Appendix 5.08 - Expert report by Frontier Economics

Estimating the equity beta for the benchmark efficienct entity

Revised 2016-21 access arrangement proposal

Response to the AER's draft decision

January 2016

Estimating the equity beta for the benchmark efficient entity

REPORT PREPARED FOR JEMENA ELECTRICITY NETWORKS, ACTEWAGL DISTRIBUTION, AUSNET SERVICS, AUSTRALIAN GAS NETWORKS, CITIPOWER, POWERCOR AND UNITED ENERGY

January 2016

Estimating the equity beta for the benchmark efficient entity

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Executive Summary

1.1 Context

1 Frontier Economics (**Frontier**) has been retained by Jemena Electricity Networks, ActewAGL Distribution, AusNet Services, Australian Gas Networks, CitiPower, Powercor and United Energy to provide our views on a number of issues relating to the estimation of the equity beta for the benchmark efficient entity (**BEE**).[1]

2 Specifically, we have been asked to:

a. Review the accuracy of beta estimates derived using the sample of networks relied upon by the AER, including (but not limited to):
    i. the width of confidence intervals for each estimate;
    ii. the stability of estimates over time and across networks; and
    iii. the adjustments made to raw beta estimates.
b. Consider whether the sample should, and if so, how it could, be expanded to inform the beta estimate for the BEE.
c. Explains whether our view as to the sample that should be used to estimate the beta changes depending on whether the AER's definition of the BEE is adopted, or if the definition of the BEE did not refer to the entity being regulated, but rather to an unregulated entity that supplies services of an analogous kind to standard control services.
d. If the answer to (b) is yes, that the sample should be expanded, review the accuracy of beta estimates derived using the larger sample or samples of firms, including (but not limited to):
    i. the width of confidence intervals for each estimate;
    ii. the stability of estimates over time and across networks;
    iii. the adjustments made to raw beta estimates; and
    iv. whether the various samples are statistically part of the same population or not.
e. In light of our opinion on the above matters, and any other relevant matters, set out our best estimate of equity beta for the benchmark

[1] In this report, we focus on the statistical estimation of beta as per the formal definition of beta in the Sharpe-Lintner CAPM – the covariance of stock and market returns divided by the variance of market returns. In our companion report, Frontier (2016 ROE), we refer to this formal statistical concept as the "starting point" beta. We then apply adjustments to the starting point beta to correct for known biases in the SL-CAPM. This report focuses on the statistical estimation of the starting point beta.

efficient entity for including as an input to the Sharpe-Lintner Capital Asset Pricing Model (**SL-CAPM**) or the Black CAPM.

3 In preparing the report, we have been asked to:

a. Consider the theoretical and empirical support for each of the possible approaches;

b. Consider any relevant comments raised by the AER and other regulators, and experts engaged by those regulators; and

c. Use robust methods and data in producing any statistical estimates.

4 A copy of the terms of reference for this report is attached at Appendix 1 to this report.

5 This report has been authored by Professor Stephen Gray. Stephen Gray is Professor of Finance at the UQ Business School, University of Queensland and Director of Frontier Economics, a specialist economics and corporate finance consultancy. He has Honours degrees in Commerce and Law from the University of Queensland and a PhD in Financial Economics from Stanford University. He teaches graduate level courses with a focus on cost of capital issues, he has published widely in high-level academic journals, and he has more than 15 years' experience advising regulators, government agencies and regulated businesses on cost of capital issues.

6 The author's curriculum vitae is attached as Appendix 2 to this report.

7 The author's opinions set out in this report are based on the specialist knowledge acquired from his training and experience set out above. The author has been provided with a copy of the Federal Court's Practice Note CM 7, entitled "Expert Witnesses in Proceedings in the Federal Court of Australia", which comprises the guidelines for expert witnesses in the Federal Court of Australia (Expert Witness Guidelines). The author has read, understood and complied with the Expert Witness Guidelines.

1.2 Summary of conclusions

8 For the reasons set out in Section 3, our view is that the AER sample of domestic comparators is too small to, by itself, provide a reliable estimate of beta for the benchmark efficient firm. The majority of the sample consists of firms that no longer exist, rolling beta estimates vary materially over time, and there is a wide distribution of estimates over the component firms.

9 In Section 4, we consider an expanded set of Australian firms that includes other infrastructure type firms that compete for equity capital among the same set of investors. We show that the additional firms are statistically similar to the AER sample. We also show that the addition of more firms produces beta estimates with improved statistical properties – estimates that are more stable and more precise. However, we conclude that the expanded set of domestic firms should not be relied upon alone, given the ready availability of international comparators.

10 In Section 5, we consider a set of US energy distribution comparators. We show that the US utilities sample is statistically similar to the expanded Australian sample. We also show that the (much larger) US sample has better statistical properties than the Australian sample – estimates that are more stable over time and much more precise.

11 We have previously recommended an equity beta estimate of 0.82 that has regard to the evidence from domestic and international energy distribution firms – where relatively more weight is given to the domestic firms. We summarise our reasons for that approach in our recent report, Frontier (Dec 2015 ROE).

12 Overall, the evidence in Table 12 suggests that, even if the firms in the US utilities sample are assigned only half the weight of the domestic firms, the 0.82 estimate is conservative.

2 Beta estimation approach

13 In this report, we compute equity beta estimates for three main sets of comparator firms:

a. The AER's sample of Australian energy distribution firms (where we separately consider the four firms that currently exist and the five firms that have been delisted for various periods of time);

b. An expanded set of similar Australian firms that are engaged in the ownership and operation of infrastructure assets; and

c. A set of US energy distribution firms.

14 Since a number of estimation issues are common to all of our estimates, we begin with a discussion of those issues.

OLS and LAD estimates

15 Ordinary Least Squares (OLS) is the standard regression technique for estimating betas from historic stock returns. This is the standard technique because, in the SLCAPM, beta is defined as the covariance between stock and market returns, divided by the variance of market returns. The slope coefficient from an OLS regression has precisely the same definition.

16 The AER has also given consideration to least absolute deviation (LAD) estimates. There are two problems with these estimates. The slope coefficient from an LAD regression does not have the same definition of beta as that used in the SLCAPM. Also, previous analysis of LAD estimates has found that they exhibit a systematic downward bias (Brooks, Diamond, Gray and Hall, 2013b). This bias is material and is approximately 0.15 for the average firm.

17 Hence we do not produce LAD estimates in this report.

Vasicek adjustment for statistical estimation bias

18 A common technique for estimating systematic risk (beta) is to perform an ordinary least squares (**OLS**) regression of stock returns on market returns. The slope of the regression line is the beta estimate. However, there is evidence that OLS beta estimates are subject to a high degree of imprecision and limited ability to predict stock returns when incorporated into an expected returns equation (Gray, Hall, Klease and McCrystal, 2009).

19 One easily-implemented technique to mitigate systematic estimation error is to incorporate the Vasicek adjustment (Vasicek, 1973). Vasicek demonstrated that, without adjustment, low beta estimates are likely to understate systematic risk and high beta estimates are likely to overstate systematic risk.[2] Similar adjustments to

[2] We note that the Vasicek adjustment is designed to correct for statistical bias caused by the estimation process. It is not designed to correct for the "low-beta bias" that arises from the systematic inability of the SLCAPM to fit the observable data. That is, there are two forms of bias. The statistical

the Vasicek adjustment are adopted by commercial beta services such as Bloomberg, ValueLine and Datastream, but have not been accepted by the AER in its 2013 Rate of Return Guideline or in any of its subsequent decisions.

20 Previous analysis (SFG, 2013) concludes that, due to the long time series of data used to estimate beta, the Vasicek adjustment does not have a large impact on the mean beta estimate. Specifically, in the SFG 2013 sample of 56 US-listed firms the average difference between the raw OLS estimate and the Vasicek-adjusted OLS estimate is 0.01. For nine Australian firms the average difference is 0.03.

21 Hence we do not apply a Vasicek adjustment in this report.

Estimates re-levered to 60%

22 All of our estimates have been re-levered to reflect 60% debt financing. We adopt the same re-levering process as the AER has consistently adopted since its 2009 WACC Review and which are used for all of the beta estimates produced by Henry (2008), Henry (2009) and Henry (2014).

23 Re-levering equity betas to produce estimates that are on the same basis and therefore comparable is the standard approach that is recommended in textbooks and applied in practice.

24 For example, Damodaran (2001) states that:

> Other things remaining equal, an increase in financial leverage will increase the beta of the equity in a firm. Intuitively, we would expect that the fixed interest payments on debt to result in high net income in good times and negative net income in bad times. Higher leverage increases the variance in net income and makes equity investment in the firm riskier, …we expect that as leverage increases (as measured by the debt to equity ratio), equity investors bear increasing amounts of market risk in the firm, leading to higher betas.[3]

25 Berk and DeMarzo (2014) state that:

> When a firm changes its capital structure without changing its investments, its unlevered beta will remain unaltered. However, its equity beta will change to reflect the effect of the capital structure change on its risk. [The re-levering formula is displayed.] It shows that the firm's equity beta also increases with leverage.[4]

26 Associate Professor Partington and his co-authors provide an example similar to the one above:

> …the debt-equity choice does amplify the spread of percentage returns. If the company is all-equity financed, a decline of $1,000 in the operating income reduces the return on the shares by 10 per cent. If the company issues risk-free debt with a fixed interest payment of $500 a year, then a decline of $1,000 in operating income reduces the return on the shares by 20 per cent. In other words, the effect of leverage

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estimation bias relates to the statistical methods that are used to produce the estimate of beta. The model bias relates to the inability of the SLCAPM to fit the data, even with a perfect estimate of beta.

[3] Damodaran, A. (2001), Corporate finance: Theory and practice, 2nd edition, John Wiley & Sons: New Jersey, p. 204.

[4] Berk, J. and P. DeMarzo (2014), Corporate Finance, 3rd ed., Pearson, p. 493.

> is to double the amplitude of the swings in [the] shares. Whatever the beta of the company's shares before the refinancing, it would be twice as high afterwards.[5]

27 Market practitioner texts are also clear about the need to re-lever equity betas to ensure that comparable quantities are being compared. For example, Copeland, Koller and Murrin of McKinsey Inc. consider a firm seeking to estimate the required return on equity for one if its divisions. They state that the:

> …approach is to identify the publicly traded competitors most similar to the division. You can then look up the betas for those companies, which are presumed to have similar risk. But there is a catch. Beta is a measure of the systematic risk of the levered equity the comparison companies, and these companies may employ leverage differently from that used by the division you are attempting to value. To get around this problem, you have to unlever the betas of the comparison companies to obtain their business risk, then relever using the target capital structure of the division you are analysing.[6]

28 Section 2 of Frontier (2015) considers the issue of re-levering in more detail and concludes that beta estimates must be re-levered to allow a like-with-like comparison to be made.

Average and portfolio estimates

29 Our estimates are formed in two ways:

a. **Average estimates**: We estimate the beta point estimate for each firm in the set of comparators over the relevant sample period and we take an equally-weighted average of the individual firm estimates; and

b. **Portfolio estimates**: We compile a portfolio returns index as an equally-weighted average of the returns of the firms in the set of comparators.[7] For each observation period (e.g., for each week or each month) we take the average over all firms in the comparator set for that period. Thus, the number of firms that contribute to the portfolio index will change over time as new firms are created and other firms are delisted.

30 One advantage of analysing individual firms is that the dispersion of coefficient estimates across firms provides an indication of the imprecision of the estimates. The greater the dispersion of the estimates across firms the more it calls into question the reliability of the estimation techniques. However, not all firms are

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[5] Brealey, R., S. Myers, G. Partington and D. Robinson (2000), *Principles of Corporate Finance*, McGraw Hill, p. 499.

[6] Copeland, T., T. Koller and J. Murrin (2000), *Valuation: Measuring and managing the value of companies*, McKinsey & Company Inc., p. 308.

[7] We do not use a value-weighted portfolio for two reasons. First, the sample firms are of different sizes, so a value-weighted portfolio would assign relatively more weight to the larger firms. In some of our Australian samples, the number of firms is very small, in which case a value-weighted portfolio would be dominated by the largest firm in the sample. Second, there is no economic or statistical reason to adopt a value-weighted portfolio – the returns and beta estimates for each firm in the sample are equally likely to represent the benchmark efficient entity.

available for analysis over all time periods, so an index of firm returns allows us to construct one time series in each market that is available over the entire 20 year period of analysis.

Statistical tests

31 Throughout this report we consider a number of different sets of comparator firms. As we consider additional firms, we apply a number of statistical tests that compare the various samples with each other. We first compare visual representations of the distributions of various samples. This simple comparison takes the mean and standard deviation of the relevant samples and compares normal distributions with those parameters. We then conduct more formal statistical tests for each comparison. The first is the Kolmogorov-Smirnov test, which examines whether the two samples being compared are drawn from the same population.[8] If the test statistic is higher than the critical value, the null hypothesis that the samples come from the same population can be rejected. The second is a *t*-test that compares the means of the samples. If the test statistic is higher than the critical value, the null hypothesis that the samples come from populations that have the same mean can be rejected.

Data sources

32 From Datastream, we obtained twenty years of stock and market returns data that ends in December 2015 for the US firms that we examine and ends in November 2015 for Australian-listed firms. The end dates coincide with the data available to us at the time of this report.

33 Our standard time period for estimation is to use 10 years of data in performing our analysis. A firm's systematic risk may change over time; so, intuitively, analysis of stock and market returns over a more recent time period provides a more relevant estimate of risk. However, the volatility of stock returns is high and the signal-to-noise ratio is relatively small – the R-squared statistics from beta regressions tend to be relatively low as stock price movements are caused by many things other than general market movements. Hence, the statistical estimation error associated with using shorter time periods for estimation also tends to be relatively large. As a sensitivity and robustness test, we also conduct regressions using 5-year estimation windows.

34 For the US sample, we have in almost all cases, a full data set of 120 months (or 520 weeks) to use for each 10-year regression. However, the Australian sample includes a number of firms that have delisted prior to November 2015 and, as such, a number of the firms do not have 120 monthly returns to utilize within the window. For these companies, we shift the end date back to the last available return date and estimate the beta from a regression utilizing up to ten years of data prior to that date. In many cases, there is still less than ten years of trading data

[8] The Kolmogorov-Smirnov test evaluates the hypothesis that two independent samples represent two different populations. For more detail see, for example, Sheskin J. (2003), Handbook of Parametric and Nonparametric Statistical Procedures, Third Edition, CRC Press, p. 453.

available, due to the firms having short listing periods. We explain our treatment of delisted firms in more detail in the relevant sections below.

35 For the Australian firms in our comparator sets, we estimate beta relative to the ASX 200 Total Return Index from Datastream. For US firms, we use the S&P 1500 index.

3 The AER sample of Australian energy distribution firms

3.1 Currently-listed Australian energy distribution firms

36 We begin with a narrow set of comparator firms that consists of all of the currently existing Australian firms that are engaged in energy distribution: Ausnet Services, Duet Group, Spark Infrastructure and APA Group. This is the same set of current firms that was examined by Henry (2014) and which is also considered in the AER's primary set of comparators. We define this set of firms to be "Group 1."

37 We begin by considering the most recent 10-year beta estimates for each firm, as reported in Table 1 below. All of these estimates have been re-levered to 60% debt using the approach adopted throughout Henry (2014). We note that the average leverage of the comparator firms is very close to the 60% leverage that the AER adopts for the benchmark efficient firm.

Table 1: Group 1 Firms

Company	D/V	Nobs (M)	Nobs (W)	Monthly Beta	Weekly Beta	Relevered Monthly Beta	Relevered Weekly Beta
APA Group (APA)	57	119	524	0.80	0.55	0.85	0.58
Ausnet Services (AST)	61	118	517	0.49	0.29	0.49	0.29
Duet Group (DUE)	74	119	524	0.64	0.55	0.41	0.35
Spark Infrastructure (SKI)	44	118	515	0.37	0.52	0.52	0.74
Average	**59**			**0.58**	**0.48**	**0.57**	**0.49**

Source: Datastream, Frontier calculations.

38 For the reasons set out below, our view is that a set of four firms is too few to provide a statistically reliable estimate. This requires an expansion of the comparator set, and we consider the following three alternatives:

a. Expanding the set to include Australian energy distribution firms that no longer exist, but for which we are able to estimate betas for different historical periods when those firms did exist;

b. Expanding the set to include other currently-listed Australian infrastructure firms; and

c. Expanding the set to include other currently-listed international energy distribution firms.

3.2 De-listed Australian energy distribution firms

39 In this section, we consider the expansion of our comparator set to include de-listed Australian energy distribution firms. We consider the same set of de-listed firms that were considered by Henry (2014) and which is also included when the AER determines its "primary"[9] range for beta. The five firms, and the last date for which data was available, is set out in Table 2 below. We refer to these five firms as "Group 2."

40 For each of these firms, we estimate the re-levered equity beta using data for the 10-year period prior (or the maximum period available if less than 10 years) to the firm's de-listing date. This produces the most recent beta estimate that is available for each firm.

Table 2: Delisted Australian firms

Company	Ticker	De-listing date	Time since delisting
AGL Energy (Pre October 2006)	AGL	October 2006	9 years
Alinta	AAN	August 2007	8 years
Envestra	ENV	September 2014	1 year
Gasnet	GAS	November 2006	9 years
Hastings	HDF	November 2012	3 years

41 The broader sample now includes nine firms – the same nine firms that are examined by Henry (2014) and which form the basis of the AER's "primary" range for beta. That is, the combination of our Group 1 and Group 2 firms comprises the AER Sample Firms (which we refer to as the AER9). Ten year average beta calculations for the nine firms in the AER sample are set out in Table 3 below. As noted above, due to shorter listing periods, the beta estimates for Alinta, GasNet and HDF are obtained from regressions that are limited to less than ten years of data. We note that the average leverage is reduced by the inclusion of AGL and Alinta – both of which had maintained low leverage in order to preserve borrowing capacity to enable them to acquire assets during a time of industry consolidation. But for these two firms, the mean leverage is again very close to the 60% gearing assumption adopted by the AER.

[9] JEN Preliminary Decision, p. 3-92.

Table 3: Beta estimates for AER sample firms

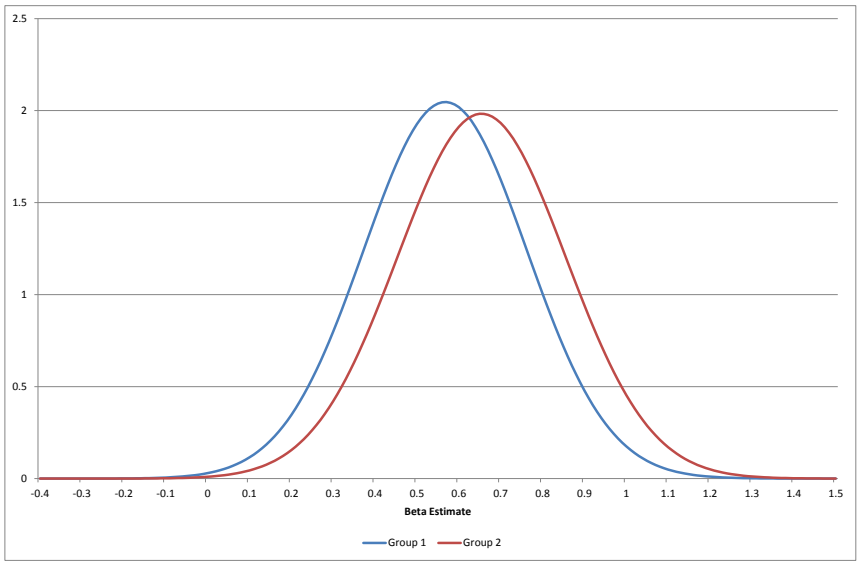
Company	D/V	N (M)	N (W)	Monthly Beta	Weekly Beta	Relevered Monthly Beta	Relevered Weekly Beta
APA Group (APA)	57	119	524	0.80	0.55	0.85	0.58
Ausnet (AST)	61	118	517	0.49	0.29	0.49	0.29
Duet Group (DUE)	74	119	524	0.64	0.55	0.41	0.35
Spark Infrastructure (SKI)	44	118	515	0.37	0.52	0.52	0.74
AGL Energy (Pre October 2006) (AGL)	31	120	522	0.40	0.46	0.69	0.79
Alinta (AAN)	42	81	342	0.62	0.59	0.89	0.85
Envestra (ENV)	68	117	522	0.93	0.68	0.75	0.54
Gasnet (GAS)	66	55	231	0.41	0.44	0.35	0.38
Hastings (HDF)	45	94	414	0.43	0.82	0.59	1.13
Mean	**54**			**0.57**	**0.54**	**0.62**	**0.63**

Source: Datastream, Frontier calculations.

3.3 Statistical comparison of current and de-listed Australian energy distribution firms

42 To determine whether the beta estimates for the four currently-listed firms differs from the estimates for the five de-listed firms, we conduct a series of statistical tests. We begin by computing the mean and standard deviation of each sample and plotting normal distributions with those parameters to conduct a visual examination of the distribution of beta estimates from each set of comparator firms. The distributions for the monthly beta estimates are set out in Figure 1 below, which shows that the majority of the area under the two curves is in common – the two distributions appear to be broadly similar. There is similarly a high degree of overlap between the distributions of weekly beta estimates between these two groups.

Figure 1: Distributions of 10-year monthly beta estimates for Group 1 and Group 2



Source: Datastream, Frontier Economics calculations.

43 The statistical tests tell a similar story. Table 4 below shows that, for both monthly and weekly beta estimates, the Kolmogorov-Smirnov *D*-statistic is below the critical value, in which case the *p*-value is above the 5% level that would be required to conclude in favour of statistical significance (that is, with 95% confidence). Hence, we cannot reject the null hypothesis that the two samples came from the same population.

Table 4: Two-sample Kolmogorov-Smirnov test for Groups 1 and 2

Statistic	Estimate (Monthly)	Estimate (Weekly)
D-statistic	0.55	0.60
p-value	0.36	0.26
D-critical	0.81	0.81

Source: Datastream, Frontier Economics calculations.

44 The results from a *t*-test of the equality of the means between samples are reported in Table 5. For both monthly and weekly beta estimates, the *t*-statistic is below the critical value, in which case the *p*-value is above the 5% level that would be required to conclude in favour of statistical significance. Therefore, the null hypothesis that the samples come from populations that have the same mean cannot be rejected.

Table 5: T-test for equality of means between Groups 1 and 2

Statistic	Estimate (Monthly)	Estimate (Weekly)
t-statistic	0.65	1.49
p-value	0.53	0.18
t-critical	2.36	2.36

Source: Datastream, Frontier Economics calculations.

45 From these statistical tests, we conclude that it is (statistically) appropriate to consider the Group 1 and Group 2 samples together. Of course, this does not imply that the combined sample, alone, is capable of producing a reliable estimate of beta for the benchmark efficient entity. The statistical test tells us only that the two samples are not statistically significantly different.

3.4 Stability and precision of estimates from Australian energy distribution firms

46 We next turn from a consideration of betas estimated with reference to the most recent data to an analysis of:

a. How beta estimates have evolved through time; and

b. The precision of the beta estimates over time.

47 We begin by considering the sample of nine current and de-listed Australian energy distribution firms set out above. At each point in time we distil the available evidence into a single beta estimate in two ways.

48 First, we compile a mean estimate across all firms for which a current beta estimate is available. Under this approach, the final beta estimate can vary over time for two reasons:

a. From one month (or week) to the next, there is an additional data point for each firm in the sample, which results in a change in the beta estimate for each firm; and

b. From time to time new firms enter the sample and existing firms exit the sample, so that the composition of sample firms changes over time.

49 Under this approach, at each point in time, the standard error of the beta estimate is computed as the standard error of the mean computed over the N companies in the sample at the relevant time. A 95% confidence interval is then computed by adding and subtracting 1.96 standard errors to the mean beta estimate.

50 Second, we compile a series of portfolio returns over our entire sample period. This is done by taking, for each month or week of the sample period, an equally-weighted average of the returns of each of the firms that is listed at the time. A

portfolio beta is then computed by regressing the portfolio return on the corresponding market return.

51 Under this approach, there is a single portfolio beta estimate at each point in time. The confidence interval is computed by adding and subtracting 1.96 times the standard error of that beta estimate.

52 We begin by constructing 10-year rolling beta estimates beginning in 1995, using both of the above estimation approaches and using returns measured at both the monthly and weekly frequency. That is, we begin with a 10-year period starting in 1995. Then we roll forward to the next month (or week) and construct another ten year window. This new window is the same as the first except it excludes the very first return observation and includes one additional return. We repeat this process until we reach the last possible window, which has as its last observation the most recently available in our entire dataset – where the most recent estimates are set out in the tables above.

53 Some estimation periods (windows) contain missing data (due to the company not yet having listed or ceasing to be listed or for any other reason). To strike the appropriate balance between not losing valuable data and having a sufficient quantity of observations with which to construct reliable estimates we adopt the following tolerance levels for our mean beta estimates:

a. For monthly 10-year windows we require that no more than four returns are missing (from a possible 120) for an estimate to be recorded;

b. For weekly ten year windows we require that no more than 20 returns (from a possible 521) are missing for an estimate to be recorded.

54 We present results that show the mean across all firms in our sample for each of the estimation windows as well as the 95% confidence interval bands for the mean estimate.

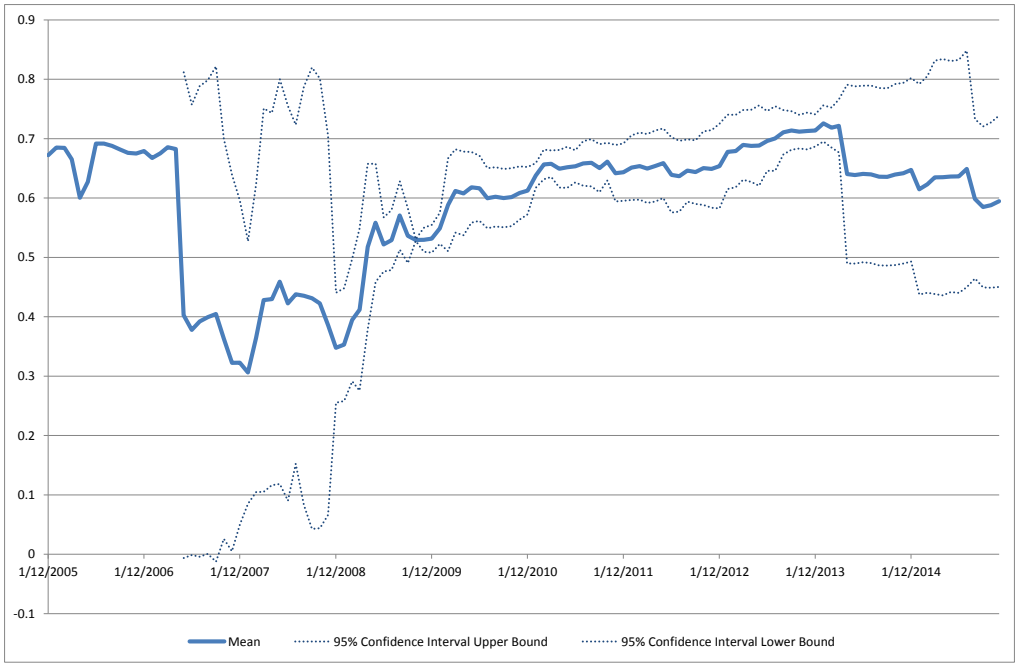
55 Figure 2 below presents the time-series of the mean beta estimates using monthly observations. We begin by noting that in the early years of the sample period there is only a single firm, AGL, in which case there is only a single estimate each period and therefore it is impossible to construct a confidence interval. The confidence interval bands then narrow in the middle part of the graph as more firms enter the sample. The confidence interval then widens materially in more recent times as HDF and Envestra exit the sample.

56 The mean estimate varies materially over time, halving in 2006-07 and then doubling over 2007-08. Since it is unlikely that the true systematic risk of the sector (or any sector) would double or halve over a short period, this volatility provides another reason to be cautious about how much reliance to place on estimates that come from such a small sample. This is not to say that the true systematic risk of a firm or industry never changes over time – just that it is unlikely that the true systematic risk would swing as dramatically as the beta *estimates* would suggest. For example, Frontier Economics (2015) documents the recent increase in risk that energy distribution businesses now face and note that at least some aspects of those

risks are likely to be systematic. However, the dramatic changes in beta estimates appear to be more reflective of statistical estimation error than changes in true systematic risk.

57 The fact that the estimate falls materially and the confidence interval widens materially as firms enter and exit the sample[10] is another reason to be cautious about the degree of reliance to place on these estimates. A firm or two entering or exiting the sample would make little difference to a larger sample, but one or two firms makes up a material portion of the AER's sample.

Figure 2: 10-year rolling monthly beta estimates for AER sample (mean beta estimates)



Source: Datastream, Frontier Economics calculations.

58 Figure 3 displays the time-series of the beta estimates for a portfolio that consists of an equal-weighted average of each of all available monthly returns every month across the 10-year window. The same general upward trend as observed in Figure 2 is present, although due to the nature of its construction the time-series is less volatile. Again, it seems unlikely that the true systematic risk of a sector would double over a short period of time, but that is what the portfolio estimates suggest.[11] A more likely explanation is that there is a material degree of estimation error arising from the use of such a small sample of firms.

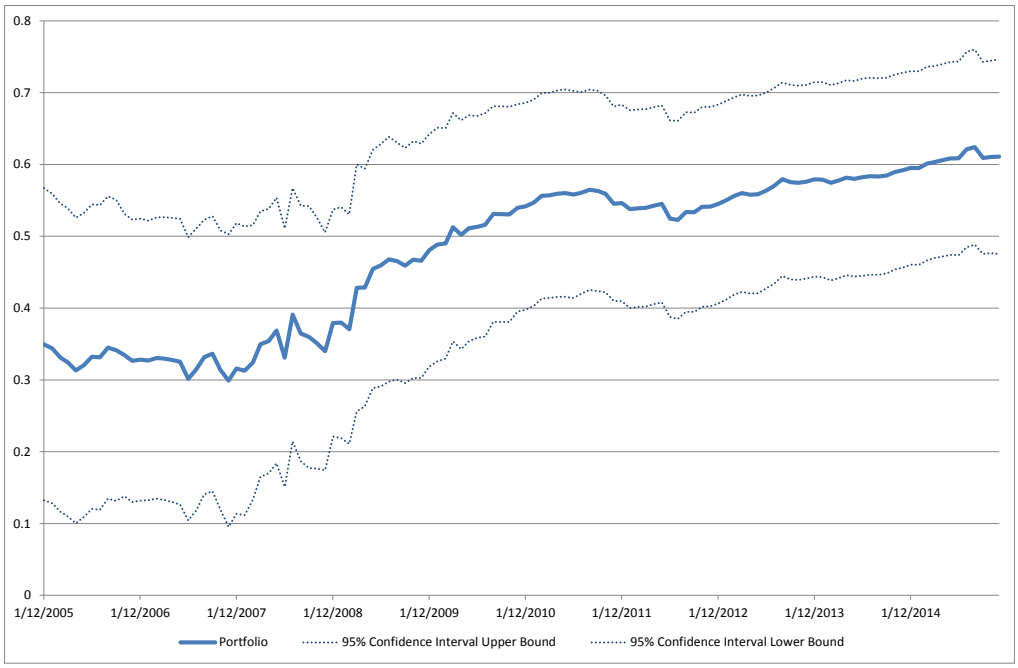
59 The most recent confidence intervals for both methods are relatively wide stretching from approximately 0.45 to 0.75. That is, statistically, the data cannot

[10] See Table 2 above.

[11] As set out above, it is plausible that the true systematic risk would increase over time as a business or industry becomes more exposed to various risk factors and as macroeconomic factors change. However, beta *estimates* can also change quite dramatically for statistical estimation reasons linked to the low signal-to-noise ratio in the stock return data – the majority of the movement in a firm's stock returns is unrelated to broad market returns.

reject any estimate from within that range. Moreover, the confidence intervals also vary quite dramatically over time. For example, in Figure 2, within a five-year period the confidence intervals go from suggesting that the equity beta is unlikely to be *above* 0.6 to suggesting that the equity beta is unlikely to be *below* 0.6. Thus, it is not clear what can be made of these confidence intervals at a particular point in time – given that the reverse signal might be obtained a short period later. For these reasons we do not recommend any sort of mechanistic reliance on the statistical confidence interval pertaining to any particular estimation method applied to any particular sample, but rather that all of the relevant evidence should be considered holistically.

Figure 3: 10-year rolling monthly beta estimates for AER sample (portfolio beta estimates)



Source: Datastream, Frontier Economics calculations.

60 We have repeated the analysis using weekly returns and we have also constructed 5-year moving average estimates. The general pattern of results is the same as for the 10-year monthly estimates set out above. The weekly mean estimates have wider confidence intervals using the mean approach and slightly narrower confidence intervals using the portfolio approach, as set out in Appendix 3 to this report. The five-year rolling estimates (which are not reported below) follow the same general patterns although the time series is more volatile, which is to be expected from a series of estimates that is based on a shorter sample period.

3.5 Interpretation of evidence from Australian energy distribution firms

61 The AER states that beta estimates from the four current and five delisted domestic comparators form the:

> Primary determinant of equity beta range, with significant weight in determining the point estimate.[12]

62 The AER concludes that the AER's domestic sample supports a range of 0.4 to 0.7 even though Henry (2014), who computes the estimates for the AER, concludes that the same data supports a range of 0.3 to 0.8.

63 The AER goes on to conclude that:

> We consider the evidence in Henry's 2014 report suggests a best empirical estimate for the equity beta of approximately 0.5[13]

explaining that:

> We consider most of the equity beta estimates from Henry's 2014 report are clustered around 0.5. In forming this view, we consider averages of individual firm estimates and fixed weight portfolio estimates.[14]

64 It is unsurprising that the average and fixed-weight portfolio estimates tend to cluster together because they effectively involve the regurgitation of the same estimate over and over again from slight variations of the same data set. For example, the AER summarises a number of portfolio estimates in Table 3-59 of its recent October and November 2015 preliminary and draft decisions.[15] For each portfolio, the AER considers four estimates – equally-weighted and value-weighted estimates including and excluding the technology boom and GFC periods. But for the one portfolio that includes AGL in a value-weighted capacity, the four estimates for each portfolio are broadly the same – which is to be expected if the only change is the manner in which the portfolio return is constructed and whether a relatively small part of the data period is included or excluded.

65 Moreover, the AER considers five different collections of firms in the portfolios that it labels P1 to P5.[16] P5 consists of five firms. P4 consists of the same five firms plus HDF. It is not surprising that the estimates are similar. P4 is also identical to P3, except that it includes SKI. Again, it is no surprise that the estimates from these two cases are almost identical. P1 is a subset of P3. It is only P2, where AGL, AAN and GAS are included on a value-weighted basis, that differs from the other portfolios in any meaningful way. The beta estimate for that portfolio is 0.70.

66 In summary, it would be quite wrong to interpret the figures in the AER's Table 3-59 as corroborating one another and providing reassurance about the "best empirical estimate" of 0.5. The figures in that table are not independent estimates that corroborate one another. Rather, they are effectively regurgitations of the same number from the same small data set. That is, there are not many

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[12] JEN Preliminary Decision, p. 3-92.

[13] JEN Preliminary Decision, p. 3-127.

[14] JEN Preliminary Decision, p. 3-127.

[15] JEN Preliminary Decisions, p. 3-480.

[16] JEN Preliminary Decisions, p. 3-480.

corroborating estimates from the AER's data set; there is a single estimate that has been regurgitated many times.

67 Thus, the key question is whether the single estimate from the AER's data set is so reliable that it can be used exclusively, or whether other relevant evidence can be usefully employed to inform the beta estimate.

68 In this regard, SFG (2014 Beta) and SFG (2015 Beta) conclude that estimates based exclusively on the small sample of domestic comparators favoured by the AER were statistically unreliable. The reasons for this conclusion included the following:

a. The estimates are imprecise with large standard errors;

b. The estimates span a wide range[17] with the vast majority of estimates for comparable firms falling outside the AER's proposed range of 0.4 to 0.7;

c. Many of the estimates varied materially across different estimation methods;

d. Many of the estimates varied materially across different sampling frequencies;

e. Many of the estimates varied materially across time;

f. Over the same period the estimates for some comparators increase by 20%, whilst others decrease by 20%. This indicates that either (a) the true systematic risk of the two firms moved materially in the opposite direction, in which case it is impossible that those two firms are both comparable, or (b) beta *estimates* are statistically subject to considerable measurement error; and

g. Many of the estimates varied materially depending on the day of the week used to measure returns.

69 In addition to these concerns, we note that the evidence above shows that:

a. The mean and portfolio beta *estimates* vary materially over time; and

b. The estimates are statistically imprecise with generally wide confidence intervals that also vary materially over time.

70 For these reasons, we consider that the consideration of additional data and evidence could usefully inform the estimation of beta.

71 In summary, our view is that there are two reasons to consider a wider set of data and evidence when estimating beta:

a. If the benchmark efficient entity is defined narrowly as an Australian energy distribution firm, we would first examine data from Australian energy distribution firms. However, this provides us with only four data points, which (for the reasons set out above)

[17] From less than 0.2 to more than 1.0.

is not enough to provide an estimate that can reasonably be relied upon. The inclusion of stale beta estimates from firms that were de-listed some time ago still does not provide a reliable estimate. Consequently, we conclude that a wider set of data and evidence should be considered. By way of analogy, suppose the task is to estimate the average temperature of Gosford, but little data are available for that particular town. Even though we require an estimate for Gosford, the estimate would be usefully informed by data for other neighbouring towns such as Sydney and Newcastle;[18] and

b. If the benchmark efficient entity is to be defined more broadly to include not just the firms that the AER regulates, but other firms in the same broad sector, seeking to attract capital from the same sorts of investors, then a wider sample of firms and evidence would be self-evidently appropriate.

[18] We note that this problem has been faced by a number of regulators. For example, the New Zealand Commerce Commission routinely considers international comparators when estimating beta, as does the ERA when estimating beta for railways. The QCA considers energy distribution firms when estimating beta for the central Queensland coal network. For airports and telecommunications monopolies there are never sufficient domestic comparators in the same industry, so the set of comparators always has to be widened.

4 Expanding the data set to include other Australian infrastructure firms

4.1 Overview

72 If one concludes that either:

a. The set of four current and five de-listed firms is insufficient to, by itself, produce reliable beta estimates for the benchmark efficient firm; and/or

b. Estimates from an expanded set of comparator firms might be relevant evidence that informs the estimation of beta,

then the question is what expanded set of comparators might be considered. That is, the AER has already expanded the set of comparators beyond listed Australian energy distribution firms to include de-listed firms. However, our view is that even that expanded set is too small to produce reliable beta estimates.

73 In our view, there are two logical avenues to pursue:

a. Expanding the set to include other Australian infrastructure and energy firms; and

b. Expanding the set to include international energy distribution firms.

74 We do not suggest that these expanded comparator sets should be used instead of the domestic comparators or even that they should each receive the same weight as the domestic comparators. However, we do suggest that they represent relevant evidence that can usefully inform the best estimate and therefore should be taken into account. In this section of the report we consider a broader set of Australian infrastructure and energy firms and in the following section we consider a set of international comparators.

4.2 Beta estimates for Australian infrastructure firms

75 We consider the following Australian infrastructure firms, which we define to be our "Group 3" firms: Asciano, Aurizon, Challenger Infrastructure Fund, Qube Holdings, Sydney Airport, Transurban Group, and Telstra. These are firms that are identified as "infrastructure" firms in the Osiris database, have a sufficient history of stock returns available, are listed on the Australian Securities Exchange, and have the majority of their operations within Australia.[19]

[19] For example, Auckland Airport was eliminated from the sample as its operations are outside Australia and ARGO Global Listed Infrastructure Fund was eliminated because only two monthly observations were available.

76 We add these firms to the AER sample of Australian energy distribution firms and set out the relevant beta estimates in Table 6 below.

77 When computing the mean beta across the expanded sample, we exclude the estimates for Asciano and Qube Holdings. These firms have been engaged in merger activity and have exhibited a number of large returns that have the effect of increasing their beta estimates.[20] Our exclusion of these firms is conservative in that doing so reduces the mean beta estimate.

Table 6: Extended sample of Australian firms: Infrastructure

Company	D/V	N (M)	N (W)	Monthly Beta	Weekly Beta	Relevered Monthly Beta	Relevered Weekly Beta
APA Group (APA)	57	119	524	0.80	0.55	0.85	0.58
Ausnet (AST)	61	118	517	0.49	0.29	0.49	0.29
Duet Group (DUE)	74	119	524	0.64	0.55	0.41	0.35
Spark Infrastructure (SKI)	44	118	515	0.37	0.52	0.52	0.74
AGL Energy (Pre October 2006) (AGL)	31	120	522	0.40	0.46	0.69	0.79
Alinta (AAN)	42	81	342	0.62	0.59	0.89	0.85
Envestra (ENV)	68	117	522	0.93	0.68	0.75	0.54
Gasnet (GAS)	66	55	231	0.41	0.44	0.35	0.38
Hastings (HDF)	45	94	414	0.43	0.82	0.59	1.13
Asciano (AIO)	46	99	435	2.20	1.40		
Aurizon (AZJ)	17	59	258	0.54	0.85	1.12	1.76
Challenger (CIF)	64	73	304	0.65	0.38	0.59	0.34
Qube (QUB)	15	104	459	1.09	0.68		
Sydney Airport (SYD)	52	118	500	0.91	0.72	1.08	0.85
Transurban (TCL)	38	119	524	0.52	0.51	0.81	0.80
Telstra (TLS)	23	119	524	0.32	0.43	0.61	0.82
Mean	**46**			**0.71**	**0.62**	**0.70**	**0.73**

Source: Datastream, Frontier Economics calculations.

[20] See, for example, http://www.theaustralian.com.au/business/qube-raises-the-stakes-in-asciano-bidding-war/news-story/10252a949d50c1bfbd7a596b11f8c097.

78 We note that the mean leverage estimate is slightly lower than for the AER sample above. This is due almost entirely to the very low leverage levels for Aurizon and Qube. Aurizon began its life as a public company with very little debt and has stated its intention to increase leverage over time. In this regard, we note that the QCA has adopted a 55% leverage assumption for Aurizon's regulated Central Queensland Rail Network. [21] Qube is in the process of seeking to acquire Asciano and has maintained low leverage to preserve borrowing capacity.[22] We note that the AER's 60% leverage assumption falls within the range of estimates for the AER sample and within the range of estimates for the expanded sample.[23] The AER's 60% gearing assumption also (appropriately) considers unlisted firms, for which leverage can be estimated but which cannot be used to estimate beta because they do not have stock returns.

4.3 Comparison of AER sample vs. other listed Australian infrastructure firms

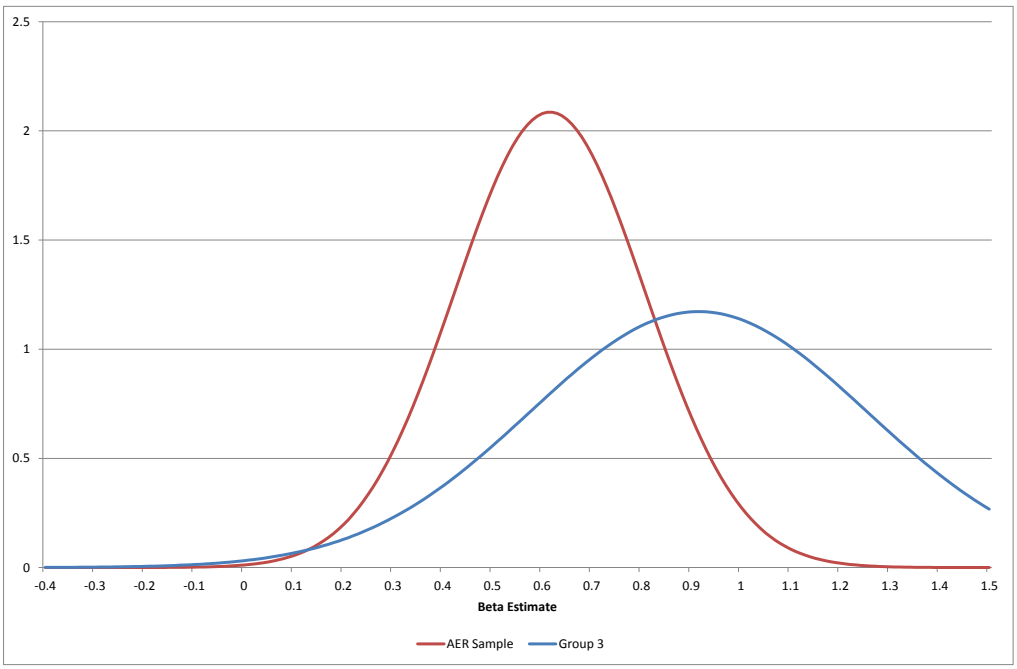
79 To compare the AER sample of nine firms to the additional infrastructure firms in the table above, we begin by computing the mean and standard deviation of each sample and simply plotting normal distributions with those parameters to provide a visual sense of the distribution of beta estimates from each set of comparator firms. The distributions for the monthly beta estimates are set out in Figure 4 below, which shows that the majority of the area under the two curves is in common. The five infrastructure firms that are examined have a higher mean and standard deviation, the latter reflecting the fact that the Group 3 sample consists of only five firms. There is a similar degree of overlap between the distributions of weekly beta estimates between these two groups.

[21] See p. 266 of the QCA's consolidated draft decision at http://www.qca.org.au/getattachment/a3144d3c-9db9-49d0-a6d8-b424f0ae098c/Volume-4-Maximum-Allowable-Revenue.aspx.

[22] See, for example, http://www.theaustralian.com.au/business/qube-raises-the-stakes-in-asciano-bidding-war/news-story/10252a949d50c1bfbd7a596b11f8c097.

[23] The AER's 60% gearing assumption is based on its consideration of a number of listed and unlisted comparator businesses. Whereas leverage can be estimated for unlisted businesses, beta cannot because unlisted firms do not have stock returns. Thus, the sample of domestic firms available to inform the estimate of leverage is larger than the sample available to estimate beta. We agree with the AER's conclusion that the relevant evidence supports leverage of 60%.

Figure 4: Distributions of 10-year monthly beta estimates for the AER sample (Groups 1 and 2) and other listed Australian infrastructure firms (Group 3)



Source: Datastream, Frontier Economics calculations.

80 The Kolmogorov-Smirnov statistical tests indicate that we cannot reject the null hypothesis that the two samples have been drawn from the same population. Table 7 below shows that for the monthly and weekly estimates, the test statistic is below the critical value and the *p*-value does not reach the standard threshold for statistical significance.

Table 7: Two-sample Kolmogorov-Smirnov test for Groups 1 and 2 vs. Group 3

Statistic	Estimate (Monthly)	Estimate (Weekly)
D-statistic	0.60	0.58
p-value	0.12	0.15
D-critical	0.69	0.69

Source: Datastream, Frontier Economics calculations.

81 The results from a *t*-test of the equality of the means between samples are reported in Table 8. For both monthly and weekly beta estimates, the *t*-statistic is below the critical value, in which case the *p*-value is above the 5% level that would be required to conclude in favour of statistical significance. Therefore, the null hypothesis that the samples come from populations that have the same mean cannot be rejected.

Table 8: *T*-test for equality of means for Groups 1 and 2 vs. Group 3.

Statistic	Estimate (Monthly)	Estimate (Weekly)
t-statistic	1.81	1.56
p-value	0.12	0.17
t-critical	2.57	2.45

Source: Datastream, Frontier Economics calculations.

82 From these statistical tests, we conclude that it is (statistically) appropriate to consider the broader set of Australian infrastructure firms together. A larger data set also has the benefit of increased statistical power.

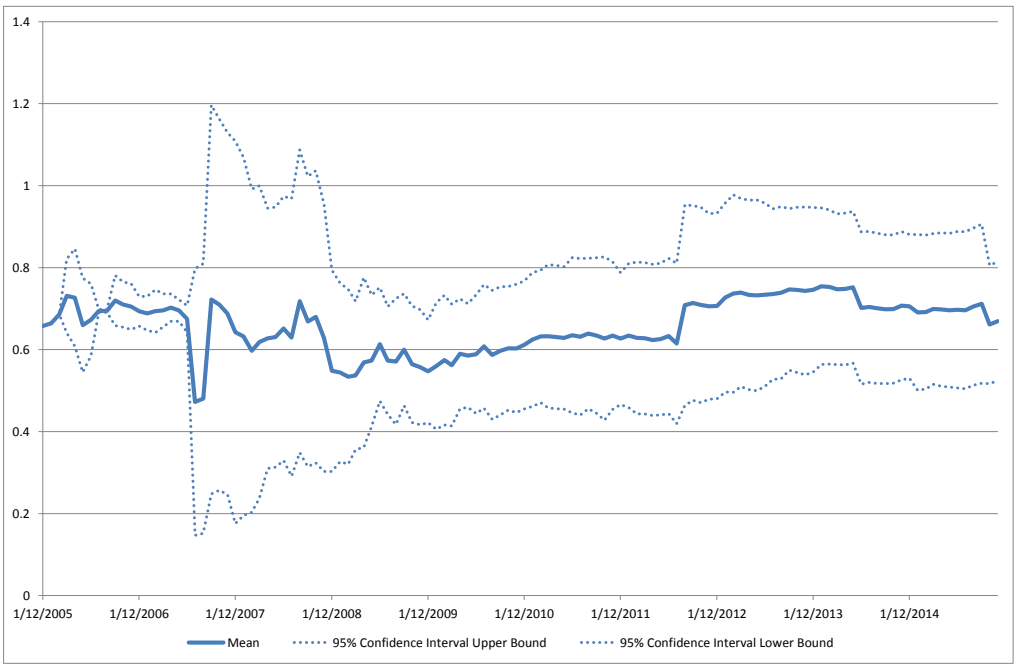
4.4 Stability and precision of expanded Australian sample

83 We compute rolling beta estimates for the expanded Australian sample as we did for the AER sample above. The results are summarised in Figure 5 and Figure 6 below for the monthly estimates and the weekly equivalents are set out in Appendix 3.

84 The estimates for the expanded Australian sample are more stable over time than the AER sample due primarily to the fact that the sample size is larger such that statistical estimation error associated with individual firms tends to cancel out over the larger sample. However, the confidence intervals remain relatively wide and there are instances of material changes and reversals in beta estimates over relatively short periods.

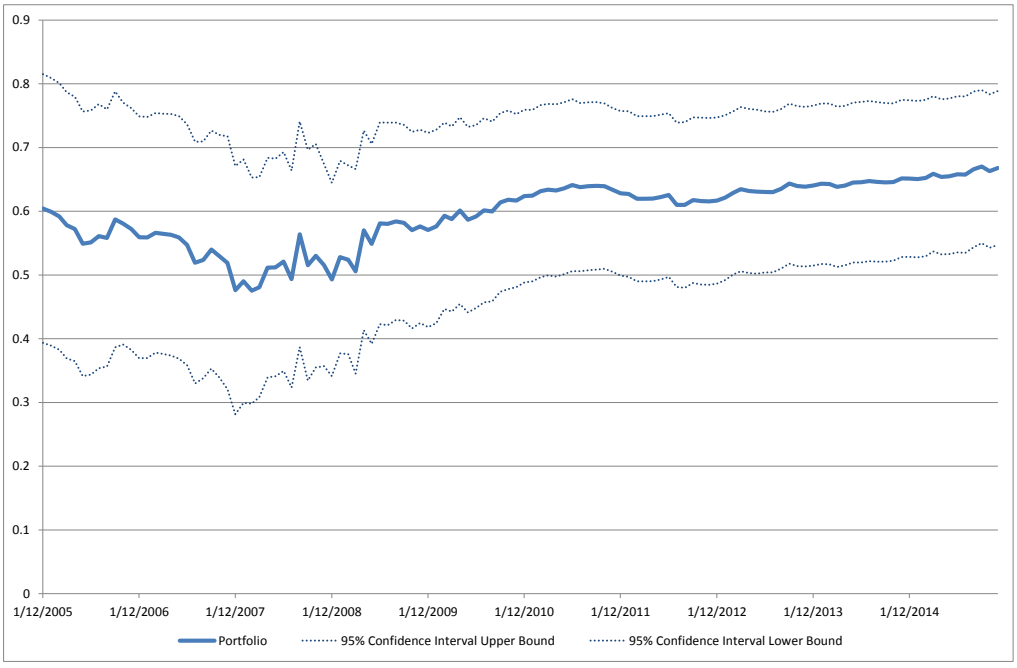
85 Whereas there is a general improvement in the statistical properties of the expanded sample relative to the AER sample, our view is that the readily available set of international comparators is likely to be of additional benefit, so we consider that sample in the following section.

Figure 5: 10-year rolling monthly beta estimates for expanded Australian sample (mean beta estimates)



Source: Datastream, Frontier Economics calculations.

Figure 6: 10-year rolling monthly beta estimates for expanded Australian sample (portfolio beta estimates)



Source: Datastream, Frontier Economics calculations.

5 Expanding the data set to include international energy distribution firms

5.1 International comparator estimates

86 In this section of the report, we consider broadening the set of comparators to include international energy distribution firms. We analysed returns on 56 US-listed energy network companies over a 20 year period from December 1995 to December 2015. The US sample was originally compiled by CEG (2013) and also used in SFG Consulting (2013). On average, these stocks have market capitalisation of US$10.3 billion and, other than two companies, all have a full ten years of return data.

87 In arriving at a set of US-listed firms, CEG began with a set of 78 firms classified by SNL Financial (SNL) under "Power" or "Gas Utility." Of these 78 firms, one firm was excluded because insufficient financial information was available for analysis and seven firms were excluded on the basis of illiquidity. SFG Consulting (2013) performed the test for liquidity. This left a set of 70 firms for consideration. CEG then retained a set of 56 firms for which at least 50% of the firm's assets were regulated.

88 The rationale for retaining these regulated firms was two-fold. First, CEG observed that firms with a low proportion of regulated assets appeared to have higher risk than more regulated firms. Specifically, for the 14 firms with less than 50% regulated assets, the average asset beta was 0.55, compared to 0.35 for the 56 firms with more than 50% regulated assets.[24] CEG estimated that the 14 firms with few regulated assets, on an ungeared basis, had approximately 57% of the risk of the average firm, compared to 37% for firms with more than 50% regulated assets.

89 CEG also considered whether to include or exclude firms on the basis of their regulatory regime, and whether they provided electricity services, gas services or both. No firms were excluded on this basis because there was no clear evidence that the risk of firms in different regulatory regimes was different, or that there was a difference in risk between electricity and gas firms. Gas businesses had lower risk metrics than electricity businesses but there were too few gas firms to make conclusions with any statistical precision.

90 Ten year average beta calculations for the 56 firms in the US sample are listed in Table 9 below. The average (debt to total value) leverage ratio is 45%. Other than CH Energy (acquired by Fortis and delisted in 2013) and NV Energy (acquired by Berkshire Hathaway and delisted in 2013) every firm has a full (or very close to)

[24] The asset beta is an estimate of what the beta of the firm would be in the absence of leverage. It is an estimate of the systematic risk of the firm's assets and operations. Leverage increases the risk of owning shares in a company as debt holders rank ahead of equity holders. Thus, other things being equal, a firm with more leverage will have a higher equity beta – reflecting the additional risk that shareholders bear as a result of the additional prior-ranking debt.

ten years of returns data for the regression analysis. The average "raw" beta estimate is 0.56 for the monthly returns data and 0.64 for the weekly returns data. Once each company's estimate has been regeared to the 60% level using the standard re-levering process the average increases to 0.77 for the monthly data and 0.88 for the weekly data.[25]

Table 9: Beta estimates for US energy distribution firms

Company	D/V	N (M)	N (W)	Monthly Beta	Weekly Beta	Relevered Monthly Beta	Relevered Weekly Beta
Southern	39	120	516	0.25	0.36	0.39	0.55
Consolidated Edison	42	120	515	0.27	0.40	0.39	0.58
Laclede Group	41	120	517	0.24	0.52	0.35	0.77
UNS Energy	60	120	448	0.66	0.64	0.65	0.64
Wisconsin Energy	42	120	515	0.34	0.47	0.49	0.68
Northwest Natural Gas	40	120	516	0.39	0.56	0.58	0.85
Northeast Utilities	51	119	517	0.47	0.57	0.58	0.70
South Jersey Industry	36	120	514	0.46	0.62	0.73	0.98
WGL Holdings	31	120	516	0.44	0.58	0.76	1.01
New Jersey Resources	29	120	514	0.43	0.57	0.75	1.02
Pepco Holdings	54	120	512	0.55	0.71	0.62	0.81
Westar Energy	48	120	513	0.60	0.63	0.77	0.82
Centerpoint Energy	61	120	516	0.55	0.82	0.54	0.80
DTE Energy	50	120	516	0.56	0.63	0.71	0.79
MGE Energy	28	120	514	0.41	0.59	0.73	1.06
Scana	48	120	518	0.52	0.55	0.68	0.72
NV Energy	62	96	410	0.59	0.76	0.57	0.73
Piedmont Natural Gas	35	120	513	0.54	0.70	0.88	1.14
Atmos Energy	46	119	513	0.53	0.61	0.72	0.82

[25] As noted above, the sample of domestic firms available to inform the estimate of leverage is larger than the sample available to estimate beta. We agree with the AER's conclusion that the relevant evidence supports leverage of 60%.

Company	D/V	N (M)	N (W)	Monthly Beta	Weekly Beta	Relevered Monthly Beta	Relevered Weekly Beta
AGL Resources	47	120	512	0.38	0.58	0.50	0.77
CMS Energy	63	119	511	0.48	0.67	0.45	0.62
Vectren	43	120	514	0.48	0.60	0.69	0.86
Firstenergy	48	120	517	0.33	0.62	0.43	0.81
Southwest Gas	47	120	515	0.75	0.74	0.99	0.98
Avista	50	120	513	0.72	0.69	0.90	0.86
Nisource	56	120	516	0.65	0.79	0.71	0.87
PPL	46	119	517	0.46	0.59	0.62	0.80
Portland General Elec.	48	116	500	0.74	0.67	0.97	0.86
CH Energy Group	38	90	388	0.55	0.53	0.85	0.82
Xcel Energy	47	120	513	0.37	0.49	0.48	0.65
Nextera Energy	43	120	517	0.55	0.69	0.78	0.97
El Paso Electric	43	119	513	0.61	0.59	0.86	0.84
Entergy	46	120	517	0.50	0.61	0.66	0.82
Idacorp	45	119	516	0.50	0.60	0.70	0.83
Empire District Electric	46	120	516	0.65	0.61	0.87	0.82
Northwestern	47	119	513	0.70	0.58	0.92	0.76
Ameren	46	119	517	0.61	0.69	0.82	0.92
Edison International	44	120	517	0.64	0.68	0.88	0.94
Alliant Energy Corp	38	120	514	0.52	0.65	0.81	1.01
Pinnacle West Capital	44	120	516	0.57	0.56	0.80	0.79
PG&E	43	120	512	0.32	0.49	0.46	0.71
Public Svs Enterprise Gr	36	119	517	0.48	0.67	0.77	1.08
American Electric Power	48	119	516	0.46	0.63	0.59	0.82
Teco Energy	48	120	513	0.76	0.79	0.99	1.02
ITC Holdings	45	120	515	0.65	0.65	0.90	0.90
UIL Holdings	46	120	517	0.75	0.64	1.02	0.87

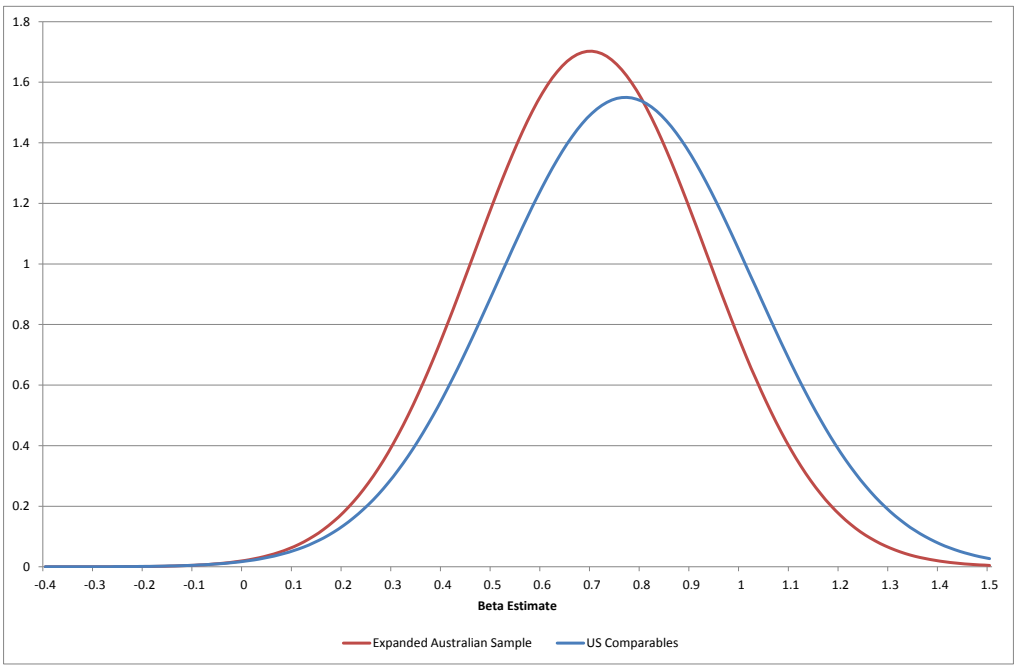
Company	D/V	N (M)	N (W)	Monthly Beta	Weekly Beta	Relevered Monthly Beta	Relevered Weekly Beta
Integrys Energy Group	42	114	493	0.81	0.83	1.16	1.19
Duke Energy	42	119	511	0.38	0.47	0.55	0.67
OGE Energy	36	120	518	0.73	0.76	1.16	1.21
Cleco	38	120	516	0.53	0.61	0.82	0.96
Great Plains Energy	51	118	511	0.74	0.66	0.91	0.80
PNM Resources	58	120	515	0.86	0.93	0.90	0.98
Sempra Energy	38	120	517	0.62	0.76	0.95	1.18
Black Hills	47	120	514	0.99	0.83	1.33	1.10
Allete	34	119	518	0.62	0.59	1.01	0.98
Otter Tail	34	120	513	1.14	0.93	1.88	1.54
Mean	**45**			**0.56**	**0.64**	**0.77**	**0.88**

Source: Datastream, Frontier Economics calculations.

5.2 Comparison of expanded Australian sample vs. US utilities sample

91 To compare the international sample with the expanded Australian sample, we again conduct a series of visual comparisons and statistical tests. Again, we begin with a visual representation of the mean and standard deviation of each of the two samples, plotting a normal distribution for each sample. It is evident from Figure 7 below that the two samples are broadly similar. They appear even closer to each other than the last comparison between the AER sample and the broader Australian infrastructure sample (Group 3).

Figure 7: Distributions of 10-year monthly beta estimates for the expanded Australian sample and the US utilities sample



Source: Datastream, Frontier Economics calculations.

92 Next we perform the same statistical tests as above. The Kolmogorov-Smirnov tests reported in Table 10 below indicate that the two samples of beta estimates are statistically similar, for both the monthly and weekly estimates. In neither case are we able to reject the null hypothesis that the two samples of beta estimates are drawn from the same population.

Table 10: Two-sample Kolmogorov-Smirnov test for AER sample vs. US utilities sample

Statistic	Estimate (Monthly)	Estimate (Weekly)
D-statistic	0.19	0.38
p-value	0.76	0.06
D-critical	0.39	0.39

Source: Datastream, Frontier Economics calculations.

93 Similarly, the *t*-statistics reported in Table 11 indicate that the means of the monthly beta estimates are not statistically significantly different between the two sub-samples, but that the *t*-test for the weekly estimates is right on the borderline of statistical significance. Taken as a whole, the statistical tests support the notion that the US utilities sample is statistically similar to the Australian sample.

Table 11: T-test for equality of means between AER sample and US utilities sample

Statistic	Estimate (Monthly)	Estimate (Weekly)
t-statistic	1.11	2.33
p-value	0.28	0.05
t-critical	2.14	2.26

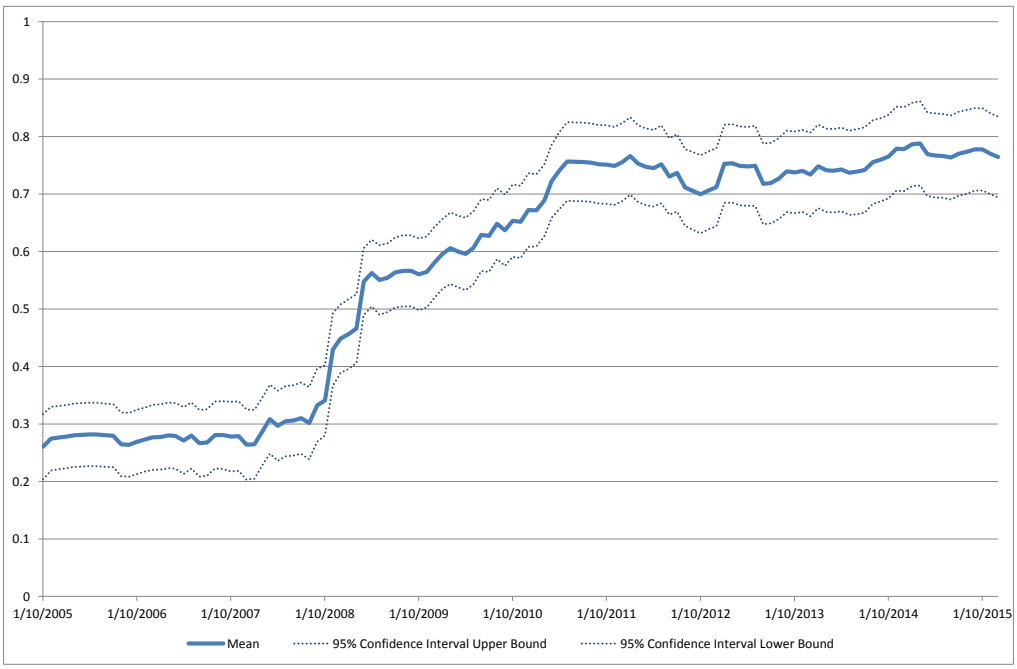
Source: Datastream, Frontier Economics calculations.

5.3 Stability and precision of US utilities sample

94 In contrast to the AER sample, the US utilities sample is much larger and the constituent firms have a long listing history. This means that the composition of the US sample is stable over time and the larger size results in estimation error for individual firms tending to cancel out across the sample. The result of this is greater congruency between mean and portfolio estimates, as well as lower standard errors and tighter confidence intervals.

95 Figure 8 below shows the 10-year rolling mean monthly beta estimates for the US utilities sample. The standard error bounds are much tighter than for the AER sample, reflecting the larger sample size and the stability of the constituent firms. The mean beta estimate increases from 2008 to 2010 as the technology bubble period (1998-2001) progressively moves out of the 10-year sample period. During this period, the mean beta estimate more than doubles from 0.3 to above 0.7. As above, we note that it is possible for the OLS beta *estimates* to deviate materially from the true systematic risk even though the confidence interval is relatively tight. For example, Frontier Economics (2015) documents the recent increase in risk that energy distribution businesses now face and note that at least some aspects of those risks are likely to be systematic. However, the dramatic changes in beta estimates appear to be more reflective of statistical estimation error than changes in true systematic risk.

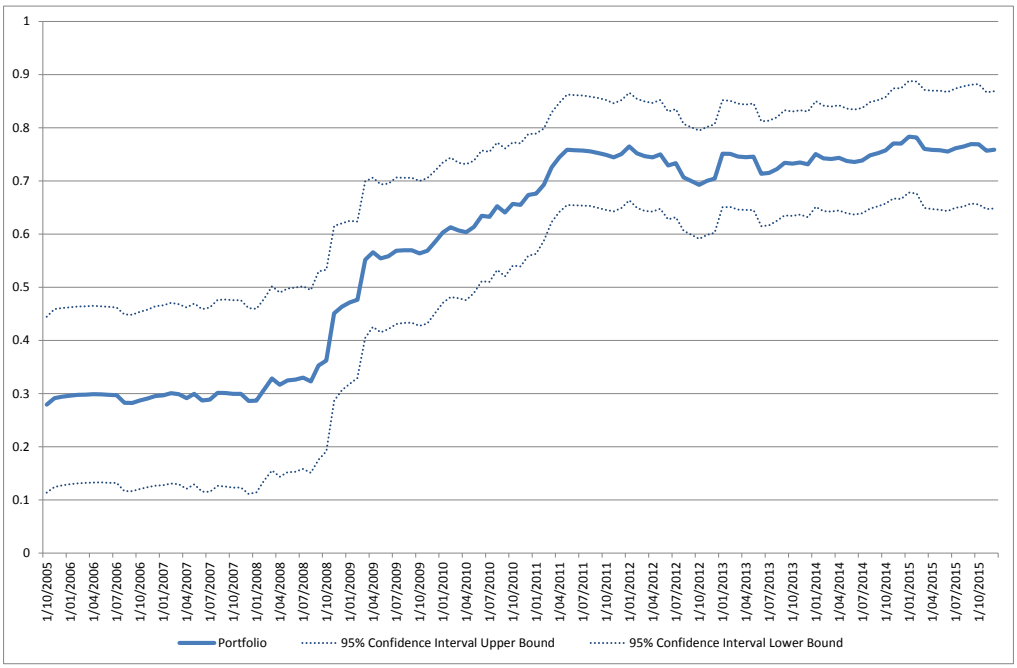
Figure 8: 10-year rolling monthly beta estimates for US utilities sample (mean beta estimates)



Source: Datastream, Frontier Economics calculations.

96 Figure 9 displays the time-series of the beta estimates for a portfolio that consists of an equal-weighted average of each of all available monthly returns every month across the 10-year window. The same general upward trend as observed in the previous figure is present. Again, the confidence interval for the US portfolio approach is tighter than for the Australian sample.

Figure 9: 10-year rolling monthly beta estimates for US utilities sample (portfolio beta estimates)



Source: Datastream, Frontier Economics calculations.

97 The corresponding figures for weekly beta estimates are set out in Appendix 3. The key features of those figures are unsurprisingly similar to those for the monthly observations and again feature very high stability and tight confidence intervals.

6 Conclusions

98 The sets of contemporaneous beta estimates are summarised in Table 12 below.

Table 12: Summary of contemporaneous beta estimates

Sample	Mean estimate		Portfolio estimate	
	Monthly	Weekly	Monthly	Weekly
AER sample (4 live firms, 5 delisted firms)	0.62	0.63	0.61	0.57
AER sample plus Australian infrastructure firms (9 live firms, 4 delisted firms)	0.70	0.73	0.67	0.62
US utilities sample (54 live firms, 2 delisted firms)	0.77	0.88	0.76	0.87

Source: Datastream, Frontier Economics calculations.

99 For the reasons set out in Section 3, our view is that the AER sample of domestic comparators is too small to, by itself, provide a reliable estimate of beta for the benchmark efficient firm. The majority of the sample consists of firms that no longer exist, rolling beta estimates vary materially over time, and there is a wide distribution of estimates over the component firms.

100 In Section 4, we consider an expanded set of Australian firms that includes other infrastructure type firms that compete for equity capital among the same set of investors. We show that the additional firms are statistically similar to the AER sample. We also show that the addition of more firms produces beta estimates with improved statistical properties – estimates that are more stable and more precise. However, we conclude that the expanded set of domestic firms should not be relied upon alone, given the ready availability of international comparators.

101 In Section 5, we consider a set of US energy distribution comparators. We show that the US utilities sample is statistically similar to the expanded Australian sample. We also show that the (much larger) US sample has better statistical properties than the Australian sample – estimates that are more stable over time and much more precise.

102 We have previously recommended an equity beta estimate of 0.82 that has regard to the evidence from domestic and international energy distribution firms – where relatively more weight is given to the domestic firms. We summarise our reasons for that approach in our recent report, Frontier (Dec 2015 ROE).

103 Overall, the evidence in Table 12 suggests that 0.82 remains a reasonable starting point equity beta estimate if any material weight is assigned to the weekly estimates for the international comparators.

7 Declaration

104 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.

_____

8 References

Australian Energy Regulator, 2009, *Electricity transmission and distribution network service providers: Review of the weighted average cost of capital (WACC) parameters*, May 2009.

Brooks, R., N. Diamond, S. Gray and J. Hall, 2013a, *The Vasicek adjustment to beta estimates in the Capital Asset Pricing Model*, June.

Brooks, R., N. Diamond, S. Gray and J. Hall, 2013b, *Comparison of OLS and LAD regression techniques for estimating beta*, June.

Brooks, R., N. Diamond, S. Gray and J. Hall, 2013c, *Assessing the reliability of regression-based estimates of risk*, June.

Competition Economists Group, 2013, *Information on equity beta from US companies*, June.

Frontier Economics, 2015, *Review of the AER's conceptual analysis for equity beta*, May.

Frontier Economics, 2016, *The required return on equity under a foundation model approach*, January.

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

Henry, O., 2009, *Estimating β*, prepared for the Australian Energy Regulator, 23 April 2009.

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

Sheskin J., 2003, *Handbook of Parametric and Nonparametric Statistical Procedures*, Third Edition, CRC Press, p. 453.

Vasicek, O., 1973, "A note on using cross-sectional information in Bayesian estimation of security betas," *Journal of Finance,* 28, 1233–1245.

9 Appendix 1: Instructions

Expert Terms of Reference

Estimating equity beta for the benchmark efficient entity

Jemena Electricity Networks (Vic) Limited
2016-20 Electricity Distribution Price Review

EDPR-5700-0010

Version B – 5 January 2016

Contact Person

Jacinta Davenport

Legal Counsel

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A	Draft	9/11/15	E Grace-Webb		
B	Final	5/1/16	E Grace-Webb	G+T	E Grace-Webb

Contents

1 Background

Jemena Electricity Networks (**JEN**) is an electricity distribution network service provider in Victoria. JEN supplies electricity to approximately 300,000 homes and businesses through its 10,285 kilometres of distribution system. JEN's electricity distribution system services 950 square kilometres of northwest greater Melbourne. JEN's electricity network is maintained by infrastructure management and services company, Jemena Asset Management (**JAM**).

JEN submitted its initial regulatory proposal with supporting information for the consideration of the Australian Energy Regulator (**AER**) on 30 April 2015. This proposal covers the period 2016-2020 (calendar years). The AER published its preliminary determination on 29 October 2015. JEN is currently preparing its submission in response to the preliminary decision, to be submitted to the AER by 6 January 2016.

As with all of its economic regulatory functions and powers, when making the distribution determination to apply to JEN under the National Electricity Rules and National Electricity Law, the AER is required to do so in a manner that will or is likely to contribute to the achievement of the National Electricity Objective, which is:

> *to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:*
>
> *(a) price, quality, safety, reliability and security of supply of electricity; and*
>
> *(b) the reliability, safety and security of the national electricity system.*

The equivalent National Gas Objective is set out in section 23 of the National Gas Law.

Where the AER is making a distribution determination and there are two or more possible decisions that will or are likely to contribute to the achievement of the National Electricity Objective, the AER is required to make the decision that the AER is satisfied will or is likely to contribute to the achievement of the National Electricity Objective to the greatest degree.

The AER must also take into account the revenue and pricing principles in section 7A of the National Electricity Law when exercising its discretion in making those parts of a distribution determination relating to direct control network services. The revenue and pricing principles include the following:

> *A regulated network service provider should be provided with a reasonable opportunity to recover at least the efficient costs the operator incurs in:*
>
> *(a) providing direct control network services; and*
>
> *(b) complying with a regulatory obligation or requirement or making a regulatory payment.*

The equivalent revenue and pricing principles for gas network regulation are set out in section 24 of the National Gas Law.

Some of the key rules governing the making of a distribution determination are set out below.

Clause 6.4.3(a) of the National Electricity Rules provides that revenue for a regulated service provider is to be calculated adopting a "building block approach". It provides:

> *The annual revenue requirement for a Distribution Network Service Provider for each regulatory year of a regulatory control period must be determined using a building block approach, under which the building blocks are:*
>
> *(1) indexation of the regulatory asset base – see paragraph (b)(1);*
>
> *(2) a return on capital for that year – see paragraph (b)(2);*
>
> *(3) the depreciation for that year – see paragraph (b)(3);*
>
> *(4) the estimated cost of corporate income tax of the Distribution Network Service Provider for that year – see paragraph (b)(4);*
>
> *(5) the revenue increments or decrements (if any) for that year arising from the application of any efficiency benefit sharing scheme, capital expenditure sharing scheme, service target performance incentive scheme, demand management and embedded generation connection incentive scheme or small-scale incentive scheme – see subparagraph (b)(5);*
>
> *(6) the other revenue increments or decrements (if any) for that year arising from the application of a control mechanism in the previous regulatory control period – see paragraph (b)(6);*
>
> *(6A) the revenue decrements (if any) for that year arising from the use of assets that provide standard control services to provide certain other services – see subparagraph (b)(6A); and*
>
> *(7) the forecast operating expenditure for that year – see paragraph (b)(7).*

Clause 6.5.2 of the National Electricity Rules, relating to the allowed rate of return, states:

> *Calculation of return on capital*
>
> *(a) The return on capital for each regulatory year must be calculated by applying a rate of return for the relevant Distribution Network Service Provider for that regulatory year that is determined in accordance with this clause 6.5.2 (the allowed rate of return) to the value of the regulatory asset base for the relevant distribution system as at the beginning of that regulatory year (as established in accordance with clause 6.5.1 and schedule 6.2).*
>
> *Allowed rate of return*
>
> *(b) The allowed rate of return is to be determined such that it achieves the allowed rate of return objective.*
>
> *(c) The allowed rate of return objective is that the rate of return for a Distribution Network 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 Distribution Network Service Provider in respect of the provision of standard control services (the allowed rate of return objective).

(d) Subject to paragraph (b), the allowed rate of return for a regulatory year must be:

(1) a weighted average of the return on equity for the regulatory control period in which that regulatory year occurs (as estimated under paragraph (f)) and the return on debt for that regulatory year (as estimated under paragraph (h)); and

(2) determined on a nominal vanilla basis that is consistent with the estimate of the value of imputation credits referred to in clause 6.5.3.

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

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

(2) 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

(3) 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

(f) The return on equity for a regulatory control period must be estimated such that it contributes to the achievement of the allowed rate of return objective.

(g) In estimating the return on equity under paragraph (f), regard must be had to the prevailing conditions in the market for equity funds.

Return on debt

(h) The return on debt for a regulatory year must be estimated such that it contributes to the achievement of the allowed rate of return objective.

(i) The return on debt may be estimated using a methodology which results in either:

(1) the return on debt for each regulatory year in the regulatory control period being the same; or

(2) the return on debt (and consequently the allowed rate of return) being, or potentially being, different for different regulatory years in the regulatory control period.

(j) Subject to paragraph (h), the methodology adopted to estimate the return on debt may, without limitation, be designed to result in the return on debt reflecting:

(1) the return that would be required by debt investors in a benchmark efficient entity if it raised debt at the time or shortly before the making of the distribution determination for the regulatory control period;

(2) the average return that would have been required by debt investors in a benchmark efficient entity if it raised debt over an historical period prior to the commencement of a regulatory year in the regulatory control period; or

(3) some combination of the returns referred to in subparagraphs (1) and (2).

(k) In estimating the return on debt under paragraph (h), regard must be had to the following factors:

(1) the desirability of minimising any difference between the return on debt and the return on debt of a benchmark efficient entity referred to in the allowed rate of return objective;

(2) the interrelationship between the return on equity and the return on debt;

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

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

(l) If the return on debt is to be estimated using a methodology of the type referred to in paragraph (i)(2) then a resulting change to the Distribution Network Service Provider's annual revenue requirement must be effected through the automatic application of a formula that is specified in the distribution determination."

[Subclauses (m)–(q) omitted].

The equivalent National Gas Rules are set out in rule 87.

Clause 6.5.3 of the National Electricity Rules, relating to the estimated cost of corporate income tax, states:

The estimated cost of corporate income tax of a Distribution Network Service Provider for each regulatory year (ETCt) must be estimated in accordance with the following formula:

$$ETCt = (ETIt \times rt)(1 - \gamma)$$

where:

ETIt is an estimate of the taxable income for that regulatory year that would be earned by a benchmark efficient entity as a result of the provision of standard control services if such an entity, rather than the Distribution Network Service Provider, operated the business of the Distribution Network Service Provider, such estimate being determined in accordance with the post-tax revenue model;

rt is the expected statutory income tax rate for that regulatory year as determined by the AER; and

γ is the value of imputation credits.

The equivalent National Gas Rule is in rule 87A.

In its initial proposal, JEN submitted several expert reports from SFG (the **Earlier Reports**) on the appropriate approach to be adopted in estimating the equity beta for the benchmark efficient entity.[1] The AER preliminary decision considered these reports.

In this context, JEN seeks a report from Frontier Economics, as a suitably qualified independent expert (**Expert**), that reviews and, where appropriate, responds to matters raised in the preliminary decision on the best estimate of equity beta. JEN seeks this report on behalf of itself, ActewAGL Distribution, Ausnet Services, Australian Gas Networks, Citipower, Powercor, and United Energy.

2 Scope of Work

In its preliminary determination, the AER relies on a sample of nine listed and regulated Australian energy networks to estimate a beta of 0.7 for the benchmark efficient entity (**BEE**). The AER defined the BEE as:

a pure play, regulated energy network business operating within Australia.

The Expert will provide an opinion report that:

1. Reviews the accuracy of beta estimates derived using the sample of networks relied upon by the AER, including (but not limited to):

   (a) the width of confidence intervals for each estimate;

   (b) the stability of estimates over time and across networks; and

   (c) the adjustments made to raw beta estimates.

[1] *SFG*, 25 February 2015, *The required return on equity for the benchmark efficient entity*; *SFG*, 13 February 2015, *Beta and Black CAPM Asset Pricing Model*; *SFG*, 27 March 2015, *The foundation model approach of the Australian Energy Regulator to estimating the cost of equity*; *SFG*,13 February 2015, *Using the Fama-French model to estimate the required return on equity*; *SFG*, 18 February 2015, *Share prices, the dividend discount model and the cost of equity for the market and a benchmark energy network*.

2. Considers whether the sample should, and if so, how it could, be expanded to inform the beta estimate.

3. Explains whether the Expert's view of the sample that should be used to estimate the beta changes depending on whether the AER's definition of the BEE is adopted, or if the definition of the BEE did not refer to the entity being regulated, but rather an unregulated entity that supplies services of an analogous kind to standard control services.

4. If the answer to (2) is yes, that the sample should be expanded, reviews the accuracy of beta estimates derived using the larger sample or samples of firms, including (but not limited to):

   (a) the width of confidence intervals for each estimate;

   (b) the stability of estimates over time and across networks;

   (c) the adjustments made to raw beta estimates; and

   (d) whether the various samples are statistically part of the same population or not.

5. In light of the Expert's opinion on the above matters, and any other matters the Expert considers relevant, and the Earlier Reports, sets out the expert's opinion of the best estimate of equity beta for the BEE as a parameter input to the Sharpe-Lintner Capital Asset Pricing Model (**CAPM**) or the Black CAPM.

In preparing the report the Expert will:

A. consider the theoretical and empirical support for each of the possible approaches;

B. consider any relevant comments raised by the AER and other regulators, and experts engaged by those regulators; and

C. use robust methods and data in producing any statistical estimates.

3 Information to be Considered

The Expert is also expected to consider the following information:

- such information that, in Expert's opinion, should be taken into account to address the questions outlined above;

- relevant literature on estimating the return on equity;

- 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 Guidelines; and

- previous decisions of the AER, other relevant regulators and the Australian Competition Tribunal on the return on equity and any supporting expert material, including the recent final decisions for Jemena Gas Networks and electricity networks in ACT, NSW, Queensland, South Australia and Tasmania.

4 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 [2];
- 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 JEN'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).

5 Timetable

The Expert will deliver the final report to Jemena Regulation by **6 January 2016**.

6 Terms of Engagement

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

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

- 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[3], 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[4]

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[5]

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

---

[3] 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].

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

[5] 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[6]; 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[7].

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[8].

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

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

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

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

10 Appendix 2: Curriculum vitae – Professor Stephen Gray

Stephen Gray is Professor of Finance at the University of Queensland Business School and Chairman of Frontier Economics (Australia). He has Honours degrees in Commerce and Law from the University of Queensland and a PhD in financial economics from the Graduate School of Business at Stanford University.

In his university role, he teaches a range of award and executive education courses in financial management, asset valuation, and corporate finance. He has received a number of teaching awards, including a national award for university teaching in the field of business and economics. He has published widely in highly-ranked journals and has received a number of manuscript awards, most notably at the *Journal of Financial Economics*.

Stephen is also an active consultant to industry on issues relating to valuation, cost of capital, and corporate financial strategy. He has acted as a consultant to many of Australia's leading companies, government-owned corporations, and regulatory bodies. His clients include the Independent Pricing and Regulatory Tribunal (IPART), Australian Competition and Consumer Commission (ACCC), Melbourne Water, Qantas, Telstra, Origin Energy, AGL, Foxtel, ENERGEX, Queensland Treasury Corporation, Rio Tinto Alcan and the Australian Securities and Investments Commission (ASIC). Projects include corporate cost of capital reviews, asset valuation, independent valuation of executive stock options, and the assessment of capital structure and financing strategies.

He has also appeared as an independent expert in several court proceedings relating to the valuation of assets and businesses and the quantification of damages.

Key experience

Cost of capital

Energy sector

- **TransGrid (2015) –** Advised the electricity transmission operator in NSW on the appropriateness of the Australian Energy Regulator's (AER's) proposed transitional arrangements before the full introduction of a trailing average approach to setting the cost of debt allowance for regulated networks. The AER recently revised its rate of return methodology. In doing so, the AER announced that it would adopt a trailing average approach to setting cost of debt allowances (similar to the approach used by Ofgem in Great Britain). However, the AER argued that it should phase this approach in to allow businesses sufficient time to align their debt management practices to the new methodology. Frontier prepared a report on behalf of TransGrid explaining the circumstances in which such transitional arrangements would not be appropriate.

- **Australian Energy Markets Commission (AEMC) (2012)** – The regulator (AER) and a group of large energy users (EURCC) proposed changes to the National Electricity Rules and National Gas Rules (Rules). The AEMC, which is the government agency that is responsible for maintaining the Rules, conducted a year-long review and consultation process in relation to the proposed rule changes. Stephen was appointed to advise the AEMC on rate of return issues. His role involved the provision of advice to the AEMC secretariat and board, the preparation of a number of public reports, the co-ordination and chairing of public hearings, and a series of one-on-one meetings with key stakeholders. The process resulted in material changes being made to the Rules, with revised Rules being published in November 2012.

- **Energy Networks Association (2013) –** The National Electricity Rules and National Gas Rules (Rules) require the regulator to publish a series of regulatory guidelines every three years. The Australian Energy Regulator (AER) conducted a year-long process in 2013 that ended with the publication of its first Rate of Return Guideline. Throughout this process, Stephen advised the Energy Networks Association (ENA) on rate of return issues. This involved working with the ENA's Regulatory Affairs Committee, specialist working groups, and legal advisors, preparing expert reports, drafting submissions, and representing the ENA at stakeholder forums.

- **TransGrid (2013) Return on Debt Analysis –** The 2012 changes to the National Electricity Rules included, inter alia, a provision that permitted the allowed return on debt to be set according to a trailing average approach. TransGrid sought an analysis of the effect that such a change would have on the residual cash flows that were available to its shareholders. Stephen developed a Monte Carlo simulation model that generated many scenarios for the possible future evolution of interest rates, incorporating empirical relationships between government bond yields, credit spreads, and inflation. His analysis quantified the extent to which the trailing average approach would better match the actual cost of servicing debt under TransGrid's longstanding debt management approach, thereby reducing the volatility of the cash flow to equity holders.

- **Aurizon Network (2014) Split Cost of Capital Analysis –** In a discussion paper, the Queensland Competition Authority advocated consideration of a split cost of capital regulatory approach. Under the proposed approach the regulator would allow a standard "debt and equity" regulated return on assets during their construction, but a "100% debt" return once the asset had been included in the firm's regulatory asset base. Stephen was retained by Aurizon (operator of a regulated coal rail network). His role was to prepare an expert report that considered the economic and financial basis for the proposed

approach, and which considered the likely consequences of such an approach. After his presentation to the QCA board, the proposal was shelved indefinitely.

- **Energy Networks (2014-15) Regulatory Reviews –** Stephen has prepared expert reports and submissions on behalf of all businesses that are in the current rounds of regulatory resets. These reports cover the whole range of regulatory cost of capital issues. Clients over the last year include ATCO Gas, DBP, ActewAGL, TransGrid, Jemena, United Energy, CitiPower, Powercor, SA Power Networks, Ausgrid, Essential Energy, Endeavour Energy, ENERGEX, and Ergon Energy.

- **Legal and Appeal Work –** Stephen has assisted a number of regulated business, and their legal teams, through merits review and appeal processes. One example is the 2011 *Gamma* case in the Australian Competition Tribunal. That case involved the "gamma" parameter, which quantifies the impact that dividend imputation tax credits have on the cost of capital. The regulator (AER) proposed an estimate that was based on (a) an assumption that was inconsistent with the observed empirical evidence, and (b) a point estimate that was based partly on a paper with questionable reliability and partly on data that was irrelevant to the task at hand. Stephen's role was to prepare a series of expert reports, to assist the legal team to understand the issues in detail, and to attend the hearings to advise as the matter was heard. The end result was that the Tribunal set aside the entire basis for the AER's proposed estimate and directed us to perform a "state of the art" empirical study. Stephen performed the required study and its results were accepted in full by the Tribunal, who set the estimate of gamma on the basis of it.

Water sector

- **Melbourne Water (2015) –** In preparation for the 2016 Victorian price review, Stephen is part of the Frontier team currently advising Melbourne Water on ways in which the rate of return methodology used by the Victorian regulator, the Essential Services Commission (ESC), could be improved, and the likely revenue impact of any methodological changes. At the last (i.e. 2013) price reset, the ESC indicated that it intended to review its rate of return methodology but to date has not done so. By comparison, most other major Australian regulators have revised their methodologies significantly, in part due to recognition of the need to make their estimation approaches more resilient to the effects of global financial crises. A comparison of the methodologies used by different regulators in Australia suggests that the ESC's methodology is out of line with best regulatory practice. Frontier's advice has focused on identifying the areas for improvement, and the development of the economic arguments that would support the case for change.

- **Unity Water, SEQ Water, Gladstone Area Water Board (2013-14) –** Stephen has prepared a series of reports for a number of Queensland water utilities. These reports include (a) a response to the QCA's (Queensland regulator) proposed split cost of capital approach (which has now been shelved indefinitely), and (b) a response to the QCA's proposed cost of capital estimates.

Telecommunications sector

- **NBN Co (2012-13) –** Stephen advised NBN Co on a range of cost of capital issues in relation to their proposed special access undertaking. This work included the drafting of expert reports, meetings with and presentations to various NBN Co committees and working groups, and representing NBN Co in discussions with the regulator (ACCC). Key issues included the length of the proposed access arrangement, the extent to which higher risk during the construction and proof-of-concept phases justified a higher allowed return, and the process by which early year losses might be capitalized into the regulatory asset base.

- **C7 Case (2006-07), Federal Court of Australia**

  The Seven Network brought an action against a number of Australian media and entertainment firms in relation to the abandonment of its cable TV business, C7. Seven alleged that the respondents colluded to prevent C7 from securing the rights to broadcast AFL and NRL matches and that this prevented its C7 business from being economically viable.

  Stephen was retained by a group of respondents including PBL, Telstra, and News Corporation. His role was to address various matters relating the quantification of damages. He prepared several reports, was involved in several discussions with other valuation expert witnesses, and was cross examined in the Federal Court.

  The Court found in favour of the respondents.

Transport sector

- **CBH Group (2015) –** Stephen was part of the Frontier team that developed, on behalf of CBH (a major Australian grain producer and access seeker to rail infrastructure in Western Australia) and its legal counsel, a submission to the Economic Regulation Authority (ERA) of Western Australia on the regulator's approach to estimating WACC. The submission focused on, amongst other issues, the ERA's approach to estimating the market risk premium, the estimation approach to beta, and the way in which the WACC ought to be used within the negotiate-arbitrate arrangements within the rail access regime.

- **Brockman Mining Australia (2015) –** Stephen was part of the Frontier team that advised Brockman, a potential access seeker to rail infrastructure in Western Australia, on its submission to the Economic Regulation Authority (ERA) of Western Australia in relation to the ERA's approach to WACC under the Railways (Access) Code 2000. Subsequently, the ERA released a Revised Draft Decision on its proposed WACC methodology. Frontier was engaged again by Brockman to help develop its submission to the ERA on the Revised Draft Decision. The submissions focused on the appropriateness of the beta estimates proposed by the ERA, the methodology used to estimate the market risk premium (and consistency between the methodologies used by the ERA in different sectors), the appropriateness of the ERA's credit rating assumption for the benchmark efficient entity (which affects the cost of debt allowance under the ERA's methodology).

- **Brookfield Rail (2014) –** The WA Railways (Access) Code requires railway operators to provide certain information to access seekers to enable them to compute "floor" and "ceiling" prices as defined in the Code. Brookfield provided access seekers with certain information and other relevant information was available from public sources. Stephen prepared an expert report that considered whether the information available to an access seeker, together with specialist assistance from relevant experts, would be sufficient to compute floor and ceiling prices.

- **Brisbane Airport Corporation (2013-14) –** Stephen was engaged by Brisbane Airport Corporation (BAC) to advise on a range of regulatory and cost of capital issues in relation to the development of the airport's new parallel runway (NPR). BAC identified the need for an additional runway to accommodate steadily increasing demand. The development of a new runway required a large capital commitment ($1.5 billion) and would take approximately eight years to complete. BAC proposed that the airlines would contribute to the financing of the NPR during construction – the alternative being the capitalisation of a return on capital expenditure until completion and a sharp spike in landing fees when the NPR become operational. One of the key issues in the negotiations with airlines was the WACC that would be used to determine the return on capital. Stephen's role was twofold. He produced an expert report providing a strong basis for BAC's proposed WACC. He also advised BAC on the likely approach of the ACCC (the regulator in question) should they become involved – the regulatory arrangements provide for the parties to negotiate a commercial outcome and for the regulator to become involved if they are unable to do so. BAC was successful in their negotiations with the relevant airlines and the NPR is now under construction.

- **Abbott Point Coal Terminal (2014) –** Stephen was engaged by a consortium of mining companies in relation to arbitration with Adani, the owner and operator of the Abbott Point Coal Terminal. The parties had in place a user agreement that was similar to a regulatory-style building block model. Stephen

advised on a range of cost of capital and other issues including detailed reports on the cost of debt and the level of corporate costs.

Financial litigation support

- **APLNG (2014-15)**
  The Australia-Pacific LNG (APLNG) project is a joint venture between Origin Energy, ConocoPhillips and Sinopec that involves the extraction of coal seam methane and processing into liquefied natural gas (LNG) for export. The relevant Queensland royalties legislation provides that a 10% royalty is to be levied on the value of the gas at the first point of disposal. Since the project is integrated from end-to-end, there is no arm's length price at the relevant point. Stephen was retained by APLNG to prepare an expert report on the process for determining what the arm's length price at the first point of disposal would be if such a thing existed. This involves estimating the costs, including a fair return on capital, for a hypothetical upstream gas producer and a hypothetical downstream LNG operator, and allocating any excess profit between the parties.

- **CDO Case (2013)**
  This case involved a class action against the Australian distributor of collateralised debt obligations (CDOs) and the international credit ratings agency that assigned credit ratings to them. The CDOs in question were financial products with a payoff that depended on the number of defaults (or "credit events") among a reference set of 150 different corporate bonds issued by companies in different industries and different geographical locations. A typical CDO structure would involve the investor being repaid all of their initial investment plus an attractive rate of interest so long as there were less than say 7 defaults out of the reference set of 150 bonds during the five-year life of the CDO. However, if there were say 11 or more defaults, the investor would lose their entire investment. If the number of defaults was between 7 and 11, the return to the investor would be proportional (e.g., 8 defaults would involve a 25% loss of principal).

  The CDOs in question were created by US investment banks and were distributed in Australia by a large Australian commercial bank. One of the key issues in the case was whether the Australian distributor made proper disclosures about risk to investors, which included individuals, self-managed superannuation funds, and local councils. The CDOs in question were assigned strong investment grade credit ratings by an international ratings agency. The process used to assign those ratings did not properly take into account the correlation between defaults – the empirical fact that during recessions and financial crises many bonds default at the same time.

Stephen's role was to prepare an expert report that explained to the Court how CDOs were structured, how they operated, and what risks were involved. His report also examined the risk disclosures that were contained in the materials that were provided to potential investors and the process by which the credit rating agency assigned ratings.

- **Wright Prospecting litigation (2012-14)**
  Wright Prospecting Pty Ltd (WPPL) is involved in several legal disputes about the payment of royalty streams in relation to iron ore and coal mining operations. WPPL had assigned various rights and licenses in relation to iron ore mines in WA and coal mines in Queensland to other parties, in return for royalties on the revenues received from the sale of the ore. Stephen's role was to prepare a series of expert reports quantifying the present value of the royalty streams.

- **Public Trustee of QLD v. Octaviar Ltd (2009), Supreme Court of Queensland**
  The Octaviar Group (formerly the MFS Group) is a Gold Coast based group of listed companies with funds management and leisure services businesses. Octaviar was unable to refinance a loan in early 2008 and sought to raise equity via a rights issue as part of a substantial corporate restructure. The stock price fell some 70% on this announcement and Octaviar subsequently sold a 65% interest in its leisure business known as Stella. Octaviar then sought to make arrangements with its creditors, including the Public Trustee, as trustee for note holders.

  Stephen was retained by the Public Trustee. His role was to prepare several reports on (a) whether the companies in the Octaviar Group were insolvent, (b) the date the companies became insolvent, and (c) whether the note holders would be made better or worse off by the proposed arrangement, relative to a liquidation. He was cross examined by four parties with an interest in these proceedings on issues relating to the date of the insolvency.

- **Telstra v. ACCC (2008), Federal Court of Australia**
  Telstra brought an action against the ACCC in relation to access charges that Telstra was allowed to charge its retail competitors for access to its fixed line and broadband networks – arguing that the return on capital allowed by the ACCC was unreasonably low.

  Stephen was retained by Telstra. His role was to prepare several reports on the issue of whether the ACCC has been inconsistent in its application of valuation methods – in a way that reduced Telstra's allowed return. He was also involved in several discussions with other valuation expert witnesses,

prepared a joint statement of experts, and was cross examined in the Federal Court individually and in a "hot tub" setting.

- **Alcan Northern Territory Alumina Pty Ltd v. Commissioner of Taxes (2006-07), Supreme Court of Northern Territory**
  First Engagement: Consulting Expert

Alcan bought out the equity of its joint venture partner in a combined bauxite mine and alumina refinery in the Northern Territory. The NT Revenue Authority claimed that the transaction was caught by the NT "land rich" provision, under which the transaction would be subject to stamp duty if more than 60% of the consideration was attributable to land assets.

The key economic issue is the apportionment of value between the mine (predominately land assets) and the refinery (substantially intangible assets arising out of intellectual property and expertise).

Stephen was retained by Alcan as consulting experts. Their role was to prepare a range of financial models and analysis to support the view that a substantial portion of the value of the transaction was attributable to non-land assets in the refinery. This involved complex financial modelling and market analysis. A full integrated model was produced, allowing users to select whether they preferred the appellant's or respondent's submission on each input parameter, and automatically re-calculating the land-rich ratio.

Stephen worked closely with Alcan's legal team, Counsel, and various independent experts. Stephen assisted the legal team during the trial and in preparing sections of final submissions.

Second Engagement: Independent Expert

The initial judgment contained findings about certain matters and was sent back to the Commissioner for re-assessment. A dispute arose between the parties about the effect of the judgment. In particular, the value of a primary 10-year lease had to be disaggregated from the value of an option to continue the project.

Stephen was retained by Alcan to produce an expert valuation report that addressed the matters in dispute. Two expert reports were prepared and Stephen was cross-examined on this material. Stephen prepared an easy to use spreadsheet calculator to assist the Court in testing how different input assumptions (where the experts could not agree) affected the bottom line.

This was used by His Honour as an *aide memoire* and was considered to be particularly helpful in the case in terms of simplifying the effects of a number of complex matters.

Judgment was in favour of Alcan. Stephen's evidence was accepted and endorsed by the Court.

Career: Professional

2014-Present	Chair, Frontier Economics
1997-2014	Director, SFG Consulting

Career: Academic

2000 - Present	Professor of Finance, UQ Business School, University of Queensland
1997-1999	Associate Professor of Finance, UQ Business School, University of Queensland
1997-2001	Research Associate Professor of Finance, Fuqua School of Business, Duke University
1995-1997	Assistant Professor of Finance, Fuqua School of Business, Duke University

Education

1987	Bachelor of Commerce (Hons), University of Queensland
1989	Bachelor of Laws (Hons), University of Queensland
1995	PhD, Stanford University

Papers and publications: Cost of capital

- Gray, S. and J. Nowland, 2015, "The Diversity of Expertise on Corporate Boards in Australia," *Accounting and Finance*, forthcoming.
- Darat, A., S. Gray, J. C. Park and S. Wu, (2014), "Corporate governance and bankruptcy risk" *Journal of Accounting, Auditing and Finance,* forthcoming.
- 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.

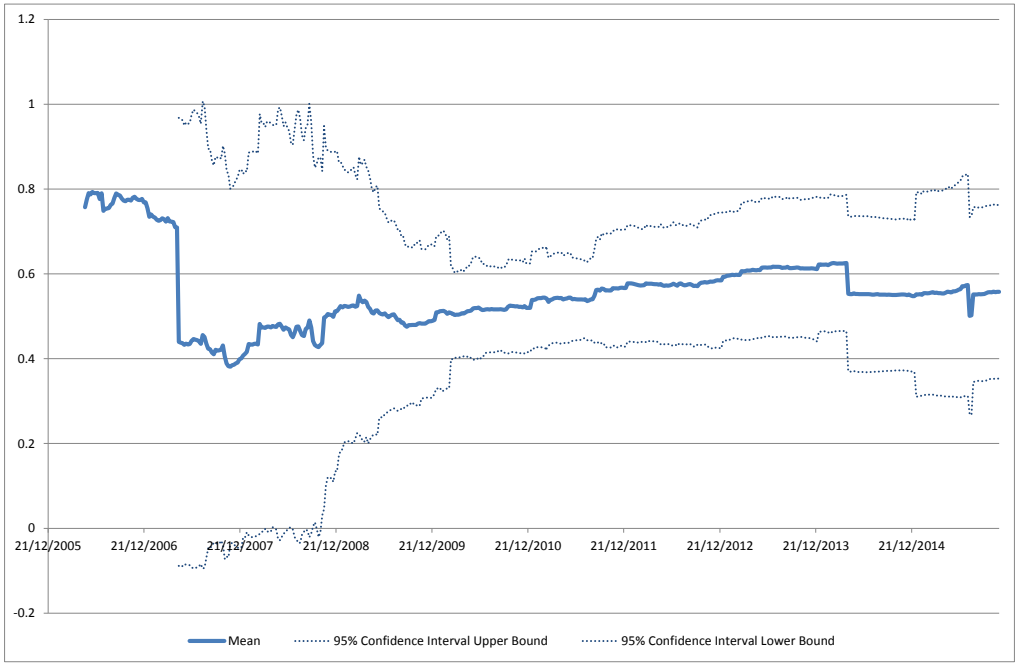
- Faff, R., S. Gray and M. Poulsen, (2013), "Financial inflexibility and the value premium," *International Review of Finance*, forthcoming.
- T. Fitzgerald, S. Gray, J. Hall and R. Jeyaraj, (2013), "Unconstrained estimates of the equity risk premium" *Review of Accounting Studies,* 18, 560-639.
- Feuerherdt, 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.
- Costello, D., S. Gray, and A. McCrystal, (2008), "The diversification benefits of Australian equities," *JASSA*, 2008, 4, 31-35.
- Gray, S. and J. Hall, (2008), "The Relationship Between Franking Credits and the Market Risk Premium: A Reply," *Accounting and Finance*, 48, 1, 133-142.
- 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.
- Cannavan, D., F. Finn and S. Gray, (2004), "The Value of Dividend Imputation Tax Credits in Australia," *Journal of Financial Economics*, 73, 167-197.
- 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.
- Bekaert, G. and S. Gray, (1998), "Target Zones and Exchange Rates: An Empirical Investigation," *Journal of International Economics*, 45(1), 1-35.
- 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.

11 Appendix 3: Rolling time series estimates for weekly data

11.1 AER sample

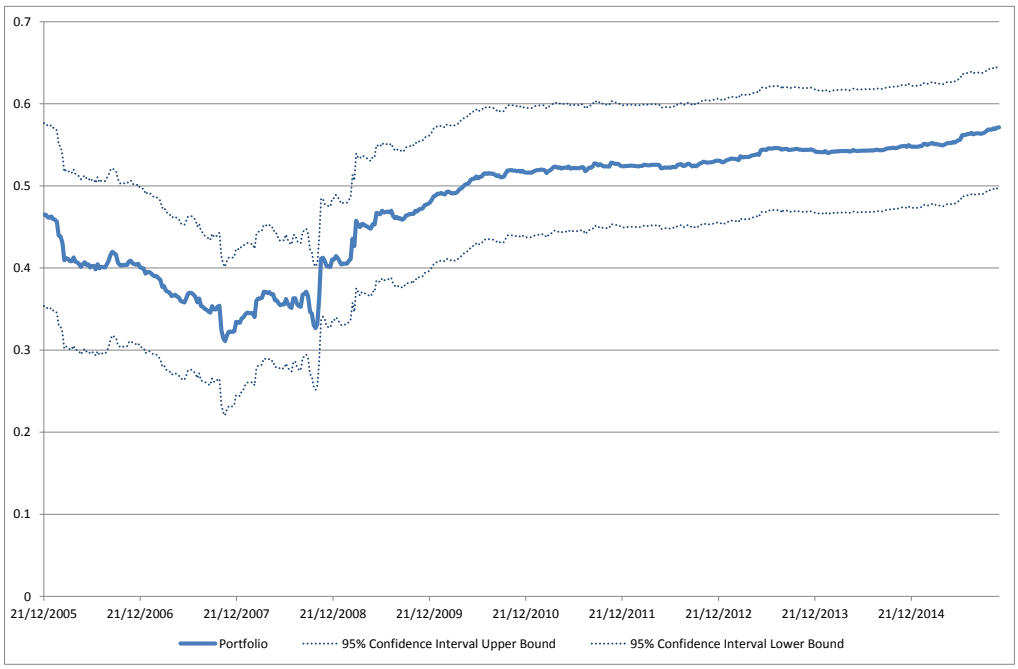
105 For the AER sample, we set out rolling beta estimates using weekly data in Figure 10 and Figure 11 below.

Figure 10: 10-year rolling weekly beta estimates for AER sample (mean beta estimates)



Source: Datastream, Frontier Economics calculations.

Figure 11: 10-year rolling weekly beta estimates for AER sample (portfolio beta estimates)

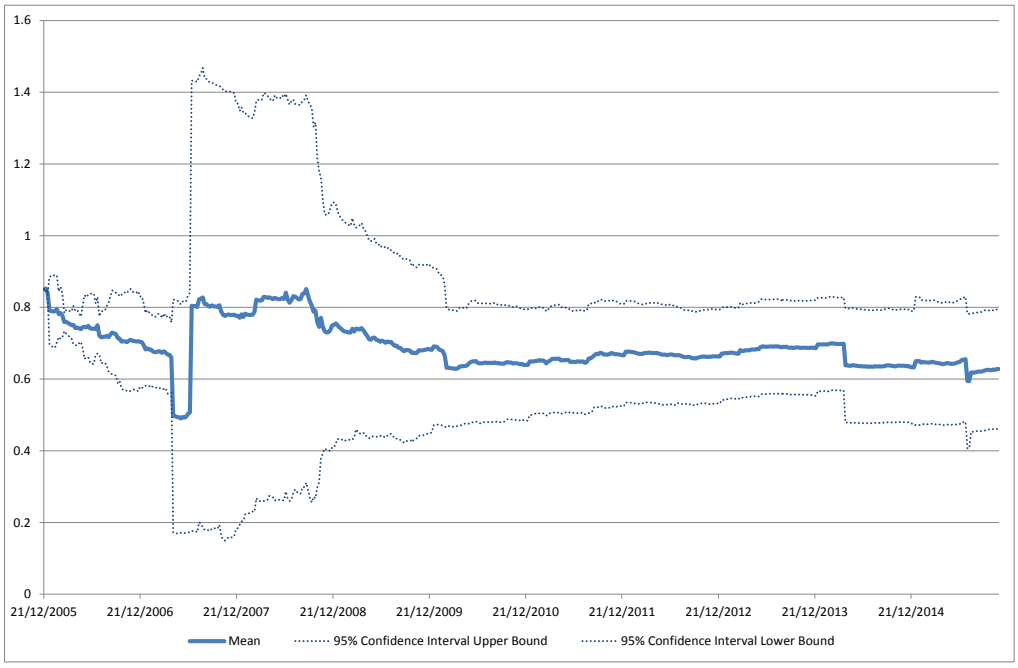


Source: Datastream, Frontier Economics calculations.

11.2 Expanded domestic sample

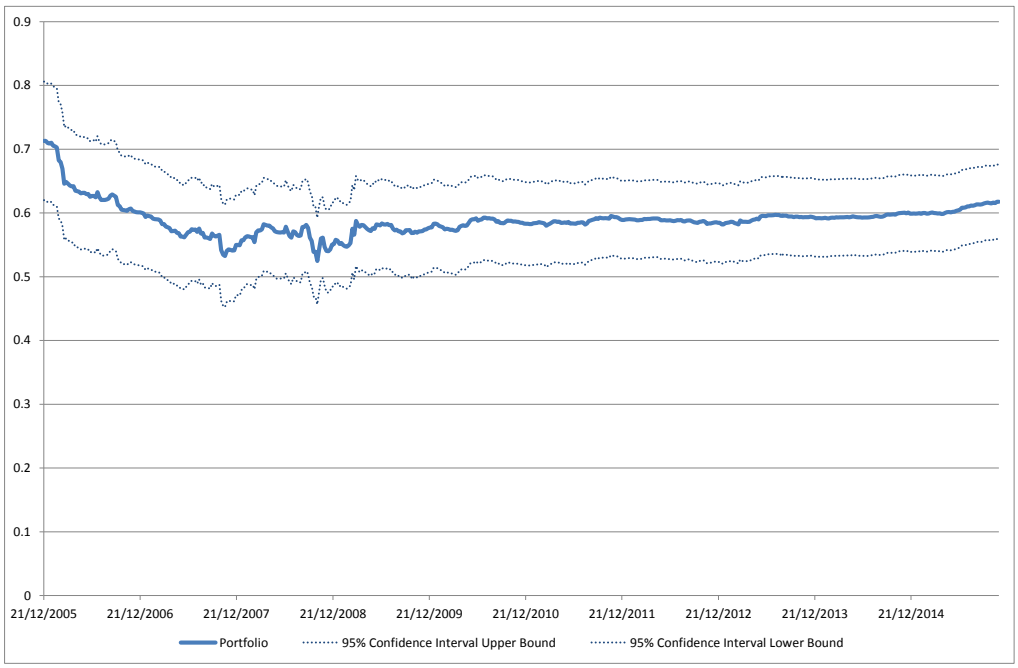
106 For the expanded Australian sample, we set out rolling beta estimates using weekly data in Figure 12 and Figure 13 below.

Figure 12: 10-year rolling weekly beta estimates for expanded Australian sample (mean beta estimates)



Source: Datastream, Frontier Economics calculations.

Figure 13: 10-year rolling weekly beta estimates for expanded Australian sample (portfolio beta estimates)

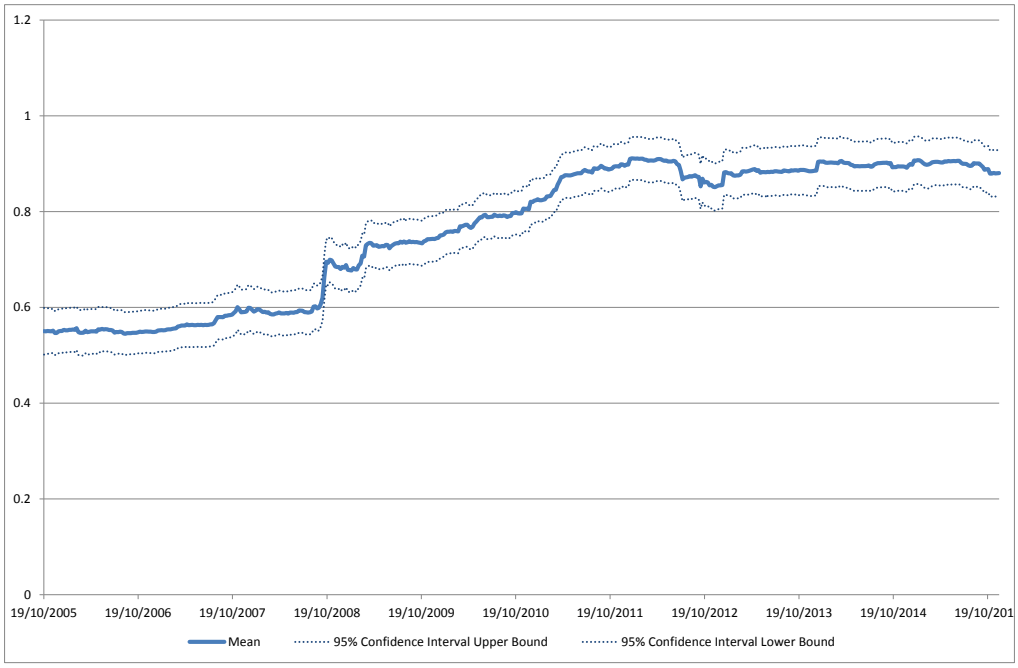


Source: Datastream, Frontier Economics calculations.

11.3 US utilities sample

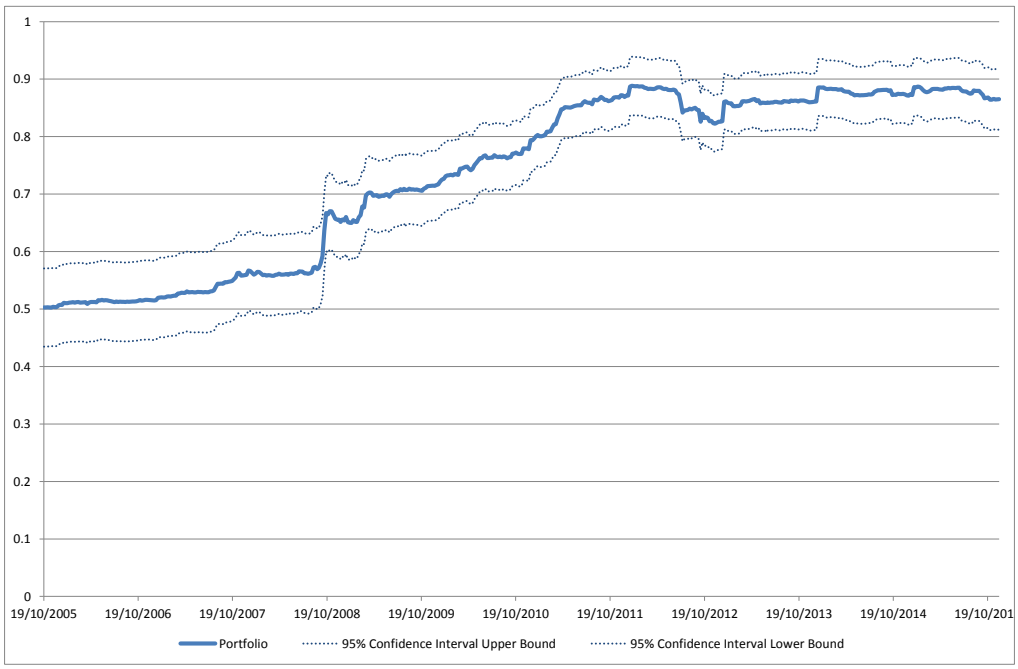
107 For the US utilities sample, we set out rolling beta estimates using weekly data in Figure 10 and Figure 11 below.

Figure 14: 10-year Rolling weekly beta estimates for US utilities sample (mean beta estimates)



Source: Datastream, Frontier Economics calculations.

Figure 15: 10-year rolling weekly beta estimates for US utilities sample (portfolio beta estimates)



Source: Datastream, Frontier Economics calculations.

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