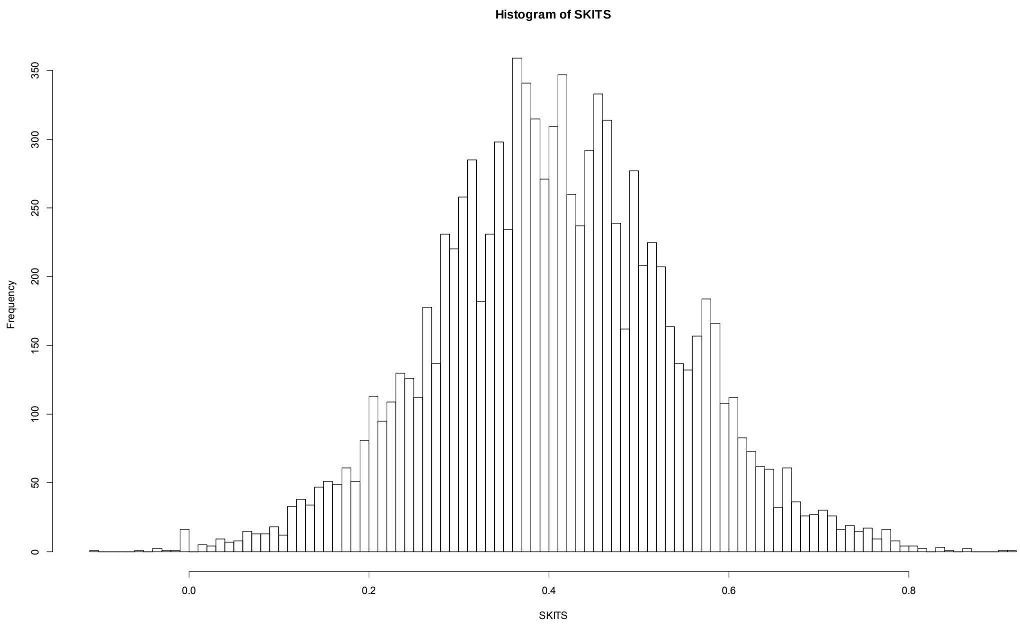


Figure 52 Bootstrap estimates of SPN using OLS regression

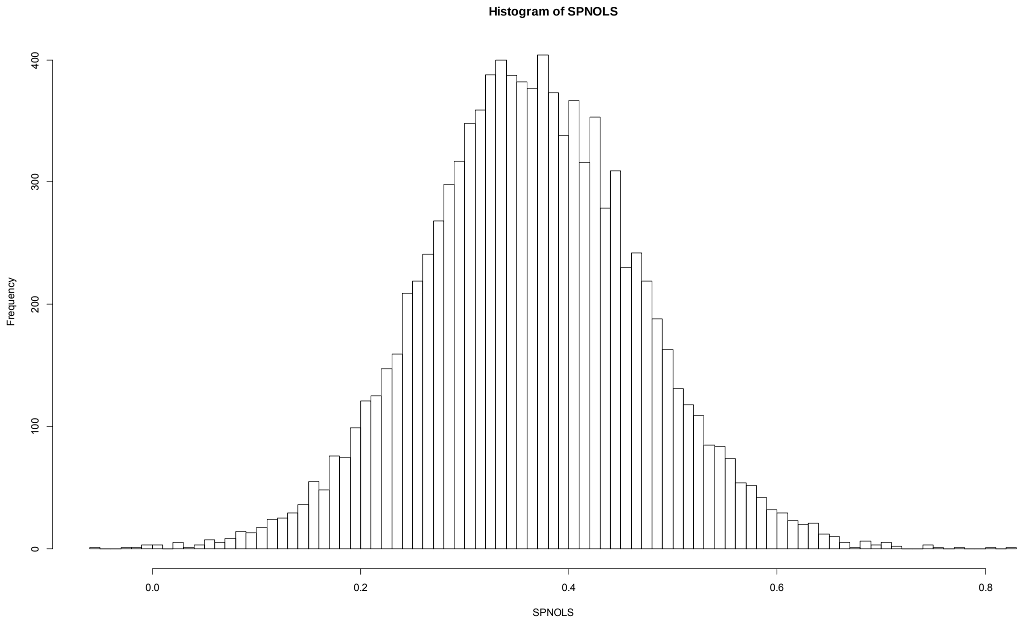


Figure 53 Bootstrap estimates of SPN using LAD regression

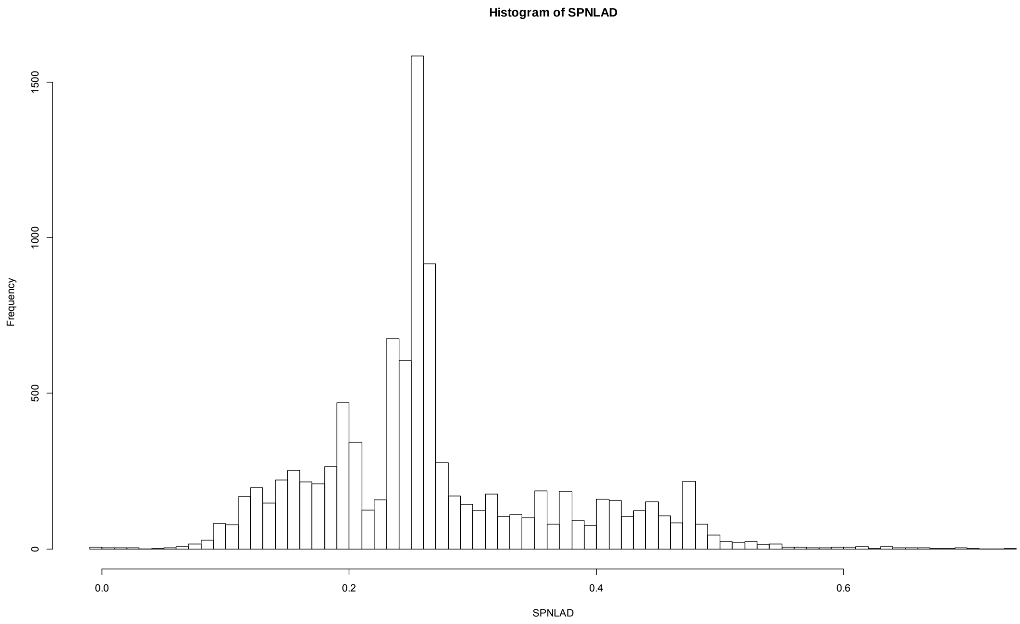


Figure 54 Bootstrap estimates of SPN using MM regression

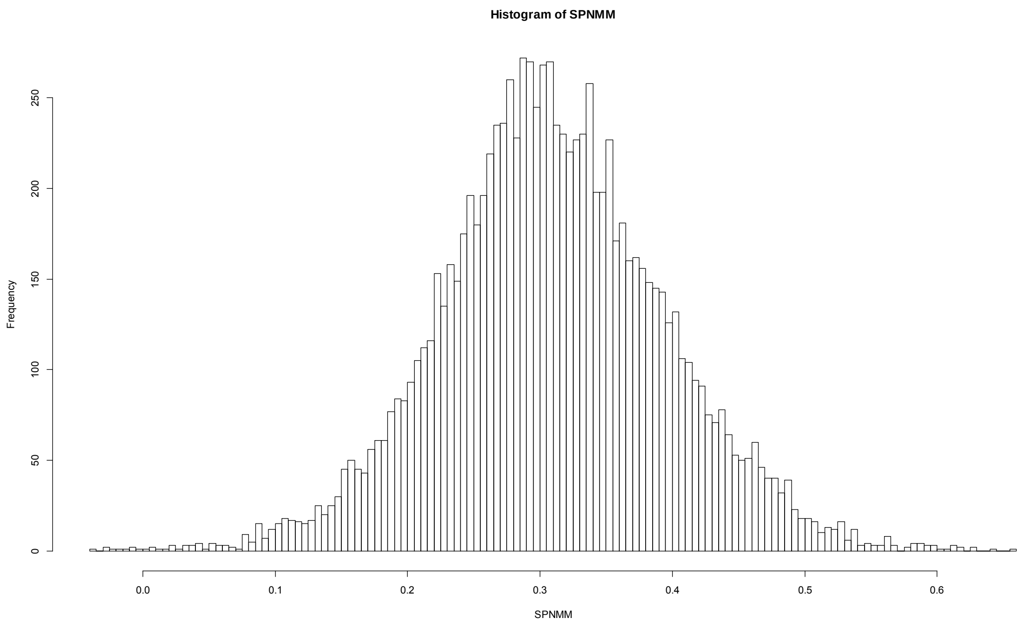
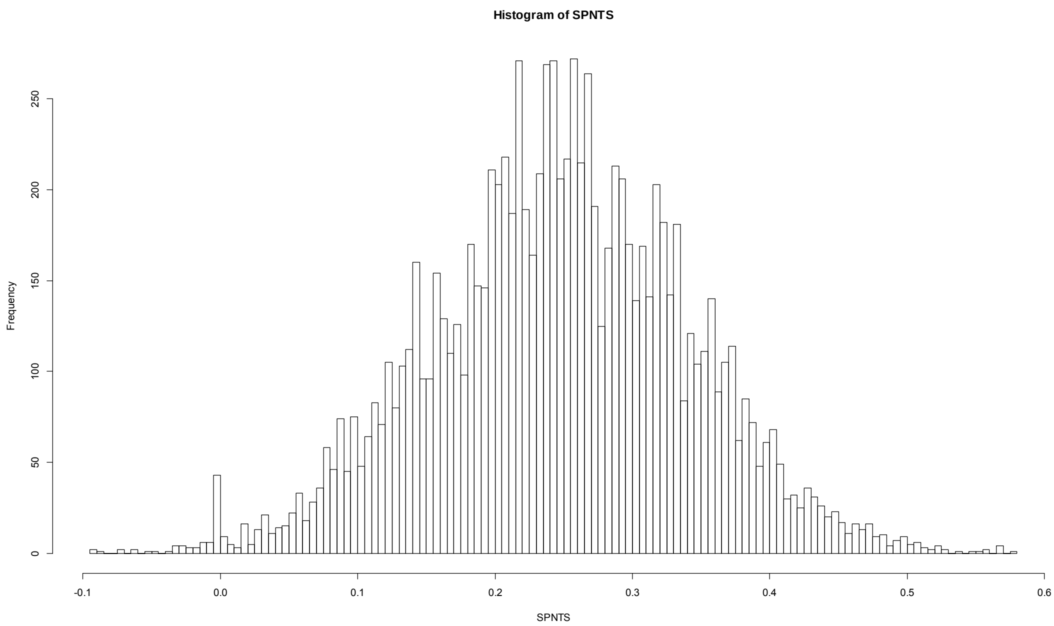


Figure 55 Bootstrap estimates of SPN using TS regression



Appendix 25 Bootstrapped percentiles – individual firm

Table 40 Value of bootstrapped equity beta by percentile quintiles

	1.0%	2.5%	5.0%	10.0%	15.0%	20.0%	25.0%	30.0%	35.0%	40.0%	45.0%	50.0%	55.0%	60.0%	65.0%	70.0%	75.0%	80.0%	85.0%	90.0%	95.0%	97.5%	99.0%
ENVOLS	0.237	0.273	0.303	0.335	0.358	0.373	0.388	0.401	0.413	0.423	0.433	0.444	0.454	0.465	0.476	0.488	0.501	0.515	0.532	0.554	0.585	0.616	0.649
ENVLAD	0.312	0.358	0.383	0.397	0.401	0.404	0.407	0.411	0.415	0.422	0.432	0.442	0.446	0.462	0.471	0.491	0.500	0.509	0.517	0.530	0.556	0.579	0.616
ENVMM	0.307	0.332	0.355	0.379	0.395	0.406	0.417	0.425	0.434	0.442	0.451	0.458	0.467	0.475	0.485	0.494	0.504	0.517	0.532	0.552	0.584	0.615	0.648
ENVTS	0.275	0.302	0.327	0.354	0.374	0.387	0.398	0.409	0.420	0.428	0.438	0.446	0.453	0.461	0.472	0.483	0.495	0.507	0.520	0.540	0.568	0.594	0.619
APAOLS	0.332	0.380	0.417	0.458	0.486	0.508	0.526	0.541	0.556	0.569	0.582	0.594	0.607	0.619	0.632	0.643	0.656	0.672	0.690	0.713	0.745	0.773	0.807
APALAD	0.386	0.417	0.440	0.468	0.490	0.500	0.508	0.519	0.540	0.551	0.563	0.577	0.599	0.617	0.632	0.647	0.667	0.680	0.697	0.716	0.742	0.776	0.792
APAMM	0.397	0.451	0.487	0.524	0.551	0.570	0.587	0.600	0.613	0.624	0.634	0.644	0.654	0.663	0.673	0.683	0.694	0.706	0.720	0.738	0.761	0.782	0.808
APATS	0.352	0.386	0.416	0.446	0.469	0.487	0.500	0.514	0.528	0.542	0.553	0.564	0.576	0.587	0.599	0.609	0.621	0.634	0.652	0.674	0.707	0.732	0.765
DUEOLS	0.110	0.133	0.153	0.177	0.192	0.206	0.219	0.230	0.239	0.249	0.259	0.269	0.279	0.290	0.301	0.312	0.325	0.340	0.357	0.379	0.413	0.441	0.474
DUELAD	0.081	0.107	0.121	0.138	0.147	0.157	0.166	0.176	0.190	0.203	0.220	0.227	0.235	0.243	0.252	0.259	0.267	0.277	0.292	0.305	0.338	0.360	0.386
DUEMM	0.076	0.095	0.113	0.132	0.146	0.158	0.169	0.180	0.190	0.201	0.211	0.221	0.231	0.242	0.253	0.265	0.277	0.292	0.308	0.329	0.359	0.390	0.426
DUETS	0.123	0.145	0.163	0.182	0.196	0.208	0.219	0.228	0.236	0.243	0.250	0.257	0.265	0.272	0.280	0.290	0.296	0.306	0.317	0.334	0.356	0.377	0.402
HDFOLS	0.541	0.636	0.731	0.832	0.911	0.970	1.030	1.078	1.124	1.174	1.220	1.269	1.317	1.367	1.424	1.486	1.551	1.627	1.719	1.851	2.048	2.218	2.441
HDFLAD	0.651	0.731	0.781	0.855	0.909	0.953	0.992	1.020	1.048	1.068	1.082	1.090	1.099	1.103	1.111	1.119	1.131	1.157	1.223	1.258	1.311	1.357	1.420
HDFMM	0.582	0.651	0.714	0.781	0.826	0.861	0.889	0.914	0.936	0.956	0.974	0.992	1.009	1.026	1.041	1.059	1.078	1.100	1.123	1.155	1.203	1.248	1.310
HDFTS	0.653	0.711	0.765	0.838	0.874	0.897	0.924	0.950	0.971	0.995	1.014	1.037	1.058	1.078	1.098	1.119	1.141	1.169	1.203	1.239	1.298	1.354	1.419
SKIOLS	0.229	0.283	0.328	0.385	0.421	0.449	0.476	0.497	0.518	0.539	0.557	0.576	0.596	0.616	0.637	0.658	0.681	0.708	0.738	0.781	0.843	0.896	0.964
SKILAD	0.126	0.151	0.175	0.211	0.250	0.282	0.318	0.339	0.347	0.362	0.365	0.367	0.372	0.380	0.396	0.441	0.490	0.536	0.586	0.647	0.714	0.779	0.882
SKIMM	0.166	0.214	0.256	0.302	0.329	0.351	0.369	0.385	0.400	0.414	0.429	0.442	0.456	0.471	0.487	0.505	0.525	0.546	0.573	0.606	0.660	0.705	0.757
SKITS	0.093	0.146	0.191	0.239	0.276	0.298	0.317	0.341	0.359	0.376	0.389	0.407	0.422	0.442	0.458	0.474	0.498	0.520	0.549	0.581	0.628	0.676	0.730
SPNOLS	0.118	0.160	0.195	0.234	0.259	0.279	0.296	0.310	0.324	0.336	0.349	0.362	0.375	0.388	0.403	0.417	0.432	0.449	0.470	0.495	0.537	0.573	0.618
SPNLAD	0.096	0.113	0.124	0.151	0.173	0.194	0.203	0.229	0.239	0.244	0.253	0.256	0.258	0.260	0.267	0.277	0.310	0.350	0.387	0.428	0.470	0.485	0.527
SPNMM	0.103	0.144	0.172	0.205	0.226	0.242	0.256	0.267	0.278	0.288	0.297	0.307	0.317	0.328	0.339	0.351	0.364	0.379	0.397	0.419	0.456	0.483	0.519
SPNTS	0.017	0.061	0.089	0.126	0.148	0.168	0.188	0.201	0.214	0.225	0.238	0.247	0.258	0.268	0.283	0.295	0.311	0.325	0.344	0.367	0.399	0.429	0.465
AVERAGE	**0.265**	**0.307**	**0.342**	**0.381**	**0.409**	**0.430**	**0.448**	**0.465**	**0.480**	**0.495**	**0.508**	**0.521**	**0.533**	**0.547**	**0.561**	**0.578**	**0.596**	**0.618**	**0.644**	**0.675**	**0.720**	**0.760**	**0.810**

Appendix 26 Empirical evidence on debt raising costs

1. There are a number of estimates of debt raising costs for regulatory purposes in Australia, these include: (i) the ACCC's 2004 estimate; (ii) the ACG's 2004 estimate for the ACCC; (iii) Deloitte's 2010 estimate for Envestra; and (iv) PricewaterhouseCoopers' 2011 estimates. In addition, based on the ACG's 2004 approach, the AER has also updated its own estimates of the debt raising costs in its regulatory decisions.

ACCC's 2004 estimate

2. The Australian Competition and Consumer Commission (**ACCC**) determined an initial allowance of 10.5 to 12.5 bppa for debt raising costs for regulated utilities in 2002 and 2003. These estimated figures were based on its own research.[272] The ACCC decisions are regarded as the decisions that led the way for other Australian regulators to use 12.5 bppa in their estimates of debt raising costs. The ACCC estimate is comprised of specific financing fees detailed in Table 41.

Table 41 The Australian Competition and Consumer Commission's debt raising cost estimate in 2004 (basis points per year)

Non-margin financing fee	Allowance (bppa)
Arranger fee	0.4
Agency fee	0.3
Placement fee	5.0
Gross underwriting fees	**5.7**
Company credit rating fees	1.2
Legal fees	0.6
Total before swap margin	**7.5**
Dealer swap margin	5.0
Total	**12.5**

Source: Australian Competition and Consumer Commission, 2002, Final Decision: GasNet access arrangement revisions for the Principal Transmission System, p.147.

ACG's 2004 report

3. In 2004, the Australian Competition and Consumer Commission (**ACCC**) engaged the Allen Consulting Group (**ACG**) to further examine and determine an accurate allowance for debt raising costs. The ACG undertook data analysis,[273] interviews with market participants and a literature review to determine an appropriate allowance. In this study, ACG estimated debt raising costs to be between 8.0 and 10.4 bppa.[274]

[272] Australian Competition and Consumer Commission, 2002, Final Decision: GasNet access arrangement revisions for the Principal Transmission System, p. 95.

[273] Data sources included Bloomberg, Basis Point, Prospectuses for IPOs and SEOs and Osbourne Associates survey of funding program fee charges.

[274] The variance in basis points per annum results from the number of issues per annum. The company credit rating fee can be divided amongst the number of issues per annum, which results in a lower overall debt raising cost fee per issue.

4. In its report, ACG outlined criteria for which fees are included or excluded in its analysis of debt raising costs for bonds. ACG first considered "Discretionary fees" that are associated with domestic corporate bond issues. ACG argued that as these outlays are optional, they should not be a part of the regulated allowance for debt issuance.

5. The first discretionary fee is that associated with interest and currency swaps. Given that an initial offering of a floating rate bond is usually subject to both exchange rate and interest rate risk, firms can hedge this risk by entering into a swap contract. As costs arising from interest rate swaps are optional, giving the firm the opportunity to eliminate interest rate risk, ACG does not consider it necessary to include it in the cost of debt allowance.

6. The second discretionary fee relates to "Credit Wrapping", the provision of a financial guarantee to the obligations made by the issuer of the bond. As credit wrapping allows a regulated entity to achieve a higher credit rating, the benefits from credit wrapping offsets the fees for credit wrapping. Therefore as credit wrapping fees are optional, they are not included in the cost of debt allowance.

7. In addition, advisory fees refer to "fees payable to a financial adviser when arranging debt". As advisory fees are optional, ACG does not consider it necessary to include these in the cost of debt allowance.

8. ACG then outlined the fee structure that is relevant for the cost of debt allowance. This structure includes various types of fees which are discussed below:

   - the management fee refers to the fee related to the arrangement on the entire bond issuance process on behalf of the client. Typically, this fee is paid to the lead arranger to act as a contact between the bond issuer and potential bond purchasers. If the bond issuance is not sold, the underwriter will take up the issuance, guaranteeing the proceeds of the issuer. As such, an underwriting fee is therefore required to be paid to the underwriter of a bond issue for taking on risk.
   - the Selling (Placement or Agent) fee refers to the fee provided to the selling agent for selling an issue to their client bases.
   - the legal costs of a debt issuance refer to the legal documentation required in a bond issuance.
   - a credit rating fee is required in order to obtain a credit rating for bond issuance. The credit rating fee is paid on an upfront basis in order to obtaining an initial credit rating, and a per annum charge is paid subsequently.

9. In order to estimate the debt issuance cost for a benchmark entity, ACG applied the following methodology:

   Step 1: Data Set selected

   The sample includes all Australian companies (excluding banks and Government Business Enterprises) issuing bonds (excluding convertible bonds) with gross underwriting fees reported by Bloomberg.

   Step 2: Group the bond issues by tenor and calculate basis points per annum (bppa)

Bond issues are grouped into 5- and 10-year maturities, in order to assess the influence of maturity on gross underwriting fees. The Bppa is then calculated by dividing the total gross fees by maturity.

Step 3: Adjust the bppa for 5 to 10 year maturity

The median tenor of international bond issues by Australian companies is calculated on a rolling 5-year basis.

Step 4: Calculate the median rolling 5 year bppa gross underwriting fee for each maturity group

The median rolling 5 year gross underwriting fee is calculated for each maturity group on the basis of the adjusted bppa fees (Step 3).

Step 5: Calculate the median maturity and issue size of bonds issued by Australian infrastructure companies in the domestic market

Step 6: Adjust the median gross underwriting cost (bppa) to the appropriate tenor assumption

The median gross underwriting fee is calculated by interpolation from the medians of both the 5 and 10 year maturity underwriting fees.

Step 7: Assess legal and ancillary costs

This is done via consultation with industry sources such as investment banks, lawyers and Standard and Poors.

Step 8: Calculate the number of issues required

To refinance all the bonds in the utility's capital structure the number of issues need to be determined. This is calculated by dividing the required debt amount by the standard assumed issue size.

Step 9: Calculate the total debt issuance transaction cost in bppa

10. Based on a given maturity assumption, divided by the total debt raised, multiplied by 10,000 yields the total debt issuance cost in bppa.

11. ACG's resulting estimated allowance for debt raising cost is comprised of specific financing fees as shown in Table 42.

Table 42 Allen Consulting Group's debt raising cost estimate (bppa), 2004

Fee	Explanation/Source	1 Issue	6 Issues
Amount Raised	Multiples of median MTN issue size	$175m	$1,050m
Gross Underwriting Fees	Bloomberg for Australian international issues	5.50	5.50
Legal and Roadshow	$75k-$100k: Industry sources	1.14	1.14
Company Credit Rating	$30k-$50k: S&P Ratings	2.86	0.48
Issue credit rating	3.5 bps up-front: S&P Ratings	0.70	0.70
Registry fees	3K per issue, Osborne Associates	0.17	0.17
Paying fees	$1/$1m quarterly, Osborne Associates	0.01	0.01
Totals	**Basis points p.a.**	**10.4**	**8.0**

Source: *Allen Consulting Group, December 2004, Debt and Equity raising transaction costs: Final report to ACCC pp. xvii.*

12. The Authority notes that the fundamental difference between the ACCC's and ACG's allowance of debt raising cost relates to the swap margin fee.[275] The ACCC included the swap margin in its estimate of the debt raising costs, whereas the ACG took the view that the swap margin should be included in the debt risk premium rather than in debt raising costs. ACG's conclusion was based on three of the four major Australian banks indicating that a swap margin should not be included in the debt raising costs.[276]

Deloitte's 2010 study

13. In 2010, Envestra Limited engaged Deloitte to provide empirical evidence on debt raising costs for a medium term note and a syndicate bank debt issue.[277] [278] Envestra requested that Deloitte provide estimates for the benchmark efficient service provider accessing two types of debt funding: (i) domestic bonds (Medium Term Notes, **MTN**) and (ii) syndicated bank debt.

14. Deloitte considered the MTNs incurred the same fee types as previously determined by ACG in its 2004 report for the ACCC. However, Deloitte was of the view that the issuance of syndicated bank debt incurred the following fees:[279]

- *Upfront/Establishment fees*: if the issuance is not underwritten, this includes due diligence and financial modelling, leading syndicate and contact. However, if the issuance is underwritten, the fee is for guarantee of issue proceeds to the issuer.

275 A credit swap margin reflects the cost of converting floating rate debt into fixed rate debt as defined in the Allen Consulting Group, 2004, *Debt and Equity raising transaction costs: Final report to ACCC*, p. xx.

276 Allen Consulting Group, 2004, *Debt and Equity raising transaction costs: Final report to ACCC*, p. xvii.

277 Deloitte, 2011, *Envestra Limited- Debt Financing Costs,* p. 3

278 MTN are issued by a domestic issuer for a 5 year tenor, whereas DRP is measured on the basis of a 10 year tenor. Deloitte, 2011, *Envestra Limited- Debt Financing Costs,* p. 5.

279 Deloitte, 2011, *Envestra Limited- Debt Financing Costs,* p. 3 and p. 11.

- *Credit margin*: payable over the applicable Commonwealth Government yield for 3 year and 5 year maturities.
- *Commitment fees*: this fee is calculated on any unused portion of the credit limit that participating banks have committed to provide.
- *Security fees*: this fee deals with the security trustee function.
- *Legal and agency fees:* these fees are defined in the same manner as ACG's definition in its 2004 estimate.

15. Fees were estimated by Deloitte from the domestic-institutional market[280] and the domestic-retail market.[281] These fees are presented in Table 43 below.

Table 43 Deloitte' estimate of debt raising cost in 2010

	Minimum Domestic-Institutional	Maximum Domestic-Institutional	Minimum Domestic-Retail	Maximum Domestic-Retail
Arranger (bp)	40	50	100	120
Structuring (bp)	-	-	30	30
Selling (bp)	-	-	100	175
Rating Agency (bppa)	5	5	-	-
Legal ($)	40,000	55,000	300,000	300,000
Registry ($ pa)	10,000	15,000	60,000	60,000

Source: Deloitte, 2011, Envestra Limited - Debt Financing Costs, *p. 9.*

16. In its report, Deloitte indicated that a unit rate of 10.1 bppa was appropriate for standard debt raising costs. In addition, Deloitte included an additional allowance of 10.2 bppa to cover bridging finance. Deloitte argued that bridging finance is required so that companies with an investment grade credit rating can meet the refinancing requirements of Standard and Poor's. As such, a total debt raising cost unit rate of 20.3 bppa was estimated.

17. In its decision in February 2011, the AER rejected the validity of Deloitte report in terms of the estimated debt raising costs and bridging finance costs. The AER was of the view that Deloitte's report in 2010:[282]

- made no allowance for multiple bond issues;
- did not adjust for the time value of money;
- used the median bond issue size from 2004 ($175 million), instead of the more up to date estimates of $250 million;
- used BBB+ rated bonds only; and
- was not transparent with regard to many key data attributes.

280 The domestic institutional market requires the issuer to have an investment grade (S&P) credit rating with transaction of $175m executed by two banks.

281 The domestic retail market comprises of portfolios of individual investors that are managed by independent financial planners or financial planning/advisory arms of banks, insurers and wealth managers. Deloitte, 2011, *Envestra Limited- Debt Financing Costs,* p. 8.

282 Australian Energy Regulator, 2011, *Envestra Limited: Access Arrangement Proposal for the South Australia Gas Network,* February 2011, pp. 317-8.

PricewaterhouseCoopers's 2011 report

18. A more recent estimate of the debt raising cost was conducted by PricewaterhouseCoopers in its 2011 report for Powerlink. The findings from the PricewaterhouseCoopers report indicate that the allowance of debt raising costs should fall within the range of 9.1 bppa (for 16 issues) and 9.7 bppa (for a standard-size issue of A$250 million). The findings from this report are presented in Table 44 below.

Table 44 PricewaterhouseCoopers' estimate of debt raising cost in 2011 (bppa)

Fee	PricewaterhouseCoopers (2011)	
	1 Issue	16 Issues
Amount Raised	$250m	$4,000m
Gross Underwriting Fees	7.2	7.2
Legal and Roadshow	1.16	1.16
Company Credit Rating	0.63	0.04
Issue credit rating	0.67	0.67
Registry and Paying fees	0.06	0.06
Totals (bppa)	**9.7**	**9.1**

Source: *PricewaterhouseCoopers,* Appendix K Debt and Equity Raising Costs, *Report for Powerlink Queensland, 2011, pp.19.*

The Australian Energy Regulator's estimate

19. The Australian Energy Regulator's (**AER**) has estimated the debt raising costs in its regulatory decisions based on the approach adopted in the ACG's 2004 report to the ACCC. In its most recent regulatory decision on the debt raising costs for APA GasNet in March 2013, the AER's estimates of debt raising costs were between 9.4 and 10.8 bppa (with a nominal weignted average cost of capital (**WACC**) of 7.22 per cent). The estimates are presented in Table 45 below.

Table 45 AER's debt raising cost estimate (bppa), 2013

Fee	Explanation/Source	1 Issue	2 Issues	3 Issues
Amount Raised	Multiples of median MTN issue size ($250m)	$250m	$500m	$750m
Gross Underwriting Fees	Bloomberg for Australian international issues, upfront per issue, amortised	6.47	6.47	6.47
Legal and Roadshow	$195K upfront per issue, amortised	1.12	1.12	1.12
Company Credit Rating	$55K for the entire company, per year	2.20	1.10	0.73
Issue credit rating	4.5 bps up-front per issue, amortised	0.65	0.65	0.65
Registry fees	$4K upfront per issue, amortised	0.02	0.02	0.02
Paying fees	$9K per issue per year	0.36	0.36	0.36
Totals	**Basis points p.a.**	**10.8**	**9.7**	**9.4**

Source: AER, March 2013, Final Decision, Access Arrangement APA GasNet Australia, Table 7.6, page 137.

20. In the past three years, the AER's estimates of debt raising costs have consistently been around 10 bppa. It is noted that the AER has amortised the fees over 10 years.

Other recent data from company's prospectuses

21. The Authority conducted its own market research to estimate current debt raising costs in Australia. The approach taken by the Authority was to estimate the costs of the individual components of debt raising fees, as contained in Table 45, which were adopted in the ACG's 2004 estimate.

22. In undertaking its research, the Authority found that very few companies included debt raising costs in their prospectuses. Moreover, for prospectuses in which debt raising cost data was available it is usually presented as an aggregated figure with limited or no information in relation to the components. As such, the Authority was unable to identify relevant components of debt raising costs.

23. Table 46 presents three examples of recent debt raising cost data for which a number of components of the total cost figure are unavailable.

Table 46 Debt raising costs from company's prospectus

Fee	AMP	APA	Caltex
Amount Raised	$300m	$350m	$525m
Gross Underwriting Fees	0.6	0.75	2.67
Legal and Roadshow	0.20	0.40	0.11
Company Credit Rating	N/D	N/D	N/D
Issue credit rating	N/D	N/D	N/D
Registry fees	N/D	N/D	N/D
Paying fees	N/D	N/D	N/D
Other (not specified)	2.03	2.42	0.08
Totals (%)	**2.83**	**3.57**	**2.86**

Source: AMP Group Financial Services, AMP Notes Prospectus, 2009, accessed from Bloomberg. APA Group, APA Group Subordinated Notes, 2012, accessed from Bloomberg. Caltex Australia Limited, Prospectus Caltex Subordinated Notes, 2012, accessed from Bloomberg. N/D shows that the data was not disclosed.

24. The percentage of the total debt raising cost is calculated as a ratio between stated expenses in relation to the issuance of debt and the total amount at issuance. The total expenses do not provide any specific estimates of cost components. As such, they are not relevant for comparison purposes with other estimates presented previously.

The Authority's estimate of debt raising costs in 2013

25. As an illustration, the Authority has conducted its own estimate of the debt raising cost for the purpose of this rate of return guidelines. In this estimate, the approach used in the ACG 2004 report is adopted. In addition, data in relation to legal and road show fees; company credit rating fee; issue credit rating; registry fee; and paying fee are sourced from the AER's final decision on APA GasNet access arrangement, released in May 2013. The Authority understands that the inputs used by the AER were based on estimates provided to the AER by credit rating agencies and investment bankers.

26. As presented in Table 47, depending on the number of issues, debt raising costs range from 11.8 bppa to 13.8 bppa. However, these estimates will vary depending on some key assumptions. It is noted that all costs are amortised over 5 years.

27. First, the range of estimates is based on an assumed vanilla WACC of 6 per cent. The WACC is determined individually for each regulatory decision. The Authority notes that, assuming that all other inputs remain unchanged, a lower WACC estimate will lead to a lower range of estimates of debt raising costs.

Table 47 The Authority's estimate of debt raising costs (bppa), 2013

Fee	Explanation/Source	1 Issue	2 Issues	4 Issues	6 Issues	10 Issues
Total Amount Raised	Multiples of median MTN issue size ($250m)	$250m	$500m	$1,000m	$1,500m	$2,500m
Gross Underwriting Fees	Bloomberg for Australian international issues, upfront per issue, amortised	8.31	8.31	8.31	8.31	8.31
Legal and Road show	$195K upfront per issue, amortised	1.85	1.85	1.85	1.85	1.85
Company Credit Rating	$55K for the entire company, per year	2.20	1.10	0.55	0.37	0.22
Issue credit rating	4.5 bps up-front per issue, amortised	1.07	1.07	1.07	1.07	1.07
Registry fees	$4K upfront per issue, amortised	0.04	0.04	0.04	0.04	0.04
Paying fees	$9K per issue per year	0.36	0.36	0.36	0.36	0.36
Totals	**Basis points p.a.**	**13.8**	**12.7**	**12.2**	**12.0**	**11.8**

Source: ACG; Bloomberg; AER; and the Economic Regulation Authority's analysis

28. Second, as indicated in the ACG 2004 estimate, the gross underwriting fee is derived from a sample of Australian bonds issued in the international markets. The criteria for including bonds in a sample are set out in the ACG's 2004 report. As the sample changes, the value of the gross underwriting fee changes.

29. Third, a change in any other input will result in a change in the estimate of debt raising costs.

30. Table 47 above presents a hypothetical example assuming that a regulated business has a regulatory asset base (**RAB**) of A$3,200 million. Given the assumed gearing of 60 per cent, the amount of debt to be raised or refinanced is A$1,920 million, which requires approximately 8 standard-size issues. In this hypothetical example, the allowance for debt raising costs would be approximately 12 bppa, being in a range of 11.8 bppa for 10 issues and 12 bppa for 6 issues.

Appendix 27 Derivation of gamma using officer's WACC framework

1. The theoretical framework for examining how franking credits alter the weighted average cost of capital (**WACC**) was proposed by Officer (1994).[283] By considering the Earnings Before Interest and Tax (**EBIT**) of a company, and how it is distributed between the government (Taxation), debt holders and equity holders the firm's before tax WACC can be derived. A firm's EBIT is distributed as follows:

$$X_O = X_G + X_D + X_E \tag{93}$$

where

X_O is operating income

X_G is the government's share of operating income (taxation),

X_D is the debt holders share of operating income, and

X_E is the equity holder's share of operating income

2. Under an imputation tax system, companies "pre-collect" personal income tax for governments when they pay company tax. The proportion of the tax collected from the company which will be rebated against personal tax is given the name gamma. It is convenient to consider gamma as the amount of personal income tax collected at the company level. As a consequence, the effective company taxation is defined as:

$$\begin{aligned} X_G &= T(X_O - X_D) - \gamma T(X_O - X_D) \\ &= T(X_O - X_D)(1-\gamma) \end{aligned} \tag{94}$$

3. Therefore, in this representation, gamma is the proportion of tax collected from the company which gives rise to franking credits. Gamma can be considered as the proportion of company tax that is used as prepayment of personal tax liabilities.[284]

4. Substituting into EBIT yields:

$$X_0 = T(X_0 - X_D)(1-\gamma) + X_D + X_E \tag{95}$$

5. Solving for X_0:

$$X_0 = \frac{X_E}{(1-T(1-\gamma))} + X_D \tag{96}$$

[283] Officer,RR (1994), "The Cost of Capital of a Company Under an Imputation Tax System", *Accounting & Finance*, 1994, pp. 1-17.

[284] Hathaway, N.J., and Officer, R.R. (2004), *The Value of Imputation Tax Credits,* Working paper, Melbourne Business School.

6. The weighted average cost of capital can be derived by substituting the perpetuity definitions of value.

   Let

$$E = \frac{X_E}{r_e} \qquad D = \frac{X_D}{r_D} \text{ and } \qquad V = \frac{X_O}{r_O}$$

where

E is the value of equity;
r_e is the required rate of return to equity holders after-company tax but before-personal tax;
D is the value of debt;
V is the sum of debt and equity;
r_D is the required return to debt holders after tax, i.e. the cost of debt capital; and
r_O is the required return before taxes or the before-tax weighted average cost of capital (WACC).

7. Substituting these definitions into (96) yields the before-tax cost of capital:

$$r_o = \frac{r_e}{(1-T(1\text{-}\gamma))}.\frac{E}{V} + r_d.\frac{D}{V} \qquad (97)$$

Appendix 28 Issues with dividend drop-off studies

8. The imprecision in Dividend Drop Off studies arises from the presence of heteroscedasticity, multicolinearity and outliers in dividend data. Dividend drop off studies assert that after a company distributes a dividend and franking credit, the resulting drop off in price is equal to the average value investors place on the dividend and franking credit, plus a random error term reflecting exogenous factors of the model. In order to estimate the value investors place on the dividend and franking credit, a large amount of historical dividend events have been collected, and regression employed to the following equation:

$$P_{c,i} - P_{x,i} = \gamma_1 D_i + \gamma_2 FC_i + \varepsilon_i \qquad (98)$$

where

γ_1 is the value investors place on the cash dividend (also referred to as the net dividend), D_i , as a proportion of its face value;

γ_2 is the value investors place on the franking credit FC_i , as a proportion of its face value;

$P_{c,i} - P_{x,i}$ is the expected price drop-off from the cum-dividend day price $P_{c,i}$,to the ex-dividend day price $P_{x,i}$; and

ε_i is an error term designed to capture all other factors that influence the DDO outside of the cash dividend and franking credit.

9. Heteroscedasticity arises in the above equation as a consequence of the size of the error term being related to a variable associated with the dividend event. For example, it is well accepted that a stock with a high price will have a larger error relative to a lower priced stock. This is due to the proportionally larger error caused by the distribution of a dividend and franking credit. Formally, heteroscedasticity refers to the non-constant variance of the error term. This can be expressed as:

$$\mathrm{Var}[\varepsilon_i \mid x_i] = \sigma_i^2 \qquad (99)$$

where

x_i is a variable related to observation *i*.

10. Variables identified in the literature as influencing the error variance include cum-dividend price[285], market capitalisation,[286] dividend yield[287,288] and inverse stock return

[285] Hathaway, N.J., and Officer, R.R. (2004), *The Value of Imputation Tax Credits, W*orking paper, Melbourne Business School.

[286] Ibid.

[287] Ibid.

[288] Michaely, R. (1991), “Ex-Dividend Day Stock Price Behavior: The Case of the 1986 Tax Reform Act”, *Journal of Finance.*

variance.[289] Intuitively, the dividend yield results in heteroscedasticity as stocks with larger dividends will cause a larger price drop-off, and as a consequence have a proportionally larger error. Stock price return variance refers to the historical volatility of the stock. A stock that is historically volatile over a long period of time is likely to have a larger error variance than a stock with low historical volatility, regardless of the size of the dividend paid.

11. Multicolinearity is another issue in Dividend Drop Off studies that causes imprecision in the estimate of theta. Multicolinearity refers to a linear relationship between the independent variables in a regression equation. Specifically, the explanatory variables are correlated. Multicolinearity results in an increase in the standard errors of the estimated regression coefficients, implying less precision in the resulting estimate. It is well documented that in situations where extreme multicolinearity arises, it is nearly impossible to separate the impact that the independent variables have individually on the dependent variable.[290] Multicolinearity can cause the estimated model to be extremely sensitive to changes in the underlying sample, regression technique used or the parametric form applied to the data.[291]

12. In dividend-drop off studies, multicolinearity arises from the fact that the franking credit is proportional to the size of the net dividend as follows:

$$FC_i = \frac{t_c}{1-t_c} D_i . f_i \qquad (100)$$

where

t_c is the corporate tax rate;

f_i is the franking proportion; and

D_i is the net dividend.

13. As most dividends are fully franked ($f_i = 1$), a high degree of multicolinearity exists in dividend drop off data. As a consequence, it becomes difficult to differentiate the influence of the franking credit and net dividend on the price drop off separately.

14. The presence of outliers is cited as another weakness of DDO studies.[292] Outliers can have a large disproportionate influence on the regression coefficients, masking the underlying trend of the rest of the data. Outliers are distinct from heteroscedasticity in that they are not simply the result of a large variance, but rather indicate the inadequacy of the current model in explaining the data. Excluding outliers based on their influence on the regression coefficient can be seen as a form of data mining, which may exclude important information from the analysis.

[289] Bellamy, D. and Gray, S. (2004), "Using Stock Price Changes to Estimate the Value of Dividend Franking Credits", Working Paper, University of Queensland, Business School.

[290] Berry, W.D. and Feldman, S. (1985) *Multiple Regression in Practice*, Sage Publications California, p. 41.

[291] Berry, W.D. and Feldman, S. (1985) *Multiple Regression in Practice*, Sage Publications California, p. 41.

[292] McKenzie, M.D. and Partington, G. (2010), Selectivity and Sample Bias in Dividend Drop-Off Studies, Finance and Corporate Governance Conference 2011 Paper, available at SSRN: http://ssrn.com/abstract=1716576 or http://dx.doi.org/10.2139/ssrn.1716576.

Appendix 29 Other relevant material to inform the rate of return

15. Information used in estimates of the rate of return may be characterised as either historical, or current and forward looking. Historical information may be further classed as stationary or non-stationary.

16. Historic financial data used in models of the rate of return are generally time series. Time series must have the property of 'stationarity' before reliable inferences can be made from the data, such as predictions of the expected mean, or of the likely confidence intervals of the range around that mean. Series that are 'non-stationary' have means and variances that change over time and therefore are of limited use for making predictions.

17. Stationarity should be tested over the longest possible observed period to ensure that periods of data, which would result in the series producing meaningless ranges and averages, are not omitted. Other statistical reasons for this view are discussed further in Appendix 16 – Is the return on equity stable.

18. While averages based on stationary historical data may produce reasonable point estimates of future average returns, these predictors do not take into account the most up to date forward looking information, such as the position in the economic cycle. Such predictors are, in the language of time series, 'unconditional' averages, meaning that the predictors are not formed or 'conditioned' on the basis of any other information. Forward looking or 'expected' returns' are often conditioned on the circumstances that exist in the market today.[293]

19. For this reason, it is preferable to use stationary historical data to inform a reasonable 'range of what is possible', in conjunction with data that is current and forward looking. The latter data may be used to inform the selection of a point within the range provided by historical data.

Historical Information

20. A range of historical information is relevant for informing estimates of the return on equity.

Historical Return on Equity

21. The Authority's analysis of the return on equity time series is based on that supplied by Brailsford et al (2012).[294] This is the longest running Australian time series the Authority is aware of and has been relied on by both the Authority and the Australian Energy Regulator for informing analysis of the return on equity.

22. This historical return on equity series was analysed by the Authority and found to be stationary (see Appendix 16), meaning that its averages and variance can produce meaningful information for informing ranges and unconditional averages for the future.

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293 Expected returns in this sense refers to the returns investors require in order to be enticed into investing in a particular asset.

294 For the most updated version see Brailsford, Handley and Maheswaran, 2012, *The Historical Equity Risk Premium in Australia: post-GFC and 128 years of data*, Accounting and Finance, Vol.52, Issue 1, pp. 237-247

The estimated mean is 11.8 per cent while the standard error is 1.5 per cent (Table 48).

23. Caution must be exercised in using the ranges estimated from historical observations on the return on equity as a way of informing expected returns. The historical return on equity exhibits an extreme range, from high positive values to low negative values. However, the lower bound of *expected* returns cannot be negative because investors would not be enticed to invest in a risky asset if the expected return were negative. It is more appropriate, therefore, to develop expectations on the basis of measures of central tendency rather than ranges.

24. The Authority considers the historic mean is relevant for checking the performance of its estimates of the overall return on equity over many deteminations. The Authority considers that if the average of its estimates of the return on equity over a number of determinations varied significantly from the long term mean of 11.8 per cent (Table 48), then it would have cause to question whether its approach to developing the return on equity was achieving the allowed rate of return objective.[295]

Table 48 Stock accumulation index statistical results

Summary Statistic	
Mean	11.8%
Standard error	1.5%
Skewness	0.11
Minimum	-43.3%
Maximum	63.7%
Count	128

Note: The return on equity is more or less symmetrically distributed as indicated by the low absolute value of the skewness coefficient (0.11).296 The implications are that if one side of the distribution around the mean return on equity can be found, the other side can be found by doubling this range.

Source: Brailsford et al 2012, ERA analysis

Historical Equity Risk Premium

25. The historical equity risk premium (**ERP**) time series utilised by the Authority is based on Brailsford et al (2012), given that this is the longest time series available.

26. The analysis by the Authority suggests that there is mixed evidence on whether the historic ERP series is stationary or non-stationary. The analysis and results are outlined in Appendix 16.

27. The Authority considers an approach for estimating the MRP in greater detail in Chapter 11 – Market Risk Premium. While the Authority notes the statistical shortcomings of the historic ERP, the Authority considers that it still remains a relevant piece of information. The analysis uses estimates based on the historic ERP as one piece of relevant evidence, in combination with other evidence.

[295] Equity beta considerations aside.

[296] A skewness coefficient in between -0.5 and 0.5 indicates a more or less symmetrical distribution.

Historical Risk Free Rate

28. The Authority's analysis of the risk free rate time series suggests that it is non-stationary. This has been a consistent empirical finding both in the early work the Authority undertook for the third Western Power Access Arrangement using Bloomberg data,[297] and in its more recent work using the Brailsford (2012) series (see Appendix 16).

29. The implication is that the most recent observation can be the best predictor of tomorrow's risk free rate, and that any linear combination of the risk free rate and another series will be non-stationary, unless they are cointegrated.

Historical Cost of Debt

30. The historical market cost of debt is theoretically useful, in that it could inform the the lower, but non-inclusive, bound of the expected return on equity. In practice the historic market cost of debt is not readily observable; however, some data series are available that provide indices.

31. Bloomberg produce fair value curves (**FVC**) to act as indices of the cost of debt at various maturities and credit ratings. However, FVC are subject to considerations of credit rating, term of debt, stationarity, data availability, and are only available back to 2001. The Authority would also need to establish that the FVC are not significantly biased.

32. If stationary, the spread between the long term historical cost of debt and cost of equity could be relevant for informing the average equity spread investors expect over certain debt classes. In a similar fashion to the range of the historic mean for the return on equity (note paragraph 24 above), the confidence interval for the range of the mean of the historical cost of debt could also provide relevant information for the Authority's approach to estimating the cost of debt, over time. The Authority considers that a long stationary series of return on debt data, if it became available, would be relevant information for informing the return on equity.

Historical Beta estimates

33. In Chapter 12 – Equity beta the Authority noted that the equity beta derived from the Sharpe-Lintner Capital Asset Pricing Model (**CAPM**) is a forward looking estimate. The use of historical time series data is necessary in estimating beta as it deals with the relationship of how two assets' returns co-vary over time.

34. Forward looking information on returns can provide point estimates and ranges for asset returns; however, it provides no indication on how the returns will co-vary as this requires a number of contemporaneous observations. For this reason the Authority can only rely on historical data to inform the beta estimate.

Current Forward Looking Information

35. A range of forward looking information can provide additional relevant material for informing the overall rate of return, and for informing the estimates of the parameters that contribute to models for the rate of return. In some cases, this additional information may be used to augment other estimation approaches.

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297 Economic Regulation Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Western Power Network*,5 September 2012, p. 664

36. A range of additional information is assessed in terms of relevance:

- asset sales information;
- share trading multiples;
- evidence of investor perceptions of market risk; and
- broker estimates;
- decisions by other regulators;
- the relationship between the return on equity and the return on debt;
- other possible sources of information.

37. The assumption underlying the relevance of each of these forward looking materials is that they are reasonably current, in order to be of use.

Investor perceptions of market risk

38. A number of different possible volatility indices can be used to estimate investors' perceptions of equity market risk, including the VIX volatility index, the 3-month call option implied volatility measure, and the 12-month call option implied volatility measure.

39. The Authority considers that it is appropriate to use the VIX index calculated by the Australian stock exchange for the purpose of informing investors' perceptions of risk, and hence as a cross check providing relevant information for the position of the market risk premium in its range.

40. The value of the Standard and Poor's (**S&P**)/Australian Stock Exchange (**ASX**) 200 VIX index has the interpretation of being the "market's expected volatility in the Australian benchmark equity index, the S&P/ASX 200".[298] Valuation of traded stock options contains an unobservable parameter which is the volatility of the underlying stock.[299] By observing the market price of traded options and substituting this value into an option valuation equation, the implied volatility of the underlying stock can be calculated by solving for the unknown volatility parameter. The implied volatility for each option thus has the interpretation of being the market's expected volatility for the underlying stock.

41. The VIX index is constructed by using the implied volatility for calls and puts written on the S&P/ASX 200 index.[300] The VIX is calculated by using options with the two nearest-term expiration months either side of a 30-day calendar period. The implied volatility is then calculated by interpolating the volatility of each of these options to arrive at the volatility consistent with a 30-day period, and is referred to as σ.

42. The VIX index has the interpretation of being an indicator of investor sentiment over the next 30 days.[301] A high value of the VIX index implies that investors expect large

298 Australian Stock Exchange 2013, S&P/ASX 200 VIX accessed 14 October 2013, <http://www.asx.com.au/documents/products/ASX-VIX-Fact-sheet.pdf>.

299 Volatility as measured by the standard deviation of the probability distribution of returns for the underlying stock.

300 S&P Dow Jones Indices 2013, S&P/ASX 200 VIX [AUD], accessed 14 October 2013, <http://us.spindices.com/indices/strategy/sp-asx-200-vix>.

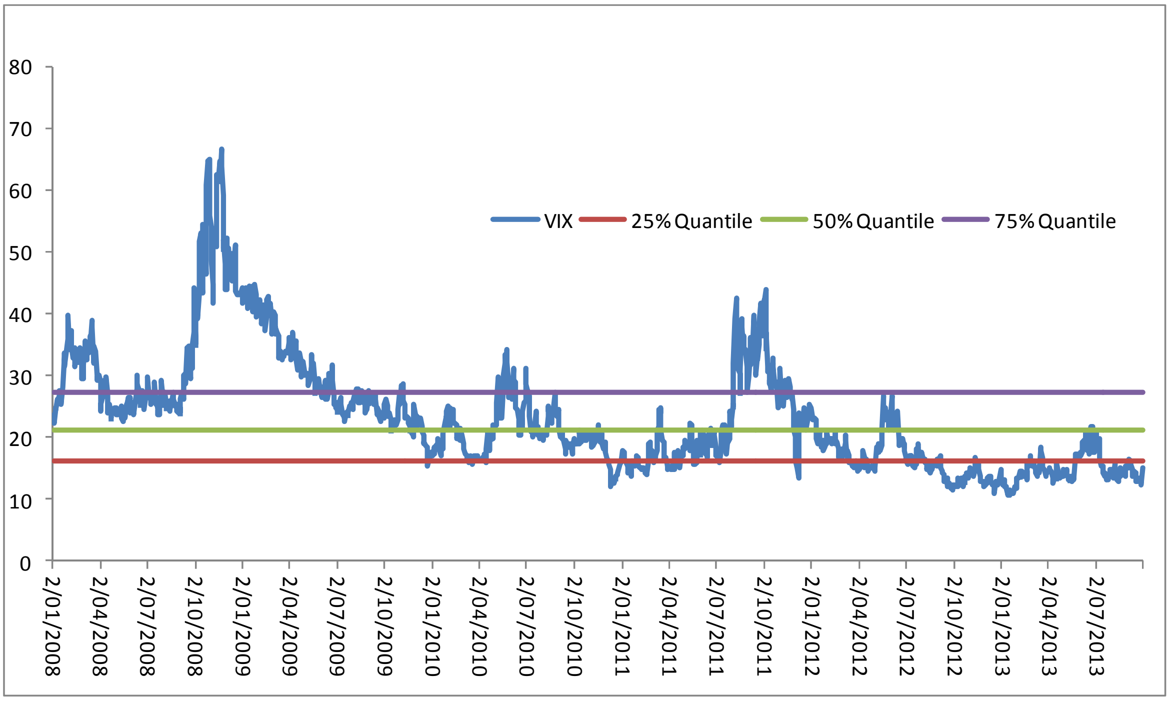
301 Australian Stock Exchange 2013, S&P/ASX 200 VIX accessed 14 October 2013, <http://www.asx.com.au/products/sp-asx200-vix-index.htm#Introduction>.

variation in the S&P/ASX 200 index over the next 30 days; conversely a low value implies investors expect little change. In particular, the value of the VIX index has the interpretation of being the standard deviation of stock returns, in annualised terms that investors expect over a 30 day period.

43. The VIX index is useful from an analyst's perspective as it provides a measure of the level of volatility present within the ASX 200 index. As a consequence, the VIX index provides a measure of investors' risk aversion. The VIX index is available for the Australian stock market dating back to 2008

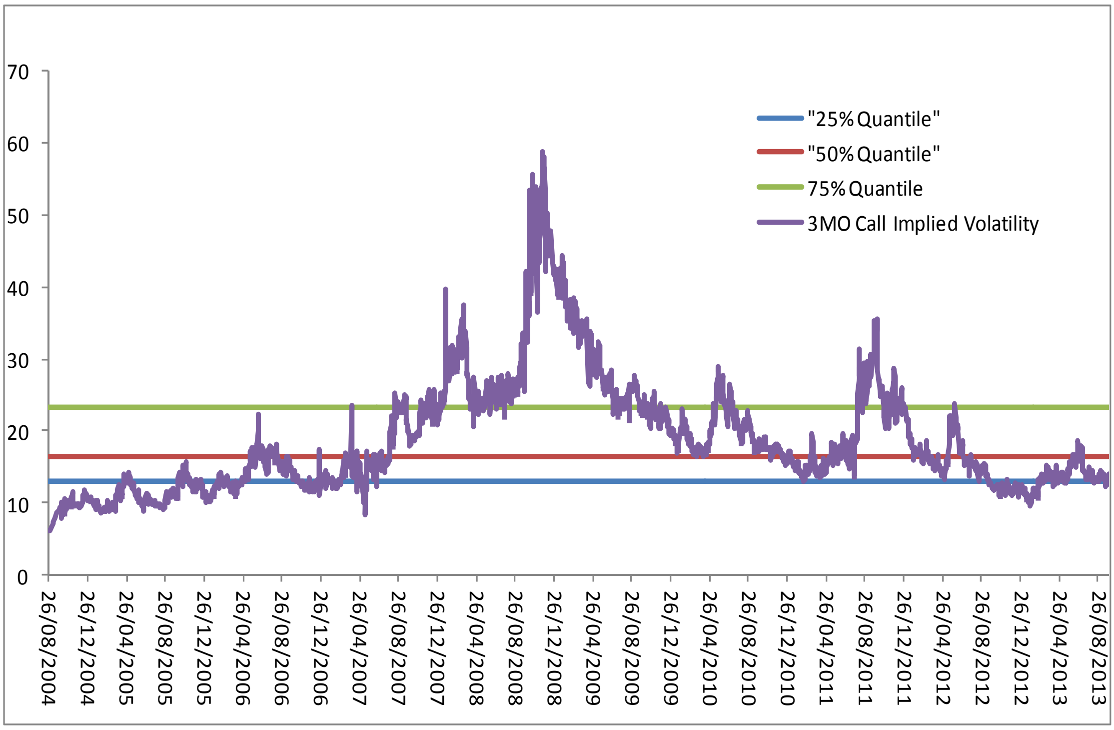
44. Figure 56). The Authority is of the view that the longest possible data set should be used.

Figure 56 The Australian VIX index, January 2008 – October 2013



Source: Australian Stock Exchange and the Authority's analysis

Figure 57 3 month call implied volatility index, August 2004 – October 2013



Source: Bloomberg and the Authority's analysis

45. The Authority also notes that the 3-month and 12 month call option implied volatility measures also provide a similar measure of risk as the VIX, albeit with a longer run of historical data dating back to 2004 (Figure 57). As such, while the VIX index provides a core tool for determining the current level of risk perception in the equity market, the 3-month call implied volatility can also be used as a cross check.

46. The Authority notes that these two indices provide a very similar trend of the level of risk perception from the Australian equity market as compared to the VIX.

47. The Authority notes the shortcomings of these measures. The Authority is aware that the VIX is a forward looking indicator of market expectations that is limited to 3 months while the maximum for the call option volatility is 12 months. This contrasts with the expectations horizon for the return on equity in the regulatory context which is 5 years. Expectations over these two different horizons can be very different. It is also noted that while the VIX quantifies volatility using variance, it does not price this volatility.[302]

Broker estimates

48. Broker and other market estimates cover equity market analysis provided to investors. Broker estimates range from regularly updated ratings of stocks, through to independent expert reports by accounting and corporate advisory firms that are used for takeover bids and other significant transactions. These estimates and reports can provide a range of information, and may include estimates of the overall rate of return and the return on equity.

302 It is noted the Value Advisor Associates provide a means by which risk can be priced; the so-called 'implied volatility' approach.

49. The Authority would have significant concern with an uncritical use of such information. This concern relates to a number of factors.

50. First, there may be potential for systematic upwards bias, given that some brokers are seeking to encourage clients to change position.[303] For example, Easton and Sommers outlined a number of studies showing that analysts generally make recommendations to buy, sometimes to hold and rarely to sell. They showed that the expected returns implied from analysts' forecasts decline monotonically as the percentage of analysts recommending 'strong buy' or 'buy' declines. They also referred to the findings of Groysberg et al. (2007) who observed that analyst's remuneration is based on realised returns in excess of the market index with the implication that analysts place more importance on stock price increases than decreases.

51. Second, there may also be issues of circularity, where brokers are endeavouring to second guess regulatory decisions.

52. Third, in some cases, there may be a lack of transparency with regard to the assumptions underpinning estimates, or the composition of such estimates, where reports relate to a mix of regulated and unregulated assets. Damodaran, for example, dismisses the common variety of broker reports:[304]

> While numbers do emerge from these surveys, very few practitioners actually use these survey premiums. There are three reasons for this reticence:
>
> – There are no constraints on reasonability; survey respondents could provide expected returns that are lower than the risk free rate, for instance.
>
> – Survey premiums are extremely volatile; the survey premiums can change dramatically, largely as a function of recent market movements.
>
> – Survey premiums tend to be short term; even the longest surveys do not go beyond one year.

53. Nevertheless, some broker reports may contain useful information. In particular, independent expert reports are subject to statutory requirements relating to independence, objectives and transparency. Reports which are required to set out a detailed estimate of discount rates are particularly useful, as they provide an alternative, current, market-based view of the return on equity. Despite the noted potential for bias in broker reports, the direction of return estimates (whether they are high or low relative to past estimates) rather than the level in percentage terms may provide useful insights for informing the choice of a point within a range.

54. For example, SFG Consulting (**SFG**) undertook a recent survey of reports over the period 2012 to 2013, and identified 34 assessments over the period which provided a detailed description of an estimate of the weighted average cost of capital (**WACC**) for the purposes of discounting expected future cash flows. Two of the assessments related to the utilities sector.[305]

55. SFG noted that every expert assessment in the sample utilised the CAPM as a starting point for determining the return on equity, but that most utilised adjustments to

[303] Easton & Sommers 2007, *Effect of Analysts' Optimism on Estimates of the Expected Rate of Return Implied by Earnings Forecasts*, Journal of Accounting Research, Vol. 45, No. 5, December, p.987.

[304] Damodaran 2006, *Damodaran on Valuation*, Wiley, p. 55.

[305] Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Attachment 4 (Use of Independent Expert Reports), www.erawa.com.au, 19 September.

determine an overall WACC. SFG considers that the degree of adjustment, the evidence and models used, and the judgment applied in calibrating models to market conditions is particularly informative.

56. SFG notes that many reports used a single upward adjustment to the cost of equity that encompasses a range of factors, including at the current time:[306]

> a) Significant interest rate volatility and abnormally low government bond yields, which have a bearing on the assessment of the risk-free rate;
>
> b) The likelihood that equity risk premiums have increased recently in response to greater market volatility, which has a bearing on the assessment of the required return on the market and consequently MRP;
>
> c) Specific risks that are not reflected in the CAPM beta (i.e., the one-factor CAPM does not consider all relevant risk factors);
>
> d) The need to include a size premium. The CAPM does not distinguish required rates of return based on the size of the enterprise. Other asset pricing models, such as the Fama-French three-factor model, do take size effects into account explicitly. Approximately a quarter (24 per cent) of all the assessments in the 2012/13 sample group used small company size as a justification for an uplift to either the cost of equity or to the overall WACC.

57. Of the 38 assessments examined for 2012/13, 13 assessments, or around a third applied an upward adjustment to the risk free rate. SFG Consulting noted that Ernst & Young, in consistently applying an uplift of 2 per cent when estimating the cost of equity and debt, stated in January 2013 that:[307]

> We believe that the current risk free rate (usually estimated with reference to the 10 year Government bond rate) is at historically low levels. Most market observers regard this as inconsistent with current share prices, the observed volatility in markets and general economic uncertainty. In response, many valuers have either used a normalised risk free rate, increased their estimates of the market risk premium or have included an additional risk factor in their calculations of the cost of equity. Our preference is to normalise the risk free rate to best reflect the longer term position

58. With regard to the required return on the market, SFG notes that across the 2012/13 sample, the average uplift was 1.7 per cent over a simple application of the contemporaneous 10 year bond yield and a market risk premium of 6 per cent, and 3.1 per cent if the uplift is solely attributed to the market (by backing out the beta from the estimate – presumably this implies the sample of companies must have on average betas lower than one).[308]

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306 Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Attachment 4 (Use of Independent Expert Reports), www.erawa.com.au, 19 September, p. 12.

307 Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Attachment 4 (Use of Independent Expert Reports), www.erawa.com.au, 19 September, p. 12.

308 SFG Consulting observe that the estimates do not make an adjustment of MRP for imputation, noting that (Energy Networks Association 2013, *Draft Rate of Return Guidelines – Meeting the requirements of the National Gas Rules*, Attachment 4 (Use of Independent Expert Reports), www.erawa.com.au, 19 September, p. 23):

The established practice of the AER is to:

a) Make an upward adjustment to its estimate of the required return on the market (and hence MRP) to include the assumed value of imputation credits. This is then used to provide an estimate of the required return on equity for the benchmark firm, inclusive of imputation credits; and then

b) Make a downward adjustment to its estimate of the required return on equity for the benchmark firm to remove the assumed value of imputation credits. This results in an estimate of the required return on equity for the benchmark firm, exclusive of imputation credits.

59. However, SFG do not provide any information about the horizon over which the independent experts were making their assessment. It may also be observed that the full data set only stretches back as far as 2008, so does not provide insights as to expert views prior to the global financial crisis.

60. The time horizon is particularly important. Expert reports generally are seeking to estimate the value of the asset, which implies that discount rates need to be consistent with the value of cashflows to perpetuity. It is understandable that analysts would seek to adjust up a low prevailing rate to ensure that it did not deliver an underestimate of the long term average rate, where this is relevant for valuing a long stream of future cash flows. Further, these adjustments may lead to significant swings at any point in time, reflecting expectations about near term outcomes, and the need to offset their weight in discounting. If anything, a large upward adjustment may simply confirm that it is acknowledged that the prevailing rate, as measured by the CAPM, is below expectations about long term returns on equity.

61. The Authority, on the other hand, is concerned with estimating the prevailing return on equity for a more limited five year period. On this basis, the Authority considers that expert reports need to be interpreted with particular care. Where the discount rate is not consistent with the Authority's time horizon, then the information may be of limited use. The Authority also notes that some of the difference will be due to the use of a 10 year term for debt, rather than the Authority's 5 years, although the resulting difference is likely to be less than 50 bp at most times.

62. Cambridge Economic Policy Associates (**CEPA**) reviewed a similar cross section of expert reports as utilised by SFG, concluding that:[309]

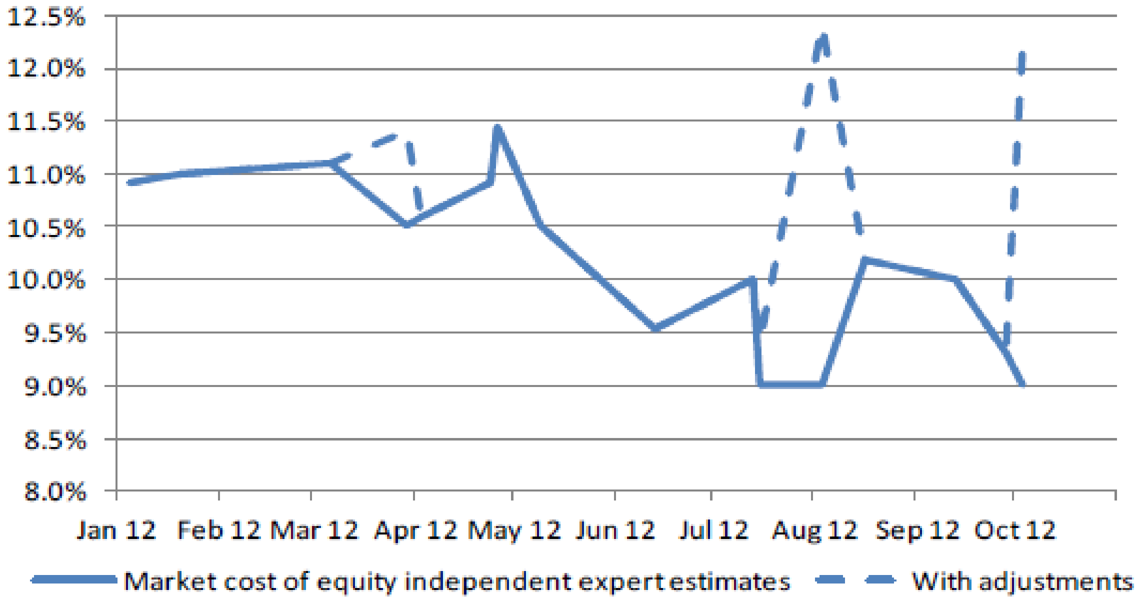
- the credibility of some sources is undermined by large unexplained swings in estimates over short time horizons;
- there is clearly a strong time trend, and arguably the more recent studies should have been given greater weight (rather than implicitly equal weight in a straight average);
- looking at the modal estimates of the individual parameters, the discrepancy between the brokers and the AER is less marked; and
- the analysis of the KPMG Consolidated Media Holdings report shows how important each report's idiosyncrasies are.

63. CEPA also shows that while independent analysts make adjustments to underlying CAPM estimates, such adjustments are not routine (Figure 58). Further, where adjustments are made – whether due to size or other risk factors – the reasoning may not always be transparent.

Ernst&Young estimate that the value of imputation credits would increase any gap estimate by a further 1 per cent (see Cambidge Economic Policy Associates Ltd 2013, *Advice on estimation of the risk free rate and market risk premium*, Report to the Australian Energy Regulator, www.aer.gov.au, p. 40).

309 Cambridge Economic Policy Associates Ltd 2013, *Advice on estimation of the risk free rate and market risk premium*, Report to the Australian Energy Regulator, www.aer.gov.au, p. 50.

Figure 58 Independent expert estimates of the market cost of equity in 2012



Source: Cambridge Economic Policy Associates Ltd 2013, *Advice on estimation of the risk free rate and market risk premium*, Report to the Australian Energy Regulator, www.aer.gov.au, p. 47.

64. Dampier to Bunbury Pipeline (**DBP**) suggest that CEPA did not take into account upward adjustments made by a number of practitioners to the risk free rate or MRP, or consider the impact of imputation credits.[310] However, the Authority considers that the evidence set out above from the CEPA report remains valid, suggesting that expert reports need to be interpreted with particular care.

65. Overall, the Authority considers that brokers' estimates may have potential to provide relevant information, particularly in terms of the parameters used in modelling, such as the market risk premium. In some cases, brokers' estimates may also provide relevant information for the overall return on equity of the regulated firm. However, as noted above, care is needed in interpreting such information. Such information is only likely to be relevant where it is supported by transparent analysis, implemented in accordance with best practice. In particular, the term needs to be consistent with the regulatory period, otherwise the economic efficiency requirements of the National Gas Law (**NGL**) and National Gas Rules (**NGR**) will be violated.

66. Despite these issues, the information may still be relevant. In particular, the relative level of estimates, as compared to earlier estimates, may be relevant for indicating the direction of changes over the short to medium term.

Decisions by other regulators

67. The Authority has in past decisions taken account of the views of other regulators in Australia in setting rate of return parameters, and in checking the reasonableness of overall outcomes for the components of the rate of return.

68. While there is some potential for circularity, the Authority considers that such comparisons should be made on merits. That is, it is useful to explore the reasons for

310 DBNGP (WA) Transmission Pty Ltd 2013, *ERA Cost of Debt and Equity Workshop Papers: DBP Response*, www.erawa.com.au, 19 November, p. 11.

any underlying similarities or differences, and to consider whether these are warranted.

69. Overall, the Authority expects to continue to use the decisions of other regulators to check outcomes from its own decisions. However, the Authority will only consider such checks relevant where comparable judgments or estimations are being made, or where specific reasons for differences are able to be identified. In this event, the reasoning for such outcomes would also provide relevant information.

Relationship between the return on equity and the return on debt

70. The Authority considers that in general, the return on equity should exceed the return on debt, given that equity is more risky than debt. Provided that the two are compared on a consistent basis, then the condition should hold.

71. However, it is not possible to be definitive about the difference between the two returns. The Authority is of the view that the difference between the return on debt and return on equity may not be constant through time. In particular market conditions, the return on equity may be significantly higher than the return on debt and vice versa (note the large swings in the return on equity in Table 48 above). Over the long run however, it is expected that a spread would become evident between the return on equity and the return on debt.

72. As such, the Authority considers that it is relevant to use such spreads as a check to ensure that estimates of return on equity are reasonable. In addition 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.

73. As discussed in paragraph 31 above, from a theoretical perspective it is noted that the long term average of the return on debt could provide relevant information for informing the lower (but non inclusive bound) of the return on equity. This is a corollary of the concept that the return on equity must be higher than the return on debt.[311]

Financial metrics

74. Financial metrics pertain to the class of information relating to financial performance that is based on metrics derived from financial statement data, as well as from data sourced from financial institutions.

Trading multiples

75. Trading multiples are reflected in the ratio of the share price valuation of the firm as compared to the book value of the regulatory asset base. It would be remiss to attribute too much precision to the results. For example, share prices for energy infrastructure have been at all time highs in recent times as a preference by investors for higher yielding defensive stocks has become widespread.

76. Judgment would be required before trading multiples could signal an issue with the rate of return. Nevertheless, sustained trading multiples below one, across the

311 This puts aside the complicating considerations of the default spread on various classes of bonds.

economic cycle, could give a relevant warning that overall rates of return were not in line with market expectations.

Asset sales information

77. Asset sales information may provide some indication as to whether the overall return on equity set by the regulator is reasonable. However, there is acceptance that sales prices need to offer some premium to induce investors to sell, such that sales prices will tend to exceed the book value of the regulatory base. This has been the common observance in recent times.[312]

78. The Authority considers that such a comparison provides only a rough guide as to reasonableness, as there are many factors that influence the degree to which sales prices might exceed the regulated asset base. For example, a purchaser may consider that it is able to apply higher gearing than the benchmark assumption, without increasing the cost of debt. This would drive up the expected return to equity.

79. Overall, the Authority considers that asset sales may be considered relevant, as a reasonableness check. If a clear trend emerged of discounting of the value of the regulated asset base in sales, then the Authority would need to review whether the overall rate of return was adequate.

Dividend Yields

80. The usefulness of dividend yields in forecasting stock returns has long been documented. Fama and French (1988) showed that small dividend yields implied low expected returns to equity while Fama and French (1989) showed that dividend yields forecast returns on stocks as well as corporate bonds. This finding was confirmed by Harvey (1991) who found this to be the case for both the US and foreign stock markets.[313]

81. The connection between dividends, prices and expected returns to equity is underpinned by theory first outlined by Williams (1938). Williams argued that asset prices in markets should reflect the assets intrinsic value as represented by future corporate earnings and dividends.[314]

82. Dividend yields, however, may exhibit trend increases due to underlying growth in the company. This suggests dividend yields are non-stationary (the mean and variance increase with time). This is particularly the case with respect to dividend yields on aggregate market indices, which are periodically adjusted so that only top firms (in terms of market capitalisation) are included (Figure 59).

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312 See for example, Australian Energy Regulatory 2013, Final decision: SPI Networks (Gas) Pty Ltd access arrangement, Part 3: Appendices, p. 60.

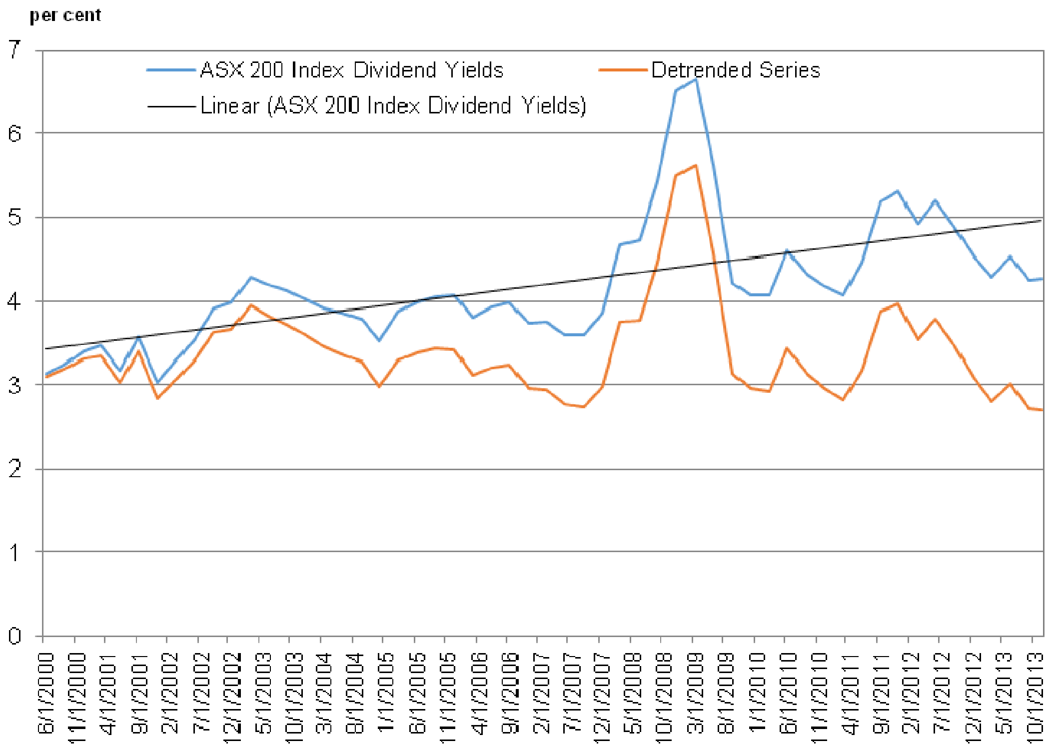
313 Fama and French,1988, *Dividend yields and expected stock returns*, Journal of Financial Economics Vol.22, pp. 3-25.

Fama and French,1989, *Business conditions and expected returns on stocks and expected returns on stocks and bonds,* Journal of Financial Economics, Vol. 25, pp.23-49.

Harvey,1991, *The world price of covariance risk*, Journal of Finance, Vol.46, pp. 111-157.

314 Williams, 1938, *The Theory of Investment Value*, Harvard University Press.

Figure 59 Dividend yields on ASX 200



Source: Bloomberg, ERA Analysis

83. The ASX dividend yield series exhibits a strong trend and as a result, comparing the current yield to past yields will not give a true indication of whether they are relatively high or low. De-trending removes the deterministic component allowing more meaningful comparison of current and past values.

84. In light of the academic underpinning and well established empirical findings on dividend yields as a forecaster of expected returns, the Authority considers this information relevant for informing the selection of a point within a range of expected returns. The de-trended data would be tested for stationarity, normalized according to the procedure discussed further below, and then used as relevant information as the forward looking return on equity.

Credit rating metrics

85. Credit rating metrics are employed by credit rating agencies as part of their credit rating methodology.[315] The metrics assist in quantify the financial risk profile of a specific firm, as opposed to the risk of the business they are in.

86. Common examples of credit rating metrics include:

- funds from operations to debt coverage;
- debt to earnings before interest tax and amortisation coverage ratios; and
- debt to capital ratios.

[315] Standard and Poor's, 2009, Global Credit Portal, RatingsDirect, Criteria Methodology: *Business Risk/Financial Risk Matrix Expanded*.

87. These metrics are ultimately taken into consideration when a firm is rated by an agency such as Standard and Poor's or Moody's. In turn the credit ratings, and perhaps the credit metrics directly, typically form part of the information set that investors use when pricing the firm's bonds. This pricing is reflected in the default spread (see the section on Term Structure Variables below).

88. It is difficult to distinguish whether factors affecting these credit metrics are a result of firm specific considerations or economy wide factors. According to the Sharpe-Linter CAPM only the latter should be compensated with higher returns.

89. For these reasons the Authority views the default spread as a summary measure of the credit metrics . If credit metrics are taken into account caution should be exercised to ensure the effects are not double counted.

Term structure variables

90. Term structure variables in this context relate to two components of the term structure of interest rates:

- the default spread which is the difference between a the yield on a risky bond and 'riskless' sovereign bond of the same tenure; and

- the term spread which is typically observed from the difference in yields on riskless sovereign bonds of different maturities.

91. Campbell (1987) documented the ability of term structure variables to predict excess stock returns as well as excess returns on bills and bonds.[316] For example, the inclusion of the default spread in returns prediction models has been justified on the basis of capturing changes in default risk facing firms.[317]

92. The inclusion of term spreads in modelling of returns seeks to measure changes in risk over a given time horizons. For example, observations of the difference between the yield on a 3 month Treasury bill and a 5 year Treasury bond can reveal information about changes in the markets the view of risk over the next five years. This reflects the changing slope of the Treasury yield curve.

93. In practice, these spreads give rise to two issues.

94. First, default spreads require a choice to be made as to which risky bond is to be used as the benchmark for comparison with the sovereign bond. This in turn may lead to issues of continuity when that benchmark bond matures. Ideally, a perpetual benchmark that retains its characteristics with respect to tenure and default through time should be used for comparison with the sovereign bond. In addition (as noted in paragraph 88) it is difficult to distinguish the proportion of the default spread that is attributed to firm specific factors and that which is attributed to economy wide factors, with only the latter requiring compensation.

95. Second, both default and term spreads may suffer from issues relating to differences in the liquidity of the debt instruments being compared. This means the spread may reflect the lack of trading in an instrument as opposed to default premiums or changes

[316] Campbell, 1987, *Stock returns and the term structure*, Journal of Financial Economics Vol.18, pp, 373-399.
[317] Chan, Chen and Hsieh, 1985, *An Explantory Investigation of the Firm Size Effect,* Journal of Financial Economics, Vol. 14, September.

Chen, Roll, and Ross, 1986, *Economic Forces and the Stock Market*, Journal of Business, Vol. 59, July.

in the slope of the Treasury yield curve. This would need to be carefully assessed, for example using information from the Australian Office of Financial Managements (**AOFM**) reports on liquidity, before the data can be relied upon.

96. It is noted that Australian dollar interest rate swaps (swaps) may provide a possible solution to these issues. The markets for these instruments are highly liquid and provide an ongoing homogeneous benchmark.[318] The instruments are also available in a number of tenors making them convenient for matching the maturities of other financial instruments or arrangements.

97. Swap spreads, on the other hand, represent the difference between the swap rate and underlying Government security. Swap spreads have reverted to more normal levels in recent times, around 40 basis points, following the high levels of uncertainty exhibited during the global financial crisis (Figure 60).

98. From a theoretical perspective the swap spread represents the additional risk in the financial system over the sovereign risk in Government securities. From this point of view they are more likely to capture economy wide risk considerations as opposed to firm specific factors. In practice however, swap spreads tend to increase with the base rate. That is, swap spreads captures both the level and slope of the yield curve. Supply and demand factors will also affect the price of using swaps, with increased demand widening spreads. Factors affecting the underlying Government debt instrument will also affect spreads; holding all other factors constant an increase in demand for the underlying bond will decrease its yield thereby increasing the swap spread.[319]

Figure 60 Interest rate swap spread on 5 year CGS

99. Given their forward looking nature and sound theoretical and empirical underpinnings outlined above, the Authority considers term structure variables have potential to be

318 See the Australian Financial Markets Assoication's Australian Financial Markets Reports.

319 Choudhry,2007, *Bank Asset and Liability Management*, John Wiley. Available online at http://www.yieldcurve.com/Mktresearch/files/Choudhry_BALMSwapSpreads_Sep06.pdf

relevant information for informing the selection of a point in ranges established expected returns. The Authority notes however, that default spreads and term spreads must be considered in light of other information such as AOFM reports and swap spreads, to ensure conclusions based on them are robust.

Normalising forward looking Information to Inform point estimates

100. The forward looking information outlined above all have shortcomings which limit their usefulness. Broker reports and regulators decisions suffer from circularity. In addition broker reports (and potentially asset sales) also suffer from issues of bias. The volatility index and trading multiples are reported in quantities which are not returns, while other information such as term structure variables are reported in returns that are on a different scale (just a few basis points) to that used in the cost of equity and parameters in models used for determing it. These issues render the absolute levels less meaningful.

101. To overcome this lack of commensurability, current forward looking measures may be assessed in terms of whether they are 'high' or 'low' relative to the past. That is, it is the relative levels which provide the relevant information.

102. To assist in the assessment of their relative level, the information can be normalised into a numeric value between 0 and 1 to determine whether the current level is high or low relative to past observations.

103. This provides a transparent means by which the relative levels of different types of current forward looking data can be summarized into a single number and compared with one another.

104. All past observations should be taken into account and the following formula used:

$$Normalised\ Level = \frac{current\ observation\ -\ \min observation}{Range} \qquad (101)$$

where

the current observation is the latest piece of information;

the min observation is the lowest observation over the entire time series available; and

the range is the difference between the highest and the lowest observation over the entire time series.

105. The normalised level can then be used to inform the selection of a point within a range based on historic information.

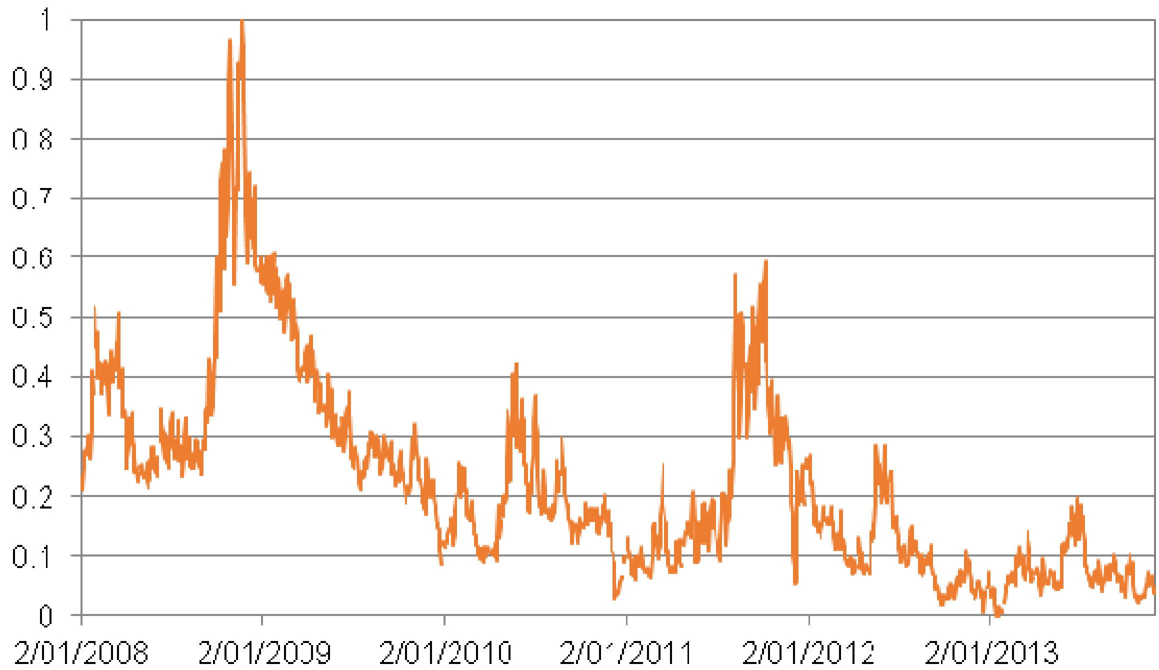
106. The normalised level will not necessarily be used directly (such as multiplicatively) in any quantitative calculations. This is in recognition of the fact that some of these series may be highly unstable and exhibit undesirable statistical properties such as

non-stationarity.[320] Unlike the historical data, the current forward looking information is intended to be used in a qualitative sense to inform the selection of a point as opposed to a formulaic application.

107. An example of this approach is given using the Standard and Poor's ASX 200 VIX, the detrended Standard and Poor's ASX 200 dividend yields and five year interest rate swap spreads which were examined above.

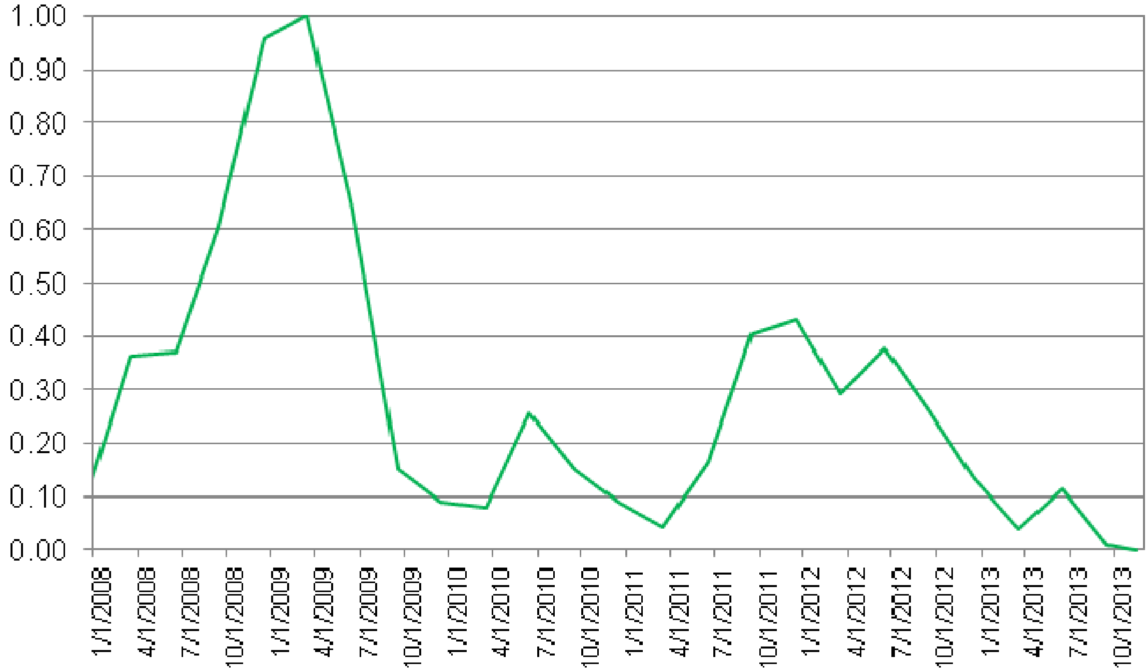
108. The dividend yield and interest rate swap spread series goes back as far as June 2000 and August 1999 respectively. They were truncated for ease of comparison to match the length of the VIX. A comparison of Figure 62, Figure 62 and Figure 63 show that the series exhibit similar patterns. The volatility index and dividend yields peak around 2009 while the swap spread peaks slightly earlier. All series have been recently declining to relatively low levels.

Figure 61 Normalized S&P ASX 200 volatility series



Source: Bloomberg and ERA Analysis

Figure 62 Normalized S&P ASX 200 dividend yield series



Source: Bloomberg and ERA Analysis

Figure 63 Normalized interest rate swap spread on 5 Year Commonwealth Government Securities

Source: Bloomberg and ERA Analysis

Conclusion

109. Table 49 summarises the information considered above, its relevance, and how it may be applied.

110. Historical time series that are non-stationary have time varying means and variances. These time series therefore have limited use for informing ranges or point estimates (unless they can be made ‘trend stationary’ as discussed in paragraph 83).

111. Stationarity need not be a requirement for forward looking information. Forward looking information may assist in ‘gauging’ the selection of a point in a range, by comparing the current value to past values, to produce a relative or normalised level. This allows determination as to whether current values are relatively high or relatively low compared to past experience. Such forward looking information therefore may provide relevant information on the position of a parameter or estimate within an estimated range.

112. As discussed elsewhere, the current risk free rate is the best forward looking indicator for the risk free rate, as it follows a random walk (see Chapter 7 – Risk free rate). The cost of debt can be based on the known forward looking expected return from contractually binding debt instruments, for example as utilised for the Authority’s bond yield approach, eliminating the need for prediction (see Chapter 8 – Debt risk premium). As these estimates are parameters that are directly used in the return on equity and return on debt estimations, their absolute levels (ie. percentage returns) are used.

Table 49 Summary of information and application

Information	Data Source	Historical/Forward Looking	Stationarity	Absolute or Relative Level	Point or Range	Relevant information?
Historical Equity Risk Premium	Brailsford et al (2012)	Historical	Mixed evidence but likely non-stationary	NA	None	Partly relevant
Historical Risk Free Rate	Bloomberg/Reserve Bank of Australia/Brailsford et al (2012)	Historical	Non-Stationary	NA	None	Not relevant
Historical Return on Equity	Brailsford et al (2012)	Historical	Stationary	Absolute	Range	Relevant
Historical Cost of Debt	Bloomberg	Historical	(To be formally tested)	Absolute	Range	Relevant
Historical Beta Estimates[321]	Bloomberg	Historical	(To Be formally tested)	Absolute	Range	Relevant
Current Risk Free Rate[322]	Bloomberg/Reserve Bank of Australia/Brailsford et al (2012)	Forward Looking	NA	Absolute	Point	Relevant
Current cost of debt[323]	Bloomberg or RBA	Forward Looking	A	Absolute	Point	Relevant
Survey Evidence	Broker Reports	Forward Looking	NA	Relative	Point	Relevant
Implied volatilty	Bloomberg	Forward Looking	NA	Relative	Point	Relevant
Term structure variables	Bloomberg, RBA or other reputable source	Forward Looking	NA	Relative	Point	Relevant
Financial Ratios	Bloomberg, RBA or other reputable source	Forward Looking	NA	Relative	Point	Relevant
Credit metrics	Credit rating agencies	Forward Looking	NA	NA	None	Relevant
Other regulators decisions	Decisions	Forward looking	NA	Absolute	Range and point	Relevant

321 See Chapter 12 – Equity beta.

322 See Chapter 7 – The risk free rate of return.

323 See Chapter 6 – The Return on debt.

Appendix 30 An indicative worked example of the approach to estimating the rate of return and gamma

1. This short, indicative example of the Authority's approach to estimating the rate of return is provided to give an illustration of how relevant estimation methods, financial models, market data and other evidence will contribute to the final estimate of the rate of return, the return on equity and the return on debt. As it is a reduced form of the Authority's approach, it necessarily only takes into account a limited set of the relevant information.

2. An indicative example is also provided for the Authority's estimate of the value of imputation credits.

An indicative worked example for a return on equity

3. As at 30 November 2013, use of the 5-steps approach would deliver the following indicative estimate of the return on equity.

Step 1 – Identify relevant materials

4. The evaluation of relevant materials is summarised elsewhere in this guideline. Detail is not provided in this example.

5. For the estimate of the return on equity, the Authority has concluded 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.

6. However, the Authority will give weight to relevant outputs from the Dividend Growth Model (**DGM**), and a range of other relevant material, when estimating the market risk premium (**MRP**) for input to the Sharpe Lintner Capital Asset Pricing Model (**CAPM**). Estimates from the DGM will be used to inform the range of the MRP. Other relevant material will be used to inform the point estimate within the range of the MRP.

7. Similarly, the Authority will take into account other relevant material when estimating the equity beta, such as insights from the empirical performance of the Sharpe Lintner CAPM. This evidence suggests that the model tends to underestimate (overestimate) a return on equity for low-beta (high-beta) assets.

Step 2 – Estimate parameters

Parameter ranges for the Sharpe Lintner CAPM

8. As at 30 November 2013, the Authority has determined the following ranges for the parameters to be used in the Sharpe Lintner CAPM:

- The range of equity beta: 0.5 – 0.7;
  - see Chapter 12 – Equity beta.
- The range of MRP: 5.0 per cent – 7.5 per cent;
  - see Chapter 11 – Market risk premium.

Parameter point estimates for the Sharpe Lintner CAPM

9. The average of the observed 40 days of the 5-year Commonwealth Government Securities (**CGS**) risk-free rate as at 30 November 2013 is 3.44 per cent. This provides a point estimate for the risk free rate.

10. The Authority considers that a 5-year term for the risk free rate is consistent with the ‘present value principle’, and also with investors’ horizons with regard to the regulated assets, given the 5-year regulatory period (see Appendix 2 – Present value principle).

11. The estimated range of the equity beta for the benchmark efficient entity is between 0.5 and 0.7. Absent other influencing factors, a mid-point estimate of 0.6 for the equity beta could be adopted.

12. A mid-point estimate of 0.6 would imply that the estimate was unbiased, symmetrically distributed, and that the mean was the best estimate for the benchmark efficient entity.

13. The estimated range of the MRP is between 5.0 per cent and 7.5 per cent. The starting point for the estimate of the MRP is around the midpoint of the range. The Authority considers that an MRP of around 6.0 to 6.5 per cent provides for an estimate that is consistent with historic data, as well as the outputs of various DGM estimates (see Chapter 11 – Market risk premium).

Step 3 – Estimate the return on equity

14. Utilising the Sharpe Lintner CAPM, informed by the point estimates for the parameters identified above, the Authority calculates that the estimated return on equity for a regulatory decision released in December 2013 would be:

Estimated return on equity = 3.44 per cent + 0.6(6.0 per cent) = 7.04 per cent

Step 4 – Consider other relevant material

15. The Authority has considered a range of other material as a test for reasonableness of the estimate derived in Step 3 (see Appendix 29 – Other relevant material for details).

Risk free rate

16. The estimate of the risk free rate is the 40 day average of the 5 year yield on Commonwealth Government Securities. As it is observed from the market, the Authority considers that it is robust.

17. The Authority notes that at 3.44 per cent, the estimate is lower than the average of 5-year rates over recent decades, reflecting a concerted downward trend (see for example Figure 12 in Appendix 12 – Co-integration between the equity risk premium and the risk-free rate of return). However, the Authority has no view as to the prospect for significantly higher rates over the next five years. The Authority considers that the prevailing estimate is the best predictor for the next five years (see Appendix 5 – Diebold Mariano test). On this basis, the Authority considers that 3.44 per cent is the best estimate for use in the Sharpe Lintner CAPM.

Market risk premium

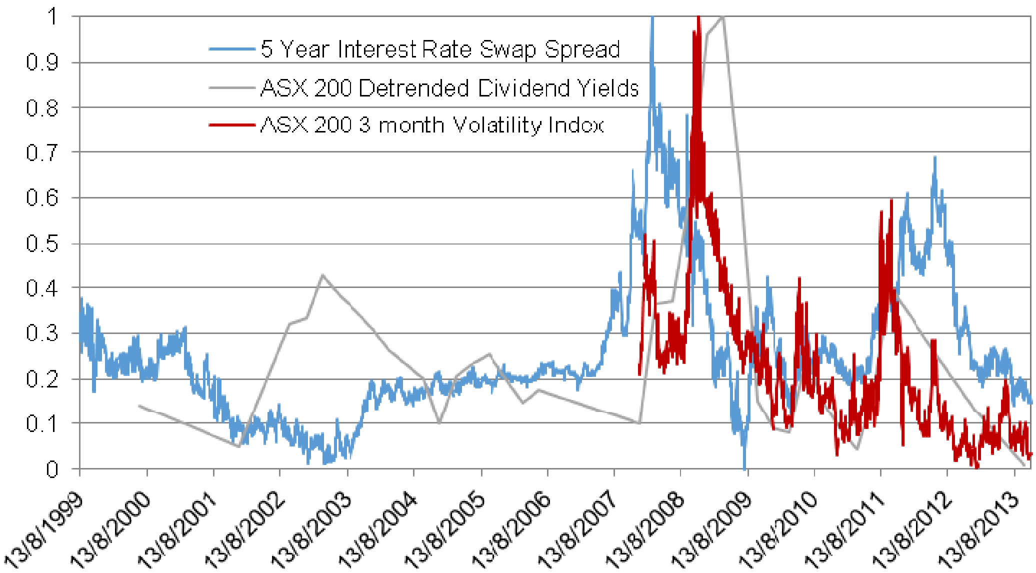
18. The Authority considers that a range of other information is relevant for determining the point estimate of the MRP (see Appendix 29 – Other relevant material to inform the rate of return for detail). To inform the Authority on the most relevant point within this range, this additional information will be considered as to whether it implies a revision, upwards or downwards, to the midpoint of the MRP range. The Authority will assess all relevant information, and on balance determine the direction and magnitude of the revision to the estimated midpoint.

19. Relevant evidence suggests that the MRP may vary in response to changes in the risk-free rate. However, there is no evidence to support a consistent systematic relationship between the MRP and risk free rate (see Appendix 16 – Is the return on equity stable?).

20. Drawing on the most recent data in 2013 on the level of volatility from a range of forward looking indicators, the Authority considers that the level of perceived risk in the equity market appears to be in the lower half of the range at the current time. This would imply an MRP towards the lower end of the range, from 5.0 to 6.0 per cent.

21. For example, the Authority considers that the 5-year interest rate swap spread provides a market based estimate of the level and price of risk looking forward five years. When normalised, the data suggests that investors' perceptions of market risk, and hence the expected value for the MRP, are in the low quartile of the range (Figure 64). Other indicators, when normalised, tell a broadly similar story, although there are timing differences (Figure 64).

Figure 64 'Normalised' 5 year interest rate swap spread over 5 year Treasury bonds



Source: ERA analysis and Bloomberg data

22. On the other hand, the Authority notes the evidence suggesting that the return on equity is mean reverting.[324] This suggests that rational investors' expectations will be

324 The Authority's analysis – based on 128 years of Australian historical data – suggests that only the return on equity is 'stationary', that is mean reverting. It exhibits significant fluctuations from year to year, but tends to fluctuate around a stable mean. The risk free rate, on the other hand, is 'non-stationary'; it is a random walk. There is mixed evidence for the 'stationarity' of the market risk premium,

conditioned by past performance of the return on equity. In particular, it suggests that expectations for the return on equity may not necessarily have moved below the historic mean to the same degree as current low interest rates. This suggests that the market risk premium may be relatively higher, all other things equal, at the current time.

23. Furthermore, the Authority notes that the global economy continues to face considerable challenges, particularly those challenges related to high sovereign debt levels in many countries, as well as the need to manage an orderly transition from quantitative easing in the developed countries, including the United States. Investors' perceptions of risk can change quite rapidly, as evidenced by the period 2010 through 2012. A longer term average of market volatility over this period is closer to the 50th percentile. Given these considerations, the Authority considers it appropriate to lift the estimate of the MRP back towards the mid-point of the range.

24. Overall, the Authority considers that an MRP of 6.0 per cent is reasonable at this point in time.

Equity beta

25. The determination takes into account other relevant material, such as insights from the empirical performance of the Sharpe Lintner CAPM. The Authority considers that relevant empirical evidence supports a view that there is some downward bias in equity beta estimates that are less than one, and upward bias in equity beta estimates that are greater than one.

26. Therefore, for the purposes of this indicative estimate, the Authority will assume a point estimate for the equity beta that is at the top end of the estimated range, at 0.7, so as to account for potential bias in the estimate.

27. The Authority intends to undertake work to quantify the extent of this potential bias prior to its next decision. This work would then assist in informing the degree to which the Authority might adjust up the point estimate of the equity beta within the estimated range, so as to account for any potential beta bias.

Overall return on equity

28. The corresponding overall return on the market implicit in the estimate is 9.44 per cent (3.44 + 6.00 per cent). This is lower than the average annual rates of return on equity over the longer term, which is around 11.8 per cent, based on a period of more than a century (Appendix 16 – Is the return on equity stable?).

29. Similarly, evidence of market analysts' views suggest expectations for the forward average returns on equity *over a longer term* are higher than the rate estimated by the Authority (see Appendix 29 – Other relevant material).

30. Nevertheless, the Authority considers that these longer term average rates of return are not consistent with the rate that can reasonably be expected to prevail over the next five years. Current low interest rates for the forward looking five year term, combined with an MRP which is in the lower half of its range, suggest that the overall rate of return for the next five years will be lower than its historic average. On this basis, the Authority is satisfied that its current estimate is reasonable.

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suggesting that the historic estimate of its mean value is less reliable for informing forward expectations than the historic mean of the return on equity (see Appendix 16 – Is the return on equity stable?).

31. The Authority considers that the estimate of the return on equity, which accounts for the full range of relevant material, will best meet the allowed rate of return objective, and the requirements of the National Gas Rules (**NGR**) and National Gas Law (**NGL**) more broadly.

Step 5 – Determine the return on equity

32. Taking into account all of the relevant information, the Authority is of the view that an expected return on equity of 7.64 per cent would be appropriate for the benchmark efficient entity. This is based on an equity beta of 0.7.

Estimated return on equity = 3.44 per cent + 0.7(6.0 per cent) = **7.64 per cent**

33. The Authority considers that the estimate is commensurate with the efficient equity financing costs of the benchmark efficient entity prevailing at this time. On this basis, the Authority considers that the estimate will meet the allowed rate of return objective.

An indicative worked example for the return on debt

34. The Authority will require the estimation method for the return on debt to be based on a risk premium over and above the risk-free rate, as well as an allowance for debt raising and hedging costs:

Return on Debt = Risk Free Rate + Debt Risk Premium + Debt raising costs + Hedging costs

35. The risk free rate will be based on an estimate of the appropriate term derived from the 40 day average of the yield on Commonwealth Government Securities (**CGS**), just prior to the start of the regulatory period (see Chapter 7 – Risk free rate).

36. The debt risk premium is derived from the Authority's bond yield approach, which observes the current debt risk premium on a weighted sample of bonds of equivalent credit risk to the benchmark efficient entity (see Chapter 8 – Benchmark credit rating and Chapter 9 – Debt risk premium). The debt risk premium will be updated annually.

37. Debt raising costs are based on a range of evidence (see Chapter 13 – Debt and equity raising costs).

38. Hedging costs are based on observed interest rate swap spreads (see Chapter 13 – Debt and equity raising costs).

39. As at 30 November 2013, the Authority has determined the following point estimates for the components to be used in the estimation of the return on debt:

- The 5-year CGS risk-free rate 3.44 per cent
- The debt risk premium observed from the bond yield approach: 2.03 per cent.
- Debt raising costs 0.125 per cent
- Hedging costs 0.025 per cent

40. Utilising this estimation method, the estimated return on debt for a regulatory decision released in November 2013 would be:

The 1-year return on debt = 3.44 + 2.03 + 0.125 + 0.025 = **5.62** per cent

41. The Authority has considered other relevant estimation material as a means to assess whether the estimate of the return on debt meets the allowed rate of return objective.

42. For example, the 40-day average of Bloomberg's 5-year cost of debt (which can be decomposed into a 5-year risk free rate and a 5-year BBB band debt risk premium) is 5.61 per cent as at 30 November 2013. This rate is slightly higher than the Authority's estimate, once the omission of debt raising costs and hedging costs are accounted for. However, the differences are small, and are likely to reflect the different composition of firms in the Bloomberg estimate.

43. As a result, the Authority considers that its estimate for the return on debt is reasonable.

44. Based on the foregoing analysis, taking into account all of the relevant estimation material, the Authority is of the view that an expected return on debt of 5.60 per cent is appropriate.

45. The Authority considers that this estimate of the return on debt will meet the allowed rate of return objective.

An indicative estimate of the overall rate of return

46. The gearing for the benchmark efficient entity is 0.6. Applying this gearing to the estimate of the return on equity and the return on debt, the resulting nominal vanilla post tax rate of return would be:

0.6 * return on debt + 0.4 * return on equity =

0.6 * 5.62 + 0.4 * 7.62 = **6.42%**

47. The resulting nominal vanilla post tax rate of return, of 6.42 per cent, is an annual rate – it would be recalculated each year to reflect the update to the debt risk premium component of the return on debt.

48. The Authority considers that this rate of return would achieve the allowed rate of return objective.

An indicative estimate of the value of imputation credits

49. Gamma is the parameter in the post tax revenue model that takes into account the value generated by the distribution of franking credits to investors. As a general rule, investors will accept a lower required rate of return on an investment that has franking credits compared with an investment that has similar risk and no franking credits.

50. The Authority considers that it is appropriate to estimate gamma (γ) as the product of two components: (i) the payout ratio (F); and (ii) the market value of imputation credits, theta (θ). This can be represented as follows:

$$\gamma = F.\ \theta$$

51. The Authority considers that an appropriate range for gamma is 0.25 to 0.39. The range is based on a payout ratio of 0.70 and a range for theta of 0.35 to 0.55.

52. As the Authority has no additional relevant material to inform the position in the range, the Authority considers that the rounded mid-point estimate of 0.3 will provide the best estimate within the range at the current time.