Equity beta

Report for Jemena Gas Networks, ActewAGL and Networks NSW

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1. Background and conclusions

Overview and instructions

1. SFG Consulting (**SFG**) has been retained by Jemena Gas Networks, ActewAGL and Networks NSW to provide our views on the estimation of equity beta for use in the Capital Asset Pricing Model (**CAPM**) under the National Electricity Rules and National Gas Rules (**Rules**). In particular, we have been asked to provide an opinion that:

    a) describes the role of the equity beta in applying the Sharpe-Lintner CAPM, including the theoretical and empirical basis for its development;

    b) describes how the equity beta is estimated in practice (and is used to estimate the return on equity) in Australia;

    c) reviews how the AER proposes to estimate the equity beta—as set out in rate of return guideline and supporting explanatory statement (released in December 2013)—and advises whether this provides an equity beta estimate for the Sharpe-Lintner CAPM that produces an allowed return on equity that is:

        i) commensurate with the efficient financing costs and degree of risk of a benchmark efficient entity; and

        ii) reflective of prevailing conditions in the market for equity funds.

    d) estimates the equity beta for the Sharpe-Lintner CAPM that produces an allowed return on equity that is:

        i) commensurate with the efficient financing costs and degree of risk of a benchmark efficient entity; and

        ii) reflective of prevailing conditions in the market for equity funds.

2. In preparing the report, we have been asked to:

    a) consider different approaches to estimating the equity beta for the benchmark efficient entity, including any theoretical restrictions on empirical estimates or any adjustments made in practice (e.g. Vasicek and Blume);

    b) consider how sample size affects the reliability of equity beta estimates;

    c) consider how leverage affects the equity beta;

    d) consider any comments raised by the AER, other regulators or their consultants on how to estimate the equity beta, including (but not limited to):

        i) whether the Black CAPM informs the equity beta estimate for the Sharpe-Lintner CAPM, and if so how;

        ii) how leverage affects equity beta,

        iii) whether and how foreign data is relevant to estimating an Australian equity beta; and

e) use robust methods and data.

3. Our instructions are set out in Appendix 1 to this report.

4. This report has been authored by Professor Stephen Gray, Professor of Finance at the UQ Business School, University of Queensland and Director of SFG Consulting, a specialist corporate finance consultancy. I have Honours degrees in Commerce and Law from the University of Queensland and a PhD in financial economics from Stanford University. I teach graduate level courses with a focus on cost of capital issues, I have published widely in high-level academic journals, and I have more than 15 years' experience advising regulators, government agencies and regulated businesses on cost of capital issues. A copy of my curriculum vitae is attached as Appendix 2 to this report.

5. My opinions set out in this report are based on the specialist knowledge acquired from my training and experience set out above.

6. I have read, understood and complied with the Federal Court of Australia Practice Note CM7 *Expert Witnesses in Proceedings in the Federal Court of Australia.*

Summary of conclusions

7. Our primary conclusions in relation to the estimation of the allowed return on equity are set out below.

Key statistical issues

8. Our conclusions in relation to key statistical issues are:

a) Equity betas must be re-levered in the standard way to ensure comparability with the assumed leverage of the benchmark efficient entity. It would be inconsistent and wrong to compare an equity beta that reflects, say, 45% leverage with a benchmark entity that has 60% leverage;

b) The Vasicek correction for the bias caused by statistical estimation error should be employed, consistent with the practice of several commercial data services and university and professional training courses;

c) The non-standard LAD estimation should not be used as it produces beta estimates that are systematically biased;

d) There is a trade-off between selecting a sample of firms that is closely comparable to the benchmark firm and having a sample size that is sufficiently large to obtain statistically reliable results. Ultimately, this issue comes down to an assessment of the reliability of beta estimates produced from the small handful of domestic firms. In Section 6 below, we consider the reliability of beta estimates from this small sample and conclude that they are not reliable. This leads to our recommendation that the equity beta should be estimated with regard to a much larger sample of international firms.

The approach proposed in the AER's Guideline

9. In our view, the procedure for estimating equity beta set out in the AER's Guideline materials, and the resulting estimate of 0.7, when input into the Sharpe-Lintner CAPM, does not produce an estimate of the required return on equity that is:

    a) commensurate with the efficient financing costs and degree of risk of a benchmark efficient entity; and

    b) reflective of prevailing conditions in the market for equity funds.

10. The reasons for this conclusion are as follows:

    a) The estimate of 0.7 is the outcome of a convoluted multi-stage approach whereby:

        i) a sub-set of the relevant evidence (regression analysis applied to domestic comparable firms, of which there are currently only five) is used to constrain the range of possible estimates to 0.4 to 0.7;

        ii) the other relevant evidence that is considered in the Guideline (e.g., international comparable firms and evidence from the Black CAPM) all supports an estimate above 0.7, but the first stage of the process constrains the maximum estimate to be 0.7; and

        iii) there is relevant evidence that is not considered in the Guideline (e.g., evidence of a value premium and evidence from the dividend discount model);

    b) The subset of evidence that is used to produce the constraining range of 0.4 to 0.7[1] is not sufficiently reliable to be used for that purpose because:

        i) The beta estimates vary wildly across firms, with the majority of estimates falling outside the 0.4 to 0.7 range that the AER adopts;

        ii) In a report commissioned by the AER, Henry (2014) recommends an expanded range of 0.3 to 0.8;

        iii) The beta estimates vary wildly over time with estimates for some firms increasing by 20% and others decreasing by 20% over a short period;

        iv) The beta estimates vary wildly depending on which sampling frequency is used;

        v) The beta estimates vary wildly depending on which regression specification is used; and

        vi) The beta estimates vary substantially depending on the day of the week and month on which they are computed;

    c) The evidence from international comparable firms suggests an equity beta materially above 0.7;

    d) To the extent that the 0.7 estimate has been influenced by the AER's conceptual analysis, it is wrong. The AER concludes that the conceptual analysis supports an equity beta materially below 1, but it does not. In this regard:

[1] Regression analysis applied to domestic comparable firms, of which there are currently only five.

i) The Frontier Economics (2013) report does not support an equity beta below 1 and Frontier Economics never say that it does; and

ii) The McKenzie and Partington (2012) report sets out two pieces of empirical evidence. One suggests that energy networks have equity betas materially above one, and the other suggests that finance risk is the primary component of beta for utilities;[2]

e) To the extent that the 0.7 estimate has been set to match the equity beta that the ACCC uses for water utilities, it is wrong. Regulatory estimates of beta for water utilities are based on regulatory estimates of beta for energy networks (which introduces circularity) and on international water utilities (which are clearly less comparable than the large set of international energy networks).

Interpretations of beta

11. In this report, we consider how to provide the best possible statistical estimate of equity beta for use in the Sharpe-Lintner CAPM – as though one considered that the Sharpe-Lintner CAPM in its pure theoretical form was all that was required to estimate the required return on equity. In particular, we note that beta has exactly the same definition in the Sharpe-Lintner CAPM and the Black CAPM, so the same estimate would be used in both models. This would lead to two different estimates of the required return on equity, because the two models use somewhat different pricing equations, even though the same estimate of beta would be inserted into both. The goal of this report is to obtain the best estimate of beta that would be used in these two models.

12. By contrast, the foundation model approach requires a different estimate of beta that, when inserted into the Sharpe-Lintner CAPM only, produces a single estimate of the required return on equity that somehow jointly reflects the Sharpe-Lintner CAPM *and* the Black CAPM. We do not consider such composite estimates of beta in this report.

The best available estimate of equity beta

13. In our view, the best approach for distilling the domestic and international empirical evidence is that set out in SFG (2013).[3] They consider the same 9 domestic firms (five of which are currently listed) that are used to compile the domestic beta estimates on which the Guideline's primary range is based. SFG also consider 56 international energy network businesses that were selected by CEG (2013) on the basis of their comparability to the benchmark efficient regulated firm. Having compiled beta estimates (re-levered to 60%) SFG conclude that the best available estimate of equity beta is 0.82. In our view, this remains the best currently available empirical estimate of equity beta for the benchmark efficient entity, having regard to the trade-off between comparability and statistical reliability.

[2] On the latter point, McKenzie and Partington note that leverage has the effect of increasing equity beta and that the benchmark firm has materially higher leverage than the average firm. They go on to conjecture that although leverage increases equity beta, the effect may be immaterial, citing some empirical work. However, the empirical work that is cited supports the opposite conclusion for utilities.

[3] SFG, 2013, *Regression-based estimates of risk parameters for the benchmark firm*, 24 June.

2. The role of equity beta in the Sharpe-Lintner CAPM

Role of equity beta

14. The Sharpe-Lintner CAPM is one of a class of asset pricing models under which the required return on equity for a particular asset or firm is determined by adding a premium for risk to the return on a risk-free asset. That is, under these asset pricing models the required return on equity is estimated as the sum of:

    a) The return that investors could obtain on a risk-free investment; and

    b) A premium for the risk of the asset or firm being evaluated.

15. The various asset pricing models differ according to the way risk is defined and the way the premium for risk is estimated. Under the Sharpe-Lintner CAPM, the premium for risk is estimated in two steps. The first step requires the estimation of the premium that would be required for an asset or firm of average risk, known as the market risk premium (**MRP**). The second step requires the estimation of the risk of the asset or firm in question relative to the average firm or asset. This is known as systematic risk or beta. The required return on equity is then estimated as:

$$r_e = r_f + \beta_e\left(r_m - r_f\right)$$

    where:

    a) r_e is the required return on equity for the asset or firm in question;

    b) r_f is the return on a risk-free asset;

    c) $\left(r_m - r_f\right)$ is the risk premium required for the average firm; and

    d) β_e is the risk of the firm in question relative to the average, also known as the equity beta.

16. The average firm has an equity beta of 1, such that the risk premium required is $\left(r_m - r_f\right)$ and the total required return is r_m. A firm with below average risk has an equity beta less than 1, such that the risk premium required is less than that required for a firm of average risk. Conversely, a firm with above average risk has an equity beta greater than 1, such that the risk premium required is more than that required for a firm of average risk.

17. Put another way, the equity beta represents the extent to which the risk premium required for the firm in question differs from the risk premium required for the average firm. This is made apparent by rearranging the Sharpe-Lintner CAPM equation above as:

$$\beta_e = \frac{r_e - r_f}{r_m - r_f}.$$

Components of equity beta

18. It is well known and generally accepted that there are two components of equity beta: business risk (or asset beta) and leverage. For example, the AER's Guideline materials state that:

> Two key types of systematic risk are relevant: business risk and financial risk.[4]

19. Business risk, also known as asset beta (or β_a), refers to the extent to which the value of the firm's assets covaries with changes in the value of the market portfolio. In this regard, the AER's Guideline materials state that:

> *Business risk* relates to the systematic risk exposure of the underlying business assets.[5]

20. Leverage refers to the proportion of the firm's assets that are financed with debt. It can be represented by the debt-to-value ratio, D/V, or the debt-to-equity ratio, D/E.

21. In the Australian regulatory setting, the approach that is used to combine the asset beta and leverage into an equity beta is:

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

22. That is, other things equal, a higher asset beta (β_a) or higher leverage (D/E) lead to a higher equity beta.

Empirical performance of the Sharpe-Lintner CAPM

23. It is well known and generally accepted that the empirical implementation of the Sharpe-Lintner CAPM provides a poor fit to the observed data. For example, the Nobel Prize Committee has recently observed that the relevant empirical literature leads to the conclusion that the CAPM has been "refuted"[6] and that:

> Most of these results were integrated in the widely cited paper by Fama and French (1992), which convincingly established that the CAPM beta has practically no additional explanatory power once book-to-market and size have been accounted for.[7]

24. That is, when the Sharpe-Lintner CAPM parameters are empirically estimated and inserted into the CAPM formula, the resulting estimate of the required return on equity bears little resemblance to observed stock returns. The feasible implementation of the Sharpe-Lintner CAPM does not fit the observed data.

25. This poor empirical performance does not disprove the Sharpe-Lintner CAPM as a mathematical economic model. Indeed, under the assumptions of the Sharpe-Lintner CAPM the CAPM pricing formula *must* be true as a matter of basic mathematics. That is, given the assumptions of the model,

[4] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 40.
[5] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 40.
[6] Nobel Prize Committee (2013), p. 37.
[7] Nobel Prize Committee (2013), p. 39.

there must be positive linear relationship between equity beta and required returns, exactly as the model suggests. The poor empirical performance of the Sharpe-Lintner CAPM is not due to an error in the logic or in the mathematical derivations.

26. One possible reason for the poor empirical performance is that the assumptions of the model may be violated in the real world. If the assumptions do not hold, there is no reason why the pricing formula (which is derived on the basis of those assumptions) would hold. The assumption that all investors can borrow or lend as much as they like at the risk-free rate has been the focus of particular attention in this regard. This has led to the development of the Black (1972) version of the CAPM, whereby that particular assumption has been replaced by the more realistic assumption that investors would have to pay a premium above the risk-free rate when borrowing. The Black CAPM, based on this more realistic assumption, provides a better fit to the data.

27. By way of another example, the assumption of perfect capital markets (no taxes or transactions costs, symmetric information, no costs associated with financial distress) leads to the implication that stock returns depend on a single factor (market returns). Relaxing that strong assumption leads to multi-factor models. Fama and French (1993) develop one such model wherein stock returns depend on market returns and two additional factors. The Fama-French model has been shown to provide a materially better fit to the observable data, relative to the Sharpe-Linter CAPM.[8]

28. The other explanation for the poor empirical performance of the Sharpe-Lintner CAPM is that we are simply unable to reliably estimate the input parameters. For example, one of the key input parameters is the required return on the market portfolio. The market portfolio is a theoretical construct consisting of *all* assets that are available to investors. The standard proxy that is used is the returns on a stock market index, which reflects only a subset of the assets that are available to investors. It is possible that the Sharpe-Lintner CAPM would provide a perfect description of the observed data if only we were able to properly measure the input parameters. In this regard Levy and Roll (2010) note that the empirical implementation of the Sharpe-Lintner CAPM provides a poor fit to observed stock returns. They then look at how much they would have to change the CAPM input parameters and the observed stock returns to have a reasonable fit between the two. They conclude that it may be the inability to reliably and precisely estimate the various parameters that is responsible for the poor performance of the Sharpe-Lintner CAPM.

29. This is an interesting theoretical idea, but does nothing to change the fact that the empirical implementation of the Sharpe-Lintner CAPM provides a poor fit to the data. Levy and Roll can only conclude that the poor performance of the Sharpe-Lintner CAPM may be due to the inability to reliably estimate the parameters – unfortunately, their approach cannot help at all in actually improving the reliability of those parameter estimates. That is, their work provides a potential explanation, rather than a solution, for the poor performance of the model. Consequently, this branch of the literature is of no use to anyone seeking to estimate required returns in practice. The Sharpe-Lintner CAPM, as best as we can estimate it with all of the data and techniques available to us, provides a very poor fit to the observed data.

Interpretation of equity beta

30. As set out above, the Sharpe-Lintner CAPM provides a poor fit to the observed data. This has led to augmentations of the model to replace certain unrealistic assumptions with more realistic ones, with a view to providing a better fit to the observed data. Examples of such augmentations to the basic model are Black (1972) and Fama and French (1993).

[8] See for example, the recent report from the Nobel Prize Committee (2013).

31. Now suppose that the equity beta estimation task has been performed and it has produced the best possible estimate of equity beta. Also suppose that the required return on equity is to be estimated by having some regard to the Sharpe-Lintner CAPM and some regard to one or more of the augmented models that better fit the observed data.

32. One way of proceeding is to insert that best possible estimate of equity beta into each of the relevant models, producing an estimate of the required return on equity for each of the models. In the regulatory setting, those estimates would then have to be distilled into a final allowed return on equity, having regard to the relative strengths and weaknesses of each model.

33. The Guideline proposes a different "foundation model" approach. Under that approach, the regulator selects a single foundation model, but may use evidence from other relevant models to inform its estimate of beta.

34. In both cases, there is a range of relevant models which must be distilled into a single allowed return on equity. In the former case, that distillation occurs at the return on equity level, whereas under the foundation model approach it occurs at the equity beta level.

35. Thus, there are two different interpretations of beta:

    a) The first (multi-model) approach requires only a single best empirical estimate of beta. That estimate is then inserted into each of the relevant models that require an estimate of beta. The various estimates of the required return on equity are then distilled into a single allowed return; and

    b) Under the foundation model approach, there is a range of beta estimates – the best empirical estimate (as above) and other estimates of beta that are consistent with the evidence relating to other relevant models. The best empirical estimate is the figure that would be used if one considered that the Sharpe-Lintner CAPM (alone) was likely to produce a reliable estimate of the required return on equity. The alternative estimates of beta that are informed by the evidence from other relevant models represent estimates of beta that, when inserted into the Sharpe-Lintner CAPM, help to correct for some of its documented theoretical and empirical failings.

36. For example, the Guideline adopts the foundation model approach with the Sharpe-Lintner CAPM as the foundation model.[9] The Guideline materials also state that the Black CAPM is considered to be a relevant model, and demonstrate how to convert a raw empirical estimate of beta into an estimate of beta that is consistent with the relevant Black CAPM evidence (i.e., the beta that, when inserted into the Sharpe-Lintner CAPM foundation model would produce the same return on equity as would be obtained by inserting the empirical estimate into the Black CAPM).[10]

37. In this report, we consider how to provide the best possible statistical estimate of equity beta for use in the Sharpe-Lintner CAPM – as though one considered that the Sharpe-Lintner CAPM in its pure theoretical form was all that was required to estimate the required return on equity. In this report, we do not consider how this estimate might be adjusted or informed by evidence about the theoretical and empirical failings of the Sharpe-Lintner CAPM.

[9] AER Rate of Return Guideline, p. 7.
[10] AER Rate of Return Guideline, Explanatory Statement, Appendix C, Table C.11, p. 71.

3. Empirical estimation of equity beta: methodological issues

Regression estimates

38. Empirical beta estimates are most commonly produced using some form of regression analysis to quantify the relationship between historical stock returns and corresponding historical market returns. The general form of the regression analysis is:

$$r_{e,t} = \alpha + \beta r_{m,t} + \varepsilon_t .$$

39. When performing this regression analysis, a number of choices need to be made including:

    a) The listed firms to include in the sample;

    b) The sample period that is used (e.g., 5 years, or 10 years, or more);

    c) The way in which returns are defined (e.g., continuous or discrete, raw returns or excess returns relative to the risk-free rate);

    d) The frequency with which returns are measured (e.g., monthly or weekly);

    e) The start date on which returns are measured (e.g., Monday-to-Monday or Tuesday-to-Tuesday, etc.);

    f) The type of regression analysis that is applied (e.g., Ordinary Least Squares [**OLS**] which minimises the sum of squared residuals or Least Absolute Deviation [**LAD**] which minimises the sum of absolute deviations); and

    g) Whether any statistical corrections are applied to account for bias introduced by estimation error.

40. Because there are so many methodological choices to be made, it is common practice to consider the sensitivity of beta estimates to the different choices that might be made. For example, betas may be estimated using weekly and monthly data, they may be estimated using different start days (e.g., Monday-to-Monday or Tuesday-to-Tuesday, etc.) and over different sample periods, and so on. In our view, such an exercise is useful and can inform an assessment of the reliability of a set of beta estimates. In particular, beta estimates that vary materially over different sample periods, or according to the day of the week on which returns are measured, would be considered to be less reliable.

41. It is important not to treat beta estimates obtained by applying different methodological choices to the same data set as though they were independent corroborating evidence. Rather, the application of regression after regression after regression to the same data set will produce many beta estimates, but this does not increase the reliability of those estimates. By way of analogy, suppose we want to estimate the IQ of the average 10-year old Australia child. Suppose we compile a sample of five 10-year old Australians and apply an IQ test, and that the results vary greatly across our five subjects. The sample size is obviously too small to conclude anything meaningful from the results.

42. Now suppose we subject the same five subjects to a different IQ test and the results vary materially for each subject but less materially for the mean (e.g., some students scored materially higher from one test to another, but an equal number scored materially lower, so the mean did not vary as materially as the individual results.) In this case, we should have even less confidence in our ability to provide a reliable estimate from such a small sample of subjects.

43. Reliability cannot be improved by applying test after test after test to the same subjects – particularly if the results for each subject varied greatly on different tests. Rather, the only way to improve reliability is to increase the sample size. In particular, reliability would be improved by expanding the sample to include 10-year old Americans, but not by applying ever further tests to the same five Australians.

Re-levering equity beta estimates

44. When estimating beta for the purpose of using an asset pricing model (such as the CAPM) to estimate the required return on equity it is common to consider equity beta estimates for a number of comparable firms. Comparable firms are usually considered to be firms that are engaged in the same type of business activities as the firm in question. This is done to ensure that the business risk (or asset beta) for the comparable firms is as close as possible to that of the firm in question.[11] However, this does nothing to control for the other component of equity beta – leverage. There can be material differences between the leverage of a comparable firm and the leverage of the firm in question. Such differences are managed by the process of re-levering. The re-levering process is as follows:

    a) Estimate equity beta for the comparable firm (reflecting the asset beta and leverage of that firm);

    b) Un-lever that equity beta to estimate the asset beta for the comparable firm using an equation such as that in Paragraph 21 above and the leverage of the comparable firm; and

    c) Re-lever the asset beta to estimate the equity beta for the comparable firm again using an equation such as that in Paragraph 21, but with the leverage of the firm in question.

45. This procedure produces an estimate of what the equity beta of the comparable firm would have been if it had the same leverage as the firm in question. The use of such a re-levering procedure is standard valuation and regulatory practice.[12] This re-levering exercise was performed in the Henry (2014) report that was commissioned by the AER.

Statistical bias corrections

46. In the CAPM, the average firm has a beta of 1, by construction.[13] If we assume that:

    a) Betas are equally likely to be above or below 1;

    b) Relatively more firms have betas close to 1 (e.g., within the range of 0.8 to 1.2) and relatively fewer firms have extreme betas (e.g., less than 0 or above 2); and

    c) Estimation error is symmetric such that any beta estimate is equally likely to be above or below that firm's true beta,

    then it is necessarily the case that beta estimates below 1 tend to understate the true beta. For example, when observing a beta estimate of 0.7, the expected true beta is strictly above 0.7.

47. In our view, the three assumptions set out above are uncontroversial. Given those assumptions (and no more) Bayes' Rule implies that equity beta estimates less than one will understate the true equity

[11] See Paragraphs 14 to 18 above.
[12] See, for example, Brealey, Myers and Allen (2011), pp. 220-221 and 427-428.
[13] See, for example, Brealey, Myers and Allen (2011), p. 174.

beta. The intuition for this result can be provided by way of a very simple example. Suppose we know that 50% of firms have a true beta of 1, 25% have a true beta of 0.9, and 25% have a true beta of 1.1. Also suppose that estimation error is equally likely to be -0.1, 0, or 0.1.[14] Finally, suppose we observe a beta estimate of 0.9. This can occur in one of two ways – either the true beta is 0.9 and estimation error turned out to be 0, or the true beta is 1 and estimation error turned out to be -0.1. The probability weighted-average of these two possibilities will obviously be greater than 0.9.[15] That is, having observed a beta estimate of 0.9, our best estimate of the true beta is something greater than 0.9. Note that this is just a simple example designed to convey the intuition. To obtain the general result that beta estimates below 1 will understate the true beta, we need nothing more than the three assumptions set out above, which we consider to be unarguable.

48. Brooks, Diamond, Gray and Hall (2013)[16] examine this issue in more detail. They note that this issue has been well known in the beta estimation issue for more than 40 years and that Vasicek (1973) has developed a statistical correction for this very issue. They also note that a number of commercial data services provide default beta estimates that employ such a statistical correction.[17] In addition, the calculation of beta estimates with such a statistical correction are a part of many university courses and applied accreditation qualifications.[18]

49. Brooks Diamond, Gray and Hall (2013) also demonstrate that Vasicek beta estimates have superior empirical performance to raw OLS beta estimates (that is, beta estimates that do not include the Vasicek adjustment).

50. The AER's Guideline materials do not address this issue, in which case the beta estimates contained in the Guideline is not informed by this evidence:

> SFG had concerns with the reliability of LAD estimates and considered Vasicek adjustment should be applied. It submitted Vasicek-adjusted OLS estimates are more reliable measures of systematic risk than unadjusted OLS estimates. We have only been able to give limited regard to these issues because of the complexity of those reports. We will consider them in more detail in the future.[19]

51. When considering this issue, there are two important points to consider. First, the proposed Vasicek correction is a statistical correction due to statistical estimation error. Similar adjustments can be motivated by the possibility that the true beta of the firm will tend to move towards 1 over time as it changes its investment mix and leverage. That motivation obviously does not apply in the regulatory setting where the investment mix and leverage are both constant. However, the statistical motivation is entirely independent of this. Moreover, it is the statistical motivation that has led commercial data service providers to employ the correction.[20]

52. The second important point to note is that in the regulatory setting the task is to estimate beta for each of the firms in the energy network industry and to distil those estimates into a single beta for the benchmark firm. Obviously, we do not know the beta for the average firm in the industry – that is what we are trying to estimate. In other settings, the true beta for the average firm in the industry is

[14] That is, the beta estimate is equally likely to be equal to the true beta or 0.1 above or below it.
[15] This is because some weight must be given to the possibility that the true beta is 0.9 and some weight given to the possibility that it is 1.
[16] Brooks, Diamond, Gray and Hall (2013), *The Vasicek adjustment to beta estimates in the Capital Asset Pricing Model*, 17 June.
[17] Brooks, Diamond, Gray and Hall (2013), p. 5.
[18] For example, the calculation of "adjusted betas" is a part of the syllabus for the Chartered Financial Analyst (CFA) accreditation – the leading professional accreditation in the US and Australia.
[19] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 58.
[20] See Brooks, Diamond, Gray and Hall (2013), pp. 5-6.

known and that figure can be used as a central reference point when estimating beta for each individual firm. But that is clearly not relevant to the regulatory setting – if we knew the true beta for the average firm in the industry we would be done and no estimation would be required at all.[21]

53. Henry (2014) was instructed not to consider any statistical bias correction methods.[22]

Estimation techniques

54. Brooks, Diamond, Gray and Hall (2013) compare the empirical performance of OLS and LAD estimates of beta.[23] They report that LAD estimates of beta are systematically lower than OLS estimates. In particular:

    a) For 75% of the firms examined, the LAD estimate of beta was lower than the OLS estimate;

    b) For all 10 industry groups examined, the LAD estimate of beta was lower than the OLS estimate; and

    c) Even where OLS estimates of beta are very low (in the bottom 5%), the LAD estimates tend to be even lower.

55. Brooks, Diamond, Gray and Hall (2013) also conduct a test to determine whether the systematic difference between OLS and LAD estimates is due to a systematic bias in one or both methods. To do this, they construct a market index from the stocks in their sample and then estimate beta relative to their market index. By definition, the weighted-average of the betas must equal 1. Whereas the mean OLS beta is very close to 1, the mean LAD estimate is materially below 1, indicating that LAD has produced downwardly biased estimates on average.[24]

56. Brooks, Diamond, Gray and Hall (2013) go on to note that the downward bias in LAD estimates is more pronounced in medium-sized and smaller firms. Consequently, the downward bias is more pronounced when an equally-weighted average of beta estimates is taken across firms in a particular industry – which is precisely the approach that is typically adopted in practice. They show that LAD estimates in such a case are, on average, 0.16 below the corresponding OLS estimates, which is a material difference.[25]

57. Brooks, Diamond, Gray and Hall (2013) also note that LAD estimation is not used to estimate betas in academic research or in commercial practice.[26]

58. As set out in Paragraph 50 above, the Guideline materials do not address these issues, in which case the beta estimates contained in the Guideline is not informed by this evidence.

59. Henry (2014) was instructed to present estimates using the LAD estimation technique[27] and not to "provide expert advice or analysis on this design decision."[28] His results also demonstrate that LAD estimates are systematically lower than OLS estimates.[29]

[21] See Brooks, Diamond, Gray and Hall (2013), pp. 4-5.
[22] Henry (2014), p. 5.
[23] Brooks, Diamond, Gray and Hall (2013), *Comparison of OLS and LAD regression techniques for estimating beta*, 26 June.
[24] See Brooks, Diamond, Gray and Hall (2013), p. 3.
[25] See Brooks, Diamond, Gray and Hall (2013), p. 3.
[26] See Brooks, Diamond, Gray and Hall (2013), p. 2.
[27] Henry (2014), pp. 8, 10.
[28] Henry (2014), p. 10,
[29] See the summary of the Henry (2014) estimates in Figure 2 below.

Sample sizes

60. Brooks, Diamond, Gray and Hall (2013) compare the statistical precision and reliability of beta estimates as a function of the size of the sample of comparable firms that is used.[30] They show that the variation in beta estimates reduces by more than half when the sample size is increased from 9 to 27 firms.[31] Variation in beta estimates reduces even further when the sample size is increased beyond 27. Thus, beta estimates are likely to be more statistically precise when based on a larger sample.

61. In this regard, we note that the domestic beta estimates set out in the Guideline materials are based on a maximum of nine sample firms, four of which have been de-listed for various lengths of time. By contrast, the sample of international comparable firms numbers 56.

62. It is generally accepted that a larger sample size will produce estimates that are statistically more precise and reliable.[32] Indeed, it is a general statistical property that, other things equal, larger sample sizes have this benefit. In the case of beta estimation, the issue is whether the international firms are sufficiently comparable to the benchmark efficient firm to be included in the analysis. Thus, there is a trade-off between statistical reliability and comparability, and this trade-off is recognised in the Guideline materials.[33]

63. This is an issue that has been considered in the Guideline materials, which note that the issue of statistical reliability vs. comparability has been the subject of previous Tribunal decisions.[34] Specifically, the question of whether WACC parameter estimates should be based on very small samples of data that are selected to be closely comparable was addressed by the Tribunal in the ActewAGL matter.[35] In that case, the AER argued that it should assess the relative reliability of the CBA Spectrum and Bloomberg fair value curves on the basis of five BBB+ bonds that it had selected. The Tribunal held that it was unreasonable to base any conclusion on the analysis of five data points:

> In the Tribunal's view, it is not reasonable to decide which of three non-linear curves best fits a set of data that consists of only five points.[36]

64. The Tribunal went on to consider whether the sample should be expanded to include floating rate bonds even though they were not as directly comparable to the fixed rate benchmark. On this issue, the Tribunal concluded that it was:

> unreasonable for the AER not to include floating rate bonds in its population. [37]

65. The Tribunal also considered whether the sample should be expanded to include BBB and A bonds, even though they were not as directly comparable to the fixed rate BBB+ benchmark. On this point, the Tribunal concluded that:

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[30] Brooks, Diamond, Gray and Hall (2013), *Assessing the reliability of regression based estimates of risk*, 17 June.
[31] See Brooks, Diamond, Gray and Hall (2013), p. 2.
[32] See, for example, Greene (2000), Chapter 4.
[33] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 47.
[34] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 64.
[35] Australian Competition Tribunal [2011] ACompT 4.
[36] Australian Competition Tribunal [2011] ACompT 4, Paragraphs 38-39. Note that in referencing these Reasons from the Tribunal, we do not endorse the adoption of a particular credit rating – which is clearly outside the scope of this report. Rather, the point is that the Tribunal has recognised the general point that sample size is an important consideration when estimating WACC parameters. When a sample is too small to produce statistically reliable results, it should be expanded in order to provide the appropriate balance between comparability and statistical reliability.
[37] Australian Competition Tribunal [2011] ACompT 4, Paragraph 55.

> The AER rejected this proposal on the basis that it would potentially give equal weight to bonds with higher and lower credit ratings than the benchmark of BBB+. We think this is too cursory a rejection of the relevance of differently rated bonds. It is one thing to hold that a differently rated bond should not be given equal weight. It is quite another to refuse to take it into account in any way. [38]

66. In particular, the yields from A- bonds exceeded the CBA Spectrum BBB+ fair value curve. The AER dismissed that evidence on the basis that those observed yields "do not reflect reasonable expectations." The Tribunal held that the AER was wrong to simply dismiss any evidence that was inconsistent with its preferred estimate. Rather, the inconsistent evidence "should have sent alarm signals calling for further analysis":

> The Tribunal considers the AER's analysis to be too superficial. In fact, the longer term A- bond yields were above the CBASpectrum curve, contrary to what would usually be expected. We also consider that the AER was wrong to conclude as it did (at 56) that "[g]iven that the observed yields do not reflect reasonable expectations it is difficult to compare the selected fair value curve to the observed yields." The very fact that observed higher rated (A-) bond yields were higher than the CBASpectrum curve for lower rated (BBB+) bonds should have sent alarm signals calling for further analysis. [39]

67. In the Jemena Gas Networks case, the Tribunal again held that WACC parameters should not be based on very small samples selected to be as comparable with the benchmark as possible:

> Given the paucity of relevant BBB+ bonds, it is appropriate to have regard to bonds (fixed and floating) with other credit ratings. There is the issue of what weight should be given to those bonds. We do not agree that greater weight should be given to the BBB+ bonds merely because they match the task of estimating the cost of 10 year BBB+ debt. That would defeat the purpose of including bonds with other credit ratings in the sample.[40]

and:

> We do not agree with Professor Handley's preferred approach to exclude nonstandard bonds. Faced with a limited number of relevant bonds, it is appropriate to include bonds with nonstandard features. [41]

68. In our view, there are strong similarities between the sample of domestic firms that is available for beta estimation and the Tribunal cases set out above. There are currently only five listed Australian companies, so only five available estimates of beta. In our view, this tiny sample size has to be weighed against the much larger sample of international firms that may not be quite as comparable – in the same way that BBB and A- bonds should be included due to the paucity of BBB+ bonds.

69. The AER's Guideline materials take a different view, concluding that the available sample of domestic firms is sufficient (alone) to provide a reliable estimate of beta:

[38] Australian Competition Tribunal [2011] ACompT 4, Paragraph 61.
[39] Australian Competition Tribunal [2011] ACompT 4, Paragraph 62.
[40] Australian Competition Tribunal [2011] ACompT 10, Paragraph 55.
[41] Australian Competition Tribunal [2011] ACompT 10, Paragraph 57.

> We do not consider the previous Tribunal's comments made in relation to the DRP are relevant to our equity beta estimation. Different to the DRP, we consider the available data on the nine reasonable Australian comparators [four of which have been de-listed for some years] is sufficient for us to form a reasonable equity beta estimate.[42]

70. Ultimately, this issue comes down to an assessment of the reliability of beta estimates produced from the small handful of domestic firms. In Section 6 below, we consider the reliability of beta estimates from this small sample and conclude that they are not reliable. This leads to our recommendation that the equity beta should be estimated with regard to the much larger sample of international firms.

71. Henry (2014) was instructed to consider only domestic firms[43] and is silent on whether the resulting estimates would be improved or made more reliable if the sample were expanded to consider other firms.

Summary of key statistical issues

72. Our conclusions in relation to key statistical issues are:

    a) Equity betas must be re-levered in the standard way to ensure comparability with the assumed leverage of the benchmark efficient entity. It would be inconsistent and wrong to compare an equity beta that reflects, say, 45% leverage with a benchmark entity that has 60% leverage;

    b) The Vasicek correction for the bias caused by statistical estimation error should be employed, consistent with the practice of several commercial data services and university and professional training courses;

    c) The non-standard LAD estimation should not be used as it produces beta estimates that are systematically biased;

    d) There is a trade-off between selecting a sample of firms that is closely comparable to the benchmark firm and have a sample size that is sufficiently large to obtain statistically reliable results. Ultimately, this issue comes down to an assessment of the reliability of beta estimates produced from the small handful of domestic firms. In Section 6 below, we consider the reliability of beta estimates from this small sample and conclude that they are not reliable. This leads to our recommendation that the equity beta should be estimated with regard to the much larger sample of international firms.

[42] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 64.
[43] Henry (2014), p. 4.

4. The Guideline's conceptual analysis

Overview of the issue

73. The Guideline materials begin the process for estimating equity beta by conducting what the materials refer to as a "conceptual analysis." This conceptual analysis begins by noting that equity beta is determined by two factors, business risk and leverage. Business risk refers to the fundamental systematic risk of the firm's business operations and is often called the firm's asset beta, β_a. Leverage refers to the extent to which the firm's assets are financed by debt. This can be represented by the debt-to-value ratio, D/V, or the debt-to-equity ratio, D/E. The Guideline materials adopt the following approach for compiling an asset beta and leverage into equity beta:

> We propose to continue using the Brealey–Myers formula to de-lever and re-lever the comparable businesses' equity beta estimates. That is:
>
> $$\beta_e = \beta_a\left(1+\frac{D}{E}\right)$$
>
> where:
> β_e is the equity beta
> β_a is the un-levered asset beta, and
> $\frac{D}{E}$ is the debt to equity ratio. [44]

74. The Guideline materials also note that:

> It is generally accepted that the benchmark efficient entity has lower business risk than the market average firm.[45]

and that:

> It is generally accepted that the benchmark efficient entity has higher financial risk than the market average firm.[176] The key characteristic causing this higher financial risk is the relatively high financial leverage (gearing) for the benchmark efficient entity (60 per cent) relative to the market average firm (roughly 30 to 35 per cent).[46]

75. That is, the benchmark firm is considered to have lower-than-average business risk (or asset beta) and much higher-than-average leverage. The former has the effect of lowering the equity beta, whereas the latter has the effect of increasing the equity beta, both relative to the market beta (of 1). The conceptual analysis is designed to examine which of the two effects might dominate the other. In this regard, the Guideline materials state that:

[44] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 51.
[45] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 40.
[46] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 41.

> The conceptual assessment of equity beta relative to the market average is determined by the direction and relative magnitude of these two systematic risk factors: business risk and financial risk.[47]

76. That is, the goal is to determine which of the two effects dominates: the benchmark firm's lower-than-average business risk or its higher-than-average leverage. The Guideline materials consider two approaches to answer this question: empirical estimation and conceptual analysis. The role of the conceptual analysis is to determine whether there is any a priori reason to expect that one factor would dominate the other – based on conceptual reasoning rather than empirical analysis (which is to be considered later).

77. The conceptual analysis in the Guideline materials is based on two consultant reports, each of which is reviewed below.

The McKenzie and Partington (2012) report

78. The conceptual analysis in the Guideline materials draws upon advice from McKenzie and Partington (2012).[48] McKenzie and Partington recognise that equity beta depends on two things:

    a) The business risk of the firm (asset beta); and

    b) Leverage (the relative proportion of debt financing).

79. McKenzie and Partington (2012) advise that:

> the level of systematic risk for the firm comes down to a question of the extent to which the higher leverage *per se* offsets the lower business risk of the firm[49]

and we agree that this is the nub of the issue. That is, what is required is a way of determining how business risk (asset beta) and leverage (the proportion of debt financing) jointly determine the equity beta.

80. McKenzie and Partington (2012) go on to note that there are a number of ways of specifying the relationship between equity beta, asset beta, and leverage, but that all of them:

> find in favour of an increasing equity beta as financial leverage increases.[50]

81. Of the various ways of specifying the relationship between equity beta, asset beta, and leverage, one is used extensively throughout the Guideline's estimation process and is embedded within the post-tax revenue model (PTRM) and the others are not. McKenzie and Partington (2012) note that the specification that has been adopted by the AER implies that equity beta is related to leverage according to the formula set out above.[51]

82. McKenzie and Partington (2012) conclude that the asset beta for a network business is likely to be lower than for the average firm, but that:

[47] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 42.
[48] McKenzie, M., and G. Partington, 2012, *Estimation of the equity beta (conceptual and econometric issues) for a gas regulatory process in 2012*, April.
[49] McKenzie and Partington (2012), p. 13.
[50] McKenzie and Partington (2012), p. 10.
[51] McKenzie and Partington (2012), p. 8.

> the assumption of 60% debt financing for a regulated network distribution or transmission business is (approximately) twice that of the average firm.[52]

83. At this stage, McKenzie and Partington (2012) have done nothing more than restate what is generally accepted:

    a) The Guideline materials have set out a formula that disaggregates equity beta into asset beta and leverage (the same formula that has been used by the AER for some years);

    b) The benchmark entity is likely to have lower than average asset beta; and

    c) The benchmark entity has approximately twice the leverage of the average firm.

84. At this stage, there is no possible way of knowing which has the greater effect on equity beta – the lower-than-average asset beta or the higher-than-average leverage. All that can be said is that one of these effects tends to lower the equity beta and the other tends to increase it. This leads McKenzie and Partington (2012) to turn to the empirical literature:

> the level of systematic risk for the firm comes down to a question of the extent to which the higher leverage *per se* offsets the lower business risk of the firm. For insights on this issue, we can look to the empirical literature for guidance.[53]

85. That is, McKenzie and Partington (2012) advise that it is impossible to conceptualise which of the two effects dominates, and that this is ultimately an empirical question. They then submit two pieces of empirical evidence to support the notion that that higher-than-average leverage has a weaker effect than that implied by the AER's re-levering formula above. This leads them to conclude that the leverage effect is relatively small (or possibly even non-existent),[54] in which case the lower-than-average asset beta would be the dominant effect.

86. However, there are three problems with this approach:

    a) This is not a conceptual analysis, it is an empirical one. Consequently it would be wrong to conclude (as the Guideline does) that one can conceptually reason that the lower-than-average business risk dominates the higher-than-average leverage. The net effect of these two factors can only ever be determined empirically;

    b) It is inconsistent with all of the Guideline's empirical beta estimates and with the PTRM, which adopt the re-levering formula set out in Paragraph 73 above; and

    c) It is wrong, in that both pieces of empirical evidence have been misinterpreted, as set out below.

87. As set out above, McKenzie and Partington (2012) use empirical evidence to support their contention that the leverage effect may be smaller than that implied by the AER's re-levering formula. For example, they state that:

[52] McKenzie and Partington (2012), p. 7.
[53] McKenzie and Partington (2012), pp. 13-14.
[54] McKenzie and Partington (2012), p. 14.

> Empirical support for this proposition may be found by looking at the industry beta tables of Damodaran (see Appendix 2). The equity betas for water, gas and electricity are the lowest in the table, while their debt to equity ratios are among the highest. Although this evidence is based on US companies, there is no reason to believe that a similar pattern would not exist in Australia. [55]

88. The specific regression-based beta estimates referred to are as follows, along with market value Debt/Equity ratios:

- Water utility beta = 0.66, Debt/Equity = 0.8142;
- Natural gas utility beta = 0.66, Debt/Equity = 0.6738;
- Electric utility (East) beta = 0.70, Debt/Equity = 0.6616;
- Electric utility (West) beta = 0.75, Debt/Equity = 0.8454;
- Electric utility (Central) beta = 0.75, Debt/Equity = 0.8616.

89. In summary, there are five utility industries with beta estimates less than one, but with all five utility industries having Debt/Equity ratios which are less than 1.5, which is the Guideline's assessment of benchmark Debt/Equity.[56] If the regression-based estimates of beta were re-estimated under the assumption that Debt/Equity is 1.5, under the exact same re-levering process the AER adopts in all of its empirical analysis, the beta estimates would be as follows:

- Water utility re-levered beta = 1.22;
- Natural gas utility re-levered beta = 1.47;
- Electric utility (East) re-levered beta = 1.59;
- Electric utility (West) re-levered beta = 1.33;
- Electric utility (Central) re-levered beta = 1.31.

90. Moreover Appendix 2 of McKenzie and Partington (2012) sets out beta estimates for 95 industries. Even without any re-levering, only three of those industries are within the Guideline's proposed range and the other 92 are above it. After re-levering, zero of those industries are within the proposed range of 0.4 to 0.7.

91. In our view, it would be wrong to interpret this evidence as providing conceptual support for the Guideline's proposed range of 0.4 to 0.7. Rather than conceptual evidence to support an equity beta below 0.7, this is in fact empirical evidence that clearly supports an equity beta well above 1.

92. The other empirical work that McKenzie and Partington (2012) use to support their contention that the leverage effect may be smaller than that implied by the AER's re-levering formula is work that suggests that equity beta depends more on sales growth risk (part of asset beta) than financial risk. In this regard, they cite Schleuter and Sievers (2014)[57] multiple times, supporting the contention that:

> intrinsic risk [asset beta] is the main driver of a firm's beta rather than either its operating or financial leverage.[58]

93. Schleuter and Sievers (2014) is a paper about how one might go about using accounting information from financial statements, rather than stock returns, to estimate beta. For example, "financial risk" is defined to be the percentage change of net income associated with a given percentage change in

[55] McKenzie and Partington (2012), p. 15.
[56] A debt-to-value ratio of 0.6 is equivalent to a debt-to-equity ratio of 1.5.
[57] McKenzie and Partington (2012) cite the 2011 working paper version of this paper, which has now been published.
[58] McKenzie and Partington (2012), p. 14.

operating income"[59] rather than in terms of the market value proportion of debt financing. For this reason, it would not appear to be directly relevant, given that all of the empirical estimates considered in the Guideline materials are based on observed stock returns from equity markets rather than on accounting information.

94. However, if it is to be used to inform the regulatory estimate of equity beta, it should be noted that the average result that underpins the advice from McKenzie and Partington (2012) does not apply to utilities. In fact, quite the contrary. In their Table 1, Schleuter and Sievers (2014) report that, for utilities, financial risk dominates all other risks, including growth risk. Moreover, financial risk is higher for utilities than for any other sector and growth risk is lower than for any other sector.[60] That is, to the extent that this paper is to be used to inform the estimation of beta, it establishes that financial risk is highly important for the utilities sector.

The Frontier Economics (2013) report[61]

95. The Guideline materials interpret the Frontier Economics (2013) report as supporting the contention that the lower-than-average business risk of the benchmark firm will more than offset its higher-than-average financial risk, and that this supports an equity beta less than 1.

96. The basis for this claim comes from Frontier's discussion of the various risks that the benchmark firm may be exposed to. The Guideline materials note that several of these risks are financial in nature (specifically, default risk, financial counterparty risk, illiquidity risk, refinancing risk, and interest rate reset risk).[62] In its discussion of these risks, the Guideline materials note that Frontier Economics assesses a number of these risks to be "low" or "medium."[63]

97. The Guideline materials also assert that these risks are likely to be reduced further under the proposed Guideline. For example, the Guideline materials state that the new trailing average approach for the cost of debt is likely to reduce interest rate risk and that the new procedure for determining the allowed return on equity is likely to procedure more stable cash flows to shareholders.[64] The Guideline materials then conclude that:

> Taken together, conceptual analysis of the new approach to the determination of the return on capital should reduce the benchmark efficient entity's exposure to financial risk.[65]

98. In our view, it is far from clear that the approach set out in the Guideline will have the effect of reducing the risk of holding equity in the benchmark firm. However, this is a moot point because the

[59] Schleuter and Sievers (2014), p. 546.
[60] Schleuter and Sievers (2011), pp. 545-546.
[61] Frontier Economics, 2013, *Assessing risk when determining the appropriate rate of return for regulated energy networks in Australia*, Report for the AER, July.
[62] Frontier Economics (2013, pp. 21-26) define *refinancing risk* to be the risk that interest rates have risen or fallen between the time that debt was initially issued and when it is refinanced, *interest rate reset risk* to be the risk that the regulatory allowed return on debt may differ from the firm's actual cost of debt, *liquidity risk* to be the risk that it may be difficult for investors to liquidate their investment at short notice, *default risk* to be the risk that the cash flows generated by the firm will be insufficient to cover its financial obligations, and *financial counterparty risk* to be the risk that a counterparty such as an insurance provider fails to meet its obligations to the regulated firm.
[63] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 42.
[64] Whether the new Guideline will result in a material reduction of risk for a particular business depends on many things including (a) the practice of the business in raising and managing its debt finance before and after the rule change and (b) the extent to which variation in the allowed return on debt and the allowed return on equity tended to offset each other under the regulatory practices adopted under the old Rules.
[65] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 42.

Guideline materials indicate that the AER does not intend to set equity beta on the basis of the possibility that its new approach may reduce risk to equity holders, but that it intends to wait until any such reduction in risk has been demonstrated.[66] Consequently, the Guideline estimates equity beta using information that is currently available.

99. This means that the relevant considerations are the extent to which the five financial risks identified in the Frontier Economics (2013) report provide a basis for the conclusion that the lower-than-average asset beta of the benchmark firm outweighs its higher-than-average leverage.

100. In particular, the Guideline materials appear to contend that leverage affects equity beta via the financial risks that are set out in the Frontier Economics (2013) report. That contention is entirely incorrect and demonstrates a fundamental misunderstanding of the way leverage affects equity beta. Leverage does not have an effect on equity beta via the five risks set out in the Frontier Economics report and Frontier Economics never say that it does. Rather, leverage will increase the equity beta simply because it has the effect of making positive returns in up-markets even better and negative returns in down-markets even worse. This is why it is called "leverage."

101. Consider the following simple analogy. Suppose five people each contribute $20,000 to buy a house for $100,000. Also suppose that the value of the house might increase to $120,000 or decrease to $90,000 over the course of a year. That is, the house may appreciate by 20% or depreciate by 10%. In this case, one share of the house might increase in value to $24,000 (up 20%) or decrease to $18,000 (down 10%).

102. Now suppose that one person contributes $20,000 equity and takes on leverage by borrowing the other $80,000 at a 5% interest rate. At the end of the year, the investor must repay the loan plus interest – a total of $84,000. If the house increases in value to $120,000, the equity increases to $36,000 (120,000-84,000) an increase of 80%. If the house decreases in value to $90,000, the equity decreases to $6,000 (90,000-84,000), a decrease of -70%. With no leverage, the range of returns were -10% to +20%. With the leverage in place, the range of returns is -70% to +80%. Leverage has dramatically increased risk – simply because leverage "levers up" the range of possible returns. None of this requires any consideration at all of liquidity or potential counterparty defaults.

103. Specifically, leverage has an effect on beta via the re-levering formula set out above, which is independent of each of the five financial risks identified in the Frontier Economics report.[67] This point is demonstrated in detail in Appendix 3 to this report. Even if all five of the financial risks are eliminated entirely, leverage would still have the same effect on equity beta.[68]

104. In our view, it is fundamentally wrong to conceptualise equity beta as a trade-off between business risk (asset beta) and the five types of financial risks set out in the Frontier Economics report. Rather, equity beta is a trade-off between business risk (asset beta) and leverage, as set out in Appendix 3.

[66] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 39.

[67] Note that the re-levering formula only requires information about the amount of leverage. No information is required about liquidity effects or the possibility of counterparty defaults etc.

[68] For example, suppose that there was no *refinancing risk* such that every bond that matured could always be refinanced at the same rate, no *interest rate reset risk* such that the regulatory allowed return on debt exactly matched the firm's actual cost of debt, no *liquidity risk* such that investors could easily liquidate their investment at short notice, no *default risk* such that the cash flows generated by the firm are sufficient to cover its financial obligations, and no *financial counterparty risk* such that all counterparties meet their obligations to the regulated firm. Even in this case, leverage has precisely the same effect on equity beta – leverage increases equity beta because it levers up the range of possible returns, not because of liquidity effects or counterparty defaults etc.

105. In summary, the Frontier Economics report provides no basis for any a priori expectation that the equity beta of the benchmark firm is less than 1, and Frontier Economics have never said that it does.

The conclusions from the AER's conceptual analysis

106. In its Guideline materials, the AER draws the following conclusions from its conceptual analysis:

> Based on the available evidence, including the expert reports from Frontier and McKenzie and Partington, we consider there are reasonable conceptual grounds to expect that the equity beta of a benchmark efficient regulated energy network will be below 1.0. However, we recognise the limits of this type of approach, and use it to inform our assessment with regard to these limitations. Further, conceptual analysis does not indicate the magnitude of the difference between the benchmark efficient entity and the market average (1.0), and we propose to rely on empirical estimates for this assessment.[69]

107. In our view, there is nothing in the Frontier Economics (2013) report to suggest an a priori expectation that the lower-than-average business risk of the benchmark firm would more than offset its higher-than-average leverage so that there is an a priori expectation that the equity beta for the benchmark firm would be less than 1. In our view this is an empirical question and cannot be answered by conceptual reasoning.

108. Moreover, the McKenzie and Partington (2012) report relies on two pieces of empirical evidence to support the notion that leverage has a smaller effect on equity beta than the AER's re-levering methodology would imply. However, one of those pieces of evidence is the Damodaran utility beta estimates which are uniformly above 1.2.[70] Rather than conceptual evidence to support an equity beta below 0.7, this is in fact empirical evidence that clearly supports an equity beta well above 1. The other piece of evidence is the result from Schleuter and Sievers (2014), however they report that financial risk is not negligible, but in fact of primary importance, for the utilities sector.

109. The conceptual analysis appears to be used to confirm the reasonableness of the proposed primary range for beta of 0.4 to 0.7:

> This empirical range is consistent with our conceptual analysis, which we use to cross check our range for the equity beta. This is because our conceptual analysis suggests the systematic risks of a benchmark efficient entity would be less than the systematic risks of a market average entity (that is, less than 1.0).[71]

110. The Guideline materials do not report how this cross check was performed or what effect it has had on the final estimate of beta. In our view:

    a) If the conceptual analysis has had no effect on the estimate of beta (i.e., the same estimate of beta would have been used whether or not the conceptual analysis had been carried out) it should be dispensed with as unnecessary and irrelevant; but

    b) If the conceptual analysis *has* had an effect on the estimate of beta, that estimate of beta should be revised in light of the issues set out above.

[69] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 43.
[70] Recall from Paragraph 85 that the relevant re-levered equity beta estimates are 1.22, 1.47, 1.59, 1.33, and 1.31.
[71] AER Rate of Return Guideline, Explanatory Statement, p. 83.

5. Regulatory estimates of beta for water utilities

Guideline consideration of regulatory estimates of beta for water utilities

111. The Guideline materials note that the AER has changed the way it intends to have regard to regulatory estimates of beta for water utilities, relative to the approach that was proposed in the draft Guideline. Whereas the draft Guideline proposed that this information would be used as a final cross check, the final Guideline gives "limited value" to this information:

> One element of our approach has changed since our equity beta issues paper. That is, we now give limited value to equity betas from regulated Australian water networks, rather than using this information as a cross check.[72]

112. The Guideline materials do not explain precisely how or where in the estimation process the "limited value" is given to regulatory equity betas for water utilities. However it appears that this information has been used to support the proposed range of 0.4 to 0.7. In particular, the Guideline materials state that:

> this information supports an equity beta estimate within our proposed range.[73]

and that:

> this information supports an equity beta estimate within a 0.55 to 0.8 range. This is similar to our proposed 0.4 to 0.7 range.[74]

Basis for regulatory estimates of beta for water utilities

113. The Guideline materials note that Australian regulatory estimates of beta are based on two pieces of evidence:

    a) Australian regulatory estimates of beta for energy networks; and

    b) Empirical estimates of beta for international water utilities.[75]

114. To the extent that they are based on regulatory estimates of beta for energy networks, the reliance on regulatory estimates of beta for water utilities would be entirely circular. The Guideline materials note that this point has been made by PIAC and other stakeholders.[76]

115. This leaves the empirical estimates of beta for international water utilities as the only new information that is contained within regulatory water betas. In our view, there is no place for such evidence because there is already a large sample of international energy network betas available. Indeed, as set out below, the Guideline's main issue with international energy network betas is that the firm's may

[72] AER Rate of Return Guideline, Explanatory Statement, p. 86.
[73] AER Rate of Return Guideline, Explanatory Statement, p. 86.
[74] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 45.
[75] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 45.
[76] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 46.

not be sufficiently comparable to the benchmark entity. Water utilities will be even less comparable.[77] There may have still been a place for water utilities if the available sample of energy networks was too small to provide statistically meaningful results, but there is a large sample of international energy networks available.

116. In this regard, the AER states that it considers empirical estimates of beta for overseas water utilities to be "problematic" and "less relevant."[78] That is, two sources of information have been used to compile Australian regulatory water betas: Regulatory energy network beta estimates are entirely circular, and empirical estimates for overseas water utilities are problematic and less relevant.

117. The AER notes that it has changed the way in which it has regard to regulatory estimates of beta for water utilities, but that the change has no effect on its primary range or point estimate:

> we consider this information should have limited application to estimating the equity beta for a benchmark efficient entity. However, this decision does not have a material impact on our proposal to apply a 0.7 equity beta point estimate from a 0.4 to 0.7 range.[79]

118. It seems that, in effect, regulatory estimates of beta for water utilities have had no observable effect on the AER's proposed range or on its point estimate. In our view:

    a) If the water betas have had no effect on the estimate of beta for the benchmark firm (i.e., the same estimate of beta would have been used whether or not the water betas had been considered) they should be dispensed with as unnecessary and irrelevant; but

    b) If the water betas *have* had an effect on the estimate of beta for the benchmark firm, that estimate of beta should be revised in light of the issues set out above.

[77] Given that the benchmark firm is defined to be an Australian energy network, an international energy network is likely to be a closer comparable than an international water network given that the international energy networks are engaged in the same line of business, providing the same service in relation to the same commodity as the benchmark firm.
[78] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 46.
[79] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 46.

6. An assessment of the Guideline approach for estimating equity beta

A multi-stage approach

119. The Guideline proposes to use the following approach to estimate equity beta:

> the AER proposes to estimate the range for the equity beta based on empirical analysis using a set of Australian energy utility firms the AER considers reasonably comparable to the benchmark efficient entity. This approach leads to a range for equity beta from 0.4 to 0.7.
>
> The AER then proposes to use other information sources to inform the selection of a point estimate from within the empirical range of equity beta estimates. This additional information includes:
>
> - empirical estimates of overseas energy networks.
> - the theoretical principles underpinning the Black CAPM.
>
> This approach leads to a point estimate of 0.7 for equity beta, chosen from within the range 0.4 to 0.7.[80]

120. In summary, the Guideline layers a "foundation implementation" on top of its foundation model approach. In relation to equity beta, the Guideline uses a subset of the relevant evidence to define a primary range and all other evidence is only used (at most) to select a point estimate from within that range, even if the other evidence supports an estimate from outside the range.

The proposed approach effectively excludes relevant evidence

121. Under the Guideline, the range for beta is fixed at 0.4 to 0.7 on the basis of the analysis of a subset of the relevant evidence. Importantly, this range is determined before the consideration of all the relevant evidence. To show why this is a problem, we consider a number of scenarios. First, suppose that there is one piece of evidence to be considered in the second stage of the Guideline's estimation process and that this evidence supports a beta of 0.9. The maximum effect that this piece of evidence can have is to cause the point estimate to be set at the top of the primary range, 0.7.

122. Now suppose that there are six pieces of evidence to be considered in the second stage of the estimation process, and that all of them support a beta of 0.9 or above. Again, the primary range constrains the possibility of setting the equity beta above 0.7. Had a different piece of evidence been used as the primary determinant, the initial range may have been set as 0.8 to 1.0. In this case, the point estimate would have to be selected from within that range – based on the five remaining pieces of evidence supporting an estimate of 0.9 or above and one piece of evidence supporting an estimate of 0.4 to 0.7.

123. In summary, under the two-stage approach, exactly the same set of evidence can produce materially different beta estimates depending on which piece of evidence is selected as the primary determinant and which is relegated to the second stage.

124. Moreover, any evidence that is relegated to the second stage is disregarded to the extent that it is inconsistent with the primary range. That is, a piece of evidence that supports an estimate above the primary range can, at most, result in the final estimate being selected at the top of the primary range.

[80] AER Rate of Return Guideline, p. 15.

Once it has been determined that the point estimate should be set at the top of the primary range, any further evidence that supports higher estimates must be disregarded, because the point estimate has already been set at the maximum that is allowed.

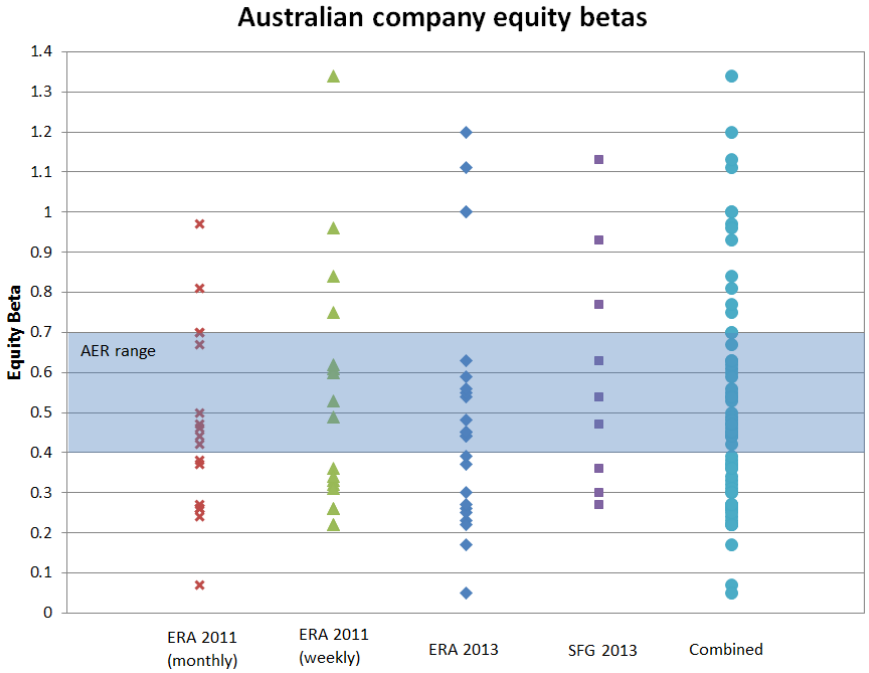
125. In our view, an approach that pre-emptively dilutes or eliminates the impact of relevant evidence (before a full consideration of the relative strengths and weaknesses of the evidence) is unlikely to produce estimates that are consistent with the allowed rate of return objective. A better approach would be to set out all of the evidence that is relevant to the estimation of beta and to select a point estimate by weighting each piece of evidence according to its relative strengths and weaknesses.

126. By way of analogy, consider some foreign tourists exchanging currency with a street vendor. If the tourists are exchanging Australian dollars for US dollars, they may decide that a reasonable range is 89-91 cents. Now suppose that there is evidence that the street vendor will not be handing over US dollars, but New Zealand dollars instead (for which a fair exchange rate would be in the order of $1.10). The Guideline process suggests that this new evidence should lead the tourists to demand a rate at the top of their "primary range" – 91 cents.[81]

Primary range is arbitrary and meaningless

127. The Guideline materials discuss a range of methods that have been used to apply statistical regression analysis on the very small set of domestic comparables (currently numbering five). A summary of the results that support the Guideline's primary range of 0.4 to 0.7 is set out in Figure 1 below.

Figure 1. Regression-based estimates of Australian-listed energy networks



Source: ERA (2011),[82] ERA (2013),[83] SFG (2013).

[81] In our experience, readers are sometimes tempted to try to extend analogies beyond the point being made. In this case, the simple point is that if there is evidence that the entire initial range is wrong, it is not an appropriate response to have regard to that evidence by simply selecting a point at one end of that initial range.
[82] Economic Regulation Authority, 2011, Western Power access arrangement: Draft Decision, March.
[83] Economic Regulation Authority, 2013, Draft Rate of Return Guidelines for Gas Transmission and Distribution Networks – Final Guidelines – Explanatory Statement, August.

128. Figure 1 above sets out re-levered (to 60%) equity beta estimates for the set of comparable firms That are used as the primary evidence for estimating beta under the Guideline. The important thing to note is that these are all estimates of the same thing – the regression-based equity beta for an energy network business with 60% leverage. However, the range of point estimates is almost uniformly distributed over a wide range that begins below 0.4 and ends well above 0.7. The lowest estimate is 0.05 and the highest is 1.34. There is no a priori reason to believe that any of these estimates is more reliable than any other – they are all supposed to be equally valid estimates of the same thing.[84]

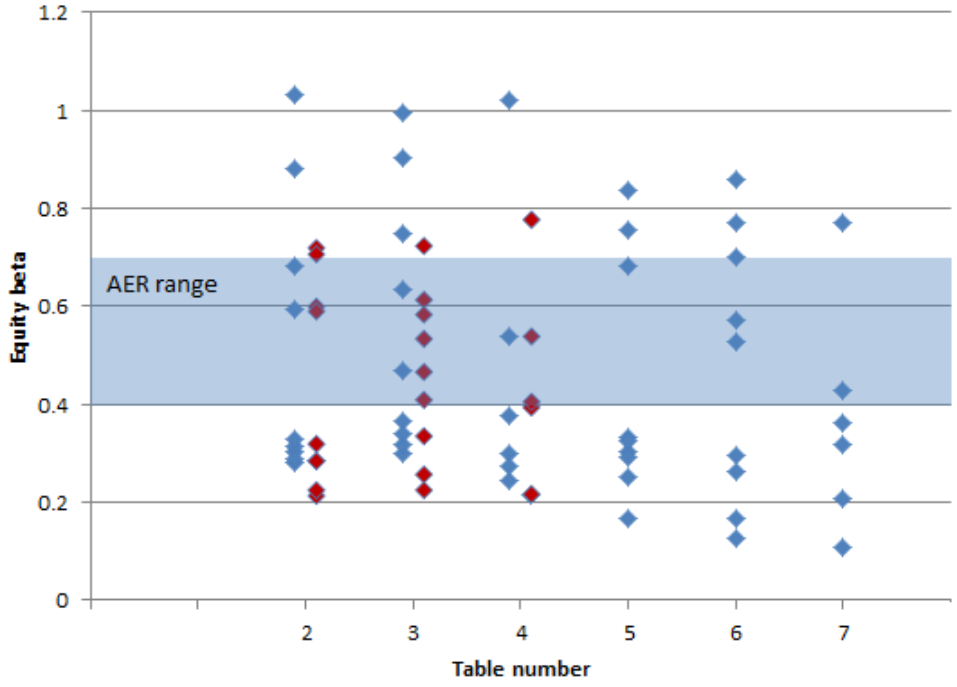
129. The Guideline provides no basis for why the range is constrained to 0.4–0.7, nor even explained what the range means. It is not a confidence interval, it is not the minimum-to-maximum, it appears to be an arbitrarily selected band. But the selection of this range is critically important because the final estimate of equity beta is constrained to come from within this range – regardless of any other relevant evidence to the contrary.

130. That is, the key point here is that this primary range is considered to be so precise and so reliable that no estimate from outside that range can be entertained, regardless of the strength of any other relevant evidence.

131. Moreover, the fact that these estimates in Figure 1 cover such a wide range should lead to questions about the reliability of the beta estimates produced from this small subsample of the available data.

132. Since the publication of the Guideline, the AER has released the report of Henry (2014). The OLS (blue) and LAD (red) beta estimates for the small sample of domestic firms, computed over different periods using weekly and monthly data are reported in his Tables 2 to 7, and are summarised in Figure 2 below.

Figure 2. Regression-based estimates of Australian-listed energy networks



Source: Henry (2014), Tables 2-7.

[84] The small clusters of estimates (some of which are below, some of which are within, and some of which are above the AER's proposed range) occur due to slight variations of the regression methodology being applied to the same data set for the same firm.

133. Figure 2 shows that the LAD estimates are systematically lower than the OLS estimates,[85] and that fewer than 20% of the Henry (2014) OLS beta estimates fall within the 0.4-0.7 range that is proposed in the Guideline.

Primary data produces unreliable estimates

134. Another reason to question the use of a primary range based on a subset of the relevant evidence is that the estimates produced by that subset of the relevant evidence have been shown to be unreliable in several respects. The very wide range of estimates in the figure above is one reason to have concern about the reliability of the estimates from the small set of domestic firms. Other reasons are set out below.

Variation in estimates across methodological choices

135. The estimates that are used to support the primary range for beta in the Guideline vary alarmingly depending on the methodological choices of regression technique and sampling period. This is best illustrated in relation to HDF. The Guideline materials summarise a number of estimates.[86] Those estimates for HDF are summarized in the following table.

Table 1
Regression-based beta estimates for HDF from ERA (2011) reported by the AER

		Regression Method	
		OLS	**LAD**
Sampling	Monthly	0.07	0.47
Period	Weekly	1.34	0.84

136. The estimates set out in the table above are for the same company for the same time period.

137. Similarly, Henry (2014) reports a weekly OLS beta estimate for HDF of 1.03. Using LAD estimation reduces the estimate to 0.70.[87] Using monthly data reduces the estimate to 0.29.[88]

Variation in estimates across time

138. According to the ERA estimates that are used to support the primary range for beta under the Guideline, the average estimate of beta for Envestra increased by 20% between 2011 and 2013. The possible explanations for this are:

a) The true systematic risk of Envestra did actually increase by 20% over a two-year period; or

b) The beta *estimates* are unreliable.

139. Moreover, the results also imply that, over the same two year period, the average estimate of beta for Enevstra *increased* by nearly 20% and the beta of DUET *decreased* by 25%. Moreover, of the six firms

[85] Consistent with the discussion in Section 3 above.
[86] AER Rate of Return Guideline, Explanatory Statement, Appendix C, Table C.7 and C.8, pp. 56-57.
[87] Henry (2014), Table 2.
[88] Henry (2014), Table 5.

examined by the ERA in 2013, three had *higher* beta estimates and three had *lower* beta estimates relative to the ERA's estimates two years earlier. Again, the possible explanations are:

a) The true systematic risk of some of the benchmark firms increased materially over the two-year period and the true systematic risk for others decreased materially (which would call into question whether these firms are all properly included in the same set of "comparables"); or

b) The beta *estimates* are unreliable.

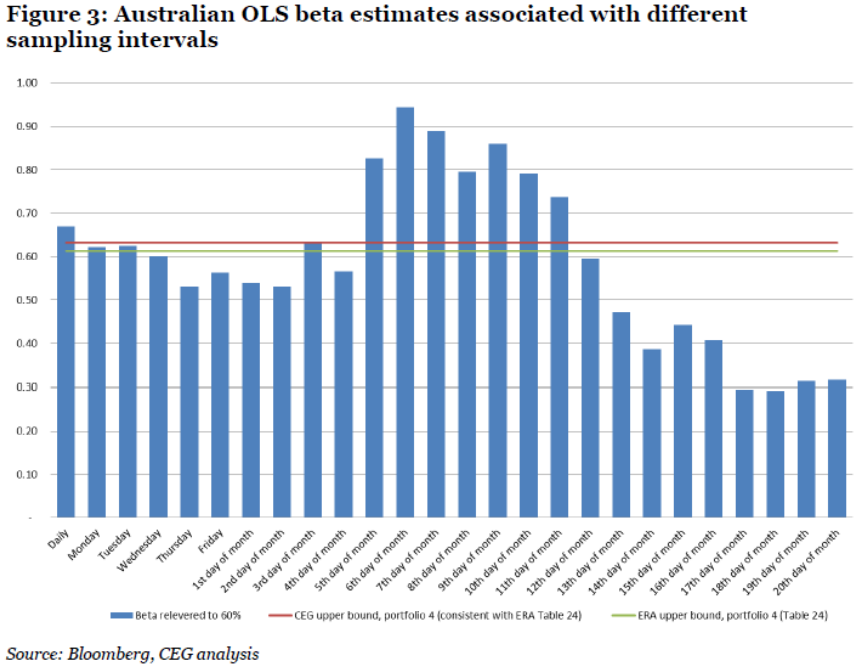
140. Similarly, weekly OLS beta estimates vary materially for the same firms between Henry (2008)[89] and Henry (2014).[90] For example, the beta estimate for AGL, Alinta and HDF *decline* by approximately 30% whereas the estimate for SKI *increases* by approximately 50% and the estimate for DUET more than doubles. In addition, Henry (2014) sets out recursive estimates of beta in the appendix to his report. The relevant figures show that beta estimates for the same firm regularly double and halve over time. Although the Hansen test is unable to detect any parameter instability, Henry (2014) notes that there are concerns about "the lack of power associated with the Hansen test in small samples."[91]

Variation in estimates across sampling days

141. The report by SFG (2013)[92] highlighted the fact that beta estimates can vary materially depending on which day of the month is used as the reference point when determining returns. In a recent submission to the ERA, CEG (2013)[93] has documented a similar pattern in weekly data. The relevant figure from that report is reproduced below. This figure shows the mean (re-geared to 60%) equity beta estimate for the ERA's sample of six domestic comparables (the five that remain listed plus HDF) according to the way returns are measured. The mean estimate of beta can change by a factor of three simply by measuring returns from the sixth day of each month rather than from the 17th.

[89] Henry (2008), Table 1.
[90] Henry (2014), Table 2.
[91] Henry (2014), p. 33.
[92] SFG Consulting, 2013, *Regression-based estimates of risk parameters for the benchmark firm*, Report for the Energy Networks Association, June.
[93] CEG, 2013, *Regression estimates of equity beta.*

Figure 3. Australian OLS beta estimates associated with different sampling intervals



Source: CEG (2013), Figure 3.2, p. 26.

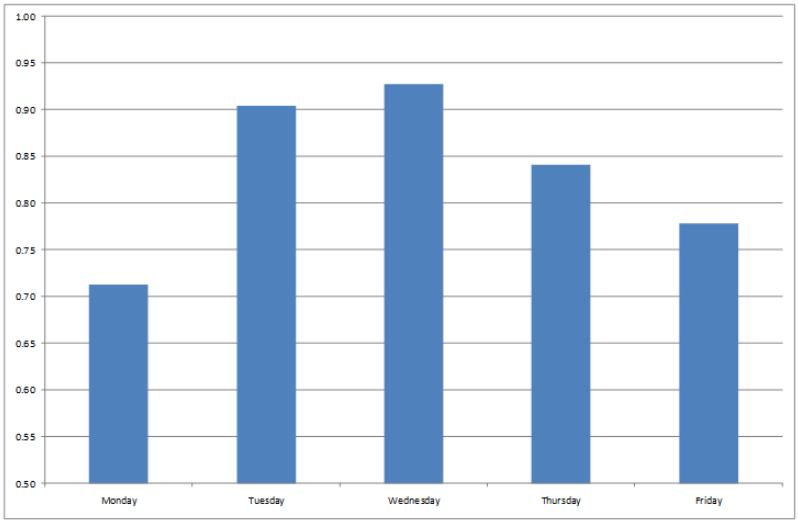
142. Moreover, CEG (2013)[94] show that there is variation in the mean beta of the sample of ten US firms that the AER instructed its consultant to examine in Henry (2008) and Henry (2009). The CEG report demonstrates that the results in Henry (2008) appear to be based on Friday-to-Friday returns and that the results of Henry (2009) appear to be based on Monday-to-Monday returns.[95]

143. The following figure, reproduced from CEG (2013) summarises the mean beta estimates for the Henry sample according to the day of the week that is used to measure returns. CEG conclude that the move from Friday-based returns to Monday-based returns:

> involves a move from the second lowest to the lowest beta. Had Henry moved from Friday to Wednesday rather than Monday the estimated beta would have been 0.21 higher.[96]

[94] CEG, 2013, *AER equity beta issues paper: international comparators*.
[95] CEG (2013), Paragraph 127.
[96] CEG (2013), *AER equity beta issues paper: international comparators*, Paragraph 129.

Figure 4. Domestic beta estimates by day of week



Source: CEG (2013), Figure 13, p. 44.

144. In our view, this wide variation in returns – caused by nothing more than changing the day of the week (or month) from which returns are measured – is evidence of a lack of reliability. This provides further evidence that adopting a narrow range of 0.4 to 0.7 for equity beta unreasonably restricts the relevance that other information can have in reaching a final decision on equity beta.

145. Henry (2014) does not address this issue.

International evidence

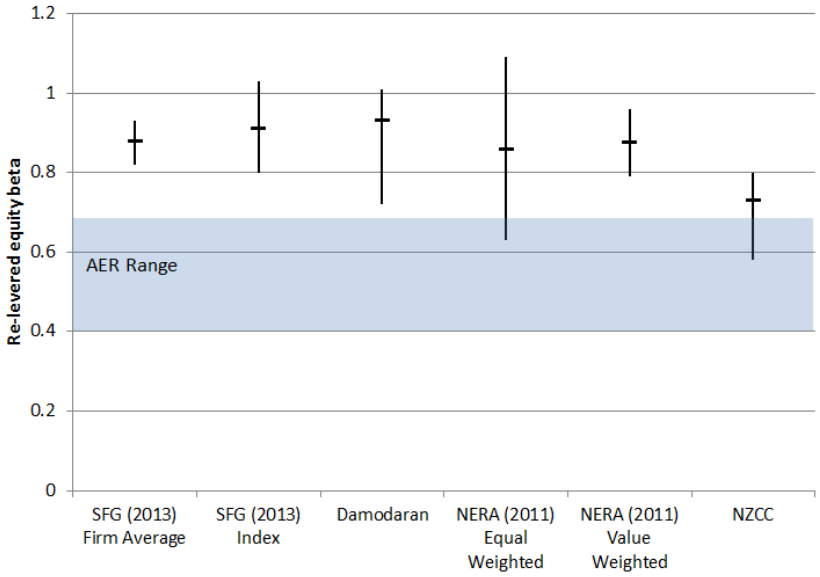
Summary of the international evidence

146. In this section of the report, we first summarise the international evidence that is set out in the Guideline materials and then we discuss the Guideline's interpretation of this evidence and its use in the beta estimation process.

147. The Guideline materials set out the relevant international evidence in Appendix C.[97] We summarise that evidence in Figure 5 below.[98]

[97] Specifically, at pp. 66–67.
[98] Note that the figure does not contain estimates from prior to 2010, such as the 2007 and 2008 Damodaran estimates of 1.34 and 1.31 that were referenced by McKenzie and Partington (2012).

Figure 5. Summary of AER international beta estimates



Source: AER Appendix C, pp. 66–67.

Notes: The AER only reports the point estimates from SFG (2013), so ranges have been obtained directly from the SFG (2013) report. The figure shows the range and mean of the four point estimates from Damodaran that are set out in the AER's appendix. The AER sets out only the ranges from NERA (2013); the figure shows the mid-point in each case. The AER sets out four estimates from the NZCC; the figure shows the range and mean.

148. Two additional points are relevant to the interpretation of the evidence set out in Figure 5:

    a) The NZCC estimates are based on a sample that includes:

        i) The Australian firms that have already been taken into account elsewhere in the estimation process; and

        ii) A number of very small US firms that trade so infrequently that their betas cannot be reliably estimated, as explained by SFG (2013); and

    b) Updated 2014 estimates provided by Damodaran indicate a mean re-levered equity beta estimate of 1.00 for utilities.[99]

149. Quite clearly, the international evidence supports an equity beta estimate above the top end of the 0.4 to 0.7 range that is proposed in the Guidelines.

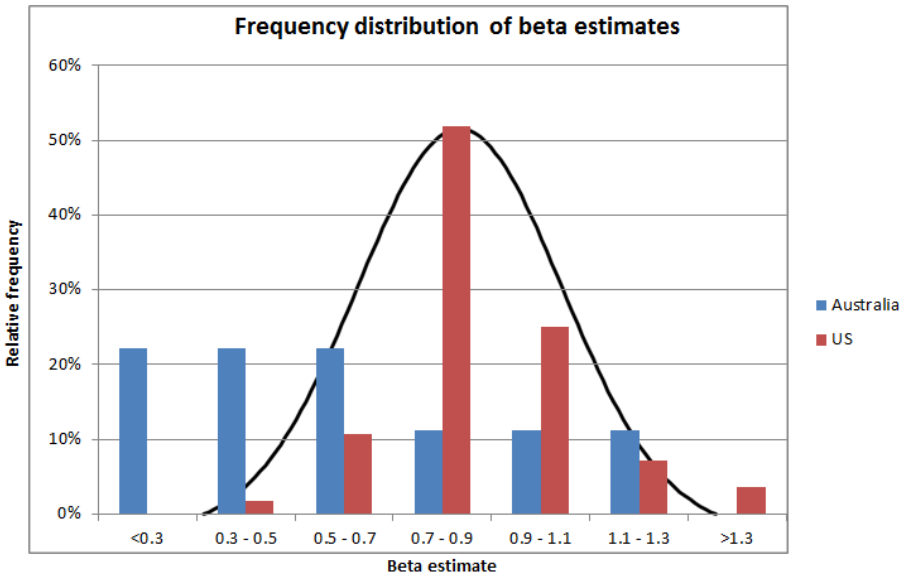
150. Another relevant consideration is the distribution of beta estimates. SFG (2013) presented equity beta estimates for nine domestic firms and 56 US firms. As noted above, the estimates for the Australian firms are disbursed over a very wide range. By contrast, the distribution of beta estimates from the much larger sample of US firms is uni-modal[100] and approximately symmetric with a large majority of estimates within a narrow range. The distributions of the two sets of beta estimates are set out in Figure 6 below.

151. We note that the Australian distribution looks like the distribution of a tiny sample of random numbers whereas the US distribution looks like the standard probability distribution of a statistically valid sample of estimates. The black curve in Figure 6 shows a normal distribution, which is the

[99] See http://www.stern.nyu.edu/~adamodar/pc/datasets/betas.xls.
[100] That is, the probability distribution has a single hump, with many estimates around that central value and with fewer estimates further away from that central value.

standard statistical distribution that would be expected from a sample of estimates of the same quantity. The distribution of 56 US beta estimates clearly aligns much more closely to the normal distribution than does the small sample of nine domestic estimates. Statistically, one would have more confidence in the mean estimate from a large sample that approximates a normal distribution than one would have in a mean from a decidedly non-normal distribution of a very small sample.

Figure 6. Frequency distribution of beta estimates



Source: Re-levered equity beta estimates from SFG (2013).

The reliability of international beta estimates

152. The Guideline materials raise a number of questions about the reliability of international beta estimates, each of which is addressed in turn below.

Climate and geographical considerations

153. The first issue raised in the Guideline materials is that the systematic risk of US firms might differ from that of Australian firms due to factors such as weather and geography. That is, the Guideline materials appear to suggest that the beta of a network business may differ materially between cold and warm climates or between city and rural areas. However, the Guideline materials do not explain the mechanism by which these factors may affect systematic risk nor do they provide any evidence that they do affect systematic risk. Moreover, if these factors do materially affect systematic risk, it would be wrong to use the same beta estimate for all network assets in Australia, because that would result in some customers being overcharged and others being undercharged. Rather, allowed returns would have to be set according to the beta that was appropriate for the climate and geography of the network in question.

Market composition

154. The Guideline materials also argue that investors may require materially lower returns from domestic energy network businesses than they might require from international energy network businesses because there are relatively more mining companies based in Australia. This conjecture is based on the following insight:

> The Australian market portfolio may exhibit a relatively high systematic risk since it contains many mining stock returns of which are very dependent on the global economy and therefore have high systematic risk.[101]

155. We cannot be sure what point is being made here, since under the CAPM the market portfolio always has a systematic risk (or beta) of exactly 1 by definition. However, it seems that the Guideline materials have in mind some version of market segmentation whereby Australian investors do not have access to US stocks and have to invest more in mining stocks – and vice versa for US investors. However, in reality any investor (Australian or US) can just as easily buy US stocks or Australian mining stocks. No evidence has been presented to support the notion that investors in the real world require lower returns from their Australian network businesses because they happen to be co-located with relatively more mining stocks. It seems unlikely that BHP and Rio moving their primary listings to the UK would cause an increase in the returns required from Australian energy network businesses.

156. Moreover, an estimate of equity beta that is based on some form of market segmentation that does not exist in the real world would not be commensurate with the prevailing conditions in the actual market for equity funds.

Vertical integration

157. The Guideline materials note that some of the firms that might be included in a sample of US comparables are vertically integrated to some extent, with some level of investment in retail and/or generation activities. The suggestion is that retail and generation activities may have higher systematic risk, in which case the beta of the integrated entity may over-estimate the beta of distribution/transmission activities only.[102]

158. By contrast, in their advice on this matter to the ACCC, Frontier Economics (2010) set out a number of reasons why:

> a vertically integrated company may be expected to have a *lower* beta than the average of its component parts.[103]

159. This led Frontier to recommend a *lower* equity beta for more vertically integrated businesses:

> Victoria's rural water sector is relatively more vertically integrated than the energy sector. In this regard an equity beta for Victorian rural water businesses would be lower than that of an energy business. The water sector in NSW is less integrated and the case for a lower equity beta is less compelling in NSW.
>
> Given the general lack of competition within an irrigation scheme, the materiality of any difference is not expected to be great.[104]

160. The issue of vertical integration would seem to be a moot point given that the Guideline materials also examine a small subsample of US businesses that are exclusively engaged in gas and electricity

[101] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 60.
[102] AER Rate of Return Guideline, Explanatory Statement, Appendix C, pp. 61–63.
[103] Frontier Economics (2010), p. 23, emphasis added.
[104] Frontier Economics (2010), p. 30.

transmission and distribution, and the mean beta for that sample remains materially above the top end of the AER's proposed range.[105]

Use of international evidence

161. The Guideline materials apparently consider the potential use of international evidence as a binary choice – that it will either rely on the small set of domestic comparables *or* on the large set of international comparables. In this regard, the Guideline materials state that:

> We consider service providers and their consultants have not established reasonable basis to conclude that US data should be used in place of Australian data.[106]

and:

> we consider this sensitivity analysis does not lead to the conclusion that Australian equity beta estimates should not be used.[107]

162. In our view, there is no binary choice to be made. Beta estimates for the few Australian firms are relevant evidence that should be considered. And beta estimates for the much larger sample of international comparables are also relevant evidence, so should also be considered. The task is not to select the "best" sub-set of evidence to the exclusion of all other evidence. Rather the relevant task is to have regard to all relevant evidence and, in our view, the Australian and the international evidence are both relevant and regard should be had to both. In having regard to both, one would consider a range of factors such as sample size and the statistical reliability of the estimates, comparability of sample firms, and so on.

163. Our understanding is that the AER has received no submissions suggesting that the international evidence should be used to the exclusion of the domestic evidence. But the Guideline materials set out a binary test in selecting a single subset of evidence to determine the primary range for beta. Given that a single subset of evidence is required to determine the primary range, the small sample of domestic firms is used for that purpose in the Guideline:

> we consider the equity beta estimates based on international comparators should not be used as the primary determinant of the equity beta range or the point estimate for the benchmark efficient entity.[108]

164. However, the Guideline imposes an artificial constraint by:

    a) Requiring that beta must be estimated by first using a subset of the relevant evidence to establish a primary range for beta; and

    b) Requiring that the primary range must be determined either by reference to domestic comparables or by reference to international comparables, but not by both.

165. Under this process, whichever piece of evidence is not used to determine the primary range is effectively relegated to having negligible weight at best. We are unaware of any other use of such a

[105] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 63.
[106] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 60.
[107] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 61.
[108] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 59.

process of defining "primary" evidence to set a range and then allowing other relevant evidence to do no more than select a point within the range. By contrast, a process whereby all relevant evidence is set out and considered in light of the relative strengths and weaknesses is more likely to produce an estimate that properly reflects the body of relevant evidence.

166. Henry (2014) was instructed not to examine the international evidence.

Evidence from the Black CAPM

167. The Guideline materials state that the Black CAPM will be used to inform the estimate of equity beta:[109]

> We account for the Black CAPM because we recognise there is merit to its theoretical basis, particularly when viewed alongside the standard Sharpe–Lintner CAPM.[110]

168. The Guideline materials further explain that the Black CAPM has the theoretical merit of relaxing one of the strongest and most unrealistic assumptions of the Sharpe-Lintner CAPM – the assumption that all investors can borrow or lend as much as they like at the risk-free rate:

> The Sharpe–Lintner CAPM assumes there is unlimited risk free borrowing and lending, a simplification that does not hold in practice. The Black CAPM relaxes this assumption and acknowledges that investors may not be able [to] undertake unlimited borrowing or lending at the risk free rate.[111]

169. In addition, the Black CAPM provides a much better fit to the observed data than does the Sharpe-Lintner CAPM.[112]

170. However, in this report, we consider how to provide the best possible statistical estimate of equity beta for use in the Sharpe-Lintner CAPM – as though one considered that the Sharpe-Lintner CAPM in its pure theoretical form was all that was required to estimate the required return on equity. In this report, we do not consider how this estimate might be adjusted or informed by evidence about the theoretical and empirical failings of the Sharpe-Lintner CAPM.

171. In particular, we note that beta has exactly the same definition in the Sharpe-Lintner CAPM and the Black CAPM, so the same estimate would be used in both models. This would lead to two different estimates of the required return on equity, because the two models use somewhat different pricing equations, even though the same estimate of beta would be inserted into both. The goal of this report is to obtain the best estimate of beta that would be used in these two models.

172. By contrast, the foundation model requires a different estimate of beta that, when inserted into the Sharpe-Lintner CAPM only, produces a single estimate of the required return on equity that somehow jointly reflects the Sharpe-Lintner CAPM *and* the Black CAPM. We do not consider such composite estimates of beta in this report.

[109] AER Rate of Return Guideline, Explanatory Statement, Guideline, p. 13.
[110] AER Rate of Return Guideline, Explanatory Statement, p. 85.
[111] AER Rate of Return Guideline, Explanatory Statement, Appendix A, p. 17.
[112] See the description of the relevant empirical evidence in SFG (2014), *Cost of Equity in the Black Capital Asset Pricing Model*, April.

Conclusions in relation to empirical estimates of equity beta

173. In our view, there is substantial evidence that the approach to estimating equity beta that is set out in the Guideline materials (by using regression analysis applied exclusively to a very small sample of domestic comparables to determine the range of allowable beta estimates) produces unreliable estimates. This evidence includes:

    a) The beta estimates vary wildly across firms, with the majority of estimates falling outside the 0.4 to 0.7 range that the AER adopts;

    b) The beta estimates vary wildly over time with estimates for some firms increasing by 20% and others decreasing by 20% over a short period;

    c) The beta estimates vary wildly depending on which sampling frequency is used;

    d) The beta estimates vary wildly depending on which regression specification is used; and

    e) The beta estimates vary substantially depending on the day of the week on which they are computed.

174. Moreover, the evidence from a larger sample of overseas comparables does not suffer, to nearly the same degree, from the problems set out above. Our view is that the evidence from foreign comparables is relevant and should be considered. When estimating other WACC parameters it is routinely recognised that the sample of domestic comparable firms is too small to provide reliable estimates (e.g., when estimating debt risk premium). In our view, the same applies to the estimation of equity beta.

175. Finally, we note that since the publication of the Guideline, the AER has released the report by Henry (2014). Henry was instructed to perform regression analyses on historical stock returns relating to a specified sample of domestic firms. Based on his analysis, he concludes that "the point estimate for β lies in the range 0.3 to 0.8"[113] and that "it is difficult to pin down a value for the beta of a typical firm."[114]

176. It is important to note that the range of 0.3 to 0.8 is Prof. Henry's assessment of a reasonable range for the slope coefficient from a regression of historical stock returns on historical market returns for the small sample of firms he was instructed to examine. Henry (2014) makes no conclusions about (a) the best available estimate of the systematic risk of the benchmark efficient entity, or (b) the estimate of beta that, when inserted into the Sharpe-Lintner CAPM, produces an estimate of the required return on equity that best reflects the efficient financing costs of the benchmark efficient entity. Henry (2014) was not asked to provide his views on those matters and, in our view, it would be impossible to meaningfully opine on those matters on the basis only of the analysis that he was instructed to perform.

[113] Henry (2014), p. 63.
[114] Henry (2014), p. 63.

7. The best empirical estimate of beta

Overview of the issues

177. In the framework that is proposed in the Guideline, there are two types of evidence that the AER will have regard to when estimating equity beta. First, there is evidence about the empirical beta estimates (primarily from regression analysis applied to comparable firms), and then there is evidence about how those estimates may need to be adjusted to take account of the empirical and theoretical failings of the Sharpe-Lintner CAPM (specifically evidence relating to the Black CAPM). In this section, we consider how to obtain the best possible empirical estimate of beta that could then be inserted into the Sharpe-Lintner CAPM or the Black CAPM.

178. The evidence that the AER uses to estimate the "pure" beta (i.e., prior to any adjustment to reflect evidence from other relevant models) is summarised as follows:

a) Regression estimates of beta for listed domestic energy network businesses;

b) Regression estimates of beta for listed international energy network businesses;

c) The AER's conceptual analysis; and

d) Regulatory estimates of beta for water utilities.

179. As set out in Section 5 above, our view is that regulatory estimates of beta for water utilities are not relevant evidence and should be disregarded. This is because those water utility beta estimates are based entirely on:

a) Regulatory estimates of beta for energy network businesses; and

b) Regression estimates of beta for international water utilities.

180. The estimates of beta for energy network businesses add nothing. Obviously it would be entirely circular to corroborate regulatory estimates of energy network betas using something that is based on regulatory estimates of energy network betas.

181. The regression estimates of beta for international water utilities are also of no marginal benefit because a large sample of international energy networks is already available. It would obviously make no sense to have more regard to evidence that is based on international water utilities than to evidence based on international energy networks.

182. The Guideline materials reach much the same conclusion:

> It is problematic to rely on these regulatory determinations, because these do not provide material additional information. [115]

183. Moreover, the Guideline materials indicate that the regulatory estimates of beta for water utilities have "limited application to estimating the equity beta for a benchmark efficient entity."[116] The

[115] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 45.
[116] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 44.

Guideline materials also note that, although the AER has changed the way they use this information "the change to our approach has no material impact on our outcome." [117]

184. In our view, regulatory estimates of beta for water utilities are not relevant evidence and should be disregarded. We note that this information appears to have had no material effect on the range or point estimate for beta that is adopted in the Guideline.

185. As set out in Section 4 above, our view is that the conceptual analysis that is set out in the Guideline materials adds nothing to the estimation of equity beta. That analysis recognises that the benchmark firm is likely to have lower-than-average business risk (asset beta) and higher-than-average leverage. The former would have the effect of reducing equity beta and the latter would have the effect of increasing it. The goal of the conceptual analysis is to determine (conceptually) which of the two effects dominates.

186. The Guideline materials conclude that the higher-than-average leverage has the smaller effect on equity beta. This conclusion is based on:

    a) The Frontier Economics (2013) report insofar as it relates to financial risks; and

    b) The McKenzie and Partington (2012) report insofar as it relates to the relative effects of business risk and leverage.

187. For the reasons set out in Section 4, our view is that the analysis set out in the Guideline materials has fundamentally misinterpreted the advice presented in both reports:

    a) The Guideline materials interpret the Frontier Economics report as supporting the notion that there is an a priori expectation that the lower-than-average business risk will dominate the higher-than-average leverage, in which case equity beta is expected to be less than 1. However, the Frontier Economics report contains no such statement and makes no such conclusion. Section 4 of this report shows that the financial risks that are reviewed in the Frontier Economics report have nothing at all to do with the way in which equity beta depends on leverage; and

    b) The McKenzie and Partington report uses the Damodaran empirical estimates of US energy network utility betas to support the proposition that "conceptually" the equity beta for such firms is likely to be materially lower than 1. However, the (re-levered to 60%) equity betas for all five industry sectors are above 1.2. That is, the Guideline materials (via McKenzie and Partington) use equity beta estimates above 1.2 to support the conceptual notion that equity beta is likely to be materially less than 1.

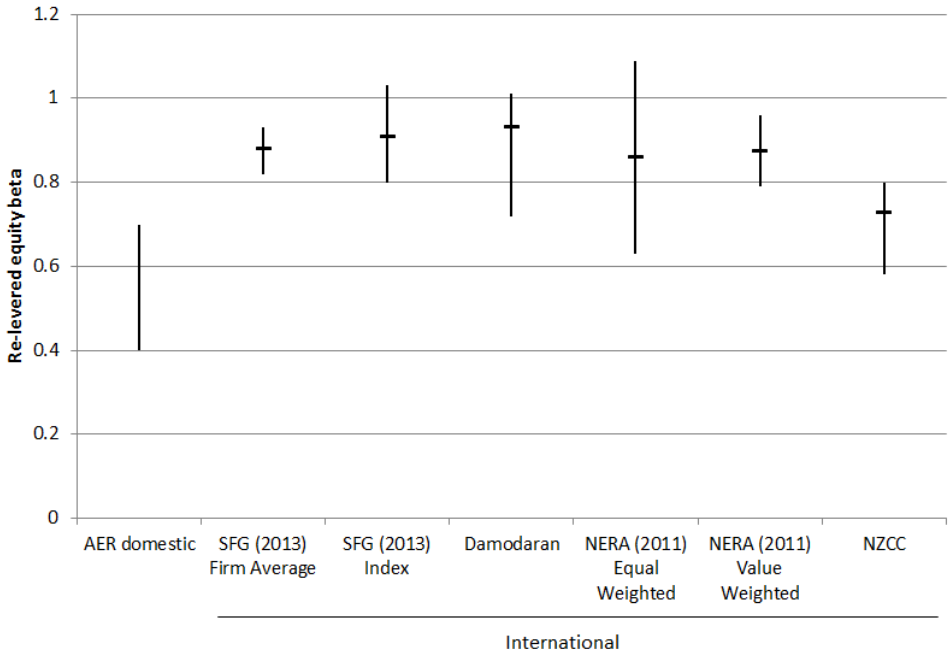
188. For these reasons, and those set out in Section 4 above, our view is that the conceptual analysis adds nothing to the estimation of equity beta. Indeed, it is difficult to imagine any circumstance in which a conceptual analysis could supplant the empirical estimates. Consistent with this view, the Guideline materials appear to have made no use of the conceptual analysis other than to conclude that it is not inconsistent with the empirical estimates of beta.

189. Since the conceptual analysis and the regulatory estimates of beta for water utilities add nothing material, we are left with the empirical estimates that are summarised in Figure 7 below. Figure 7 sets out the empirical estimates from Appendix C to the Guideline, and the AER's interpretation of that evidence. For example, the figure shows that the AER's interpretation of the domestic data is that it

[117] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 44.

supports a range of 0.4 to 0.7. The international evidence that is included in Figure 7 has previously been summarised in Figure 5 above.

Figure 7. AER empirical estimates of beta



Source: AER Appendix C.

190. The empirical evidence set out above must then be distilled into a regulatory estimate of the raw beta. This will involve a consideration of the relative strengths and weaknesses of each piece of evidence. For example, the five domestic energy network firms that remain in the sample are likely to be more comparable to the benchmark firm, which the Guideline defines to be a firm operating in Australia. Conversely, the international samples include dozens of firms, which improves the precision and statistical reliability of the estimates.

191. In our view, the best approach for distilling the domestic and international empirical evidence is that set out in SFG (2013).[118] They consider the same 9 domestic firms (five of which are currently listed) that are used to compile the domestic beta estimates on which the Guideline's primary range is based. SFG also consider 56 international energy network businesses that were selected by CEG (2013) on the basis of their comparability to the benchmark efficient regulated firm. Having compiled beta estimates (re-levered to 60%) SFG state that:

> The next question is to consider how much weight should be placed on the evidence from Australian-listed firms and the U.S.-listed firms. In reaching a conclusion we considered the issues of comparability and reliability. Ideally we would have a large number of Australian-listed firms to analyse. But the reality is that this sample is so small that to consider it in isolation leads to estimates that are highly unreliable, as demonstrated in our companion report. It should also be noted that the set of comparable firms from the United States was carefully scrutinised by CEG (2013) with respect to the proportion of assets under regulation, their industry classification and their prior use in comparable firm analysis for regulatory decision-making.

[118] SFG, 2013, *Regression-based estimates of risk parameters for the benchmark firm*, 24 June.

> So in reaching our final parameter estimates we allowed for each observation of an Australian-listed firm to count for twice as much weight as a U.S.-listed firm. This means that the weight placed on the evidence from the Australian-listed firms is 24% [that is, 9 × 2 ÷ (9 × 2 + 56) = 0.24] and the weight placed on the estimates from the U.S.-listed firms is 76%.[119]

192. Whenever there are two relevant sources of data (such as the Australian and US samples above), some element of judgment will be required to distil them into a single point estimate. The judgment applied by SFG (2013) is to assign twice as much weight to the domestic firms. In applying their judgment, SFG considered the small set of domestic comparables (and the fact that such a small sample, by itself, produces statistically unreliable estimates) on the one hand, and the likelihood that the domestic firms are relatively more comparable to the benchmark efficient firm on the other. SFG weighed up this trade-off and used their judgment to assign twice as much weight to the domestic firms.

193. The application of judgment in such circumstances is inevitable. The only question is whether the application of judgment is applied in a transparent or opaque manner. SFG (2013) are explicit in where and how they have exercised their judgment – where estimation ends and where judgment begins. By contrast, the Guideline materials state that they have had regard to the international evidence, but there is no explanation of how this evidence has been taken into account. For example, the Guideline materials do not specify what effect the international evidence has had on the final beta estimate, or even whether the final beta estimate would have been any different at all had the international evidence been ignored.

194. In summary, the SFG (2013) approach produces a final equity beta estimate of 0.82. In our view, this remains the best currently available empirical estimate of equity beta for the benchmark efficient entity, having regard to the trade-off between comparability and statistical reliability.

[119] SFG (2013), p. 16.

8. Summary and conclusions

Estimate of beta for use in multi-model framework

195. One way of having regard to the range of relevant models and evidence is to estimate the required return on equity under each of the relevant approaches and then to determine an allowed return on equity after having regard to the relative strengths and weaknesses of each approach. Under such a multi-model approach, we would adopt a Sharpe-Lintner CAPM beta of 0.82 – the raw estimate of beta that does not reflect any evidence other than the historical statistical relationship between stock returns and market returns for the relevant set of comparable firms. Under the multi-model approach, other relevant evidence (e.g., of the low-beta premium or the value premium) will be taken into account in other estimates of the required return on equity. To also include that other evidence in the estimate of the Sharpe-Lintner CAPM beta would involve double counting. Consequently, we would adopt a beta estimate of 0.82 for use in a multi-model framework.

Declaration

196. I confirm that 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 from the Court.

Professor Stephen Gray.

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Appendix 1: Instructions

Expert Terms of Reference

Estimating Equity Beta

Jemena Gas Networks
2015-20 Access Arrangement Review

AA15-570-0058

Version C – 1 May 2014

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Version	Status	Date	Prepared	Checked	Authorised
A	Draft	11/03/14	E Grace-Webb		
B	Draft	12/03/14	E Grace-Webb		
C	Final	01/05/14	E Grace-Webb		E Grace-Webb

Contents

1 Background

Jemena Gas Networks (**JGN**) is the major gas distribution service provider in New South Wales (**NSW**). JGN owns more than 25,000 kilometres of natural gas distribution system, delivering approximately 100 petajoules of natural gas to over one million homes, businesses and large industrial consumers across NSW.

JGN is currently preparing its revised Access Arrangement proposal (**Project**) with supporting information for consideration by the Australian Energy Regulator (**AER**). The revised access arrangement will cover the period 1 July 2015 to 30 June 2020 (July to June financial years).

As with all of its economic regulatory functions and powers, when assessing JGN's revised access arrangement (**AA**) under the National Gas Rules and the National Gas Law, the AER must do so in a manner that will or is likely to contribute to meeting the National Gas Objective, which is:

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

For electricity networks, the AER must assess regulatory proposals under the National Electricity Rules and the National Electricity Law in a manner that will or is likely to achieve the National Electricity Objective, as stated in section 7 of the National Electricity Law.

The AER must also take into account the revenue and pricing principles in section 24 of the National Gas Law and section 7A of the National Electricity Law, when exercising a discretion related to reference tariffs. The revenue and pricing principles include the following:

> "(2) A service provider should be provided with a reasonable opportunity to recover at least the efficient costs the service provider incurs in—
>
> a) providing reference services; and
>
> b) complying with a regulatory obligation or requirement or making a regulatory payment.
>
> (3) A service provider should be provided with effective incentives in order to promote economic efficiency with respect to reference services the service provider provides. The economic efficiency that should be promoted includes—
>
> (a) efficient investment in, or in connection with, a pipeline with which the service provider provides reference services…
>
> […]
>
> (5) A reference tariff should allow for a return commensurate with the regulatory and commercial risks involved in providing the reference service to which that tariff relates.

(6) Regard should be had to the economic costs and risks of the potential for under and over investment by a service provider in a pipeline with which the service provider provides pipeline services."

Some of the key rules that are relevant to an access arrangement and its assessment are set out below.

Rule 74 of the National Gas Rules, relating generally to forecasts and estimates, states:

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

(2) A forecast or estimate:

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

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

Rule 87 of the National Gas Rules, relating to the allowed rate of return, states:

(1) Subject to rule 82(3), the return on the projected capital base for each regulatory year of the access arrangement period is to be calculated by applying a rate of return that is determined in accordance with this rule 87 (the allowed rate of return).

(2) The allowed rate of return is to be determined such that it achieves the allowed rate of return objective.

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

(4) Subject to subrule (2), the allowed rate of return for a regulatory year is to be:

(a) a weighted average of the return on equity for the access arrangement period in which that regulatory year occurs (as estimated under subrule (6)) and the return on debt for that regulatory year (as estimated under subrule (8)); and

(b) determined on a nominal vanilla basis that is consistent with the estimate of the value of imputation credits referred to in rule 87A.

(5) In determining the allowed rate of return, regard must be had to:

(a) relevant estimation methods, financial models, market data and other evidence;

(b) the desirability of using an approach that leads to the consistent application of any estimates of financial parameters that are relevant to the estimates of, and that are common to, the return on equity and the return on debt; and

(c) any interrelationships between estimates of financial parameters that are relevant to the estimates of the return on equity and the return on debt.

Return on equity

(6) The return on equity for an access arrangement period is to be estimated such that it contributes to the achievement of the allowed rate of return objective.

(7) In estimating the return on equity under subrule (6), regard must be had to the prevailing conditions in the market for equity funds.

[Subrules (8)–(19) omitted].

The equivalent National Electricity Rules are in clauses 6A.6.2 (for electricity transmission) and 6.5.2 (for electricity distribution).

Accordingly, the independent opinion of SFG Consulting, as a suitably qualified independent expert (**Expert**), is sought on the equity beta for the Sharpe-Lintner CAPM to estimate a return on equity that complies with the requirements of the National Gas Law and Rules and National Electricity Law and Rules, including as highlighted above. JGN seeks this opinion on behalf of itself, ActewAGL, and Networks NSW.

2 Scope of Work

The Expert will provide an opinion report that:

1. describes the role of the equity beta in applying the Sharpe-Lintner CAPM, including the theoretical and empirical basis for its development;

2. describes how the equity beta is estimated in practice (and is used to estimate the return on equity) in Australia;

3. reviews how the AER proposes to estimate the equity—as set out in rate of return guideline and supporting explanatory statement (released in December 2013)—and advises whether this provides an equity beta estimate for the Sharpe-Lintner CAPM that is:

   (a) commensurate with the efficient financing costs and degree of risk of a benchmark efficient entity; and

   (b) reflective of prevailing conditions in the market for equity funds.

4. estimates the equity beta for the Sharpe-Lintner CAPM that is:

   (a) commensurate with the efficient financing costs and degree of risk of a benchmark efficient entity; and

   (b) reflective of prevailing conditions in the market for equity funds.

In preparing the report, the Expert will:

A. consider different approaches to estimating the equity beta for the benchmark efficient entity, including any theoretical restrictions on empirical estimates or any adjustments made in practice (e.g. Vasicek and Blume);

B. consider how sample size affects the reliability of equity beta estimates and approaches for overcoming this, including using foreign data;

C. consider how leverage affects the equity beta;

D. consider any comments raised by the AER, other regulators or their consultants on how to estimate the equity beta, including (but not limited to) (i) whether the Black CAPM informs the equity beta estimate for the Sharpe-Lintner CAPM, and if so how, (ii) how leverage affects equity beta, or (iii) whether and how foreign data is relevant to estimating an Australian equity beta; and

E. use robust methods and data.

3 Information Provided by JGN

The Expert is encouraged to draw upon the following information which JGN will make available:

- an expert report by Stephen Gray and Jason Hall (of SFG Consulting) and Niel Diamond and Robert Brooks (of Monash University) titled "The Vasicek adjustment to beta estimates in the Capital Asset Pricing Model", dated 17 June 2013;
- an expert report by SFG Consulting titled "Regression-based estimates of risk parameters for the benchmark firm", dated 24 June 2013;
- an expert report by Stephen Gray and Jason Hall (of SFG Consulting) and Niel Diamond and Robert Brooks (of Monash University) titled "Comparison of OLS and LAD regression techniques for estimating beta", dated 26 June 2013;
- an expert report by CEG titled "Information on equity beta from US companies", dated June 2013;
- an expert report by CEG titled "AER equity beta issues paper: international comparators", dated October 2013;
- a letter from Stephen Gray (of SFG Consulting) to Warwick Anderson (of the AER) on equity beta, dated 28 October 2013;
- a submission by the Energy Networks Association to the AER titled "Response to the Equity Beta Issues Paper of the Australian Energy Regulator", dated 28 October 2013; and
- other relevant expert reports on equity beta.

4 Other Information to be Considered

The Expert is also expected to consider the following additional information:

- such information that, in Expert's opinion, should be taken into account to address the questions outlined above;
- relevant literature on the rate of return;
- the AER's rate of return guideline, including explanatory statements and supporting expert material;
- material submitted to the AER as part of its consultation on the rate of return guideline; and
- previous decisions of the AER, other relevant regulators and the Australian Competition Tribunal on the rate of return and any supporting expert material.

5 Deliverables

At the completion of its review the Expert will provide an independent expert report which:

- is of a professional standard capable of being submitted to the AER;
- is prepared in accordance with the Federal Court Practice Note on Expert Witnesses in Proceedings in the Federal Court of Australia (CM 7) set out in Attachment 1, and includes an acknowledgement that the Expert has read the guidelines [1];
- contains a section summarising the Expert's experience and qualifications, and attaches the Expert's curriculum vitae (preferably in a schedule or annexure);
- identifies any person and their qualifications, who assists the Expert in preparing the report or in carrying out any research or test for the purposes of the report;
- summarises JGN's instructions and attaches these term of reference;
- includes an executive summary which highlights key aspects of the Expert's work and conclusions; and
- (without limiting the points above) carefully sets out the facts that the Expert has assumed in putting together his or her report, as well as identifying any other assumptions made, and the basis for those assumptions.

The Expert's report will include the findings for each of the five parts defined in the scope of works (Section 2).

[1] Available at: http://www.federalcourt.gov.au/law-and-practice/practice-documents/practice-notes/cm7.

6 Timetable

The Expert will deliver the final report to Jemena Regulation by **30 April 2014**.

7 Terms of Engagement

The terms on which the Expert will be engaged to provide the requested advice shall be:

- as provided in accordance with the Jemena Regulatory Consultancy Services Panel arrangements applicable to the Expert.

ATTACHMENT 1: FEDERAL COURT PRACTICE NOTE

Practice Note CM 7

EXPERT WITNESSES IN PROCEEDINGS IN THE FEDERAL COURT OF AUSTRALIA

Commencement

1. This Practice Note commences on 4 June 2013.

Introduction

2. Rule 23.12 of the Federal Court Rules 2011 requires a party to give a copy of the following guidelines to any witness they propose to retain for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based on the specialised knowledge of the witness (see **Part 3.3 - Opinion** of the *Evidence Act 1995* (Cth)).

3. The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence[2], and to assist experts to understand in general terms what the Court expects of them. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.

Guidelines

1. General Duty to the Court[3]

1.1 An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise.

1.2 An expert witness is not an advocate for a party even when giving testimony that is necessarily evaluative rather than inferential.

1.3 An expert witness's paramount duty is to the Court and not to the person retaining the expert.

2. The Form of the Expert's Report[4]

2.1 An expert's written report must comply with Rule 23.13 and therefore must

(a) be signed by the expert who prepared the report; and

(b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and

(c) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge; and

(d) identify the questions that the expert was asked to address; and

(e) set out separately each of the factual findings or assumptions on which the expert's opinion is based; and

---

[2] As to the distinction between expert opinion evidence and expert assistance see *Evans Deakin Pty Ltd v Sebel Furniture Ltd* [2003] FCA 171 per Allsop J at [676].

[3] The "*Ikarian Reefer*" (1993) 20 FSR 563 at 565-566.

[4] Rule 23.13.

(f) set out separately from the factual findings or assumptions each of the expert's opinions; and

(g) set out the reasons for each of the expert's opinions; and

(ga) contain an acknowledgment that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c) above[5]; and

(h) comply with the Practice Note.

2.2 At the end of the report the expert should declare that "[the expert] has *made all the inquiries that* [the expert] *believes are desirable and appropriate and that no matters of significance that* [the expert] *regards as relevant have, to* [the expert's] *knowledge, been withheld from the Court*."

2.3 There should be included in or attached to the report the documents and other materials that the expert has been instructed to consider.

2.4 If, after exchange of reports or at any other stage, an expert witness changes the expert's opinion, having read another expert's report or for any other reason, the change should be communicated as soon as practicable (through the party's lawyers) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court[6].

2.5 If an expert's opinion is not fully researched because the expert considers that insufficient data are available, or for any other reason, this must be stated with an indication that the opinion is no more than a provisional one. Where an expert witness who has prepared a report believes that it may be incomplete or inaccurate without some qualification, that qualification must be stated in the report.

2.6 The expert should make it clear if a particular question or issue falls outside the relevant field of expertise.

2.7 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports[7].

3. Experts' Conference

3.1 If experts retained by the parties meet at the direction of the Court, it would be improper for an expert to be given, or to accept, instructions not to reach agreement. If, at a meeting directed by the Court, the experts cannot reach agreement about matters of expert opinion, they should specify their reasons for being unable to do so.

J L B ALLSOP
Chief Justice
4 June 2013

[5] See also *Dasreef Pty Limited v Nawaf Hawchar* [2011] HCA 21.

[6] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565

[7] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565-566. See also Ormrod *"Scientific Evidence in Court"* [1968] Crim LR 240

Appendix 2: Curriculum Vitae of Professor Stephen Gray

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Academic Qualifications

1995 Ph.D. (Finance), Graduate School of Business, Stanford University.
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Committee Chairman: Ken Singleton
1989 LL.B. (Hons), Bachelor of Laws with Honours, University of Queensland.
1986 B.Com. (Hons), Bachelor of Commerce with Honours, University of Queensland.

Employment History

2000-Present Professor of Finance, UQ Business School, University of Queensland.
1997-2000 Associate Professor of Finance, Department of Commerce, University of Queensland and Research Associate Professor of Finance, Fuqua School of Business, Duke University.
1994-1997 Assistant Professor of Finance, Fuqua School of Business, Duke University.
1990-1993 Research Assistant, Graduate School of Business, Stanford University.
1988-1990 Assistant Professor of Finance, Department of Commerce, University of Queensland.
1987 Specialist Tutor in Finance, Queensland University of Technology.
1986 Teaching Assistant in Finance, Department of Commerce, University of Queensland.

Academic Awards

2006 Outstanding Professor Award, Global Executive MBA, Fuqua School of Business, Duke University.
2002 Journal of Financial Economics, All-Star Paper Award, for Modeling the Conditional Distribution of Interest Rates as a Regime-Switching Process, JFE, 1996, 42, 27-62.
2002 Australian University Teaching Award – Business (a national award for all university instructors in all disciplines).
2000 University of Queensland Award for Excellence in Teaching (a University-wide award).
1999 Outstanding Professor Award, Global Executive MBA, Fuqua School of Business, Duke University.
1999 KPMG Teaching Prize, Department of Commerce, University of Queensland.
1998 Faculty Teaching Prize (Business, Economics, and Law), University of Queensland.
1991 Jaedicke Fellow in Finance, Doctoral Program, Graduate School of Business, Stanford University.
1989 Touche Ross Teaching Prize, Department of Commerce, University of Queensland.
1986 University Medal in Commerce, University of Queensland.

Large Grants (over $100, 000)

- Australian Research Council Linkage Grant, 2008—2010, Managing Asymmetry Risk ($320,000), with T. Brailsford, J.Alcock, and Tactical Global Management.
- Intelligent Grid Cluster, Distributed Energy – CSIRO Energy Transformed Flagship Collaboration Cluster Grant, 2008-2010 ($552,000)
- Australian Research Council Research Infrastructure Block Grant, 2007—2008, Australian Financial Information Database ($279,754).
- Australian Research Council Discovery Grant, 2006—2008, Capital Management in a Stochastic Earnings Environment ($270,000).
- Australian Research Council Discovery Grant, 2005—2007, Australian Cost of Equity.
- Australian Research Council Discovery Grant, 2002—2004, Quantification Issues in Corporate Valuation, the Cost of Capital, and Optimal Capital Structure.

- Australian Research Council Strategic Partnership Grant, 1997—2000, Electricity Contracts and Securities in a Deregulated Market: Valuation and Risk Management for Market Participants.

Current Research Interests

Benchmark returns and the cost of capital. Corporate Finance. Capital structure. Real and strategic options and corporate valuation. Financial and credit risk management. Empirical finance and asset pricing.

Publications

Gray, S., I. Harymawan and J. Nowland, (2014), "Political and government connections on corporate boards in Australia: Good for business?" *Australian Journal of Management,* forthcoming.

Brailsford, T., S. Gray and S. Treepongkaruna, (2013), "Explaining the bid-ask spread in the foreign exchange market: A test of alternate models," *Australian Journal of Management,* forthcoming.

Faff, R., S. Gray and M. Poulsen, (2013), "Financial inflexibility and the value premium," *International Review of Finance,* forthcoming.

T. Fitzgerald, S. Gray, J. Hall and R. Jeyaraj, (2013), "Unconstrained estimates of the equity risk premium" *Review of Accounting Studies,* 18, 560-639.

Gray, S. and J. Nowland, (2013), "Is prior director experience valuable?" *Accounting and Finance,* 53, 643-666.

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Chan, K-F., R. Brooks, S. Treepongkaruna and S. Gray, (2011), "Asset market linkages: Evidence from financial, commodity and real estate assets," *Journal of Banking and Finance*, 35, 6, 1415-1426.

Parmenter, B, A. Breckenridge, and S. Gray, (2010), 'Economic Analysis of the Government's Recent Mining Tax Proposals', *Economic Papers*: *A Journal of Economics and Policy*, 29(3), September, 279-91.

Gray, S., C. Gaunt and Y. Wu, (2010), "A comparison of alternative bankruptcy prediction models," *Journal of Contemporary Accounting and Economics*, 6, 1, 34-45.

Feuerherdt, C., S. Gray and J. Hall, (2010), "The Value of Imputation Tax Credits on Australian Hybrid Securities," *International Review of Finance*, 10, 3, 365-401.

Gray, S., J. Hall, D. Klease and A. McCrystal, (2009), "Bias, stability and predictive ability in the measurement of systematic risk," *Accounting Research Journal*, 22, 3, 220-236.

Treepongkaruna, S. and S. Gray, (2009), "Information volatility links in the foreign exchange market," *Accounting and Finance*, 49, 2, 385-405.

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Gray, S., A. Mirkovic and V. Ragunathan, (2006), "The Determinants of Credit Ratings: Australian Evidence," *Australian Journal of Management,* 31(2), 333-354.

Choy, E., S. Gray and V. Ragunathan, (2006), "The Effect of Credit Rating Changes on Australian Stock Returns," *Accounting and Finance*, 46(5), 755-769.

Gray, S. and J. Hall, (2006), "The Relationship Between Franking Credits and the Market Risk Premium," *Accounting and Finance*, 46(3), 405-428.

Gray, S. and S. Treepongkaruna, (2006), "Are there non-linearities in short-term interest rates?" *Accounting and Finance*, 46(1), 149-167.

Gray, P., S. Gray and T. Roche, (2005), "A Note on the Efficiency in Football Betting Markets: The Economic Significance of Trading Strategies," *Accounting and Finance*, 45(2) 269-281.

Duffie, D., S. Gray and P. Hoang, (2004), "Volatility in Energy Prices. In V. Kaminski," (Ed.), *Managing Energy Price Risk: The New Challenges and Solutions* (3rd ed.). London: Risk Books.

Cannavan, D., F. Finn and S. Gray, (2004), "The Value of Dividend Imputation Tax Credits in Australia," *Journal of Financial Economics*, 73, 167-197.

Gray, S. and S. Treepongkaruna, (2003), "Valuing Interest Rate Derivatives Using a Monte-Carlo Approach," *Accounting and Finance*, 43(2), 231-259.

Gray, S., T. Smith and R. Whaley, (2003), "Stock Splits: Implications for Investor Trading Costs," *Journal of Empirical Finance*, 10, 271-303.

Gray, S. and S. Treepongkaruna, (2003), "On the Robustness of Short-term Interest Rate Models," *Accounting and Finance*, 43(1), 87-121.

Gray, S. and S. Treepongkaruna, (2002), "How to Value Interest Rate Derivatives in a No-Arbitrage Setting," *Accounting Research Journal* (15), 1.

Gray, P. and S. Gray, (2001), "A Framework for Valuing Derivative Securities," *Financial Markets Institutions & Instruments*, 10(5), 253-276.

Gray, P. and S. Gray, (2001), "Option Pricing: A Synthesis of Alternate Approaches," *Accounting Research Journal*, 14(1), 75-83.

Dahlquist, M. and S. Gray, (2000), "Regime-Switching and Interest Rates in the European Monetary System," *Journal of International Economics*, 50(2), 399-419.

Bollen, N., S. Gray and R. Whaley, (2000), "Regime-Switching in Foreign Exchange Rates: Evidence from Currency Options," *Journal of Econometrics*, 94, 239-276.

Duffie, D., S. Gray and P. Hoang, (1999), "Volatility in Energy Prices. In R. Jameson," (Ed.), *Managing Energy Price Risk* (2nd ed.). London: Risk Publications.

Gray, S. and R. Whaley, (1999), "Reset Put Options: Valuation, Risk Characteristics, and an Example," *Australian Journal of Management*, 24(1), 1-21.

Bekaert, G. and S. Gray, (1998), "Target Zones and Exchange Rates: An Empirical Investigation," *Journal of International Economics*, 45(1), 1-35.

Gray, S. and R. Whaley, (1997), "Valuing S&P 500 Bear Market Warrants with a Periodic Reset," *Journal of Derivatives*, 5(1), 99-106.

Gray, S. and P. Gray, (1997), "Testing Market Efficiency: Evidence from the NFL Sports Betting Market," *The Journal of Finance*, 52(4), 1725-1737.

Gray, S. (1996), "Modeling the Conditional Distribution of Interest Rates as a Regime- Switching Process," *Journal of Financial Economics*, 42, 27-62.

Gray, S. (1996), "Regime-Switching in Australian Interest Rates," *Accounting and Finance*, 36(1), 65-88.

Brailsford, T., S. Easton, P.Gray and S. Gray, (1995), "The Efficiency of Australian Football Betting Markets," *Australian Journal of Management*, 20(2), 167-196.

Duffie, D. and S. Gray, (1995), "Volatility in Energy Prices," In R. Jameson (Ed.), *Managing Energy Price Risk*, London: Risk Publications.

Gray, S. and A. Lynch, (1990), "An Alternative Explanation of the January Anomaly," *Accounting Research Journal*, 3(1), 19-27.

Gray, S. (1989), "Put Call Parity: An Extension of Boundary Conditions," *Australian Journal of Management*, 14(2), 151-170.

Gray, S. (1988), "The Straddle and the Efficiency of the Australian Exchange Traded Options Market," *Accounting Research Journal*, 1(2), 15-27.

Teaching

Fuqua School of Business, Duke University, Student Evaluations (0-7 scale):

- Financial Management (MBA Core): Average 6.5 over 7 years.
- Advanced Derivatives: Average 6.6 over 4 years.
- Empirical Issues in Asset Pricing: Ph.D. Class

1999, 2006 Outstanding Professor Award, Global Executive MBA, Fuqua School of Business, Duke University.

UQ Business School, University of Queensland, Student Evaluations (0-7 scale):

- Finance (MBA Core): Average 6.6 over 10 years.
- Corporate Finance Honours: Average 6.9 over 10 years.

2002 Australian University Teaching Award – Business (a national award for all university instructors in all disciplines).
2000 University of Queensland Award for Excellence in Teaching.
1999 Department of Commerce KPMG Teaching Prize, University of Queensland.
1998 Faculty Teaching Prize, Faculty of Business Economics and Law, University of Queensland.
1998 Commendation for Excellence in Teaching, University-wide Teaching Awards, University of Queensland.
1989 Touche Ross Teaching Prize, Department of Commerce, University of Queensland.

Board Positions

2002 - Present: Director, Financial Management Association of Australia Ltd.
2003 - Present: Director, Moreton Bay Boys College Ltd. (Chairman since 2007).
2002 - 2007: External Risk Advisor to Board of Enertrade (Queensland Power Trading Corporation Ltd.)

Consulting

Managing Director, Strategic Finance Group: www.sfgconsulting.com.au.

Consulting interests and specialties, with recent examples, include:

- **Corporate finance**
  - ⇒ **Listed multi-business corporation:** Detailed financial modeling of each business unit, analysis of corporate strategy, estimation of effects of alternate strategies, development of capital allocation framework.

- **Capital management and optimal capital structure**
  - ⇒ **State-owned electricity generator:** Built detailed financial model to analyze effects of increased leverage on cost of capital, entity value, credit rating, and stability of dividends. Debt of $500 million issued.

- **Cost of capital**
  - ⇒ **Cost of Capital in the Public Sector:** Provided advice to a government enterprise on how to estimate an appropriate cost of capital and benchmark return for Government-owned enterprises. Appearance as **expert witness** in legal proceedings that followed a regulatory determination.
  - ⇒ **Expert Witness:** Produced a written report and provided court testimony on issues relating to the cost of capital of a cable TV business.
  - ⇒ **Regulatory Cost of Capital:** Extensive work for regulators and regulated entities on all matters relating to estimation of weighted-average cost of capital.

- **Valuation**

⇒ **Expert Witness:** Produced a written report and provided court testimony. The issue was whether, during a takeover offer, the shares of the bidding firm were affected by a liquidity premium due to its incorporation in the major stock market index.

⇒ **Expert Witness:** Produced a written report and provided court testimony in relation to valuation issues involving an integrated mine and refinery.

- **Capital Raising**
  - ⇒ Produced comprehensive valuation models in the context of capital raisings for a range of businesses in a range of industries including manufacturing, film production, and biotechnology.

- **Asset pricing and empirical finance**
  - ⇒ **Expert Witness:** Produced a written report on whether the client's arbitrage-driven trading strategy caused undue movements in the prices of certain shares.

- **Application of econometric techniques to applied problems in finance**
  - ⇒ **Debt Structure Review:** Provided advice to a large City Council on restructuring their debt portfolio. The issues involved optimisation of a range of performance measures for each business unit in the Council while simultaneously minimizing the volatility of the Council's equity in each business unit.
  - ⇒ **Superannuation Fund Performance Benchmarking:** Conducted an analysis of the techniques used by a large superannuation fund to benchmark its performance against competing funds.

- **Valuation of derivative securities**
  - ⇒ **Stochastic Volatility Models in Interest Rate Futures Markets:** Estimated and implemented a number of models designed to predict volatility in interest rate futures markets.

- **Application of option-pricing techniques to real project evaluation**
  - ⇒ **Real Option Valuation:** Developed a framework for valuing an option on a large office building. Acted as arbitrator between the various parties involved and reached a consensus valuation.
  - ⇒ **Real Option Valuation:** Used real options framework in the valuation of a bio-tech company in the context of an M&A transaction.

Appendix 3: The effect of leverage

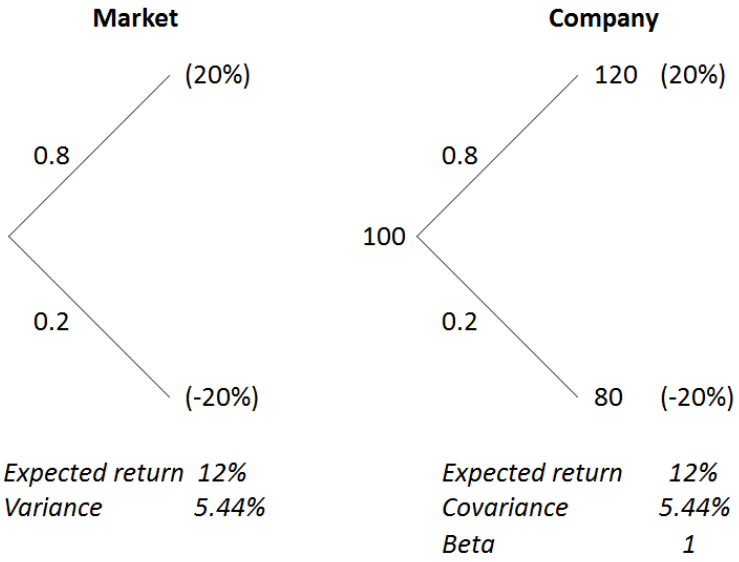
197. The reason that leverage increases the systematic risk of equity, by definition, is that it increases the variability of the returns to shareholders. To see this via a simple illustration, consider an unlevered firm that currently has assets valued at $100. Over the next year there is an 80% chance of a market expansion and a 20% chance of a contraction. In the event of an expansion the value of the assets will increase to $120 and in the event of a contraction the value of the assets will fall to $80. In this case, the expected return for the firm is:

$$r_e = 0.8 \times 20\% + 0.2 \times (-20\%) = 12\%$$

as set out in the figure below.

198. Also suppose that the market return is 20% in the expansion state and -20% in the contraction state. In this case the beta of this unlevered firm is 1.0. In particular:[120]

$$\beta_e = \frac{\text{cov}(r_e, r_m)}{\text{var}(r_m)} = \frac{0.0544}{0.0544} = 1.$$



199. Now suppose the same firm is financed with $70 equity and $30 debt, on which the interest rate is 10% p.a. At the end of the period, the firm must repay its debt plus interest, a total of $33. The residual is then available to the shareholders as set out in the figure below.

200. In this case, the return on equity in the up-market is better than before and the return on equity in the down-market is worse than before. Again, this is why it is called "leverage." In this case, the

[120] $\text{var}(r_m) = 0.5(0.20 - 0.12)^2 + 0.5(-0.20 - 0.12)^2 = 5.44\%$ and
$\text{cov}(r_e, r_m) = 0.5(0.20 - 0.12)(0.20 - 0.12) + 0.5(-0.20 - 0.12)(-0.20 - 0.12) = 5.44\%$.

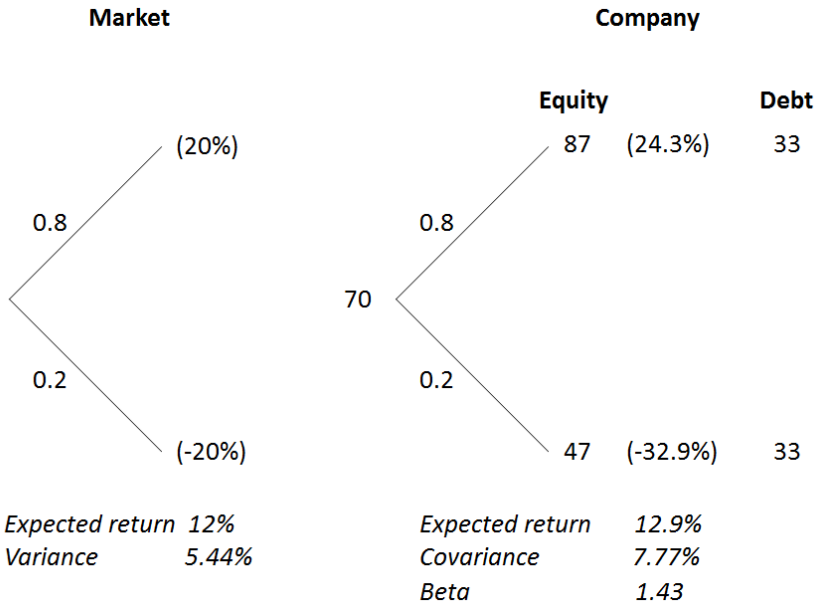
leverage has no effect on the fundamental business risk of the firm (the asset beta), but it does increase the systematic risk of equity (the equity beta). In particular, the equity beta increases to:

$$\beta_e = \frac{\text{cov}(r_e, r_m)}{\text{var}(r_m)} = \frac{0.0777}{0.0544} = 1.43$$

and the expected return on equity rises, commensurate with the increase in the equity beta:

$$r_e = 0.8 \times 24.3\% + 0.2 \times (-39.9\%) = 12.9\%.$$

201. These effects are all set out in the figure below.



202. Note that the relationship between the (levered) equity beta and the (unlevered) asset beta is described perfectly by the re-levering equation that the AER has adopted. The asset beta is known to be 1 from the analysis of the unlevered firm above. With 30% leverage, the levered equity beta is 1.43. In this case:

$$\beta_a = \beta_e \frac{E}{V}$$
$$1 = 1.43 \times 0.7.$$

203. Also note that in this case there is no default risk (even in the down-market the firm is able to service its debt), there is no counterparty risk, there is no illiquidity risk, there is no refinancing risk and there is no reset risk. That is, even if the five financial risks in the Frontier report are eliminated entirely, leverage still has an important effect on the equity beta – an effect that is captured by the AER's re-levering formula. The five financial risks are *not* the means by which leverage has an effect on equity beta. Leverage has an effect on equity beta by widening the range of possible returns, as captured by the AER's re-levering formula. The actual leverage effect is entirely independent of the five types of

risk discussed in the Frontier report – indeed, the same leverage effect exists even if all five risks are eliminated entirely.

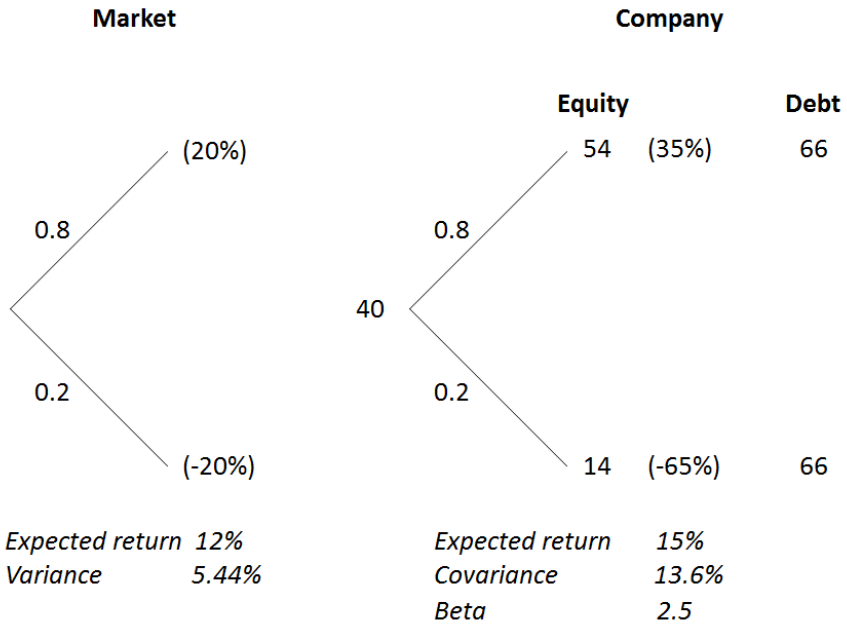
204. Now suppose the firm's leverage is doubled to 60%. At the end of the period, the firm must repay its debt plus interest, a total of $66. The residual is then available to the shareholders as set out in the figure below.

205. In this case, the return on equity in the up-market is even better than before (+35%) and the return on equity in the down-market is even worse than before (-65%). Again leverage has no effect on the fundamental business risk of the firm (the asset beta), but it does increase the systematic risk of equity (the equity beta). In particular, the equity beta increases to:

$$\beta_e = \frac{\text{cov}(r_e, r_m)}{\text{var}(r_m)} = \frac{0.136}{0.0544} = 2.5.$$

and the expected return on equity rises, commensurate with the increase in the equity beta:

$$r_e = 0.8 \times 35\% + 0.2 \times (-65\%) = 15\%.$$



206. Again, the relationship between the (levered) equity beta and the same (unlevered) asset beta is described perfectly by the re-levering equation that the AER has adopted:

$$\beta_a = \beta_e \frac{E}{V}$$
$$1 = 2.5 \times 0.4.$$