The reliability of empirical beta estimates: Response to AER proposed revision of WACC parameters

Report prepared for ENA, APIA, and Grid Australia

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Context

1. This report has been prepared by Professor Stephen Gray, Professor of Finance at the University of Queensland Business School and Managing Director of Strategic Finance Group (SFG Consulting), a corporate finance consultancy specialising in valuation, regulatory and litigation support advice.

2. I have previously prepared a report dated 15 September 2008 and titled *The reliability of empirical beta estimates* in relation to this decision-making process. Some elements of that report were considered by the AER in its *Review of WACC parameters: Explanatory statement* (the *Explanatory Statement*).[1]

3. I have now been engaged by the ENA, APIA, and Grid Australia to provide a response to the *Explanatory Statement*. In particular, I have been asked to provide responses to a number of specific questions. In the remainder of this Executive Summary I set out the questions I have been asked and summarise my views. The remainder of this report provides the reasoning and analysis for the answers to each of the questions below.

4. For the purposes of preparing this report I was provided with a copy of the Federal Court guidelines *Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia* dated 5 May 2008. I have reviewed those guidelines and this report has been prepared consistently with the form of expert evidence required by those guidelines. In preparing this report, I have made all the inquiries that I believe are desirable and appropriate and no matters of significance that I regard as relevant have, to my knowledge, been withheld.

Reasonableness of proposed required return on equity

5. The first question I have been asked to address is:

> If the WACC parameters (other than the equity beta) were to remain as the previously adopted parameters (or gamma was to reduce to 0.3), given the need to ensure that the businesses have a reasonable opportunity to recover at least the efficient cost of equity of the operator, is there persuasive evidence to depart from an equity beta of 1? How much confidence can be placed in the results of the AER given its methodology?

6. For the reasons set out in this report (and in my earlier report) my view is that there is no persuasive evidence to depart from an equity beta of 1.0, and that no material confidence can be placed in the results of the AER given its methodology. The reasons for these conclusions are summarised below.

AER proposal

7. I demonstrate in this report that the parameter estimates proposed in the *Explanatory Statement* lead to estimates of the required return on equity as summarised in the following table.

[1] Australian Energy Regulator (2008), Electricity transmission and distribution network service providers -- Review of the weighted-average cost of capital (WACC) parameters: Explanatory statement, December.

Return	Benchmark firm with 60% debt financing	Benchmark firm with all-equity financing
Equilibrium required return from CAPM	8.77%	5.89%
Expected return from dividends and capital gains (and total return available to non-resident investors)	6.86%	4.61%

8. That is, the parameter estimates set out in the *Explanatory Statement* imply that a benchmark firm with no debt could attract the required amount of equity capital by offering shareholders a combined expected return from dividends and capital gains of 4.61%. And a benchmark firm with 60% debt financing could attract the required amount of equity capital by offering shareholders a combined expected return from dividends and capital gains of 6.86%. For reasons set out below, I do not consider that these returns would provide the businesses with a reasonable opportunity to recover at least the efficient cost of equity.

Conceptual issues

9. The *Explanatory Statement* correctly notes that a firm's systematic risk (its equity beta) will depend "on its business activities and its level of financial leverage."[2] For reasons set out in this report, it is my view that the *Explanatory Statement* confuses the way financial leverage affects equity beta with a different concept that is referred to as "financial risk." This leads to an a priori expectation that the equity beta of the benchmark firm must be less than 1.0. It is my view that the reasoning on this point in the *Explanatory Statement* is inconsistent and incorrect and that there should be no such a priori expectation.

Economic reasonableness

10. Lenders to AA rated institutions are presently being promised fixed returns that are higher than any of the required returns to equity implied by the AER's parameter estimates and set out in the table above. In my view, an estimated return to equity holders (who are residual claim holders and are not guaranteed or promised any particular level of return) that is lower than the yield on AA rated debt (which involves a contractual series of payments being promised by an institution with a *very* high credit rating) is implausible. For this reason, I conclude that the required return on equity implied by the parameters proposed in the *Explanatory Statement* is not consistent with prevailing market conditions.

11. It is generally agreed that "availability of data (cross-sectional and across time) and consistency of empirical estimates (over time, across businesses, across empirical methods)" are also key criteria when estimating equity beta.[3] For the purpose of estimating the equity beta of the benchmark firm, the availability of data is low (there are few comparable firms and they have short trading histories) and the empirical estimates that are generated from the data vary greatly over time, businesses, and empirical methods.

12. I conclude in this report that the empirical estimates that are relied upon in the *Explanatory Statement* fail a number of tests of economic reasonableness. This leads to the conclusion that one should have no confidence in them.

[2] *Explanatory Statement*, p. 181.
[3] *Explanatory Statement*, p. 48.

Standard errors and confidence intervals

13. It is generally agreed that the width of the confidence interval (which is based on the standard error of the estimate of beta) "is an indicator of the precision" of the estimate.[4]

14. It is my view that the precision of an estimate is an important consideration when determining how much weight to apply to a particular empirical estimate and how much confidence one should have in it. Also, standard errors and confidence intervals are required to determine whether a particular beta estimate is significantly different from the currently adopted estimate and to determine the probability of the regulated return being sufficient to recover the efficient cost of capital.

15. In this regard, I note the conclusion of ACG (2008) is that confidence intervals around beta estimates formed using Australian data tend to include 1.0. From a statistical perspective, the conclusion from this is that these estimates are no significantly different from 1.0 and there is no persuasive evidence to depart from an estimate of 1.0. In the report I set out reasons why these confidence intervals may be understated, in which case one would have even less confidence in any present estimates being less than 1.0.

16. The conclusion in the *Explanatory Statement* is that standard errors and the resulting confidence intervals will not be used when determining the appropriate equity beta. Specifically, "the AER has had regard to the point estimates rather than the range of possible estimates within confidence intervals."[5]

R-squared statistics

17. There appears to be general agreement that in circumstances where the R-squared is low it is "more difficult to obtain statistically reliable estimates."[6] Consequently, the R-squared statistic is directly informative about the statistical reliability of empirical beta estimates.

18. I show that the noise in the available data is such that R-squared statistics are low and in these circumstances it is likely that one will obtain beta *estimates* that are lower than 0.8 even when the true value is 1.0. In my view, this is an important consideration when determining the weight to be afforded to those estimates and whether there is any persuasive evidence to depart from an estimate of 1.0.

19. I note that the *Explanatory Statement* does not consider or report any R-squared statistics.

Bias in beta estimates

20. My earlier report[7] shows that beta *estimates* less than 1.0 are more likely to be below the true beta than above it and are therefore downwardly biased. When we obtain a beta estimate that is less than 1.0 we know that it is more likely to have been affected negatively by estimation error such that our best estimate of the true value of beta is *higher* than the estimated value.

21. In my view, the potential for estimates to have been affected by bias is an important consideration when determining the weight to be afforded to those estimates and whether there is any persuasive evidence to depart from an estimate of 1.0.

[4] *Explanatory Statement*, p. 216.
[5] *Explanatory Statement*, p. 219.
[6] *Explanatory Statement*, p.215.
[7] Gray (2008) Section 3.

22. I note that a number of commercial data providers use statistical techniques to correct for bias. The *Explanatory Statement* rejects the use of these measures.

Efficient cost of equity

23. The second question I have been asked to address is:

> Taking into account the quality and reliability of the data, what value for equity beta would need to be adopted to ensure that the allowed cost of equity that resulted was at least sufficient to recover the efficient cost of equity of the businesses?

24. I note that the proposed equity beta in the *Explanatory Statement* is 0.8. In this report, I conclude that in estimating the relevant equity beta one should have regard to a number of things that were not incorporated into the estimate of 0.8 including:

a. Whether the beta estimate of 0.8 provides an estimate of the required return on equity that is economically reasonable or plausible;

b. The size of standard errors and the width of the resulting confidence intervals;

c. Whether noise in the data results in such low R-squared statistics that the empirical results are unreliable; and

d. Whether empirical estimates are downwardly biased.

25. Each of these considerations has several elements that are set out in the body of this report.

26. It is impossible to precisely quantify the impact of each of these considerations. It is also impossible to precisely quantify the true equity beta or the equity beta that would ensure that the allowed cost of equity that resulted was at least sufficient to recover the efficient cost of equity of the businesses. However, it is possible to apply standard statistical approaches (e.g., in relation to confidence intervals and bias adjustment) and professional judgment (e.g., in relation to the plausibility of estimated required returns on equity). For the reasons set out in more detail in this report, and given the other parameter estimates proposed in the *Explanatory Statement*, it is my view that an equity beta of at least 1.0 is required to ensure that the allowed cost of equity that resulted was at least sufficient to recover the efficient cost of equity of the businesses.

Professor Stephen Gray
1 February 2009

1. AER proposal

Overview

27. In this section I set out the key aspects of the AER's proposed WACC parameter estimates that are relevant to the estimate of equity beta and the required return on equity. This material is largely drawn from Chapter 8 of the *Explanatory Statement*. In this section, I do not comment upon the reasonableness or appropriateness of any of the AER's estimates or methodologies – I simply set out the AER's position on the relevant issues.

Equity beta, asset beta and required returns

28. The *Explanatory Statement* proposes an equity beta of 0.8, a market risk premium of 6% and that the risk-free rate should be estimated as the yield on 5-year Commonwealth Government Securities (3.97% as at the date of this report[8]). The *Explanatory Statement* then uses the Sharpe Capital Asset Pricing Model (CAPM) to estimate the required return on equity. Using the risk-free rate of 3.97% at the date of this report gives:

$$\begin{aligned} r_e &= r_f + \beta_e \times MRP \\ &= 3.97\% + 0.8 \times 6\% = 8.77\%. \end{aligned}$$

29. This is an estimate of the total return on equity that investors require (in equilibrium) to provide the requisite amount of equity capital to the firm.

30. The *Explanatory Statement* correctly notes that a firm's systematic risk (its equity beta) will depend "on its business activities and its level of financial leverage."[9] That is, the proposed equity beta of 0.8 reflects (a) the business activities of the benchmark firm and (b) the assumed financial leverage of the benchmark firm.

31. The *Explanatory Statement* also sets out the approach that AER proposes to disaggregate the equity beta into these two components:[10]

$$\beta_e = \beta_a \left(1 + \frac{D}{E}\right)$$

where β_a is the asset beta, which reflects the systematic risk of the business activities of the benchmark firm but not the effect of leverage, and $\left(1 + \frac{D}{E}\right) = \left(1 + \frac{60}{40}\right) = 2.5$ at the assumed 60% level of financial leverage.

32. According to these figures in the *Explanatory Statement* the asset beta is 0.32:

[8] http://www.rba.gov.au/Statistics/Bulletin/F02Dhist.xls.
[9] *Explanatory Statement*, p.181.
[10] *Explanatory Statement*, p.202.

$$\beta_e = \beta_a\left(1+\frac{D}{E}\right)$$
$$0.8 = 0.32\left(1+\frac{60}{40}\right).$$

33. Consequently, the proposed equity beta of 0.8 is made up of 0.32 units of systematic risk relating to the business activities of the benchmark firm and 0.48 units of systematic risk relating to the assumed leverage of the benchmark firm.

34. It further follows that the total required return on equity for a benchmark firm with no debt financing would be:

$$\begin{aligned} r_e &= r_f + \beta_a \times MRP \\ &= 3.97\% + 0.32 \times 6\% = 5.89\%, \end{aligned}$$

and that the remaining 2.88% (of the total 8.77% required return) is compensation for the additional risk caused by the assumed level of financial leverage.

35. The AER's conclusion, as set out in the *Explanatory Statement* is that shareholders in a benchmark distribution or transmission firm with no debt, would require a total expected return on equity of 5.89% p.a. in order to commit equity capital to the firm. The AER further concludes that an additional return of 2.88% p.a. (giving a total of 8.77%) is required to compensate shareholders for the additional systematic risk that is caused by the assumed amount of financial leverage.

Return on equity and the impact of franking credits

36. The return to shareholders can be further disaggregated into (a) the return delivered in the form of dividends and capital gains, and (b) the return delivered in the form of dividend imputation franking credits. In relation to franking credits, the *Explanatory Statement* proposes an estimate of gamma of 0.65. The AER uses the Officer CAPM-WACC framework within which Officer (1994) shows that a fraction:

$$\frac{1-T}{1-T(1-\gamma)}$$

of the total return to equity is delivered in the form of dividends and capital gains and the remainder is delivered in the form of franking credits.[11] In this equation, T represents the relevant corporate tax rate and γ represents the extent to which the creation of a \$1 franking credit (by the payment of \$1 of Australian tax) is reflected in the stock price.

37. If $T = 0.3$ and $\gamma = 0.65$ we have:

[11] On this point, I note that Handley (2008, pp. 4-5) argues that the Officer CAPM-WACC framework requires that valuation exercises be performed on the basis that all earnings are immediately paid out as dividends and that there are no capital gains. I also note that the AER has accepted this argument and based its parameter estimates on it (*Explanatory Statement*, p. 297). Throughout this report I refer to "dividends and capital gains" for generality, although I note that there can be no capital gains in the Handley-AER framework.

$$\frac{1-T}{1-T(1-\gamma)} = \frac{1-0.3}{1-0.3(1-0.65)} = 0.78,$$

in which case 78% of the return to equity comes in the form of dividends and capital gains[12] and 22% is assumed to be via franking credits. That is, share prices are assumed to be set so that dividends and capital gains provide 78% of the total required return and the other 22% comes from franking credits.

38. According to the parameter estimates set out in the *Explanatory Statement*, a benchmark firm with no debt could attract the required amount of equity capital by offering shareholders a combined expected return from dividends and capital gains of 4.61% (=0.78 × 5.89%). And a benchmark firm with 60% debt financing could attract the required amount of equity capital by offering shareholders a combined expected return from dividends and capital gains of 6.86% (=0.78 × 8.77%).

39. Of course, non-resident investors do not receive the benefit of franking credits so they will receive only the 78% of the equity return that comes in the form of dividends and capital gains.

40. Consequently, the AER's conclusion, as set out in the *Explanatory Statement* is that non-resident shareholders in a benchmark distribution or transmission firm with no debt, would require a return of 4.61% p.a. in order to commit equity capital to the firm. The AER further concludes that non-residents would require an expected return of 6.86% p.a. to commit equity to a benchmark firm with 60% debt financing.

Summary of AER proposal

41. Table 1 below summarises the AER's estimates of the expected returns that are required to attract the investment of equity capital into a benchmark distribution or transmission business. The figures in Table 1 are the direct result of the parameter estimates that are proposed in the *Explanatory Statement*, requiring only direct mechanical mathematical computations.

Table 1. Summary of required returns on equity from AER *Explanatory Statement*

Return	Benchmark firm with 60% debt financing	Benchmark firm with all-equity financing
Equilibrium required return from CAPM	8.77%	5.89%
Expected return from dividends and capital gains (and total return available to non-resident investors)	6.86%	4.61%

[12] Dividends only, under the Handley – AER framework.

2. Conceptual issues

Components of equity beta

42. As set out above, the *Explanatory Statement* correctly notes that a firm's systematic risk (its equity beta) will depend "on its business activities and its level of financial leverage."[13] That is, the proposed equity beta of 0.8 reflects (a) the business activities of the benchmark firm and (b) the assumed financial leverage of the benchmark firm.

43. With regard to the business activities of the regulated firm, the AER concludes that:

> there are strong conceptual reasons to suggest that the exposure of a benchmark efficient service provider's to non-diversifiable risk due to business activities would be less than that of the market. That is, the asset beta of a benchmark efficient service provider would be less than the asset beta of the market.[14]

The AER also notes that there is general agreement from the MEU and JIA on this point.

The way in which financial leverage affects equity beta

44. With regard to the effect of financial leverage, the AER notes that the JIA has pointed out that the regulator assumes that the benchmark firm has financial leverage that is double that of the average firm. That is, although the benchmark firm is likely to have lower than average systematic risk due to its business activities (i.e. a lower than average asset beta) it is assumed to have much higher than average financial leverage. These two effects will act to offset each other and the net effect on equity beta is unclear.

45. That is, the AER correctly notes that there are two components to the equity beta: (a) the business activities of the benchmark firm and (b) the assumed financial leverage of the benchmark firm. The risk of the business activities of the benchmark firm is known as the asset beta. Financial leverage is relevant in the way that the asset beta is levered up to obtain the equity beta. The AER recognises, on p. 202 of the *Explanatory Statement*, that this is done via a specific mathematical formula:

$$\beta_e = \beta_a\left(1+\frac{D}{E}\right)$$

where β_a is the asset beta, $\frac{D}{E}$ measures financial leverage, and β_e is the resulting asset beta.

46. According to the AER's parameter estimates, beta estimates for the benchmark firm are characterised as follows:

$$\beta_e = \beta_a\left(1+\frac{D}{E}\right)$$

$$0.8 = 0.32\left(1+\frac{60}{40}\right)$$

[13] *Explanatory Statement*, p.181.
[14] *Explanatory Statement*, p.193, error in original.

Comparison with average firm

47. The average listed Australian firm has an equity beta of 1.0, leverage of 30% debt finance, and an asset beta of 0.7. Using the AER's framework, the AER's re-levering formula, and the AER's parameter estimates, the risk of the assets (asset beta) of the benchmark firm are considered to be 0.32 whereas the risk of the assets of the average listed firm is 0.7. That is, the business operations of the average listed firm are considered by the AER to be less than half as risky as the average firm.

48. As a reference point, if the benchmark firm were considered to have an equity beta of 1.0, this would correspond to an asset beta of 0.4.

49. In summary, the risk of the business operations of a firm (asset beta) is the first of two components of the equity beta. The asset beta estimates that are relevant to the present decision-making process are as follows:

    a. The average listed firm has an asset beta of 0.7;

    b. The AER proposes an equity beta of 0.8, which corresponds to an asset beta of 0.32;

    c. An equity beta of 1.0 corresponds to an asset beta of 0.4.

50. It is generally agreed that the benchmark firm would have a lower asset beta than the average Australian firm and in my view it is reasonable to have an a priori view to this effect.

51. However, there is a second component of the equity beta – financial leverage. The mathematical formula set out above shows how financial leverage "levers up" the asset beta and produces an estimate of the equity beta. The benchmark firm is assumed to have twice as much financial leverage as the average firm. So although the benchmark firm might have a lower asset beta, this is levered up by a greater amount and the effect on equity beta is unclear. In my view it is not unreasonable to hold an a priori view that the two effects may cancel one another. For example, if the benchmark firm is assumed to have an asset beta of 0.4 (compared with 0.7 for the average firm) but leverage of 60% (compared to 30% for the average firm), the benchmark firm will have an equity beta of 1.0 (the same as that of the average firm).

The AER's concept of "financial risk"

52. After correctly noting that the equity beta is made up of two components (the risk of the firm's business activities [asset beta] and the amount of financial leverage), the AER then proposes that the benchmark firm would score lower on *both* components. That is, the JIA submission is that the benchmark firm has a lower asset beta than the average firm, but higher financial leverage, and these two effects will tend to cancel each other in terms of their impact on equity beta. By contrast the AER argues that the benchmark firm will score lower than the average firm on both components and that this gives rise to an a priori belief that the benchmark firm must have an equity beta less than 1.0 (the equity beta of the average firm).

53. In my view, the AER's reasoning in this regard is fundamentally wrong. The second component of equity beta is financial leverage – what are the relative proportions of debt and equity finance. The AER has replaced this notion with what they call "financial risk." It seems that the AER considers "financial risk" to refer to various risks associated with borrowing activities and the variability in interest rates in particular. In setting out their reasoning on this point, the AER states that the JIA's reasoning:

> … assumes that a businesses exposure to financial risk is determined by financial leverage alone. The AER notes that an additional aspect of the regulatory regime is that the cost of debt is based on prevailing market conditions as sourced from a reliable data service provider at the time of the determination. This 'pass-through' nature of borrowing costs is likely to reduce exposure to financial risk, compared to an unregulated business (or the market in general) with the same benchmark level of gearing.[15]

54. Based on this reasoning, the AER reaches the following conclusion:

> Accordingly, the AER considers that the exposure of a benchmark efficient service provider to business risk and to financial risk overall, is less than that of the market. That is, that the equity beta is likely to be less than one.[16]

55. In my view, the AER's reasoning on this point has misconstrued the way that financial leverage affects the equity beta. The second component of equity beta has nothing to do with interest rate risk or any sort of borrowing or "financial risk" as the AER claims on p. 193 of the *Explanatory Statement*. Rather, the second component of equity beta is the amount of financial leverage and it affects equity beta via the formula set out above and used by the AER on p. 202 of the *Explanatory Statement*.

56. In a simple example in the Appendix, I show that even if all of the risks and costs pertaining to the firm's debt finance could be immediately "passed through" to customers and indeed even if all borrowing was completely risk free and a rate that was perfectly known well in advance, financial leverage would still affect equity beta in exactly the same way.

57. That is, on page 202 of the *Explanatory Statement* the AER sets out the method (a mathematical formula) that it, and its consultant, has used to incorporate the effect of financial leverage on equity beta. But on page 193 of *the Explanatory Statement* the AER argues that the relationship between financial leverage and equity beta has something to do with "financial risk" defined to mean the interest rate on debt financing and the extent to which that can be passed on to customers. This is inconsistent with the mathematical formula that is used for the same purpose only nine pages later.

58. The JIA's submissions on this point are based on the mathematical formula used on page 202 of the *Explanatory Statement*. If this is taken as correct, the JIA's submission on this point stands – although the benchmark firm is likely to have lower than average systematic risk due to its business activities (i.e., a lower than average asset beta), it is assumed to have much higher than average financial leverage and these two effects will act to offset each other and the net effect on equity beta is unclear. The AER's rejection of this submission is based on the reasoning on page 193 of the *Explanatory Statement*, which is inconsistent with the reasoning and mathematical formula used elsewhere in that it misconstrues what is meant by "financial risk" and how leverage affects equity beta.

[15] *Explanatory Statement*, p.193, error in original.
[16] *Explanatory Statement*, p.194.

Summary and conclusion

59. The AER is wrong to suggest that there are conceptual reasons to support an a priori view that the equity beta of the benchmark firm would be less than 1.0.

60. On page 193 of the *Explanatory Statement* the AER argues that the relationship between financial leverage and equity beta is driven by the interest rate risk on debt financing and the extent to which that can be passed on to customers.

61. I show, via a simple example, that this is not the case. Financial leverage affects equity beta by increasing the variability (and consequently the systematic risk) of possible returns to equity. Indeed this is the source of the term "leverage." My example shows that financial leverage has the same effect on equity beta even if there is no interest rate risk whatsoever.

62. The correct way to account for the effect that financial leverage has on equity beta is via a mathematical formula that is set out on Page 202 of the *Explanatory Statement*. When this precise formula is used, there is no evidence to support an a priori view that the equity beta for the benchmark firm would be less than 1.0.

3. Economic reasonableness

Economic reasonableness is a key criteria

63. My earlier report noted that equity betas cannot be observed or measured, but can only be estimated with reference to the market data that is available.[17] I noted that in its assessment of Telstra's ULLS and LSS monthly charge undertakings, the ACCC states that:

> Because each WACC parameter cannot be known with certainty, there is a *range* of input parameters which could be termed 'reasonable'. This seems to be an area of common agreement.[18]

64. My earlier report[19] also noted that there is presently a range of views among Australian regulators about the reliance that should be placed on beta estimates that are based on the available Australian data. In its recent gas distribution decision, the Essential Services Commission of Victoria (ESC, 2008) adopted an equity beta of 0.7 based largely on estimates from the available Australian data. By contrast, the most recent energy decision by the Queensland Competition Authority (QCA, 2006) adopts an equity beta of 1.1 and states that:

> [E]mpirical estimates are not currently sufficiently accurate to be heavily relied upon.[20]

65. In the context of clear uncertainty in the estimation of beta, an important consideration when determining how much weight to apply to a particular empirical estimate of beta is whether the resulting required return is economically reasonable. That is, one would take the particular estimate of beta, determine the required return on equity implied by that estimate, and then ask whether investors would really be willing to commit equity capital to the benchmark firm if they expected to receive that level of return.

66. Consistent with this, the AER states that it supports the view that:

> economic reasonableness or the plausibility of the estimates[21]

is one of the key criteria for estimating WACC parameters.

Relative returns of lower-risk debt with higher-risk equity

67. In the present setting, the AER's estimates of the return that would be required to induce investors to commit equity capital to the benchmark firm are set out in Table 1 above. These required returns are a direct result of the AER's estimate of 0.8 for the equity beta of a benchmark firm with 60% debt financing (and its assumption of a 6% market risk premium). In my view, a very important consideration is whether these required returns are plausible or economically reasonable in the circumstances.

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[17] Gray (2008), p.7.
[18] ACCC (2005). *Assessment of Telstra's ULLS and LSS monthly charge undertakings: Draft decision,* p.62.
[19] Gray (2008), p.7.
[20] QCA (2006, p.106).
[21] *Explanatory Statement*, p. 48.

68. CBA Spectrum reports that, as at 31 December 2008, the yield to maturity on various debt securities is as summarised in Table 2 below.

Table 2. Yield to maturity of various debt securities

Credit rating	Yield to maturity 5 years	Yield to maturity 10 years
AA	8.2%	8.8%
A	8.5%	9.1%
A-	8.6%	9.3%
BBB+	8.9%	9.6%
BBB	9.2%	9.9%

Source: CBA Spectrum, yield on 5-year and 10-year debt securities, 31 December 2008.

Required return on equity vs. highly-rated debt

69. All of these values are very high relative to the required returns on higher-risk equity that are derived from the parameter estimates set out in the *Explanatory Statement* and summarised in Table 1 above. That is, the figures in Table 1 and Table 2 together imply that:

a. The equilibrium required return on equity for the benchmark firm with 60% gearing is 8.77% (with non-resident investors receiving only 6.86% as they do not benefit from the assumed value of franking credits); but that

b. Investors would be able to lend to a AA rated counterparty (e.g., equivalent to the highest rating of any Australian bank) and be promised a return of 8.8% or lend to a BBB rated (investment grade) counterparty and be promised a return of 9.9%.[22]

70. In my view, it is implausible that investors would require a lower return on their residual equity investment in the benchmark firm (which ranks behind the assumed 60% debt financing) than they could obtain in the form of fixed income payments from a very highly rated institution.

Required return on equity vs. debt in the benchmark firm

71. Moreover, Table 1 and Table 2 also imply that: the equilibrium required return on debt and equity for the benchmark firms with 60% gearing are approximately equal. The AER's estimate for the total return required by shareholders in the benchmark firm is 8.77%. The AER also assumes that the benchmark firm will obtain 5-year financing at an A- rating. According to CBA Spectrum, the cost of this financing (as at 31 December) is 8.62%. These results imply that lenders require the firm to promise them a return of 8.62% before they will lend money under contractual terms at a fixed rate, but that shareholders require a total return of only 8.77% to provide the required residual equity capital to the benchmark firm.

72. An investor who holds a debt security from its inception to its maturity knows exactly what payments they will receive and exactly when they will receive them – but for a default by the firm (e.g., caused by the bankruptcy of the firm). The risk of an A-rated corporate bond defaulting within a five-year period is 0.0061.[23] But for such a default, investors receive a guaranteed series of payments.

[22] There is, of course, some risk of a default by the borrower. However, this risk is small for plain vanilla investment grade corporate debt. For example, Elton, Gruber, Agrawal and Mann (2001) estimate the risk of default to amount to less than 5 basis points for AA rated bonds.

[23] Standard and Poors, Corporate Ratings Criteria.

73. By contrast, equity investors are guaranteed nothing. They hold a residual claim that ranks after the debt holders and are only entitled to some return after the debt holders have received everything they are due. Also, as explained in Section 2, the very existence of debt increases the risk borne by the shareholders. In short, an equity investment in a particular firm is considerably riskier than a loan made to that firm. Consequently, shareholders (who have a residual claim and no guarantee of any return) require a higher expected return than debt holders (who receive a series of known fixed payments, but for the case where the firm being unable to pay its debts as and when they fall due – in which case the debt holders may still receive some payment and equity holders receive nothing).

74. However:

a. According to the AER's parameter estimates, the required return on equity is only 15 basis points (0.15%) higher than the assumed cost of debt. In my view, it is not plausible that the large difference between the risk facing debt and equity holders in the benchmark firm would result in an almost negligible differential in required returns.

b. According to the AER's parameter estimates, non-resident investors will supply equity capital to the benchmark firm for an expected return of 6.86%, but will receive a yield of 8.62 % on a fixed rate loan to the same benchmark firm. In my view, it is illogical to expect any investor to behave in this manner.

c. Australian regulatory precedent is to use the yield on 10-year corporate debt as a proxy for the benchmark firm's cost of debt financing and to adopt a credit rating assumption of BBB+ or BBB. Either or both of these changes would result in the required return on debt being *higher* than the required return on equity that flows from the AER's estimate of equity beta and this is impossible.

75. In my view, it is illogical for investors to require a higher return for lending under contractual terms at a fixed rate to a firm, than for providing residual equity finance to the same firm.

Required return on equity in unlevered benchmark firm

76. Table 1 and Table 2 also imply that the equilibrium required return on equity for the benchmark firm with no gearing is 5.89% (with non-resident investors receiving only 4.61% as they do not benefit from the assumed value of franking credits). This is the required return that the AER's parameter estimates suggest is appropriate to compensate investors for the risk associated with the business activities of the benchmark firm. That is, if there was no debt finance levering up the equity risk, these are the returns that are assumed to be sufficient to attract the required amount of equity capital.

77. The economic reasonableness of the AER's parameter values on this point can be assessed by asking whether it is likely that investors would require a return on equity of 5.89% (with non-residents receiving only 4.61%) when those same investors are being promised dramatically higher returns for lending money under contractual terms at a fixed interest rate to AA rated institutions.

78. Moreover, the AER estimates that lenders to the benchmark firm require fixed payments of 8.62%. These lenders are assumed to provide 60% of the finance under contractual terms at a fixed interest rate. These payments are backed by 100% of the available cash flow in the sense

that the debt holders are entitled to be paid everything they are due before equity holders are entitled to any return.

79.	In my view, it is not plausible that the benchmark firm could be financed entirely by equity holders who required returns that were dramatically lower than the returns that debt holders required (under contractual terms at a fixed interest rate) in the same benchmark firm or in highly-rated institutions.

Long-term perspective

80. As set out above, it is my view that the AER's estimate of the equity beta of the benchmark firm fails the tests of economic reasonableness and plausibility. One of the reasons for this conclusion is that the AER's proposed parameter estimates imply that the required return on equity in the benchmark firms is lower than the returns that debt holders presently require (under contractual terms at a fixed interest rate) in the same benchmark firm or in highly-rated institutions.

81. The rates of return available on debt are the rates that are currently available for long-term investments. For example, the AER's proposed parameter estimates imply that the returns currently available for a long-term loan to a AA rated institution is higher than the return required by investors to provide residual equity capital to the benchmark firm – ranking behind the assumed 60% debt financing.

82. This relativity, which I regard as implausible, pertains to present long-term investments in debt and equity. Consequently, I consider the AER's proposed required return on equity to be implausible in the current market conditions.

83. I understand that the AER's final parameter estimates will be used to fix regulated WACCs up to five years from now. It is, of course, impossible to predict in advance what will happen to the relative costs of debt and equity over this period. The best we can do in this regard is to examine the present conditions of the market for funds and all of the data that is presently available to us. In my view, this data all suggests that the AER's proposed required return on equity is implausibly low.

Other aspects of economic reasonableness

84. My earlier report also set out two other criteria for assessing the economic reasonableness, plausibility and reliability of beta estimates with a view to determining how much weight to afford those estimates:

> The size of the set of comparable firms, the length of data available for each, and the consistency of beta estimates for individual firms over time. A larger set, with long data, and consistent estimates through time would provide greater confidence in the reasonableness of the resulting estimate;

> The variation of beta estimates across firms. Since the betas of all firms (after re-levering) are all estimates of the same thing, they would be expected to be similar. A close grouping of beta estimates across comparable firms would provide greater confidence in the reasonableness of the resulting estimate.[24]

85. Consistent with this, the AER states that it supports the view that:

> reliability of the empirical estimates, availability of data (cross-sectional and across time), consistency of empirical estimates (over time, across businesses, across empirical methods)[25]

are all "key objective criteria" for estimating WACC parameters.

86. However, the beta estimates on which the AER relies are available for only six "comparable" firms, none of which are pure-play electricity distribution or transmission firms. The AER has instructed its consultant to examine only the period since 2002 and only two of the six "comparables" have data for the whole of this period.[26] In my view, these facts alone are enough to question the reliability of the resulting estimates – the data that is required to produce reliable estimates simply does not exist.[27]

87. Moreover, the estimates that have been produced vary substantially over time, across businesses and across empirical methods. For example, the recursive estimates computed by Henry (2008) show that it is quite common for equity beta *estimates* to double or triple over the course of several months.[28] These figures also illustrate the tremendous width of the confidence intervals, which in almost every case contain the value of 1.0. That is, the data cannot reject the hypothesis that the equity beta is 1.0.

88. There is also substantial variation in beta estimates across firms. The re-levered beta estimates for different firms reported by Henry (2008) (which are all supposed to be estimates of the same thing) range from less than 0.3 to more than 1.0.[29]

89. There is also substantial variation in beta estimates across empirical methods, including different estimation techniques (OLS, LAD, etc.) and different sampling frequencies (weekly, monthly, etc.). For example, Henry (2008) reports that some of the "comparable" firms have equity beta estimates that are more than five times the estimates for other firms. For some individual firms the estimate doubles or halves if a different variation of the empirical method is used. These great variations should lead one to have less confidence in the reliability of the results.

90. In summary, it is difficult to imagine any set of estimates faring worse on these "key objective criteria." In my view, this indicates that the data that is required to produce reliable estimates simply does not exist. The estimates that have been produced are neither plausible nor economically reasonable and should not be afforded material weight.

91. It would be standard in a statistical context to consider the 95% confidence interval around any estimate and to conclude that the data is unable to reject any estimate within that interval. It

[24] Gray (2008), p.30.
[25] *Explanatory Statement*, p. 48.
[26] Henry (2008), p.4.
[27] See also Section 7 below for more detail on these methodological issues.
[28] Henry (2008), Appendix 1 and 2.
[29] Henry (2008), p.18.

would also be standard to examine possible sources of bias and other statistical issues that may cause an estimate to be unreliable. Another consideration would be the economic reasonableness or plausibility of any estimate.

Summary and conclusions

92. It is my view that the required return on equity implied by the AER's proposed parameter estimates is implausible. I have reached this conclusion for the following reasons:

a. The estimated required return on equity is lower than the return that investors are currently being promised for lending money to highly rated institutions under contractual terms at a fixed rate;

b. The proposed parameters imply that investors require approximately the same return from lending money to the benchmark firm under contractual terms at a fixed rate, as they require for providing residual equity finance to the same firm; and

c. The proposed parameters imply that an unlevered benchmark firm could fund itself entirely with equity with a required return that is dramatically lower than the fixed rates that are currently available on very highly rated debt.

4. Standard errors and confidence intervals

Estimation of equity beta

93. Empirical equity beta estimates are obtained from regression analysis that seeks to quantify the relationship between stock returns for a particular company and the returns of a broad market index. There is no single standard approach for estimating equity beta. Rather, there are many dimensions to the estimation of equity beta and a range of alternatives are available for each dimension. For example, an analyst estimating equity beta would need to make a series of determinations including those set out below:[30]

a. Which empirical method, or variation of regression analysis, to use (e.g., ordinary least squares (OLS), weighted OLS, least absolute deviation (LAD) and so on);

b. Whether to apply any statistical correction for non-synchronous trading (e.g., Scholes-Williams, Dimson);

c. Whether to apply any statistical correction for bias (e.g., Vasicek, Blume);

d. Whether to use discrete or continuously compounded returns;

e. Which market index to use as the independent variable;

f. Whether to include an assumed value of franking credits as part of the return;

g. What frequency of data to use (e.g., daily, weekly, monthly);

h. What length of data to use (e.g., 4 years, 7 years, 10 years);

i. Whether to include or exclude certain periods that are thought to be unrepresentative (e.g., the technology bubble period);

j. Whether to use a method to screen out or down-weight the influence of outlier data points, and if so, which method to use;

k. Which firms to include in the set of comparables;

l. Whether foreign firms should be included in the analysis, and if so how;

m. When computing portfolio estimates, whether to use equal- or value-weighted average returns or median returns;

n. Which re-levering formula should be used to adjust equity beta estimates to the level of gearing assumed for the benchmark firm;

o. What level of gearing to use for the benchmark firm. That is, what is the efficient level of gearing for an efficiently financed electricity distribution or transmission firm? This cannot be known for sure, and must itself be estimated.

[30] I examine a number of these key choices in more detail in Section 7 below. This section, however, investigates only the impact that the uncertainty about these choices may have on the estimation of standard errors.

94. Different sets of choices along the dimensions set out above can produce substantially different equity beta estimates. There are a very large number of combinations and permutations of the different dimensions to equity beta estimation set out above. Each one of these will produce a different beta estimate and some will be materially different from others. Consequently, the process will produce a range of beta estimates.

95. This is consistent with the views of the ACCC, who state that:

> Because each WACC parameter cannot be known with certainty, there is a *range* of input parameters which could be termed 'reasonable'. This seems to be an area of common agreement.[31]

Role of standard errors

96. The regression analysis that is used to obtain beta estimates produces a standard error for each estimate. The standard error is a statistic that quantifies the statistical uncertainty of a particular beta estimate *conditional* on the particular set of choices made in relation to the factors set out in Paragraph 93 above.

97. The theory and practice of statistics recognises that the regression analysis used to estimate equity beta can only ever produce an *estimate*. The true, but unobservable, equity beta might be above or below the estimate that is produced by applying regression analysis to a particular sample of data. This is consistent with the view of the ACCC set out above. Moreover, the use of historical data to provide an estimate of equity beta involves the assumption that the historical relationship between stock and market returns is a predictor of the future relationship. Relevant considerations in this regard are the reliability and precision of the historical beta estimates. Of course, the forecast of the future beta becomes more imprecise the further into the future we look. That is, the confidence interval around any point estimate becomes wider as we look further into the future.

98. The standard error is designed to provide an indication of how far the true value might differ from the estimate that has been produced. Specifically, there is a 95% chance that the true value falls within a range of approximately two standard deviations below the point estimate to two standard deviations above the point estimate. This range is known as the 95% confidence interval and is quite standard in statistics and econometrics.

99. The standard error and the resulting confidence interval are designed to reflect the statistical uncertainty of a particular estimate. They provide an indication of the statistical precision of the estimate that has been obtained by applying a particular regression technique to a particular set of data. They are *conditional* on the particular technique as applied to the particular sample of data.

100. The standard error and the confidence interval estimate the precision of the estimate obtained by applying a particular econometric method to a particular data sample. They have nothing to say about the range of choices that is available in relation to empirical techniques and data sampling – as set out in Paragraph 93 above.

[31] ACCC (2005). *Assessment of Telstra's ULLS and LSS monthly charge undertakings: Draft decision,* p.62.

AER's conclusion in relation to standard errors

101. The *Explanatory Statement* discusses standard errors of beta estimates at some length and states among other things that:

> The width of the confidence interval is an indicator of the precision of the point estimate.[32]

I agree with this and consider it to be uncontroversial.

102. However, the AER ultimately concludes that it will not use standard errors and the resulting confidence intervals when determining the appropriate equity beta. The *Explanatory Statement* clearly sets out the AER's rejection of confidence intervals in relation to estimates of equity beta:

> …it is likely that a forward-looking equity beta will be represented by a the point estimate of the equity beta rather than the upper and lower bounds.[33]

and that in relation to beta estimates:

> …the AER has had regard to the point estimates rather than the range of possible estimates within confidence intervals.[34]

103. It is my view that one cannot possibly determine the weight to apply to a particular empirical estimate without proper consideration of the statistical precision and reliability of that estimate.

104. I stated this view at the Experts Roundtable[35] and I note that the *Explanatory Statement* endorses this view:

> At a high level Professor Gray stated that it was important to consider all relevant data, different econometric techniques, and market practice.
> It was argued that a considered approach, taking into account all of these aspects, will inevitably apply different weights to the various pieces of empirical evidence available. In doing so, Professor Gray stated as relevant considerations statistical precision and reliability of the empirical estimates…
>
> The AER supports these key objective criteria for estimating WACC parameters as outlined by Professor Gray. The AER's application of these criteria is parameter specific and detailed considerations are contained in the chapters discussing individual WACC parameters.[36]

105. My previous report set out a number of reasons for my belief that the empirical beta estimates available to the AER are statistically imprecise and unreliable and should be afforded little if any

[32] *Explanatory Statement*, p. 216.
[33] *Explanatory Statement*, p.219, error in original.
[34] *Explanatory Statement*, p.219.
[35] AER (2008), Australian Energy Regulator review of WACC parameters for electricity transmission and distribution, Transcript of proceedings, Melbourne, 10 October 2008, pp..3-9.
[36] *Explanatory Statement*, p.48.

weight.[37] The available data is so scant and contaminated that any econometric technique applied to it (no matter how carefully applied) will produce estimates that are imprecise and unreliable.

106. In rejecting the use of standard errors, confidence intervals and R-squared statistics (dealt with in the subsequent section) the AER has no basis at all for determining the precision or reliability of empirical beta estimates.

Other matters in relation to standard errors

107. The *Explanatory Statement* notes that:

> The JIA argue based upon advice from SFG that confidence intervals generally understate the true uncertainty surrounding beta estimates as they do not account for uncertainty surrounding re-levering, gearing and whether the firms are appropriate comparators.[38]

108. Indeed there is uncertainty around a whole range of dimensions of equity beta estimates, as set out in Paragraph 93 above. The *Explanatory Statement* rejects the notion that the confidence intervals (which are already very wide due to the imprecision with which betas are estimated stemming from the data that is available) may be understated due to uncertainty about the items set out above:

> In response to SFG view as to the uncertainty regarding comparator firms, the AER has used the same businesses as proposed by the JIA to obtain a benchmark efficient level of gearing and equity beta. Further, the AER has discussed in sections 5.6 that the market valuation of gearing remains unchanged at 60 per cent and tends to be relatively stable over time. On the issue of re-levering, the AER is unaware of relevering approaches used by regulators resulting in significantly different equity beta estimates. Accordingly, the AER does not consider that the uncertainties flagged by SFG report are likely to be significant to the extent that the range of true values of equity beta (represented by confidence intervals) should be widened.[39]

109. I note that it is unnecessary for the AER to address this issue given that it has "had regard to the point estimates rather than the range of possible estimates within confidence intervals." If, however, the statistical precision of beta estimates (as measured by confidence intervals) *was* considered to be relevant in determining how much weight to assign to those estimates, the uncertainty about the items set out in Paragraph 93 would need to be considered.

110. In my view, there is uncertainty around a whole range of choices (set out in Paragraph 93 above) that must be made when estimating beta and a particular confidence interval is *conditional* on the particular set of choices that has been made and makes no allowance for the fact that it might be quite reasonable to have made a different set of choices – notwithstanding the above quote form the *Explanatory Statement*. In particular:

[37] These reasons include the low R-squared statistics that characterize recent beta estimates, the bias in beta estimates less than 1.0, the low precision with which equity betas are estimated, and a series of economic reasonableness and plausibility considerations.
[38] *Explanatory Statement*, p. 217.
[39] *Explanatory Statement*, p. 217.

a. *Set of "comparable" firms.* One of the key problems in estimating the equity beta of the benchmark firm is that there are *no* listed firms that are truly comparable. Indeed, there are only a small handful of firms that might be considered similar to the benchmark electricity transmission or distribution firm and the majority of these have short and incomplete trading histories. The JIA submission, the AER's consultant report, and the *Explanatory Statement* examine these firms simply because that is all there is. There is certainly no generally-accepted view that a particular set of comparable firms must be the basis of analysis. This should be obvious from the AER's own consultant report – Henry (2008) examines five different combinations and permutations of the set of "comparables."

b. *Efficient level of gearing.* Even if the regulatory process resulted in the benchmark firm having a constant level of gearing (which it does not) this is entirely beside the point. The issue here is whether the 60% gearing level is known for sure with 100% confidence or whether it is an estimate. Clearly, it is an *estimate* of the proportion of debt funding that an efficiently financed benchmark firm could sustain in the circumstances. It is impossible to *know* the optimal capital structure of any firm – at best this can be *estimated.*

c. *Re-levering approaches.* The *Explanatory Statement* reviews a number of different re-levering procedures[40] There are different mathematical formulas and different assumptions about debt betas that can be used. There is no question that these different approaches will result in different equity beta estimates. Consequently, uncertainty about this choice results in uncertainty about the beta estimate.

111. Ignoring any of these uncertainties, or indeed any of those set out in Paragraph 93, would understate the uncertainty in the equity beta estimates and overstate the precision of those estimates.

Use of standard errors in the regulatory setting

112. I have already noted that the standard error of a beta estimate is a measure of the precision of that estimate, conditional on the empirical method that has been selected and on the particular data sample that has been chosen. The precision of the available beta estimates is, in general, one of the relevant considerations to take into account when determining whether to afford material weight to those estimates. In the present regulatory environment there are two other specific reasons to employ standard errors and the associated confidence intervals.

113. First, a confidence interval allows one to conclude whether a particular econometric method applied to a particular sample of data produces an estimate that is significantly different from a particular value. For example, in the current decision-making process it might be argued that the current regulatory precedent is to adopt an equity beta of 1.0. In this context, a confidence interval allows one to test whether or not a particular estimate is significantly different from 1.0. For this reason, it would seem that confidence intervals and standard errors would be relevant considerations.

114. Second, I noted in my previous report (p. 6) that "it follows logically that higher regulatory beta estimates will (other things equal) result in higher regulatory returns and a commensurately higher probability that the regulatory return will be sufficient for network service providers to recover at least the efficient cost of capital employed." If, in the present context, the probability of the regulated return being sufficient to recover the efficient cost of capital is a relevant consideration,

[40] *Explanatory Statement*, pp. 201-202.

some way of estimating this probability is required. This is exactly what the standard error and confidence interval is designed to do.

Summary and conclusion

115. It is generally agreed that confidence intervals based on estimated standard errors measure the statistical precision of the estimate. In particular, the noise (or random variation) in a particular data set means that the true value may be above or below the estimated value. The confidence interval is a measure of how far above or below the estimate the true value might be.

116. There are also a range of data sets and a range of methodological choices that must be applied when estimating beta. Each set of choices produces a different beta estimate. This is another source of uncertainty about what the true beta might be.

117. In my view, both sources of uncertainty about beta estimates should be taken into account and the precision of the beta estimate is a key consideration in determining how much weight to apply to the estimate and whether that estimate justifies (statistically) the conclusion that the estimate is significantly different from an existing default value.

5. R-squared statistics

Interpretation of R-squared statistic

118. In relation to the R-squared statistic in equity beta regression analysis, there appears to be general agreement that:

> A low R-squared indicates that more of the variation in the variables is noise that is unrelated to the effect that is being measured, making it more difficult to obtain statistically reliable estimates.[41]

119. Consequently, the R-squared statistic is directly informative about the statistical reliability of empirical beta estimates, which in turn is a key consideration when determining the weight to be afforded to those estimates. It is standard practice to report the R-squared statistic with any regression results – consistent with the relevance and informativeness of that statistic

120. The *Explanatory Statement* and the AER's consultant report[42] do not report, consider, or give weight to any R-squared statistics. Consequently, the AER has determined that R-squared has no bearing at all on the weight to be applied to empirical estimates of equity beta.

121. My earlier report sets out the R-squared statistics reported by the AGSM Risk Management Service for the available set of "comparable" firms.[43] These R-squared statistics are uniformly very low and in some cases are zero (meaning that the available data is completely uninformative in identifying the relationship between stock and market returns that the beta regression is seeking to measure). We know from the above quote from the *Explanatory Statement* that in these conditions it is "difficult to obtain statistically reliable estimates." In my view, this itself is highly relevant in determining how much weight to apply to those estimates – if an estimate is obtained in circumstances in which it is "difficult to obtain reliable estimates," one should be very cautious about affording any material weight to that estimate.

122. My earlier report also seeks to quantify just how unreliable these sorts of estimates might be. To do this I use a very standard simulation technique.[44] I generate stock and market return data in a setting where the true equity beta is 1.00 (the signal) and where there is random variation in the data (the noise) commensurate with what is observed in practice. I then use the standard regression technique to obtain a beta estimate. This estimate will differ from the true value (of 1.00) due to the noise in the data. I then repeat this procedure one million times and summarise the results in the table that is reproduced below.

[41] *Explanatory Statement*, p. 215.
[42] Henry, O.T. (2008), *Econometric advice and beta estimation*, November 28.
[43] Gray (2008) Section 2.
[44] Gray (2008) Section 2.

Table 3. Simulation results illustrating the relationship between R-squared and beta estimates

Decile	Mean R-squared (%)	Mean beta estimate	Standard deviation of beta estimate	Proportion in which estimates are below 1.0 (%)	Proportion in which estimate is reported as significantly [a] below 1.0 (%)	Proportion in which estimate is reported as significantly [a] above 1.0 (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	4	0.66	0.50	80	13	0
2	15	1.06	0.42	55	5	1
3	25	1.07	0.34	51	5	4
4	36	1.05	0.24	49	4	5
5	46	1.04	0.18	46	4	5
6	56	1.04	0.15	43	3	6
7	65	1.04	0.12	42	3	7
8	75	1.02	0.10	43	4	8
9	86	1.01	0.07	45	4	7
10	95	1.00	0.04	46	4	6
Overall	50	1.00	0.29	50	5	5

a: Significance is determined with reference to a 95% confidence interval.

123. The key result in the table above is the shaded row. What this shows is that where the true beta is 1.00 and the noise in the data is such that the R-squared statistic is very low, the standard regression approach is likely to produce beta estimates that are substantially below the true value of 1.00. That is, the noise in the data, which manifests itself in a low R-squared value, results in beta estimates being downwardly biased. The table shows that it is likely that the standard regression approach will produce beta estimates of 0.66 even where the true beta is 1.00 – in circumstances where the noise in the data is such that the signal-to-noise ratio and R-squared statistic is very low.

124. That is, it is most likely that one will obtain beta *estimates* that are lower than the AER's estimate of 0.8 even when the true value is 1.0 – if the noise in the data is such that the R-squared statistic is low. In my view, this is an important consideration that goes to the weight that should properly be afforded to the empirical estimates. However the AER does not consider (or even report) any R-squared statistics.

125. Figures 1 and 2 of my earlier report show the relationship between the R-squared statistic and equity beta estimates over time for AGL (which is the only "comparable" firm for which a reasonable history of data is available). It is clear that for all observations with an R-squared above 30%, the beta estimate is around 1.0 or more. Moreover, the lower beta estimates tend to be associated with R-squared statistics of less than 10%. That is, the results of the simulation analysis are consistent with the limited empirical data on this point. Based on the simulation results, one would place more weight on those estimates that are associated with higher R-squared statistics. In the case of AGL, this would involve placing more weight the beta estimates that are around 1.0 (with higher R-squared statistics) and less weight on the very low beta estimates that have very low R-squared statistics.

AER's views about R-squared statistics

126. The *Explanatory Statement* sets out several issues in relation to the simulation analysis in my previous report. In this section I summarise and respond to each of these points.

Bias when the R-squared statistic is high

127. The AER states that:

> …the AER observes that SFG has chosen to focus on a sample of results (with 'low' R-squared values) in its simulation and does not comment on whether there may be bias when conducting the experiment for 'high' R-squared results.[45]

128. My previous report focussed on the "low R-squared" case because that is the relevant one – the R-squared statistics for the available set of "comparable" firms are uniformly low. Nevertheless, it should be conceptually obvious that the "high R-squared" case is the converse of the low case. A high R-squared statistic indicates that the signal is strong relative to the noise and that the relationship between stock and market returns (beta) will be more reliably estimated. This is also quite apparent for Decile 10 in Table 3 above (which is reproduced from my earlier report[46]) – where the R-squared statistic is very high, the regression technique reliably recovers the true beta value.

Source of noise

129. The AER states that:

> …when discussing the impact of noise, SFG seems to ignore the cause of the noise. As SFG recognises in its report, this noise is being created by business-specific factors. In other words the signal coming from market risk has not changed rather it is other signals that are evident.[47]

130. What *causes* noise in the data is not relevant to this issue. The point is entirely about the *amount* of noise relative to the signal, and the effect this has on the ability to reliably estimate the underlying signal. The issue in relation to R-squared is the ratio of the signal to the noise. When the R-squared is low, the signal is swamped by noise. I agree with the AER that "this noise is being created by business-specific factors." The point is that the noise is there and it swamps the signal, making beta estimates unreliable.

Purpose of model

131. The AER states that:

> …the model used is not designed to explain as much of total risk as possible. If it was, it may include non-systematic risk factors. Instead the model is a single factor model designed to estimate beta (the sensitivity to market risk).[48]

132. Nowhere in my earlier report[49] do I suggest that we should seek to increase R-squared statistics by adding additional (non-systematic risk) factors or by any other means. I simply make the quite standard point that in circumstances where the R-Squared statistic is low it is difficult to obtain statistically reliable estimates. Nowhere do I advocate anything other than that (a) we should

[45] *Explanatory Statement*, p. 215.
[46] Gray (2008, p. 12).
[47] *Explanatory Statement*, p. 215.
[48] *Explanatory Statement*, p. 215.
[49] Gray (2008).

compute and report R-squared statistics, as is standard practice whenever using regression analysis, and (b) where the R-squared statistic is low, we should be cautious in affording material weight to the resulting estimate.

Alternative statistics

133. The AER states that:

> …the R-squared statistic…is not a direct measure of the precision or stability of the beta point estimate. These are better assessed by sequential and recursive estimates, Hansen's test, and, confidence intervals.[50]

134. Again, the key point (about which there appears to be general agreement) is that in circumstances where the R-Squared statistic is low "it is difficult to obtain statistically reliable estimates." In my view, this alone should lead one to (a) compute and report R-squared statistics, as is standard practice whenever using regression analysis, and (b) apply great caution in affording material weight to the resulting estimate where the R-squared statistic is low.

135. The AER suggests that we should instead conduct sequential and recursive estimates, Hansen tests for structural breaks and so on. This is not relevant to the issue at hand. A time series of beta estimates showing how the *estimate* varies over time could, of course, be conducted. But the point at hand is what weight should be applied to the various estimates that are conducted. Where the R-Squared statistic is low it is difficult to obtain statistically reliable estimates and those estimates should receive little weight. Simply having more estimates to choose from (computed sequentially over different periods of time), but with no R-squared statistic reported for any of them, is no solution at all. In my view, the R-squared statistic for *every* estimate should be reported (as is standard practice whenever reporting regression result) and this should be an important consideration when determining how much weight to apply to the estimate.

Use of simulation analysis

136. The AER states that:

> The AER considers that the simulation analysis of equity beta conducted by the SFG cannot be applied to the empirical estimation of beta since the true value of the equity beta is assumed in the former but truly unknown in the latter.[51]

137. This quote sets out the AER's understanding that simulation analysis is somehow an alternative estimation technique that is proposed to be applied to the available data to obtain an empirical estimate. This is *not* the purpose of simulation analysis in my earlier report[52], or in any of the extensive academic and practitioner literature on the issue.

138. Simulation analysis is regularly used to test the reliability of an econometric method applied to a data set with certain characteristics. The idea is to simulate data that has characteristics that are similar to the real data and then to apply the econometric method to it. One can then compare the estimate obtained by the econometric method with the true value of the parameter. In a simulation analysis, the true value of the parameter is known, because the researcher has

[50] *Explanatory Statement*, p. 215.
[51] *Explanatory Statement*, p. 216.
[52] Gray (2008).

generated the data. If the econometric method consistently and reliably produces estimates that are close to the true value, one can have confidence when it is applied to real data. If the econometric method produces estimates that are highly variable or consistently above or below the true value, one would have no confidence when it is applied to real data. That is, the point of simulation analysis is to determine the degree of confidence we would have in the estimates that are obtained from applying a particular econometric method to a data set with particular characteristics. Simulation analysis is not proposed as, and is never used as, an alternative econometric method for estimating parameters.

139. In the case at hand, simulation analysis is used to create a data set in which the true value of beta *is* known, but which otherwise has characteristics that are similar to real data. We can then apply estimation techniques to the simulated data set and compare the resulting estimate to the known true value. This provides a measure of the reliability of the estimate – whether the particular estimation technique applied to the data produces an estimate that is reliable in the circumstances. The simulation analysis in my earlier report[53] demonstrates that in circumstances where the R-Squared statistic is low it is difficult to obtain statistically reliable estimates, and I consider that point to be uncontroversial.

140. The reason we need simulation analysis is that when analysing real data, the true value of beta can never be known. We can obtain an estimate, but we cannot know how reliable it is in the circumstances. Simulation analysis is not a way of *producing* empirical estimates. It is a technique that is designed to inform about the reliability of an *existing* estimate, in the circumstances.

Conclusion

141. The key point (about which there appears to be general agreement) is that in circumstances where the R-Squared statistic is low "it is difficult to obtain statistically reliable estimates." In my view, this alone should lead one to (a) compute and report R-squared statistics, as is standard practice whenever using regression analysis, and (b) apply great caution in affording material weight to the resulting estimate where the R-squared statistic is low.

142. I note that no R-squared statistics are reported in the *Explanatory Statement* or the AER's consultant report. The *Explanatory Statement* sets out a number of reasons to support this stance and I respond to each of these reasons in turn above. In my view, the AER's proposed reasons illustrate a misconception of the results and purpose of the simulation analysis.

[53] Gray (2008).

6. Bias in beta estimates

Existence of bias

143. In my earlier report, I demonstrated that beta estimates derived from an OLS regression of stock returns against market returns are systematically biased in that low estimates have a high probability of understating the true risk of the stock. Importantly, I showed that this statistical bias exists even though "noise" or "random error" in the data is perfectly symmetric – being equally likely to increase or decrease stock prices.[54]

144. Conceptually, it should be clear that *every* beta estimate below 1.0 is negatively biased (i.e., more likely to underestimate the true value than overestimate it) even if noise is perfectly symmetric – the only question is the extent of the bias. I explained this conceptual point in my earlier report as follows:

> Suppose that every firm is known to have a true beta of 1, but when we run regressions there is estimation error, so the regression estimates can be above 1 or below 1. Those estimates that are below 1 are known to have negative estimation error (as that is the only way the estimate could have been below 1 in this setting) and those that are above one are known to have positive estimation error. That is, by observing the beta estimate, we can infer something about how it has been affected by estimation error.
>
> Now suppose that all firms have a beta of either 0.9, 1.0 or 1.1, with one third of stocks in each group. But we don't know which is which, so we have to rely on our beta *estimates*. Also suppose that every time we estimate beta there is a one-third chance that we recover the true value or that our estimate is over- or under-estimated by 0.1. That is, there are a range of true betas, and estimation error for any individual beta estimate is symmetric. Now suppose you estimate a particular firm to have a beta of 0.9. There are two possibilities here (a) the true beta is 0.9 and the estimation error was 0; or (b) the true beta is 1 and the estimation error was -0.1. That is, in this case, we know from observing the beta estimate of 0.9 that it has either zero or negative estimation error – this is a negative bias.
>
> But does this negative bias disappear when we introduce the possibility that some stocks might have a true beta of 0.8, so that our estimate of 0.9 has been contaminated by *positive* estimation error? No – imagine betas being normally distributed around 1. There are more firms with a beta close to 1 than with beta far from 1. So there will always be more chance that a beta estimate of 0.9 will be from a true beta of 1 with negative estimation error than from a true beta of 0.8 with positive estimation error. Moreover the further our beta estimate is below 1, the more likely it is to have been affected by negative estimation error.[55]

145. My earlier report also noted that this conceptual point – all equity beta estimates less than 1.0 are downwardly biased – is well-known in the relevant literature.[56] Bias means that when we obtain a

[54] Gray (2008) Section 3.
[55] Gray (2008), p.20.
[56] Gray (2008) Section 3.

beta estimate that is less than 1.0 we know that it is more likely to have been affected by negative estimation error than by positive estimation error. Consequently, our best estimate of the true value of beta is *higher* than the estimated value.

146. The *Explanatory Statement* does not address this conceptual point or the explanation of it in my earlier report.[57]

147. Moreover, the *Explanatory Statement* presents equity beta estimates that are less than 1.0. These estimates are certain to be downwardly biased. There is no question about the existence of bias – the only question is about the magnitude of that bias. However, the *Explanatory Statement* does not recognise the existence of bias and does nothing to quantify or correct for that bias in the estimates of equity beta – even though the existence of bias is well-recognised in the relevant literature and bias correction methods are commonplace among commercial data service providers.

Materiality of bias

148. My earlier report also contained the results of a simulation analysis designed to illustrate the potential materiality of the bias in equity beta estimates.[58] In this analysis, each firm was assigned a true beta. Stock and market returns were then generated to be consistent with that true beta, and with the same degree of (symmetric) random variation or noise that is observed in actual data. The true betas could be higher or lower than 1.0, with the mean true beta being 1.0 – as must be the case according to the very definition of beta. Table 4 below summarises the relevant results.[59]

Table 4. Simulation results illustrating the bias in beta estimates

Decile	Mean actual beta	Mean beta estimate	Prob Estimate > Actual Beta (%)
(1)	(2)	(3)	(4)
1	0.53	−0.66	1
2	0.72	0.02	5
3	0.82	0.36	14
4	0.90	0.64	27
5	0.97	0.88	42
6	1.03	1.12	58
7	1.10	1.37	73
8	1.18	1.64	86
9	1.28	1.99	95
10	1.46	2.66	99

149. This table ranks the beta estimates from lowest to highest and summarises the results for each decile. The average *true* beta for the firms in each decile is reported in Column (2) and the average beta *estimate* is reported in Column (3). What the results show is that in *all* cases where the estimate is less than 1.0 it is downwardly biased (less than the true value) – consistent with the conceptual argument above. For example, in Decile 4 for the average firm the beta estimate is 0.64 whereas the true value is 0.90. Of course, the reverse is true for estimates above 1.0.

[57] Gray (2008) Section 3.
[58] Gray (2008) Section 3.
[59] Gray (2008), p. 22.

150. The AER's response to this evidence is as follows:

> In the simulation, a beta estimate below one is only more likely to underestimate the true beta because it is known that the estimate is drawn from a distribution with a mean of one. If, for example, the distribution of true betas was known to have a mean of 0.7, and all the rest of Professor Gray's assumptions were held constant, this result would be markedly different. In this simulation, all beta estimates between 0.7 and 1.0 (or greater) would be more likely to overestimate the true beta than overestimate it. The higher the beta estimate above 0.7, the more likely the beta estimate would be to overestimate the true beta.
>
> Assuming the mean of the distribution is one may be a reasonable assumption when the beta is randomly selected from the market at large, but that is not the case here. The population is not the entire market but a small set of comparator firms that have been carefully selected. Whilst the mean of the true betas from this population cannot be observed, strong empirical and conceptual evidence, as outlined above, would suggest that the mean of the true betas is less than 1.0. Accordingly it is incorrect to infer that a beta estimate from any of the carefully selected comparator firms less than one is more likely to understate than overstate the true beta.[60]

151. I have used a mean beta of 1.0 in my simulation analysis because the mean beta must be 1.0 according to the very definition of beta. It would be entirely inappropriate to use any other value.

152. Moreover, the results in Table 4 above clearly show that even for deciles where the true beta *is* less than 1.0, beta estimates are downwardly biased. For example, in Decile 4 for the average firm the beta estimate is 0.64 whereas the true value is 0.90.

153. The AER seems to be suggesting that its empirical estimates are not downwardly biased because they already know the true value to be less than 1.0 on the basis of "empirical and conceptual evidence."[61]

154. Consider first the "empirical" evidence. The AER produces empirical estimates that are less than 1.0 then argues that there is no bias in them because there is empirical evidence that the values are less than 1.0. This is entirely circular. Even if various beta estimates corroborated one another (which they do not – there is tremendous variation in the estimates across firms and even for the same firm across time) this still has nothing to do with bias. *All* beta estimates less than 1.0 are downwardly biased, so the fact that two estimate might both be less than 1.0 does nothing to alleviate the problem.

155. This leaves the "conceptual" evidence that is discussed in Section 2 above. Here the argument is that, even before any empirical estimation is performed, the AER knows that the beta parameter will be less than 1.0 – based on its own conceptual reasoning. Section 2 above establishes that this reasoning is flawed due to a misconception about the role of financial leverage. In my view, there is no basis for an a priori view belief that the equity beta for the benchmark firm must be less than 1.0.

[60] *Explanatory Statement*, pp. 228-229.
[61] *Explanatory Statement*, pp. 228-229.

156. Even if it were correct for the *Explanatory Statement* to set out a priori view that the equity beta for the benchmark firm must be less than 1.0 (which it is not), it would surely not be claimed that conceptual reasoning would lead anyone to believe that any firm with 60% gearing would have an equity beta of 0.44, which is what the AER concludes is supported by the available data.[62] Using the AER's unlevering procedure produces an asset beta of 0.176 which cannot seriously be considered to be plausible. Consequently, the observed estimate is below even the lowest possible pre-conceived expectation (even based on faulty conceptual reasoning) and is therefore downwardly biased. Again, the question is not about the existence of bias, but only about the amount of bias and the effect this has on the weight that should properly be applied to the empirical estimates.

157. In summary, my earlier report[63] shows that beta *estimates* less than 1.0 are more likely to be below the true beta than above it and are therefore downwardly biased. When we obtain a beta estimate that is less than 1.0 we know that it is more likely to have been affected negatively by estimation error. Consequently, our best estimate of the true value of beta is *higher* than the estimated value. The AER argues that it is reasonable to hold an a priori view that the equity beta of the benchmark firm is less than 1.0 based on "empirical and conceptual evidence." In my view, the "empirical" evidence is circular and the "conceptual" evidence is based on flawed reasoning and does not contradict the existence of bias in any event.

AER approach

158. The AER considers the approaches that commercial data service providers use to correct for bias in beta estimates and concludes that:

> Rejecting these adjustments, which are intended, in part, to improve the precision of beta estimates, does not mean that the AER has not had regard to the issue of precision. Rather, the AER considers that the issue of precision can better be improved through other methods…such as:
> calculating industry portfolio betas to reduce the estimation error in individual beta estimates
> applying a number of different beta estimation techniques to deal with outliers
> estimating betas across extended time periods
> excluding data from the 'tech bubble', and
> using foreign betas of comparable firms as a 'cross-check'.[64]

159. The AER has apparently misunderstood the purpose of the approaches that are used by commercial data service providers. These approaches are designed to correct for the *bias* in equity beta estimates that is explained conceptually above and illustrated by the simulation analysis. The AER rejects these approaches on the basis that they are designed to improve *precision* and that the AER has other methods to do that. But *bias* and *precision* are two quite different concepts.

160. *Precision* refers to the standard deviation of the estimate – an imprecise estimate has a wide confidence interval such that the true value of beta might vary considerably from the estimate.

[62] *Explanatory Statement*, p. 11.
[63] Gray (2008) Section 3.
[64] *Explanatory Statement*, p. 230.

Precision is a symmetric concept – the true value is equally likely to be above the point estimate as below it.

161. *Bias*, however, is a directional concept. As explained above, when we obtain a beta estimate that is less than 1.0 we know that it is more likely to have been affected negatively by estimation error. Consequently, our best estimate of the true value of beta is *higher* than the estimated value. That is, beta estimates below 1.0 are likely to be lower than the true value of beta.

162. The beta estimates available to the AER are both imprecise *and* biased. None of the things the AER has done have any relevance to bias, and the AER itself states that it has done these things to improve *precision*. However, precision is measured in terms of standard errors and confidence intervals and, as summarised in Section 4 above, the AER has rejected the use of such measures and decided to rely on point estimates of beta instead.

163. In my view, the point estimates on which the AER relies are both biased and imprecise. But given the quality and amount of data, there are no magic cures. The AER has a *very* small set of "comparable" firms and a very short period of data (since most of the firms in the data set have only been listed for a very short time). It is simply not possible to produce unbiased and precise beta estimates from the scant and noisy data that is available.

164. Rather, it is my view that statistical problems such as bias and imprecision in the point estimates on which the AER relies add further weight to the conclusion that these estimates are unreliable and should be afforded little or no weight.

Summary and conclusions

165. If one has no preconceived ideas about what the true equity beta of a particular firm should be, the best prior expectation of its equity beta is 1.0, the beta of the average stock. If one then estimates the equity beta and obtains an estimate less than one, it is certain to be downwardly biased – in the sense that the estimate is more likely to have been negatively affected by estimation error. This is a direct consequence of the fact that the distribution of betas is bell-shaped around a mean of 1.0. Consequently, the best expectation of the true beta is something above the estimated value.

166. The AER argues that its an a priori view that the equity beta for the benchmark firm is less than 1.0 is justified by conceptual reasoning. In my view, this reasoning is flawed and is based on a misconception of the relationship between financial leverage and beta. Consequently, any beta estimate less than 1.0 is downwardly biased and this should be considered when determining how much weight to afford any empirical estimate.

167. Even if the AER's a priori view is correct, the beta estimate on which it places most reliance is below even the lowest possible a priori expectation (even based on faulty conceptual reasoning) and is therefore still downwardly biased. The question is not about the existence of bias, but only about the amount of bias and the effect this has on the weight that should properly be applied to the empirical estimates.

7. What can be learned from the data analysed by the AER? A review of Henry (2008) and the AER's interpretation of the results

Description of data

168. The *Explanatory Statement* sets out the AER's analysis of the empirical estimates of beta. The AER considers beta estimates for a set of Australian firms and for a set of international firms. It is clear that the AER considers the estimates in relation to the Australian firms to be most relevant and the international firms to provide only a cross check. Specifically:

> …the AER will be exercising extreme caution when examining foreign beta estimates for the purposes of setting a benchmark efficient equity beta…The AER considers that it may be appropriate to use the point estimates of foreign equity betas as a cross check.[65]

169. In relation to beta estimates for Australian firms, the AER was specific in the instructions given to its consultant in terms of the time period to be examined. Henry (2008) notes that:

> The consultant was instructed by the ACCC to examine data over the period January 1st 2002 to 1st September 2008.[66]

170. Henry (2008) examines a total of ten firms. Four of these firms are ultimately excluded from the analysis due to concerns that they are not representative:

> Given the concerns about the impact of takeover activity and the quality of the data available for AAN and GAS expressed in section 5.1 below, we exclude these stocks from our portfolio analysis. Moreover, data on these stocks is not available for the full sample period January 1st 2002 – September 1st 2008 as both stocks were delisted prior to the end of the sample. Similarly, AGKX was excluded because of concerns about the impact of corporate restructuring on the price data. Finally, given that the focus of ORGX is retail rather generation we do not consider this stock.[67]

171. This leaves only six firms. Of these six firms, only two had data available for the period specified by the AER (Henry, 2008, p.5).

172. The most standard approach for estimating equity betas uses returns sampled at the monthly frequency. However, the paucity of the data that is available is clearly a concern for the AER's consultant, who concludes that:

> Given the short sample available for firms such as DUEX, HDFX, SPAU and particularly SKIX, the use of monthly data is unlikely to produce statistically valid inference.[68]

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[65] *Explanatory Statement*, p.197.

[66] Henry (2008, p.4). Note that Henry (2008, p.6) does mention estimates for two firms based on longer time periods, but these periods include the tech bubble and use a price index instead of the universally adopted accumulation index as the proxy for the market return, and should therefore be ignored.

[67] Henry (2008, p. 8).

[68] Henry (2008, p. 5). As a result, Henry uses returns sampled at the weekly frequency. I discuss this further below.

173. Due to these problems with the availability of data, Henry (2008) uses returns sampled at the weekly frequency. It appears that Henry uses weekly returns due to the fact that the more standard monthly returns would produce such a small number of observations that nothing of any use could be derived from it. He refers to the weekly returns as nothing more than a "best compromise" in the circumstances.[69]

174. Consequently, the sample of data that forms the basis of the AER's empirical estimates of beta consists of returns for only six firms, none of which are pure play electricity transmission or distribution businesses, and for only two of which is data available for the (short) period specified by the AER.

175. In my view, the scant and incomplete data set that is relied upon by the AER is not sufficient to produce beta estimates that are robust or reliable.

176. In this regard, I note the view of the AER that:

> The AER considers that a sample of four firms is unlikely to provide a robust equity beta estimate.[70]

and that the data set on which the AER's estimates are based consists of four firms or less for the majority of the sample period.

Analysis of data

177. In my view, a reliable estimate of the equity beta cannot be obtained from the data set available to Henry (2008). He has available only six firms, none of which are directly comparable and only two of which have data for the truncated period specified by the AER. The problem is that there is simply not enough data. That problem cannot be remedied by measuring returns in different ways or applying variations to the estimation methodology. If there is not enough food to feed a family, slicing or dicing it in different ways will not help. Henry has analysed the data set in accordance with his instructions – but it is so small and incomplete that nothing can be done to it to produce reliable results. It is not surprising that, as set out above, the analysis of this data set produces results that are implausible.

178. Table 1 of Henry (2008) sets out equity beta estimates based on returns measured in continuous and discrete form and based on the OLS and LAV regression methodologies.[71] All of the different combinations of return measures and empirical technique are applied to the same limited data set. For the reasons set out above, it is my view that the data is insufficient to expect that any variation of the methodology could produce robust and reliable results. If, however, the estimates from this table are to be taken at face value, the following considerations would apply:

a. They are raw beta estimates and must be re-levered to 60% before they can be compared with the equity beta for the benchmark firm;

b. Several of the estimates in the table are clearly implausible and could not possibly be taken seriously as estimates that one would use in the CAPM to estimate the required return on

[69] Henry (2008, p.20).
[70] *Explanatory Statement*, p. 195.
[71] Henry (2008, p.5) and reproduced in the *Explanatory Statement*, p. 200.

equity. For example, the estimated equity beta of 0.13 for Envestra implies a required return of 4.75%,[72] and an asset beta of 0.0375;[73]

c. The estimates differ greatly between firms and across estimation methods. Some of the "comparable" firms have equity beta estimates that are more than five times the estimates for other firms. For some individual firms the estimate doubles or halves if a different variation of the empirical method is used. These great variations should lead one to have less confidence in the reliability of the results. Indeed Henry (2008, p. 6) notes that "it is clear that the estimates themselves vary across estimator, which may suggest the presence of outliers or structural instability."

179. In my view, the sample data used by the AER is insufficient to produce robust and reliable estimates. An examination of the characteristics of the estimates that *are* produced from this data set confirms this view.

Adjustment for non-synchronous trading

180. It is well known in the relevant literature that the beta estimate of a stock that trades less frequently than the average stock in the index will be downwardly biased. Henry (2008) considers various statistical adjustments for this non-synchronous trading to try to address this form of bias.

181. By far and away the major issue in relation to the estimation of equity beta is that there is not nearly enough data. The Australian data from 2002-2008 is scant and incomplete at best and realistically incapable of generating robust and reliable estimates – there is just not enough of it. In reality, it really doesn't matter how many different ways we process that data, it is the same tiny and incomplete data set that is being used over and over and over again. The fact that we might use discrete or continuous returns or that we might create equal- or value-weighted portfolios out of it does not change that fact that there is simply not enough data to produce anything that is robust or reliable.

182. The problem of insufficient data cannot be overcome by applying slightly different methodological refinements to the same data set. Applying an adjustment for non-synchronous trading to the AER data set is analogous to putting a band aid on a paper cut while leaving a severed aorta untreated – it will improve things, but relatively little.

183. It should certainly not be interpreted that these different methodological variations are in any way independent and corroborate one another. It is the same inadequate data set that is being processed and re-processed in slightly different ways.

Portfolio estimates

184. The AER concludes that:

> Individual equity beta estimates should not be used to inform a forward looking equity beta for a benchmark efficient network service provider. Rather, primary weight should be placed on portfolio estimates of equity betas.[74]

[72] Using a risk free rate of 3.97% and a market risk premium of 6%.
[73] Using the approach adopted by the AER to convert between asset and equity betas.
[74] *Explanatory Statement*, p. 251.

185. Henry (2008) reports equal- and value-weighted portfolio estimates in his Tables 3 and 5 respectively. His portfolio estimates for the time period specified by the AER (his P1) contains only two firms. Moreover, his portfolio estimates based on six "comparable" firms (his P5) cover only 19 months of data.

186. By any measure, the data available for these analyses is wholly inadequate. Two firms and 19 months of data would not even be referred to by most practitioners as "portfolio estimates" of beta. Estimates can be mechanically produced by running this data through the relevant computer programs, but it would be folly to rely on the results that are obtained from such a scant and incomplete set of data.

187. The AER produces its own portfolio estimates.[75] The AER's approach is to use whatever firms are available over its 2002-2008 period. That is, the portfolio consists of only two firms for the first two-and-a-half years and then more firms are added until the last 19 months is based on all six firms. This is another slant on the same scant and incomplete set of data that cannot be expected to produce robust and reliable estimates.

188. The fact that the AER has produced and relied on this portfolio estimate is surprising given its stated view (with which I agree) that:

> The AER considers that a sample of four firms is unlikely to provide a robust equity beta estimate.[76]

189. The portfolio that the AER has produced contains four or less firms for the majority of the data period examined. At a maximum it contains six firms, but this is only for 19 months. Moreover, if a set of four firms is "unlikely to provide a robust equity beta estimate," a sample of six firms for part of the data period should not distil great confidence in the estimate produced.

Adjustment for bias from estimation error

190. Section 3 above sets out the means by which random (symmetric) noise causes a downward bias in equity beta estimates. In this section I address the specific issue of how Henry (2008) implements the Vasicek adjustment to mitigate this effect.

191. The task for the regulator is to estimate an appropriate beta from a cross-section of firms (between two and six over the sample period). The approach of Henry (2008) is to (1) estimate an appropriate beta from a cross-section of firms, then (2) use that estimate as the "prior" in the Vasicek technique. But if we already have an appropriate beta estimate in Step (1), the job is complete and no further analysis is required. The second step is entirely circular – if we start with the mean of the beta estimates of our sample of firms, then we adjust all of the individual beta estimates towards that mean, then we again take the mean of the (adjusted) individual estimates, we are back where we started, by construction!

192. I made this point in my earlier report[77] and it is acknowledged in the *Explanatory Statement*.[78] However, the AER appears to endorse the approach of Henry (2008) on the basis that:

[75] *Explanatory Statement*, p. 236.
[76] *Explanatory Statement*, p. 195.
[77] Gray (2008) section 3.
[78] *Explanatory Statement*, p. 229.

> Vasicek (1973) recommends that the parameters of the distribution 'are chosen to reflect ***all*** the information on beta available prior to sampling.'[79]

193. But Vasicek is seeking estimates of betas for *individual* firms – not an average beta across firms or the beta of a portfolio of firms. The betas for individual firms *will* move as they are adjusted toward the mean beta for a sample of firms. This is the point that Vasicek is making. But if one then re-takes the mean of the adjusted betas (which is effectively what the regulator is doing) we are back where we started – by construction – and the whole exercise is pointless. Suppose we have three numbers: 1, 2, and 3. The mean is 2. If we adjust all numbers 50% of the way towards the mean, we would have adjusted numbers of 1.5, 2, and 2.5. Some of the individual numbers have changed. But if we then re-take the mean, it is again 2.

194. For Vasicek (1973), the *starting* point is a reliable estimate of the mean beta for a sample of firms and the task is to find beta estimates for individual firms.

195. In the task at hand, however, the *ending* point is a reliable estimate from the sample of firms. The starting point is that we don't know what the appropriate beta estimate is and we have no preconceived ideas other than our knowledge that on average the appropriate equity beta is 1.0 and that this is consistent with regulatory precedent.

196. For these reasons, it remains my view that any Vasicek adjustment should be based on a "prior" or default value of 1.0 rather than on the mean beta estimate from the small sample of "comparable" firms.

Use of data prior to the technology bubble

197. The AER's instructions to its consultant were to construct beta estimates using data from the 2002-2007 period for the small set of Australian "comparables."[80] Henry (2008) also produces estimates for AGL beginning in 1990, but these estimates are based on a non-standard proxy for market returns and include the technology bubble period.[81] No estimates are provided by the consultant nor considered by the AER for any period prior to 1990.

198. As set out above, I conclude that the post-bubble Australian data is so scant and incomplete that one cannot reasonably expect robust and reliable beta estimates to be produced from it. I also note that the estimates that are produced from this small amount of data are simply implausible in a number of respects. My view is that the data from the pre-bubble period is relevant and should be considered. The AER takes a different view and does not consider this additional data, concluding that:

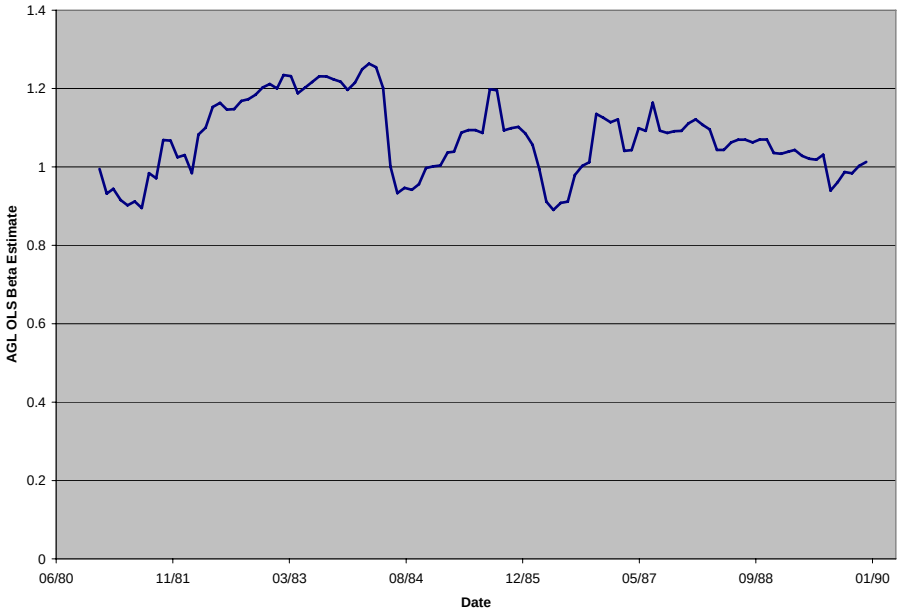
> …the AER observes that for the majority of the period prior to the technology boom that only two energy network businesses (AGL and Envestra) traded on the stock market and is therefore the period prior to the technology bubble may not provide a robust industry average of equity beta estimates.[82]

[79] *Explanatory Statement*, p. 230.
[80] Henry (2008, p.4).
[81] Henry (2008, p.6).
[82] *Explanatory Statement*, p. 207.

199. In fact, the AER is incorrect about there being only two comparable firms for most of the pre-bubble period. Envestra was not listed until 1997, so for the great majority of the pre-bubble period AGL was the only listed comparable firm.

200. I agree with the AER that one cannot expect data from two (or one) firm to provide robust or reliable beta estimates. However, given the paucity of post-bubble data it would seem that beta estimates from the pre-bubble period are relevant and should at least be considered – even if only as a cross-check. However, the AER has not considered the pre-bubble estimates and its consultant did not examine any data or construct any estimates prior to 1990. Figure 2 below plots the AGSM-CRIF raw beta estimates for AGL for the decade prior to 1990.

Figure 2: Raw AGSM-CRIF beta estimates for AGL



Source: AGSM Centre for Research in Finance, Risk Management Service.

201. Figure 2 shows that the beta estimates for AGL right through the 1980's were around 1.0 and on average higher than 1.0. During this period, AGL's assets were substantially regulated ones subject to rate of return regulation. I do not suggest that these estimates alone would provide a robust and reliable basis for estimating the beta of the benchmark business. However, it is my view that these estimates are relevant to the estimation of the equity beta for the benchmark firm and should be considered. This is especially the case where the other data that is available is scant and incomplete and produces output that is implausible.

Summary and conclusions

202. In my view, the scant and incomplete data set that is relied upon by the AER is not sufficient to produce beta estimates that are robust or reliable.

203. Different variations in which the same data set is processed and re-processed cannot address the problem of lack of data and do not provide independent estimates of beta.

Appendix: "Financial risk" and equity beta

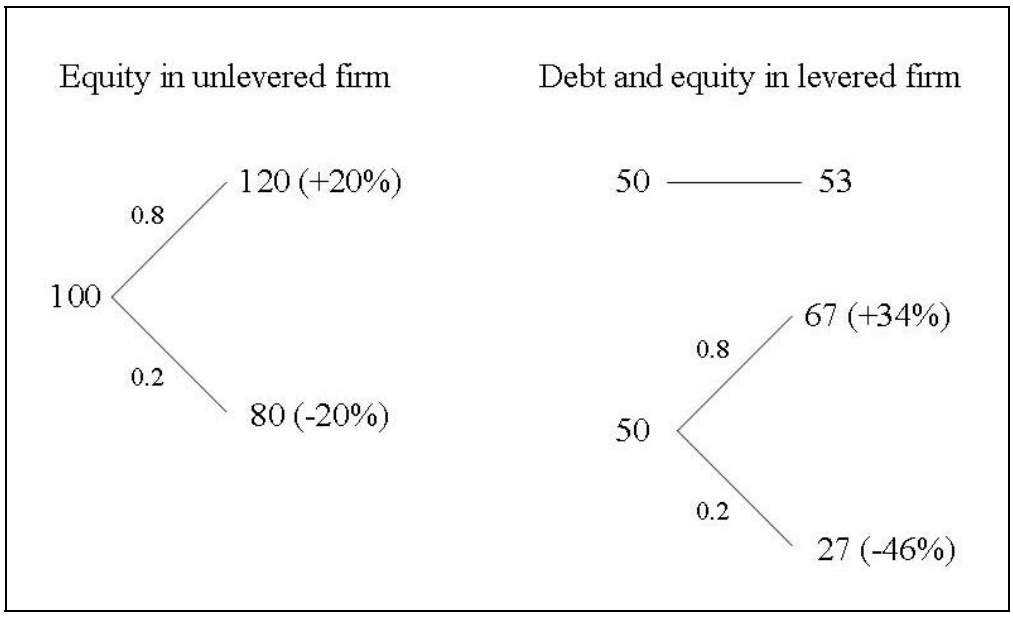
204. It is universally agreed that the equity beta is made up of two components (the risk of the firm's business activities [asset beta] and the amount of financial leverage). There are different views about how to interpret the second component. The JIA view is that the second component of equity beta is the amount of financial leverage (the amount of debt vs. equity finance) and that its effect on equity beta can be quantified via a specific mathematical formula that multiplies the asset beta by the amount of financial leverage to obtain the equity beta. This same approach is also used by the AER on p. 202 of the *Explanatory Statement*.

205. The AER then sets out an alternative approach on p. 193 of the *Explanatory Statement*. This alternative approach introduces a notion of "financial risk" which seems to refer to various risks associated with borrowing activities and the variability in interest rates in particular.

206. In a simple example in this Appendix, I show that even if all of the risks and costs pertaining to the firm's debt finance could be immediately "passed through" to customers and indeed even if all borrowing was completely risk free and a rate that was perfectly known well in advance, financial leverage would still affect equity beta in exactly the same way as proposed by the JIA and adopted on p. 202 of the *Explanatory Statement*.

207. Suppose a firm currently has assets with a market value of $100mm. Over the course of the next year, there is an 80% chance that the value of the assets will increase to $120mm, and a 20% chance that the value of the assets will fall to $80mm. If this firm is unlevered, there is no debt and the equity holders will have the sole claim over the assets. This is illustrated in the left-hand panel of Figure 1 below. In this case, note that the value of equity may appreciate (with probability 0.8) or depreciate (with probability 0.2) by 20% over the course of the next year and the expected return on equity is 12% (= 0.8 × 20% + 0.2 × −20%). This would be consistent, for example, with a risk-free rate of 6%, an equity beta of 1.0, and a market risk premium of 6%.

Figure 1: Illustrative example – financial leverage and equity beta



208. If this firm were 50% levered, the value of the debt holders' claim amounts to 50% of the value of the firm's assets. The value of the equity holders' claim accounts for the other 50%. In this case, the current value of debt is $50mm and at an interest rate of 6% p.a., $53mm will be

required to pay out the debt holders one year from now. Note that the debt is risk-free. Even in the worst possible scenario, the firm's assets are worth $80mm, which is more than enough to pay the debt holders the $53mm they are due. This is illustrated at the top of the right panel of Figure 1 above.

209. The current value of equity is $50mm, and one year from now the equity holders will be entitled to the value of all of the assets of the firm less the $53mm required to pay out the debt holders. This is illustrated at the bottom of the right-hand panel of Figure 1. Thus, in the "good" state the value of the firm's assets is $120 million, $53 million of which is used to repay debt, leaving $67 million to be distributed to equity holders. In the "bad" state the value of the firm's assets is $80 million, $53 million of which is used to repay debt, leaving $27 million to be distributed to equity holders. In this case, note that the potential change in the value of equity is much more extreme than for the unlevered firm (from +34% to –46%). This is financial risk caused by the fact that the firm has borrowed funds. The expected return on equity has increased to 18% (= 0.8 × 34% + 0.2 × -46%) to compensate equity holders for bearing this financial risk. The equity beta (which now also reflects the financial risk that comes from debt financing) consistent with this expected return is 2.0:

$$\begin{aligned} r_e &= r_f + \beta_e \times MRP \\ &= 6\% + 2.0 \times 6\% = 18\%. \end{aligned}$$

210. Note that all of this example is consistent with the AER's approach for incorporating the effect of financial leverage set out on p.202 of the *Explanatory Statement*:

$$\begin{aligned} \beta_e &= \beta_a \left(1 + \frac{D}{E}\right) \\ 2.0 &= 1.0 \left(1 + \frac{50}{50}\right). \end{aligned}$$

211. That is, the precise way in which financial leverage affects the equity beta is clearly set out by the AER in the *Explanatory Statement* itself.

212. Also note that throughout this example the debt is risk free and the interest rate is known with certainty well in advance. The effect that debt financing has on equity beta has nothing at all to do with uncertainty about what interest rates might be and whether this can be passed through to customers (as set out on p.193 of the *Explanatory Statement*). This is beside the point. Rather, financial leverage affects equity beta by levering up the range of possible returns to equity. More financial leverage means more levering up of equity returns and a commensurately higher equity beta (as set out on p. 202 of the *Explanatory Statement* and in the formula above, and as illustrated in the example).

References

Australian Energy Regulator, (2008), "Review of the weighted average cost of capital (WACC) parameters for electricity transmission and distribution," 8 August, www.aer.gov.au/content/index.phtml/itemId/722190

Australian Energy Regulator (2008), Electricity transmission and distribution network service providers – Review of the weighted-average cost of capital (WACC) parameters: Explanatory statement, December, www.aer.gov.au/content/index.phtml/itemId/722190

Elton, E. J., M. J. Gruber, D. Agrawal, and C. Mann, (2001), *Journal of Finance*, LVI, 1, 247-277.

Essential Services Commission, (2008), "Gas Access Arrangement Review 2008 – 2012: Final Decision," 7 March.

Handley (2008), *A note on the value of imputation credits*, December, www.aer.gov.au/content/index.phtml/itemId/722190.

Henry, O.T. (2008), *Econometric advice and beta estimation*, November 28, www.aer.gov.au/content/index.phtml/itemId/724620

Queensland Competition Authority, (2006), "Revised access arrangement for gas distribution networks: Envestra (Final Decision)," May.