The Allen Consulting Group

Beta for regulated electricity transmission and distribution

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Report to Energy Networks Association, Grid Australia and APIA

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Executive Summary

Box 1.1

KEY FINDINGS: BETA FOR REGULATED ELECTRICITY TRANSMISSION AND DISTRIBUTION

- The purpose of this study by the Allen Consulting Group was to provide an opinion on whether the empirical evidence provides persuasive evidence that the equity beta for a regulated electricity transmission or distribution business should be moved from the previously adopted equity beta.
- In our view the previously adopted value for the equity beta for both electricity transmission and distribution businesses should be taken as 1 at a financial gearing of 60 percent debt to assets. It is noted that the value of 1 does not imply a level of systematic risk equal to the average of the market portfolio of stocks. While the market beta is 1 by definition, this is at the level of gearing of the market of approximately 25 per cent debt to assets. When re-levered to 60 percent gearing, the equity beta for the market portfolio of stocks is in the order of 1.8 to 1.9.
- Statistical estimation of beta values for nine Australian businesses for periods up until May 2008 indicates central estimates of an equity beta value for an Australian electricity transmission or distribution business (at a gearing of 60 percent debt to assets) of 0.65 to 0.9 depending on the estimation method applied.
- Comparisons of these results with the results of an earlier (2007) study of beta values undertaken by the Allen Consulting Group for the Essential Services Commission of Victoria indicate a rising trend in beta estimates. An additional 29 months of data (for June 1990 to June 1991 and February 2007 to May 2008) has resulted in estimated beta values for the comparable Australian businesses increasing by 0.1 to 0.2 (i.e. to between 0.65 and 0.9 depending on estimation methodology) when estimated over a long period. By adding 16 months of observations (February 2007 to May 2008) the beta estimate rose by approximately 0.4 (to approximately 0.7) when estimated over the most recent 60 months of data.
- The rising trend in beta values for comparable Australian businesses is also observed in estimates of beta values for comparable businesses in the United States. Compared with the Allen Consulting Group's 2007 study, estimates of equity beta values (at a gearing of 60 percent debt to assets) derived from a sample of 21 US electricity and gas transmission and distribution businesses have increased by 0.2 (i.e. to between 0.5 and 0.7 depending on estimation methodology) for a long period (from 1990), and have increased by approximately 0.4 (to between 0.7 and 1.1) when estimated over the most recent 60 months of data.
- Estimation of betas is subject to a high degree of imprecision, and the Australian data that are available for the estimation of the beta of a regulated electricity transmission or distribution business are depressingly poor. Upper bounds on confidence intervals for estimates of an equity beta value (at a gearing of 60 per cent debt to assets) from the set of portfolios of Australian businesses range from 0.9 to 1.2.
- Conventional confidence intervals alone do not capture the full uncertainty associated with beta estimates. With the benefit of today's perspective, the period between 2002 and early 2007, which was an important part of our previous study of beta values for the Essential Services Commission of Victoria, was a period of exceptionally low market volatility, that was likely to have depressed beta estimates for regulated electricity transmission and distribution businesses relative to other businesses. Emergence from this period is consistent with the observations of increasing estimates of beta values.
- Taking into account the limitations of the data set, the size and incompleteness of statistical error margins around the beta estimates, and evidence of a recent rising trend in beta estimates, we do not consider that current empirical evidence on beta values would provide convincing or persuasive evidence to conclude that the (60 percent geared) equity beta for a regulated electricity transmission or distribution business is different from 1.

The brief

The Australian Energy Regulator (AER) has commenced its review of the cost of capital values and methods for the electricity transmission and distribution businesses, which will remain in place thereafter for a period of at least 5 years. The Energy Networks Association, Grid Australia and the Australian Pipeline Industry Association jointly engaged the Allen Consulting Group to analyse beta values for Australian energy transmission and distribution businesses. More specifically, we have been asked to undertake the following tasks:

1. Update evidence on the betas for Australian utility-type firms, and seek to identify the reasons for changes in betas over time.
2. Critically assess the reliability of the Australian evidence.
3. Assess how the application of the Blume and Vasicek adjustments may affect the empirical estimates of betas for Australian firms, and assess the justification for these adjustments.
4. Examine the appropriateness and materiality of adjustments that could be made to the US beta estimates to adjust for country differences.
5. Provide an opinion on whether the empirical evidence provides persuasive evidence that the equity beta for a regulated electricity transmission or distribution business should be moved from the previously adopted equity beta.

Framework for the assessment of equity betas

The estimation of betas is subject to high degrees of imprecision, which makes the interpretation of the empirical information difficult. In all of our previous advice to regulators, we have emphasised that the objectives of regulatory stability and predictability make it important to employ caution in how new evidence is interpreted at successive reviews.

Consistent with this, we note that the National Electricity Rules require the AER to continue to use the 'previously adopted' value for a parameter unless it determines there to be 'persuasive evidence' to change that value. While we note that the precise meaning of these terms ultimately is a matter of law, in our view the previously adopted value for the equity beta for electricity transmission is 1 at a financial structure of 60 per cent debt to assets. A beta of 1 has been the 'norm' for the equity beta for a regulated electricity transmission, and distribution business as well, over much of the period since about 2000, and since that time the majority of regulatory decisions for electricity transmission and distribution businesses have adopted an equity beta of 1. Therefore we take a value of 1 as being the previously adopted equity beta.

Accordingly, in this report, we provide an opinion on whether we consider there to be 'persuasive evidence' for a change from the previously adopted value of 1, on the basis of the empirical evidence on betas that we analyse.

Methodological approach

Over the recent years, we have provided a number of reports for regulators in relation to the beta for regulated energy transmission and distribution activities. Principal amongst these were reports for the Essential Services Commission of Victoria (ESC or 'the Commission') in 2007,[1] and the Australian Competition and Consumer Commission in 2002.[2] The current report applies substantially the same methods for estimating betas as presented in those reports, with the extensions and additional sensitivities explicitly noted.

There are two main differences between our most recent advice and the current report. The first difference is the availability of an additional 29 months of data, and an increased number of US comparator firms with electricity transmission and distribution operations.[3] The second difference is the scope of our brief from the client. In our previous report we did not provide an opinion on what beta should be applied by the regulator. In our previous report, which related to gas pipelines, we stated that:[4]

> We have not been asked to advise the Commission on the most appropriate equity beta to use for a regulated gas distributor. Hence, we do not address matters such as whether stability and predictability may be promoted by requiring a hurdle to be satisfied before the beta is changed from the previous level... We note that in several previous advices, our view has been sought on how such matters should influence the beta that is adopted for regulatory purposes, and accordingly the conclusions presented in this report may differ to those expressed under a more expansive scope of work.

For the current report we have been asked to form an opinion on whether the empirical evidence provides persuasive evidence that the equity beta for a regulated electricity transmission or distribution business should be moved from the currently applied equity beta of 1.

Estimation method

The key methodological choices employed in the current report are as follows:

- We have employed three estimation techniques for betas. The first is the 'ordinary least squares' regression technique, which is the standard technique for estimating betas. The other two techniques are directed to removing or dampening the effects of outliers were also applied, namely Re-Weighted OLS (Re-OLS), which essentially assigns a lower or no weight to observations that are considered to be outliers, and Least Absolute Variation (LAV), which involves estimating betas using a technique that is less sensitive to outliers.[5]

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1 Allen Consulting Group (June 2007), *Empirical evidence on proxy beta values for regulated gas distribution activities*, Report to the Essential Services Commission of Victoria.

2 Allen Consulting Group (July 2002), *Empirical evidence on proxy beta values for regulated gas transmission activities*, Report to the Australian Competition and Consumer Commission.

3 The data in our previous report began in July 1991 and concluded in January 2007 (187 months), while the current report includes data from June 1990 to May 2008 (216 months). The technology bubble period is defined as the 42 months from July 1998 to December 2002. Hence, our previous report included 145 months of data excluding the bubble period and the current study incorporates 174 months excluding the bubble period.

4 Allen Consulting Group (June 2007), p.6.

5 More specifically, the ordinary least squares technique essentially involves finding a line of best fit that minimises the sum of the squares of the distance between each observation and that line. As the technique minimises the squared distance, outliers can have a material impact on results. The Least absolute variation approach involves finding the line of best fit that minimises the (absolute) distance between each observation

- We have presented estimates of betas for comparable entities drawn from Australia (9 entities) and the US (21 entities) both estimated against their respective home share market indices. Compared to our most recent work, we have expanded the sample of US firms to include electricity and gas transmission and businesses (our recent work for the ESC included only gas businesses, as that was the purpose of that report).

- The beta estimates have been calculated using data drawn from the period commencing in June 1990 and ending in May 2008. Estimates have been presented for the whole of the period and for the most recent five-year period, although, in keeping with what now has become generally accepted practice, we have eliminated from the data set all observations within the period 1 July 1998 to 31 December 2001, as these dates corresponded with the 'technology bubble'.[6] In addition, we have presented 'rolling' five-year beta estimates, which show how the beta estimate would change over time as a new observation is added and the oldest observation is dropped. In all cases, we have presented estimates using monthly return observations. Almost all the financial market data have been drawn from Bloomberg.[7]

- We have presented 95 per cent confidence intervals for the beta estimates, to provide an indication of the level of imprecision of the estimators, and have applied the Newey-West method to estimate the standard errors.[8] However, we do not consider that traditional measures of confidence provide a full measure of the degree of imprecision of beta estimates, which we return to below.

- All of the betas presented in this report have been adjusted (de-levered and re-levered) to be consistent with a gearing level of 60 per cent debt-to assets. We have used to simplest levering method for this purpose, following our previous studies, but have also presented the effects of using alternative levering methods as a sensitivity analysis.

Betas for foreign firms

Following our previous reports, we have advised that most weight should be placed upon the Australian beta estimates, given the difficulties of 'transplanting' betas from one market to another. However, given the limited – and poor quality – data that are available in Australia, we consider it appropriate to place weight on betas from other comparable countries, and have presented beta estimates from the US for which there is a larger set of comparable businesses. As an addition to our earlier work, we have also tested the effects of three factors that may cause a different beta for the same activity between Australia and the US, namely:

- the weight of the different sectors on the respective share markets, which we have tested following an approach suggested by the Brattle Group (1999)[9];

and that line. As the technique minimises the (absolute) distance, outliers have less of an impact on the resulting estimate.

6 The choice of these dates for the 'technology bubble' is consistent with the report we undertook for the ESC in 2007, and is explained in that report.

7 In a few instances (Envestra, Spark Infrastructure and SP AusNet) we also drew on publicly available data provided by these companies to better understand their actual and 'see through' gearing levels.

8 The Newey-West method produces unbiased estimates of the standard errors if the error terms in the regression are no longer identically and independently distributed, for example if they have a non-constant variance (hetroskedasticity) or successive errors are correlated (autocorrelation).

9 See section 3.8 below.

- the average level of gearing for the firms on the respective share markets, which we have tested following an approach suggested by Lally;[10] and
- the form of regulation between US firms (many of which are subject to rate of return regulation) and in Australia (which are all subject to a form of CPI-X regulation), which we have tested by comparing the betas for US rate of return regulated firms to those that are subject to some form of incentive regulation.

Improving the precision of beta estimates

Pooling estimates

Given the imprecision of individual beta estimates, we have recommended that most weight be placed upon 'pooled' beta estimates. We have presented the results of two methods for pooling estimates, namely by:

- taking the simple average of the beta for the set of comparable entities, which we have limited to only those companies that have a sufficient trading history; and
- estimating the beta for a portfolio formed from the set of comparable entities and, following Gray and Officer (2005),[11] presenting results for an equally-weighted portfolio of the firms and for a portfolio reflecting the median return across the firms.[12]

Assembling portfolio estimates allows quantification of confidence intervals and error margins around the relevant beta estimate, and therefore allows the degree of precision in the estimates to be identified.

Adjustments to beta values

Given the imprecision of individual beta estimates, we have reported the results obtained from applying two adjustments to the 'raw' beta estimates that are intended to improve precision, which are:

- the Blume adjustment, under which the raw beta estimates are 'pushed' towards the average of the market by applying a fixed adjustment, applying a weight of 67 per cent to the raw beta and a weight of 33 per cent to the market average (of one); and
- the Vasicek adjustment, under which the raw beta estimates are 'pushed' towards a prior belief about the beta according to the relative precision of the raw beta and the prior belief.

[10] See section 3.8 below.

[11] Gray, S. and R.R. Officer (17 April, 2005), *The Equity Beta of an Electricity Distribution Business*, Report prepared for ETSA Utilities.

[12] We have used all firms – including those with a short trading history – in the calculation of the portfolio betas. However, we note that the weight of firms in the portfolio will be affected by the length of their trading history.

We do not recommend the application of the Blume adjustment. One of the justifications for the adjustment is that it allows for the tendency of the true beta for firms to proceed towards one over time, arising from such factors as diversification and changes to gearing – both of which are irrelevant when the beta is being used for a specific regulated activity and a constant benchmark level of gearing is assumed. A second justification is to account for the potential for error in the estimates – while this justification for an adjustment cannot necessarily be rejected, the adjustment is rough, amongst other things, having no regard to the precision of the raw beta estimate.

The Vasicek adjustment has a number of desirable aspects compared to the Blume adjustment, including that the adjustment is motivated only by the relative prevision of the 'prior belief' and not to account for movement on true betas, and is sensitive to the precision of the new information. The difficult question for the Vasicek adjustment is the prior belief that is formed for the estimate and the level of precision assumed for that prior belief.

As in our own previous advice, we have assumed that the prior belief would be informed by the average beta from a set of comparable entities, and concluded this would add little if the same set of entities was used as the set of comparable entities when estimating the beta for the regulated activities. Having said that, in the time that we have been advising on equity betas for regulatory purposes, the reliability and stability of the beta estimates in Australia has remained depressingly poor, notwithstanding our predictions that the situation would improve.[13]

In our view, it cannot be rejected that the Vasicek adjustment may provide valid information that a regulator may consider when determining the equity beta for regulatory purposes. We also consider that the only practicable prior belief is one that is informed by beta estimates for the market as a whole, following the method of the London Business School.[14]

The specification of the prior belief – and the level of precision of that information – is not an exact science. Accordingly, we have reported results for our base case using a prior belief of a 60 per cent geared equity beta of 1, with the precision of the prior belief taken as the dispersion of observed beta estimates. We have also tested the sensitivities of two other approaches to estimating the precision of this prior belief, namely that:

- the dispersion in beta estimates is calculated placing more weight assigned on the betas of larger firms; and
- the dispersion in beta estimates is calculated placing more weight assigned on the betas that are more precisely estimated.

These different assumptions on the precision of the prior belief translate into weightings of the prior belief of between 1.5 and 8 per cent in calculating average and median portfolio beta estimates.

[13] See ACG (2002), p.6.

[14] London Business School Risk Measurement Service, www.london.edu/finance/riskmeasurementservice.html .

While it may be argued that a prior of an equity beta of 1will bias upwards the beta estimate, we do not consider there to be strong grounds for this view. While Vasicek seemed to assume that a prior belief of 0.80 was appropriate for utilities, we note that the average US utility has a much lower level of gearing than their Australian counterparts, and that the 0.80 would translate into a 60 percent geared equity beta of about 1 when adjusted for the gearing levels. More generally, the regulatory benchmark level of gearing for Australian energy utilities of 60 per cent debt-to-assets is approximately twice that of the average listed firm – so that a prior of a 60 per cent geared equity beta of 1 still implies that regulated utilities are materially less risky than the average firm.

Measuring the reliability of estimates

Following our earlier work, we present the 95 per cent confidence intervals for the beta estimates. The 95 per cent confidence interval tells us that, if a large number of independent random samples of market observations were generated, the true value would lie within the range of the samples 95 per cent of the time. Wide confidence intervals indicate that a beta estimate is less precise (which implies lower confidence can be applied in being able to ruling in or ruling out any particular outcome). This report uses a 95 per cent confidence interval because this is a widely used standard of statistical significance in econometrics, and is consistent with how we have presented beta estimates previously.

However, we also consider that conventional confidence intervals alone do not capture the full uncertainty with respect to beta estimates. Like many parameters in financial economics, the beta that we estimate is the *measured beta* of the relevant asset over a historical period, whereas the beta of interest is the *expected beta*. Given that the sensitivity of a particular asset's returns to those of the market portfolio will differ depending on the macroeconomic shock that occurs, it is plausible that the measured beta could depart materially from the expected beta if the actual macroeconomic shocks in a period differ materially to what was (and may be) expected. More specifically:

- if there was a greater incidence than expected of market wide events that have a relatively larger effect on the returns to the asset in question relative to the market, then the measured beta will exceed the expected beta for that period; whereas
- if there was a lower incidence than expected of market wide events that have a relatively smaller effect on the returns to the asset in question relative to the market, then the measured beta will be lower than the expected beta for that period.

As a tangible example, the returns to regulated electricity transmission and distribution entities are likely to be more sensitive than the market portfolio to unexpected changes to interest rates, but much less sensitive to unexpected changes to the exchange rate. An import competing-firm that has a low level of gearing may be in a contrary position. Thus, if the measurement period experienced more exchange rate risk than expected – and less interest rate risk – the measured beta for the regulated entity may understate its expected value, and vice versa for a reversal of positions. It follows that there is a second source of uncertainty associated with estimates of the expected beta, in particular:

- the first source of uncertainty is that associated with interpreting the historical evidence as reflected in the conventional confidence intervals for those estimates discussed previously; and
- the second source of uncertainty is that caused by the potential for the expected incidence of market wide events to differ from their historical incidence.

It is difficult to either adjust for or quantify the additional uncertainty for beta estimates that is caused by the potential for the historical and expected incidence of market wide events to differ. In this report, we have removed the effects of an event that almost certainly would be assigned only a small chance of happening in the next five year period – namely, the 'technology bubble' – by removing (or ignoring the effect of) beta estimates using data drawn from the relevant period. In addition, we have:

- presented beta estimates that use data drawn over a longer time horizon; and
- demonstrated how beta estimates using a fixed number of observations have changed over time (i.e., the rolling beta estimates).

The first of these techniques should assist in reducing (but not necessarily eliminating) the difference between the measured and expected beta, as the historical incidence of events should converge to their expected incidence as the period of analysis is extended. The second of these techniques provides a visual representation of how betas – and the confidence intervals that would be constructed – have changed over time, which reflects in part the effect of the incidence of the specific market wide events over time. Lastly, we also analyse qualitatively some of the events that have been observed in Australia over the period of analysis and draw inferences for beta estimates.

Summary of empirical findings

Summary of results

The results for the portfolio estimates reported in this study can be summarised as follows.

- For the **Australian firms**, the average (geared to 60 percent) beta for the whole period (excluding the technology bubble, which we defined as between 1 July, 1998 and 31 December, 2001) ranged between 0.7 and 0.9 depending on the estimation technique. In addition, 4 out of 6 of the estimates having an upper 95 percent confidence interval that was greater than or equal to 1 (ranging up to 1.2). The results for the most recent five years were 0.7 across all three estimation techniques, with the 95 percent confidence interval ranging from 0.9 to 1.

- For the **US firms**, the average (geared to 60 percent) beta for the whole period (excluding the technology bubble) ranged between 0.5 and 0.7, with all the upper 95 per cent confidence intervals being between 0.7 and 0.9. However, the betas measured over the most recent five years were materially higher, ranging between 0.7 and 1.1, with all of these estimates having an upper 95 percent confidence interval greater than 1 (and up to 1.4). For the last five years of observations average geared beta of the US firms was 1, and if an adjustment for market gearing is undertaken, we find this estimate increases to 1.1. On the other hand, if an additional adjustment is also undertaken for the difference in the composition of the US and ASX markets, the estimate falls to 0.89. In either case, the tests we have undertaken are indicative that the US estimates are worthy of some consideration given the much stronger data set that is available.

The most striking feature of these results, however, is the material change that has occurred in the period since we undertook a major study for the ESC. For the Australian firms, the only difference in method was the addition of a relatively small number of months of observations.[15] A larger sample was also employed for the US firms – this time covering electricity utilities as well as gas utilities. Compared to the results described above, the equivalent results in our previous report found:

- for **Australian firms over the longest period**, with the central beta estimates having a range of 0.6 to 0.7 (cf. 0.7 to 0.9 in the current report), with one estimate having an upper 95 per cent confidence interval above 1;
- for **Australian firms over the recent period**, a range of 0.2 to 0.4 (cf. 0.7 in the current report), with none of the estimates having an upper 95 per cent confidence interval above 1;
- for **US firms over the longest period**, a range of 0.4 to 0.6 (cf. 0.5 to 0.7 in the current report); and
- for **US firms over the recent period**, a range of 0.5 to 0.8 (cf. 0.7 to 1.1 in the current report), with only two of the estimates having an upper 95 per cent confidence interval above 1.

In our view, the fact that the estimates of betas for similar or the same firms can change so materially in such a short period underscores the high degree of imprecision of estimates of beta. It also underscores the inadequacy of conventional measures of statistical precision to account fully for the uncertainty that is inherent in beta estimation.

[15] As mentioned previously, the 'whole period' in the current study has 174 observations, which is 29 observations more than our previous study. The final 60 month rolling regression results in the current study have 16 different observations to the corresponding estimate in the previous study.

Market influences on measured betas and confidence intervals

There is a range of factors that may affect the precision of beta estimates. Traditional statistical measures of uncertainty show the extent of confidence as to whether a particular relationship existed over a historical period. However, the beta of concern is the *expected* beta not a *measured* beta, which will only coincide if the market conditions during the period of the study correspond to what investors expect to occur in the future. That is, statistical estimates of historical beta values are only of relevance to a judgement on expected beta values to the extent that market conditions for the future period are considered likely to be materially the same as market conditions over the historical period of the beta estimate.

A number of plausible hypotheses could be advanced as to why the future may differ to the past. With the benefit of today's perspective, it would appear that the period of unusually low market volatility observed in the 5 years to the beginning of 2007 (which constituted the period of data for our previous study) was a short-term aberration. The average 5-year market volatility of the ASX since 1980 is 13.7 percent. But the lowest point of this series was reached late in 2005, and at the beginning of 2007, was still much lower than the 28-year average. Since mid-2007 the 5-year average market volatility has increased markedly, and this has coincided with the rise in the beta estimates for energy transmission and distribution in both Australia and the US.

We have noted in our previous advice that low levels of market volatility make it more difficult to estimate betas – and result in wider statistical confidence intervals – as regression techniques rely on variation in the key inputs. However, it is also possible that the low level of volatility may have led to a downward bias in betas over that period if the absence of volatility was due to the absence of macroeconomic factors that have a particular impact on utilities. Equally, however, coinciding with the return to normal market volatility has been a sharp increase in interest rates and an increase in interest rate volatility, which may have a more pronounced effect on utilities and be over-represented in current observations.

In our view, a proper assessment of the true level of uncertainty in beta estimates needs to take account of the potential for the change in the mix of macroeconomic events between periods to have a material effect on betas, which implies the true level of uncertainty would be materially higher than what is implied by statistical confidence intervals.

Conclusion

We have been asked to form an opinion on whether the empirical evidence provides persuasive evidence that the equity beta for a regulated electricity transmission or distribution business should be moved from the previously adopted regulatory equity beta of 1 at a financial gearing of 60 per cent debt to assets.

Of the results for Australian firms summarised above, a beta of 1 is within the 95 per cent interval in a significant proportion of the estimates. In addition, even though all of the estimates for the US firms using the whole period of data would appear sufficient basis to reject the proposition that the 60 percent geared beta is 1, this is not the case for the latest 60 month period, where none of the estimates would provide a basis to reject the proposition that the 60 percent geared equity beta is 1. The contradictory implications of results over different time periods highlight that only limited reliance can be placed on conventional statistical tests of the reliability of the data.

As is demonstrated in this report, there is a great deal of uncertainty about the equity beta for regulated electricity transmission or distribution business that is currently expected by the market. This high degree of uncertainty makes it difficult to form a strong view about what is the best estimate of that equity beta. The estimation of beta for the Australian regulated energy sector has been hampered by a paucity of data over a longer period, but the material rise in the estimates of beta (up to 0.40 higher) observed for the Australian portfolio data since our last report in 2007 due to a substitution of 16 months of more recent data gives even greater cause for concern about the reliability of the estimates than had previously existed.

In conclusion, we do not consider that the evidence in this report provides convincing or persuasive evidence that the equity beta for a regulated electricity transmission or distribution business is different from 1.

Chapter 1

Framework for the analysis

1.1 The Brief

Energy Networks Association (ENA), Grid Australia and the Australian Pipeline Industry Association (APIA) have engaged the Allen Consulting Group (ACG) to undertake an analysis of beta for Australian electricity transmission and distribution businesses.

Our brief requires us to undertake the following tasks:

1. Update evidence on the betas for Australian utility-type firms, and seek to identify the reasons for changes in betas over time.

2. Critically assess the reliability of the Australian evidence.

3. Assess how the application of the Blume and Vasicek adjustments may affect the empirical estimates of betas for Australian firms, and assess the justification for these adjustments.

4. Examine the appropriateness and materiality of adjustments that could be made to the US beta estimates to adjust for country differences.

5. Provide an opinion on whether the empirical evidence provides persuasive evidence that the equity beta for a regulated electricity transmission or distribution business should be moved from the previously adopted equity beta.

1.2 Framework for the assessment of equity betas

The estimation of betas is subject to high degrees of imprecision, which makes the interpretation of the empirical information difficult. We note that the National Electricity Rules require the AER to continue to use the 'previously adopted' value for a parameter unless there is 'persuasive evidence' to change that value. A 60 percent geared equity beta of 1 is the value established by the National Electricity Rules for application to electricity transmission.

We have presumed for the purpose of this report that the 'previously adopted' value would be taken as 1 for both transmission and distribution, reflecting the value that has been used for the transmission businesses and for the majority of distribution businesses.

This report presents our opinion in relation to two matters. First, we analyse and provide our opinion on the best estimate of the beta for regulated transmission and distribution businesses from the available data and provide our opinion about the reliability of those estimates. Secondly, we address specifically whether the evidence presented is sufficient to reach a view that the 'previously adopted' value for beta is incorrect.

1.3 Measures of reliability of beta

Confidence estimates

The first indicator of reliability that we present is a confidence interval for the estimates. The underlying assumption of classical statistical inference is that the sample we are observing is one sample from a possibly infinite number of independent random samples generated by the same process. A confidence interval – which is an interval around the central estimate for the parameter generated by the sample – shows the proportion of times that the true value would be expected to lie within that interval if repeated independent random samples were taken.

In this report, we present the 95 per cent confidence intervals around our beta estimates. The 95 per cent confidence interval tells us that, if a large number of independent random samples of market observations were generated, the true value would lie within that range 95 per cent of the time. Wide confidence intervals indicate that a beta estimate is less precise (which implies lower confidence can be applied in being able to ruling-in or ruling-out any particular outcome). This report uses a 95 per cent confidence interval because this is a widely used standard of statistical significance in econometrics, and is consistent with how we have presented beta estimates previously.

Expected vs. measured beta

Conventional confidence intervals alone do not capture the full uncertainty with respect to beta estimates. Like many parameters in financial economics, the beta that we estimate is the *measured* beta of the relevant asset over a historical period, whereas the beta of interest is the *expected* beta. That is, the cost of capital for an asset will depend upon the returns that are available elsewhere (as reflected in the risk free rate and market risk premium) and the relative risk that the asset in question is expected to have over the future period, the latter of which under the Sharpe-Lintner CAPM is reflected in its beta. It is plausible that the *measured* beta could depart materially from the *expected* beta.

The degree of non-diversifiable risk associated with a particular asset reflects the extent to which the returns to that particular asset are expected to move with returns to the market as a whole (i.e., the market portfolio). The returns to both an individual asset and those of the market portfolio both vary with market-wide events – so that the beta for an asset will reflect the extent to which market-wide events affect its returns compared to the effect on the returns of the market portfolio.[16] A wide range of potential market-wide events exist in principle, and the importance of each event is likely to vary across assets. Thus, the returns to a particular asset could be affected by much more than the market portfolio if some events occur, and by much less than the market portfolio if other events occur, with the expected beta reflecting the combined effect of all events.

16 It can be shown that, under a number of assumptions, the beta of an asset can be expressed as a linear function of the sensitivity of its returns to categories of market-wide events (factors) multiplied by the sensitivity of the overall market return to that factor: Dybvig, P. and S. Ross, 1985, 'Yes, the APT is Testable', *The Journal of Finance*, Vol.XL, No.4, p.1181.

The beta that investors will *expect* for a future period will reflect their perceptions about the relative effect on the returns to the asset in question and the market of the market-wide events expected in the period ahead. As investors cannot know which events will occur, investors will weight the importance of each type of event by their probability of occurrence when forming their view about beta. For example, an event like a substantial increase in the rate of inflation may be assigned a weight (likelihood) of ten per cent over the next five-year period, but if it actually occurs, its weight in the measured beta will be 100 percent.

In contrast, the beta that is *measured* for a historical period will reflect the events that actually occurred during that period. Clearly, the events that actually occurred during a period will differ to what was expected – and even if the possibility of an event was foreseen, it may have been assigned only a small probability of occurrence, which compares to a weight of one implicit in the measured beta if the event occurred. Similarly, there are likely to be numerous events to which investors assigned some weight that did not occur. Thus, the *measured* beta for the historical period inevitably will differ to the *expected* beta for that period. More specifically:

- if there was a greater incidence than expected of market wide events that have a relatively larger effect on the returns to the asset in question relative to the market, then the measured beta will exceed the expected beta for that period; whereas
- if there was a lower incidence than expected of market wide events that have a relatively smaller effect on the returns to the asset in question relative to the market, then the measured beta will be lower than the expected beta for that period.

It also follows that the beta that is measured for a historical period is also likely to differ to the expected beta even if no structural change to the market as a whole or the asset in question is expected. That is, investors will continue to assign weights to future market wide events according to their perceived probability of occurrence, which can differ to the historical incidence of those events. It follows that there is a second source of uncertainty associated with estimates of the expected beta, in particular:

- the first source of uncertainty is that associated with interpreting the historical evidence as reflected in the conventional confidence intervals for those estimates discussed previously; and
- the second source of uncertainty is that caused by the potential for the expected incidence of market wide events to differ from their historical incidence.

It is difficult to either adjust for or quantify the additional uncertainty for beta estimates that is caused by the potential for the historical and expected incidence of market-wide events to differ. In this report, we have removed the effects of an event that almost certainly would be assigned only a small chance of happening in the next five year period – namely, the technology bubble – by removing (or ignoring the effect of) beta estimates using data drawn from the relevant period. In addition, we have:

- presented beta estimates that use data drawn over a longer time horizon; and
- demonstrated how beta estimates using a fixed number of observations have changed over time (i.e., the rolling beta estimates).

The first of these techniques should assist in reducing (but not necessarily eliminating) the difference between the measured and expected beta, as the historical incidence of events should converge to their expected incidence as the period of analysis is extended. The second of these techniques provides a visual representation of how betas – and the confidence intervals that would be constructed – have changed over time, which reflects in part the effect of the incidence of the specific market-wide events over time. Lastly, we also analyse qualitatively some of the events that have been observed in Australia over the period of analysis and draw inferences for beta estimates.

1.4 Overview of the Report

The remainder of the study is organised as follows:

- In Chapter 2 we outline the criteria used to select the sample of domestic and foreign comparables.
- In Chapter 3 we set out the methodological approach we have taken in this report.
- Chapter 4 reports our results and draws our conclusions about beta.

Chapter 2

Choice of comparable entities

2.1 Introduction

Given the statistical noise associated with beta estimates, in order to consider an estimate of the appropriate regulatory beta for an electricity transmission or distribution utility it is advisable to obtain as many observations in the sector as possible. This creates an immediate problem in Australia, as there are a limited number of listed energy transmission and distribution businesses with significant trading histories.[17] We have therefore searched among US firms. In order to maintain a maximum objectivity in sample selection, we have relied on the UBS Utilities Index and have drawn upon all the sample firms that are described as being engaged in energy transmission and/or distribution.

2.2 Role of comparable entities

Comparable entities

The estimation of equity betas requires continuous information on the economic returns to assets and hence can only be undertaken for firms that are listed on a stock exchange. Thus, as a practical matter, it will not be possible to estimate an equity beta for the majority of the regulated electricity transmission and distribution entities, but rather the beta will need to be inferred from the estimates of betas for other entities. In addition, even if beta estimates were available for all of the regulated electricity transmission and distribution entities, a compelling argument would exist for combining the 'information' obtained from the beta estimates for each of the entities. In particular, as discussed further in Chapter 3, individual beta estimates are subject to substantial imprecision, and hence it is common practice to 'pool' estimates to improve the degree of precision of the resulting estimate.

The set of companies for which betas can be estimated that are used to draw inferences about the betas for regulated electricity transmission and distribution entities are referred to in this report as the comparable entities. Given the objective of the current study, it is important to select entities that are considered to have a level of systematic risk that is considered to be as similar as possible to an entity that is engaged only in regulated electricity transmission or distribution activities.

17 Ideally, a sample of 15 or more companies with significant (and liquid) trading histories would be necessary for meaningful statistical analysis. If a smaller sample is available, considerable professional judgement needs to be applied in order to estimate an appropriate range of beta values for an industry of activity.

There is a large empirical literature on the characteristics of assets that may affect their level of non-diversifiable risk, including such factors as the presence of regulation, nature of a firm's output, operating leverage, nature of contracts with suppliers, presence of real options and market weight.[18] In practice, however, the only characteristic described above for which a rigorous adjustment for differences between individual companies is possible is for the level of financial leverage, which is discussed in section 3.5 below.

In principle, the other characteristics that affect non-diversifiable risk could be taken into account by selecting firms that undertake activities and have characteristics that are identical to the relevant regulated electricity transmission or distribution activities. In practice, however, it is only ever possible to find firms that have *similar* characteristics. There are very few firms that undertake only regulated activities, and the characteristics of the regulated activities across firms inevitably differ. In contrast, a reasonable number of comparable entities (and hence equity beta estimates) is required in order to obtain any degree of precision in the estimated beta, with the precision improving with the number of firms. A trade-off therefore exists between maintaining the relevance of the comparable entities (reducing bias) and ensuring a sufficient number of firms in the sample (improving precision). The criteria that we have applied for this purpose are set out below.

Foreign comparables

The objective of this report is to provide empirical beta estimates relevant to regulated electricity transmission or distribution activities. While we consider that some caution needs to be exercised when using equity beta estimates for foreign companies (measured against their home market portfolios) to draw inferences about the betas risk of Australian activities, we remain of the view that, nevertheless, regard be had to these beta estimates, at least as a secondary source of information. We note that, of the foreign information that is available, the US is by far the most useful source, having a large number of listed utilities with a long trading history.

As discussed above, betas are a measure of the strength of the relationship between returns to individual stocks and the share market as a whole.[19] Therefore, an implicit assumption is the use of a beta for a foreign firm (measured against its home index) as a comparable for a domestic firm is that the strength of this relationship is approximately constant across share markets.

[18] This summary of the characteristics of assets that may affect their non-diversifiable risk is taken from Lally, M., 2000. *The Cost of Equity Capital and Its Estimation*, McGraw-Hill Series in Advanced Finance Volume 3, Sydney: McGraw-Hill, pp 27–29.

[19] Formally, the covariance between the returns to the stock and the overall market, divided by the variance of the returns to the overall market.

While, on the face of it, this may seem a reasonable assumption, there are a number of factors that may influence the strength of the relationship between the returns to a regulated electricity transmission or distribution provider and the overall market, which may vary across markets. Differences in the weights of the different market sectors may affect the covariance of the return of any asset to the market as a whole. Even apart from market weight effects, the sensitivity of the returns to a regulated electricity transmission entity to macro-economic shocks may differ across countries – for example, reflecting institutional factors within each country (including the policies of governments), and betas also may be affected by differences in taxation regimes, as well as differences in market-average levels of gearing.

In this report, we have attempted to adjust for three of the factors that could lead to a difference in the beta for a particular activity between countries.

- First, we have attempted to allow for the effect of the differences in the weights of the various market sectors between Australia and the US, essentially by re-weighting the US market portfolio to resemble Australia. The method we adopted follows an approach recommended earlier by the Brattle Group, and is discussed further in section 3.6.
- Secondly, we have adjusted for the predicted effect on the Australian beta of the difference in the average leverage level of the US share market compared to Australia using a technique proposed by Lally, which is discussed further in section 3.3.
- Thirdly, we have tested whether the difference in the form of regulation applying the US firms – whether rate. of return or incentive based – appears to have affected the beta, thus testing for a factor that many commentators have suggested will affect betas.

Lastly, we have restricted the foreign comparables to those operating in economies with very similar legal systems and regulatory regimes as Australia, and that have much more information available than Australia, which we have taken as the US.

Notwithstanding, however, we note that any such adjustments are approximations only and incomplete, so that the need for caution remains.

2.3 Criteria for selection

As in our 2007 study for the ESC, we began with the UBS utilities index, which includes a broad population of listed energy and water businesses around the world. We then chose the Australian and US energy related businesses due to broad similarities in their legal, financial, market and regulatory frameworks. From that group:

- For Australia we eliminated businesses that do not have a relatively significant component of regulated energy distribution or transmission; and
- For the US we retained only those businesses that are almost exclusively electricity and/or gas distribution and transmission businesses.

Choice of comparators

The choice of appropriate comparators is a critical part of the analysis, and it is therefore essential that the criteria used to choose the group of comparable businesses have been well defined. In the current study we are concerned with estimates of betas for electricity transmission and distribution businesses. However, given the belief in Australia (with which we concur) that regulated gas and electricity utilities have similar level of systematic risk[20], we have extended the sample to include relevant energy (gas and electricity) entities rather than merely electricity.[21] Having said that, the dominance of gas businesses in the sample does raise the question of how reliable the evidence is for electricity activities.

The current UBS Utilities Index is an objective starting point for deriving a sample of comparable companies for gas and electricity transmission and distribution. We selected Australia and the US as markets with comparable economic, market and legal systems.[22] Within these countries we considered the classification of businesses engaged in the supply of energy. As shown in Table 2.1 below, these categories are: transmission and distribution; integrated regulated, integrated; and generation.

Table 2.1

UBS UTILITIES INDEX – AUSTRALIAN ENERGY RELATED

Transmission & Distribution	Integrated Regulated	Integrated	Generation
APA Group		Alinta Energy	BB Wind Partners
Envestra		AGL Energy	EDL
DUET		Origin Energy	
HDUF			
Spark Infrastructure			
SP Ausnet			

Source: UBS

In Table 2.1, the companies in the generation category are not suitable comparators for a benchmark electricity and/or gas transmission/distribution business, since their operations are almost exclusively energy generation or retail. A number of businesses that were until recently part of the UBS Utilities Index have been acquired or merged. We also note that four of the businesses (APA, Envestra, HDUF and DUET) are largely gas businesses. Thus, the evidence relating specifically to Australian electricity transmission and distribution businesses is extremely limited, with APA Group and Envestra being the only two businesses with trading histories of more than 60 months, but also being gas rather than electricity transmission and distribution businesses.

Table 2.2 shows a larger possible sample size of US businesses.

[20] It will be noted that in the majority of Australian regulatory jurisdictions, gas and electricity transmission and distribution businesses have been accorded the same equity beta.

[21] While a reasonable sample of gas-only entities can be established for the US, only four of our set of US firms is electricity-only.

[22] UBS Utilities Index.

Table 2.2

UBS UTILITIES INDEX – US ENERGY RELATED

Transmission & Distribution	Integrated Regulated	Integrated	Generation
Gas Transmission and Distribution only:	Ameren Corp	American Elec. Power	AES Corp
AGL Resources	ALLETE Inc	Constellation Energy	Dynergy Inc
Atmos Energy	Avista Corp	CMS Energy	Mirant Corp
Cascade Natural Gas	Allegheny Energy	Dominion Resources	NRG Energy
Kinder Morgan	Black Hills	DTE Energy Co	Ormat Technologies
Kinder Morgan Mgmt	CLECO Corp	Duke Energy	Reliant Energy
Laclede	DPL Inc	Energen Corp	
NICOR	Empire District Electric	Edison Intl	
Northwest Natural Gas	El Paso Electric	El Paso Corp	
Peoples Energy	FirstEnergy Corp	Entergy Corp	
Piedmont Natural Gas	Great Plains Energy	Exelon Corp	
South Jersey Industries	Hawaiian Electric	FPL Group	
Southwest gas	IDACORP Inc	Keyspan Energy	
Valero GP Holdings	Aquila Inc	Alliant Energy	
WGL Holdings	MGE Energy	MDU resources	
Electricity & Gas Transmission and Distribution:	Northwestern Corp	National Fuel Gas	
CH Energy Group	OGE Energy	ONEOK Inc	
CenterPoint Energy	Otter Tail Corp	Public Serv. Ent.	
Consolidated Edison	PG&E Corp	Portland General Electric	
Energy East	Progress Energy Inc	Sempra Energy	
NiSource Inc	PNM Resources	Questar Corp	
NJ Resources	Pinnacle West Capital	Southern Union	
NSTAR	PPL Corp	TXU Corp	
Northeast Utilities	Puget Energy	UGI Corp	
Electricity Transmission and Distribution only:	SCANA Corp	Williams Cos.	
Duquesne Light Hlds	Southern Co	Xcel Energy Inc	
Sierra Pacific	TECO Energy		
UIL Holding Corp	Unisource Energy		
Pepco Holdings	Vectren Corp		
	Wisconsin Energy		
	WPS Resources		
	Westar Energy		

Source: UBS and ACG

2.4 Comparable entities selected

Australia

Of the firms that are currently or have recently been listed on the Australian stock exchange, the 9 businesses listed in Table 2.3 could be characterised as sufficiently comparable entities for regulated energy infrastructure, although there are caveats as set out below.

Table 2.3

FINAL SAMPLE DETERMINATION: AUSTRALIA

Transmission & Distribution – currently listed	Included – not currently listed	Excluded
1. APA Group		
2. DUET		
3. Envestra		
4. HDUF		
5. SP AusNet		
6. Spark Infrastructure		
	7. Alinta (prior to acquisition)	
	8. AGL (prior to restructure)	
	9. GasNet (prior to acquisition)	
		United Energy (listed in tech bubble period)

Source: UBS and ACG

There are, however, potential problems with the quality of the data associated with these nine businesses, which are as follows:

1. Envestra – Listed in August 1997, it has been subject to takeover offers at times, and is engaged in gas transportation.

2. APA Group – Listed in June 2000, and has undertaken a series of acquisitions in recent years (including Murraylink, the GasNet system in Victoria and the Allgas gas distribution network in Queensland), as well as being subject to takeover offers during 2006/2007. It is a pipeline business.

3. DUET – Listed in August 2004 and hence has a short trading history. DUET also has an interest in a US business (Duquesne Power, which serves over 580,000 electricity customers around Pittsburgh). DUET's major business, however, is the Dampier to Bunbury gas pipeline.

4. Hastings Diversified Utilities Fund – Listed in December 2004 and hence has a short trading history. It also has interests in the UK water sector (Mid Kent Water and South East Water). In Australia, moreover, its operations are largely gas.

5. Spark Infrastructure – Listed in December 2005, and so has an even shorter trading history than the above. Cheung Kong Infrastructure (CKI) retains ownership of 51 per cent of the underlying assets and has a 10 per cent stake in the listed entity. Since Spark owns parts of operating businesses, its ultimate 'see through' gearing needs to be considered.

6. SP AusNet – Listed in December 2005 with a 51 percent ownership by Singapore Power, and so has a short trading history. Since it owns parts of businesses, its ultimate 'see through' gearing needs to be considered.

Recently delisted firms for which beta estimates can be derived include:

7. Alinta – Listed at October 2000, Alinta has been involved in a series of mergers or takeovers since its listing, and at times has had substantial activities outside of regulated infrastructure. Alinta was acquired by the Babcock & Brown and Singapore Power Consortium in late August 2007, and was delisted in September 2007. Its operations were largely gas.

8. AGL – Delisted in October 2006 due to its restructure, its share price was affected by merger speculation for a period prior to it being delisted.

9. GasNet – Listed in December 2001 and delisted in November 2006 after being acquired by APA. Its share price was affected by merger speculation for a period prior to it being acquired. Again, its operations were gas-based.

The tenth company, United Energy, was delisted in July 2003. We have not included it in the sample as it had little trading history outside of the period affected by the technology 'bubble'.

The United States

The derivation of the final sample of US comparator companies is shown in Table 2.4. A total of 21 companies have been included.

Table 2.4

FINAL SAMPLE DETERMINATION: UNITED STATES

Transmission & Distribution	Excluded	Reason for exclusion
1. AGL Resources		
2. Atmos Energy		
3. CH Energy Group Inc		
4. CentrePoint Energy		
5. Energy East		
6. Consolidated Edison		
7. NICOR Inc		
8. ITC Holding Corp		
9. Laclede Group		
10. NiSource Inc		
11. New Jersey Resources		
12. NSTAR		
13. Northeast Utilities		
14. Northwest Natural Gas		
15. Piedmont Natural Gas		
16. Pepco Holdings		
17. South Jersey Industries		
18. Sierra Pacific		
19. Southwest Gas		
20. UIL Holdings Inc		
21. WGL Holdings Inc		
	Cascade Natural Gas	Merger underway
	Kinder Morgan	Management buy-out
	Kinder Morgan Management	Management company
	Peoples Energy	Has been acquired
	Valero GP Holdings	Listed in 2006
	Duquesne Power	Acquired

Source: UBS and ACG

Chapter 3

Methodological issues

3.1 Introduction

There are numerous methodological approaches that may be applied in generating beta estimates. In this chapter we describe the methodology that has been applied in the present report in some detail. In earlier reports that ACG has undertaken for the ACCC and the Victorian ESC on beta estimation for regulated gas transmission activities, we included a detailed discussion of methodological issues, and we will draw on that discussion as required.[23]

3.2 Background – the cost of capital and beta

The cost of capital that is associated with an asset is the return that investors would need to expect to receive from a project in order to justify committing funds to that investment. That is, the return on capital available to investors in the next-best investment opportunities, taking into account the relative risk of the projects. The cost of capital is dependent upon the aggregate demand and supply of investment funds, and the risk in cash flows potentially generated by the asset relative to the risk associated with other assets.

While the price at which shares are traded can be observed, the future dividend stream and capital gains assumed by investors when buying the shares – and hence, the return required by investors to hold the relevant asset – cannot. As a result, the cost of capital associated with an asset can only be *estimated* from the available information from the capital markets, such as share prices, dividend payments, and so forth. Moreover, as with any estimation process, a model needs to be applied that links these observed parameters to the cost of capital associated with an asset, which may reflect theory about how asset prices are determined, coupled with simplifying assumptions about such matters as the preferences of investors, and the workings of capital markets.

The Rules require the cost of capital to be estimated as the weighted average of the costs of equity and debt, with the former to be estimated using the Sharpe-Lintner form of the Capital Asset Pricing Model (CAPM). Under the CAPM, the cost of equity is expressed as the sum of the return available on a risk free asset, together with a premium required to accept the risk associated with the asset in question. This risk premium, in turn, is a function of two inputs:

- the risk premium that investors would require in order to hold a widely diversified portfolio of assets, which is also the return that an investor would require in order to hold an asset which has an 'average' level of risk – commonly known as the market (or equity) risk premium; and

[23] See Allen Consulting Group (July, 2002), *Empirical Evidence on Proxy Beta Values for Regulated Gas Transmission Activities*, Final Report for the Australian Competition and Consumer Commission; and Allen Consulting Group (May, 2007), *Empirical Evidence on Proxy Beta Values for Regulated Gas Distribution Activities*, Report to the Essential Services Commission of Victoria.

- a ranking of the risk associated with the particular asset relative to the risk associated with the well-diversified portfolio of assets – which is the beta of the asset (where the beta for the asset of average risk, and the beta for the market portfolio, is one).

Thus, the equation for the Sharpe-Lintner CAPM has the following form:

$$K_e = R_f + \beta_e.MRP$$

where K_e is the cost of equity, R_f is the risk free rate of return and β_e is the equity beta.

An assumption of the CAPM is that investors hold diversified portfolios and hence eliminate much of the risk that is associated with the returns to a particular at no cost through diversification. As this risk can be eliminated at no cost, it does not require compensation. However, diversification cannot eliminate all risk. This is because part of the volatility in expected returns arises from economy-wide events that affect all assets, although to differing extents. This portion of the risk is often referred to as non-diversifiable risk. Within the framework of the CAPM, the beta of an asset reflects the extent of non-diversifiable risk of the asset in question compared to the asset of average risk having a beta greater than one, and vice versa for assets that have less non-diversifiable risk than the average asset.

3.3 Choice of estimation techniques

In our previous report for the ESC we applied three different empirical techniques for estimating betas, namely ordinary least squares (OLS) and two methods for addressing the presence of outliers, namely a re-weighted least squares (Re-OLS) and a technique known as 'Least Absolute Variation' (LAV). We have again applied these techniques, which are explained below.

In addition, in this study we have also estimated betas using a technique that is used to address the potential for thin or thick trading of a particular security to cause bias – of which we have applied the Scholes-Williams (S-W) beta – which is also described below.

Ordinary least squares

Ordinary least squares regression (OLS), minimises the sum of the squared errors, and is the approach traditionally applied to estimate beta based on market return observations. The least squares estimator is unbiased and has the least variance of all other estimators if the properties of the errors in the model are identically and independently distributed. The values of ε_t. cannot be observed, and therefore we need to make assumptions as to the nature of the errors by examining the estimates of the errors as formed by the residuals $\hat{\varepsilon}_t$ (here we drop the *i* subscript) where:

$$\hat{\varepsilon}_t = R_t - \hat{\alpha} - \hat{\beta} R_{Mt}$$

and the $\hat{\alpha}$ and $\hat{\beta}$ are estimates of the parameters of the model.

An important characteristic of $\hat{\varepsilon}_t$ is whether the distribution of this error appears to be generated by a distribution that has a large number of extreme values or not. Concern that outliers will influence the estimated beta has led to the development of a number of robust regression techniques.

The least squares solution for the estimate of the β in $R_{it} = \alpha + \beta R_{Mt} + \varepsilon_{it}$ is defined as the value of an estimate of α and β that minimizes the sum of the squared error which is defined as:

$$\underset{\text{min w.r.t } \alpha \text{ and } \beta}{SSE} = \sum_{t=1}^{T} \left(R_{it} - \hat{\alpha} + \hat{\beta} R_{Mt} \right)^2$$

This criterion for a solution is very powerful, since the estimates can be found from the application of simple calculus and via the central limit theorem the distribution of the parameter estimates $\hat{\alpha}$ and $\hat{\beta}$ become normally distributed as the sample size grows if the distribution of the errors is identically and independently distributed with a finite variance and expected value. This property allows the formation of probability statements concerning the values of the estimated parameters.

However, this assumption may not hold or the sample size may be too small for these properties to hold. One way to ensure that we have sufficient observations is to remove (or adjust) those observations that may be from another distribution so that the errors in the sample we observe are from one that allows the parameters to be normally distributed with a smaller sample.

Re-weighted Ordinary Least Squares

Martin and Simin (2003) proposed a re-weighted least squares approach in order to ensure that the properties of the least squares estimator are appropriate.[24] This is achieved through removing observations considered to be "outliers" through a method based on weighting the sum of the squared errors:

$$\underset{\text{min w.r.t } \alpha \text{ and } \beta}{WSSE} = \sum_{t=1}^{T} w_t \left(R_{it} - \tilde{\alpha} + \tilde{\beta} R_{Mt} \right)^2$$

Where the sum of squared error is now minimised with respect to the estimates, however the errors are weighted individually. Note that if $w_t = 1$ for all observations, we would obtain the least squares solution. However, in this case we have some observations with $w_t < 1$, and for extreme outliers we set $w_t = 0$, which allows us to use the least squares regression method, but with a consideration for the possibility of extreme values.

Martin and Simin (2003) use the residuals from a preliminary regression, and use the residuals from this regression, where the estimated errors are defined as:

$$\hat{\varepsilon}_t = R_{it} - \hat{\alpha} + \hat{\beta} R_{Mt}$$

[24] Martin, R. Douglas and Timothy T. Simin, (2003),"Outlier-Resistant Estimates of Beta", *Financial Analysis Journal*, Sept/Oct, 56-69.

The errors are assumed to be distributed with an expected value of zero and a variance of σ_ε^2. Thus we can form a statistic that is distributed as: $\hat{\phi}_t = \frac{\hat{\varepsilon}_t}{\hat{\sigma}_\varepsilon} \sim (0,1)$ with a mean of zero and a variance equal to 1. To make a probability statement about this value Martin and Simin use the normal distribution which would indicate that any value of $|\hat{\phi}_t|$ that is greater than 2 is quite unlikely. Next, they define a weighting function based on the value of $|\hat{\phi}_t|$ defined as $w_t = f(|\hat{\phi}_t|)$. According to this weighting function value of $|\hat{\phi}_t|> 2.7$ implies that the $w_t = 0$ and those values where $|\hat{\phi}_t|< 1.8$ have weights equal to one.

Under this approach outliers to the initial regression are excluded from the analysis in the second step regression. It should be noted that the origin of these cut-off values is not defined, and the use of alternative values would result in different estimates. On the other hand, the weights were chosen by Martin and Simin independently of this study.[25]

Least Absolute Values (LAV)

Least Absolute Values (LAV) is an alternative widey used robust regression method that we applied in our 2007 study.[26] Under this methodology the objective is to determine the values of the parameters that minimise the sum of the absolute value of the errors:

$$\underset{\min \text{ w.r.t } \alpha \text{ and } \beta}{SAE} = \sum_{t=1}^{T} \left| R_{it} - \breve{\alpha} + \breve{\beta} R_{Mt} \right|$$

Compared with OLS, this criterion is less likely to be influenced by extreme values because the size of the error has a linear impact on the objective function compared with the squared effect in least squares regression.

Under LAV, the optimal parameter values that minimise *SAE* are not found from the solution to a set of linear equations as with least squares, but instead require a linear programming algorithm that produces an iterative cycle of solutions, which may not always converge. In this study we use the Madsen and Nielsen algorithm.[27] The estimation of the standard error of these estimates is also dependent on an approximation method. As in our 2007 study we use the McKean-Schrader approximation.[28]

[25] The Martin and Simin approach has some resemblance to the approach applied by Gray and Officer (2005), which applied exclusion criteria of 2 (1.5 and 1) standard errors. However, there are two differences. First, Martin and Simin do not exclude observations unless S.E. exceeds 2.7 (compared with 2 and below for Gray and Officer). Secondly, for S.E.s of between 1.8 and 2.7, Martin and Simin allocate a weight that falls from unity to zero.

[26] This method is also referred to as Least Absolute Deviation (LAD) or Minimum Absolute Deviation (MAD) or the Percentile Regression among other titles.

[27] Madsen, K. and H. B. Nielsen, (1993), "Finite Smoothing Algorithm for Linear L_1 Estimation", *SIAM Journal on Optimization*, 3, 223-235.

[28] McKean, J. W. and R. M. Schrader, (1987), "Least Absolute Errors Analysis of Variance", in *Statistical Data Analysis – Based on L_1 Norm and Related Methods*, ed. Y. Dodge, Amsterdam: North Holland, 297-305.

Thin and thick trading

'Thin trading' is one of the problems encountered in beta estimation for smaller stocks where trading may be infrequent. This problem is compounded when more frequent return periods (such as weekly or daily) are used, since there may be no trades at all between these periods. In general, thin trading tends to bias downward the estimate of beta, as there will be a disproportionate number of observations for the stock with zero observations when there are positive or negative observations for market returns. This in turn will bias upwards the beta of frequently (thickly) traded stocks.

To counteract the effect of thin and thick trading, ordinary least squares regression has typically been extended by the introduction of lagged and leading market returns. One such technique is the Scholes-Williams (S-W) beta, which is applied by a number of commercial beta providers.[29] The Scholes and Williams beta estimate can be represented as follows:

$$\hat{\beta}_i(SW) = \frac{(\hat{\beta}_i^- + \hat{\beta}_i + \hat{\beta}_i^+)}{(1 + 2\hat{\rho}_m)}$$

Where,

$\hat{\beta}_i(SW)$	is the Scholes-Williams beta estimate
$\hat{\beta}_i^-$	is the slope estimate in the simple regression with the market return lagged one period
$\hat{\beta}_i$	is the slope estimate in the simple regression in the standard market model
$\hat{\beta}_i^+$	is the slope estimate in the simple regression with the market return led one period
$\hat{\rho}_m$	is the first order serial correlation coefficient for the market return.

A distinguishing characteristic of the Scholes-Williams beta is that it recognises that the security's return will be related to the market return over more than one period.

[29] Scholes, M. and J. Williams (1977), 'Estimating Beta from Nonsynchronous Data', *Journal of Financial Economics*, December, pp.309-327.

A consequence of the additional estimation parameters in the SW beta is that the precision of the individual betas is reduced. Thus, it is ill-advised to use the SW method unless 'thin' or 'thick' trading is considered significant. In our previous research we relied on the LM statistic calculated by the AGSM's Centre for Research in Finance, which indicated that none of the Australian sample would be likely to show biased results.[30] Indeed, one of the justifications for adopting a monthly trading interval is that it will reduce the potential for these sources of bias. However, in the March 2008 issue of the AGSM's Risk Measurement Service the LM statistic for Envestra was calculated at 0.022, indicating a potential for bias. We therefore undertook a sensitivity analysis for the Envestra beta estimate using the Scholes-Williams methodology.

3.4 Empirical specification of the CAPM

We apply the Sharpe CAPM model as follows:

$$R_{it} = \alpha + \beta R_{Mt} + \varepsilon_{it}$$

Where R_{it} is the return on the asset i for period t, α and β (Beta) are parameters to be determined and R_{Mt} is the rate of return for the portfolio of the entire market. Numerous methodological choices that must be made when estimating betas. The choices we have made on the most important methodological issues are discussed below.

Discrete vs. continuous returns

Discrete returns are calculated as the return in a given period from the change in the stock price plus dividend, relative to the initial stock price. Continuously compounded returns are calculated as the natural logarithm of one plus the discrete return. Continuous returns can be aggregated over different periods of time and are more likely to be normally distributed and therefore less likely to be subject to outliers.[31] Since the use of continuous returns is commonly applied, we have adopted this approach and define returns as:

$$R_{it} = \ln((P_t + D_t)/P_{t-1})$$

Where R_{it} is the return on the asset i for period t, P_t is the price of the asset in period t, and D_t is the dividend payed in period t.

The measures of returns were calculated using Bloomberg closing prices and Bloomberg dividend data.

30 According to the AGSM an LM statistic of less that 0.05 would indicate a potential thin trading problem.

31 Brailsford, Faff and Officer (1997), p.8.

Market index

The market index should be calculated consistently with the returns calculated for securities. Theoretically the market index should comprise all risky assets available to investors, but researchers proxy all assets with the assets contained in a broad based stock market index, which adds another level of uncertainty as it is not an ideal proxy. Australian regulators apply a domestic version of the CAPM, so we have applied the domestic market index in both cases. However, we also adjust these raw returns for differences in market composition and market gearing. The broad stock market accumulation indexes for each of the three markets examined were:

- Australia: The All Ordinaries Accumulation Index; and
- United States: Standard & Poor's 500 Total Return Index.

Since each of these is a value-weighted index, it is more consistent with the true market portfolio defined in the Sharpe CAPM.

Return period

The most common return period interval is monthly, although weekly and daily estimates have sometimes been applied by researchers.[32] In the UK, Wright, Mason and Miles showed that betas estimated with daily data will be more stable than weekly or monthly data, as there are more observations, and events on particular days will have less proportionate impact. However, shorter time periods are more susceptible to bias caused where the security is traded more or less often than the market average (non-synchronous trading, or 'thin and thick' trading). Monthly data for a period of 60 months is the standard approach used in beta analysis, and we estimate monthly betas in this report.

Autocorrelation and heteroskedasticity and estimates of standard errors

One of the important assumptions of the OLS method is that error terms are identically and independently distributed, which can be violated with beta estimation. While OLS will continue to produce unbiased estimates of the beta parameter in the presence of hetroskedascity (non-constant variance of the error terms) or autocorrelation (correlation between successive error terms), the OLS estimates of the standard errors of those estimates will be biased.

Newey and West[33] proposed a general covariance estimator that is consistent in the presence of both heteroskedasticity and autocorrelation of unknown form. In the estimation of betas over time we are using data where both heteroskedasticity and autocorrelation is possible. Accordingly, we have applied Newey-West standard errors throughout.

[32] See Wright, Mason and Miles (13 February, 2003).

[33] Newey WK & West KD (1987), "A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix". *Econometrica*, **55**, 703–708.

Return window

In our earlier studies we have considered it appropriate in principle to have regard to the longest period of observations available when estimating betas for a regulated utility. Additional observations will improve the statistical precision of estimates, however, there is a risk that over longer periods the nature of the company's operations or regulatory framework have changed. In a major review of beta methodological issues, Brailsford, Faff and Oliver concluded that 'five years of data is often used as a rule of thumb', since 'this choice generally satisfies both requirements'.[34] For regulated businesses it is unlikely that company activities will have changed, therefore the disadvantage of a long time period of data does not apply. Therefore, we have in the past recommended that regard should be paid to the longest set of data available for regulated businesses, and remain of this view.

However, as a practical matter, using a longer time series implies placing increasing weight on observations for AGL, given that it was the only firm that had more than 7 years of observations if the period of the technology bubble was excluded. Having said that, we consider AGL to be a close comparable entity during the period from 1990 to 1997 (i.e. prior to the technology bubble).[35] That is, while AGL undertook material non-infrastructure activities, much of these activities were also provided on a monopoly basis during this period.

Thus, we have reported beta estimates for returns measured over the following periods:

- As many months of monthly data as possible up to May 2008 excluding the period of the technology bubble (up to 177 months);
- Betas estimated using data drawn from the last five years (60 months); and
- Rolling regressions, which use 60 months of observations based on monthly data up to May 2008.[36]

3.5 Adjusting for leverage

The primary concern of this report is to provide an opinion in relation to the equity beta for regulated electricity transmission and distribution entities that is consistent with a regulatory-benchmark level of gearing of 60 percent debt-to-assets. Since the equity beta is affected by its financial leverage or gearing, it is necessary to adjust the estimated betas to take account of any difference between the actual gearing of the firm for which the beta is estimated and the regulatory benchmark level of 60 percent debt-to-assets. This process is referred to as de- and re-levering, the de-levering step involving adjusting the beta estimate to be consistent with zero debt (an asset beta) and the re-levering step involving adjusting the asset beta to be consistent with the regulatory benchmark level of gearing.

As we have previously explained,[37] the relationship between beta and the gearing level is subject to some debate, and depends upon:[38]

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34 Brailsford, Faff and Oliver (1997), p.16.

35 Note that AGL was dividend regulated until the mid 1980s, and was an oil and gas explorer and producer from the mid 1980s to early 1990s.

36 In the case of Scholes-Williams estimates we had to use observations up to April 2008, since lead and lag observations were also required.

37 ACG (2002), pp.25-29.

- whether the debt policy is *active* (debt is maintained at a constant proportion of the market value of assets) or *passive* (debt is maintained at a constant level);
- the marginal tax advantages associated with debt (reflecting both company tax considerations, and the relative personal taxation of debt and equity); and
- whether or not debt is risky (or materially risky), the implication of which is whether or not debt providers share some of the beta risk associated with the project.

From 1999-2000 the ACCC adopted the Monkhouse formula as the standard re-levering approach that it applies.[39] The Monkhouse formula is a version of the general formula for the relationship between equity betas and leverage, which can be expressed as follows:[40]

$$\beta_e = \beta_a\left(1 + (1 - T^*)\frac{D}{E}\right) - \beta_d(1 - T^*)\frac{D}{E}$$

where:

- T* is the marginal tax rate of the firm if *passive* debt management is assumed, or the marginal tax rate of the firm multiplied by:

  $$\frac{r_d}{1 + r_d}$$

  if *active* debt management is assumed, where rd is the cost of debt finance for the firm; and
- β_d is the debt beta for the firm, which reflects the systematic risk of the firm's debt.

It is noted that if *active debt management* is assumed, then the tax terms in the expression no longer have a material effect on the result. The simplest levering formula ignores both the tax term (approximately equivalent to an assumption of passive debt management) and assumes that the beta on debt is not material, and is as follows:

$$\beta_a = \beta_e \frac{E}{V}$$

where β_a is the asset beta (being the beta for a security that has no gearing), β_e is the equity beta and *E/V* is the share of equity in the financing structure.

We have used this simplest levering formula in our advice to regulators in recent years, and have therefore adopted it as the preferred levering method in the current matter. However, we also show the effect of the other end of the range of plausible levering methods on the equity betas (re-levered to the regulatory benchmark), namely assuming:

[38] Lally, M. (1998), 'Correcting betas for changes in firm and market leverage', *Pacific Accounting Review* 10(2): 99.

[39] ACCC (27 May, 1999), *Statement of Principles for the Regulation of Transmission Revenues* (Draft), p.81. ACCC (January, 2000) *NSW and ACT Transmission Revenue Caps: Decision*, p.36.

[40] Monkhouse, P. (1997), 'Adapting the APV valuation Methodology and the Beta Gearing formula to the Dividend Imputation Tax System', *Accounting and Finance*, Vol.37.

- an active debt management policy and a marginal tax rate in the US of 39 per cent and Australia of 15 per cent (reflecting the gamma value of 0.5 generally assumed by regulators);[41] and
- a debt beta of 0.1.[42]

Our expectation is that these assumptions will result in:

- the average and portfolio Australian betas falling slightly, as both the taxation and debt beta terms result in a lower re-levered beta where the average level of gearing in the market is less than the target (as was the case); but
- an indeterminate effect on US betas, as the effect of including a debt beta would have the same effect as discussed above for the Australian betas, but the use of a different marginal tax rate between the US and Australia imparting an upward effect on the beta re-levered for Australian conditions, potentially by a material amount.

Turning to our method for measuring gearing, for consistency with the measurement of beta, we have used the average level of gearing over the return window period that is used to estimate the raw beta. Gearing is defined as the book value of net debt divided by the sum of the market value of equity and the book value of net debt. Since equity values are available daily but debt values are constrained to reporting dates, we interpolated the debt levels to derive gearing levels on a monthly basis. We have defined the average level of observed gearing G, as:

$$\bar{G} = \frac{\bar{D}}{\left(\bar{D} + \bar{E}\right)}$$

Where D is the book value of net debt and E is the market value of equity.

3.6 Adjusting for unusual events – the technology bubble

Many commentators have maintained that the 'bubble' in technology stocks experienced in the late 1990s substantially reduced the measured betas for US utility firms over the period, and which is not considered a reliable guide to the future. As noted in a US study of this phenomenon:[43]

> Sharp recent declines in telecom, media and technology valuations suggest that the past three to five years were truly extraordinary… But in assessing future values for betas, most practitioners look to the equity returns of the recent past – and the most recent three to five-year averages and correlations of returns to shareholders are of course quite extreme. By excluding the bubble years entirely, it is possible to calculate betas that are more consistent with the long-term historical results and indicate more accurately the relative risk borne by companies in other sectors. In the absence of such a correction, data drawn from the bubble years may generate artificially low betas for the next couple of years.

41 We have used a gamma estimate of 0.50 as this is the number generally assumed by regulators. This does not imply that we necessarily concur with this approach. The re-levered beta would not be materially affected if the gamma assumption was 0.30 or zero.

42 This figure reflects the ACCC's recent acceptance of a proposal from Australia Post to apply a debt beta of 0.10. See ACCC (July, 2008), *Australian Postal Corporation- Price Notification: Decision*, p.165.

43 Annema A. and M. Goedhart, 2003, 'Current Research – A Better Beta', *McKinsey Quarterly*, No.1, p.8.

In Australia, while the share market as a whole did not experience the 'boom and bust' of the US market, the fortunes of the new economy and old economy sectors over the period differed substantially. Over the period from about mid 1998, the telecommunications sector (the proxy for the 'new economy') experienced substantial growth in share prices and then an equally substantial decline. At the same time, the utilities sector moved largely counter to the telecommunications sector and counter to the market as a whole – particularly during the subsequent decline in the telecommunications sector. A more normal relationship occurred after about the end of 2001. The effect of utility stocks moving contrary to the general movements in the share market over an extended period would have been to depress artificially beta estimates that use data from this period.

Accordingly, beta estimates for utility companies that employ data for this period are expected to be biased (and most likely, downward biased). Accordingly, with the exception of the 'rolling beta' estimates,[44] the beta estimates in this report exclude data drawn from the period of the technology bubble. We note that betas to the current time using five years of observations are now free of the effects of this potential bias.

As in our previous study, for each sample company in each market we define the technology bubble period as 1 July 1998 to 31 December 2001. This definition has the advantage of also excluding another unusual market event, the 11 September, 2001 terrorist attack and its impact.

We note, however, that the technology bubble is not the only factor that may lead to betas for one period not to be representative of the expected beta for that period or for the future. This matter is discussed further in section 4.6 below.

3.7 Adjusting to improve precision

This section discussed three different measures for improving the degree of information that is contained in the individual beta estimates, which are to:

- combine or 'pool' the beta estimates or to calculate the beta for a portfolio of firms; and
- to apply certain adjustments to the individual beta estimates.

These are discussed in turn.

Pooling beta estimates and estimating betas for portfolios

The precision of beta estimates typically is very poor. As we calculate below, the weighted average standard error of the beta for all firms on the ASX200 index calculated using 5 years of monthly data was approximately 0.275. This means that the 95 per cent confidence interval for the firm of average risk would be between approximately 0.5 and 1.5. Accordingly, it is standard practice to combine or pool beta estimates from a group of comparable entities in order to increase the information quality of the estimates.

44 The rolling beta charts are shown in Appendix C.

The simplest method of pooling beta estimates is to take a simple average of the beta estimates. The standard error of the average beta across a set of comparable entities will always be lower than the average standard error of each of the firms, and hence increases the precision of the estimate. Other measures of central tendency could also be adopted, such as the median of the group. We strongly advise against placing substantial weight on any single beta estimate.

One of the problems with taking a simple average of beta estimates is that the standard error of the resulting estimate cannot be derived simple, given that it depends on the standard error of the individual beta estimates and the degree of covariance between the errors. One means of pooling beta estimates and obtaining an estimate of the standard error of the estimate is to calculate a beta for a portfolio of firms rather than individually – that is, and industry beta. In this regard, we again follow Gray and Officer and have estimates betas for two portfolio concepts:[45]

- *Average portfolio* – This portfolio calculates the average returns across all comparable entities during a given time interval, which is equivalent to an equally-weighted portfolio of those securities.
- *Median portfolio* – This portfolio calculates the median return that would have been delivered by any of the securities in the set of comparable entities during the given time interval.

We note here that an implicit assumption in our analysis is that the asset beta for the firms in the set of comparable entities either is the same or sufficiently similar. It has been noted elsewhere that as the firms have different levels of gearing this means that many firms have sub-optimal levels of gearing, making the assumption of that asset betas are equal across the set of comparable entities implausible. We do not agree with this view. In our view, the theory and empirical evidence can provide only a plausible range for the optimal capital structure, and thus firms with materially different gearing levels all could have an optimal capital structure.

Adjustments to raw betas – Blume and Vasicek

We have been asked to present beta estimates that incorporate two adjustments intended to improve the precision of beta estimate that are known in the finance literature and practice, namely:

- the Blume adjustment; and
- the Vasicek adjustment.

The adjustments and their merits are discussed in turn.

The Blume adjustment

The Blume adjustment involves drawing individual beta estimates towards 1 (the beta for the firm of average risk). This is achieved in practice by determining the Blume-adjusted beta as the weighted average of the 'raw' (observed) beta and 1 (where there weights are predetermined).[46] Specifically, the formula is:

$$\beta_{adj} = \beta_{raw} \text{ x } w + 1.(1 - w)$$

[45] Gray, S. and R.R. Officer (17 April, 2005), *The Equity Beta of an Electricity Distribution Business*, Report prepared for ETSA Utilities.

[46] The adjustment was first suggested in: Blume, M. (1971), "On the assessment of risk", *Journal of Finance*, 26, pp.1-10.

where w is the weight that is applied to the raw beta, and so $(1-w)$ is the weight that is applied to the beta for the firm of average risk ($0 \geq w \geq 1$). In principle, the weight applied to the raw beta could be any value within this range; however, the most commonly applied weight to the raw beta is 0.67.[47]

The justification for the Blume adjustment derived from an observed empirical regularity that betas do tend to move towards one over time – the original work conducted by Blume did not include stem from an a priori basis. However, several reasons have since been posited as to why betas tend towards one, including that:

- the true beta of firms does tend towards one, which reflect the initiatives of management. These initiatives include changing the gearing structure or changing the scope of activities, either through organic growth or acquisitions or divestitures. It has been posited that management may engage in these activities because firms that have a beta closer to one also tend to experience fewer bankruptcies.[48]
- the true beta does not change, but rather than the observed regression towards one is merely the unwinding of an error, and – at least when considered on average across all securities – this unwinding should be towards one.

Thus, if the first hypothesis is believed, then the Blume adjustment may be appropriate for projecting the beta for a particular firm over time if the beta commences some distance from one. However, we have previously concluded that it is inappropriate to assume that the true beta for a regulated firm will regress towards one, given that it is assumed that the firm engages only in the relevant regulated activities and gearing is assumed to remain constant at the benchmark level. We remain of this view.

However, in principle, the potential for the Blume adjustment to remove the error associated with individual beta estimates cannot be dismissed so easily. That said, if the objective of the Blume adjustment is to reduce error, then it is an imprecise adjustment for achieving this purpose. First, the weights that would appear most commonly applied are derived from another market in another time. Secondly, it cannot be determined how much (if any) of the observed regression tendency in betas is due to a change in the true beta over time and how much (if any) is due to the effect of errors in estimates. Thirdly, the same predetermined adjustment applies irrespective of the precision of the particular beta estimate. Thus, we remain of the view that it is inappropriate to apply the Blume adjustment to raw beta estimates. For completeness, however, we have demonstrated the effect of the Blume adjustment on beta estimates.

That said, we note that the Vasicek adjustment has been derived specifically with the purpose of taking account of previous information on beta estimates and takes account of the relative precision of the new source of data. Accordingly, if it was decided that it was appropriate to adjust individual beta estimates, the Vasicek adjustment would be more appropriate for this purpose, which is discussed next.

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47 This is the weight derived by Blume, and is applied by Bloomberg for the betas that it calculates.

48 For example see Sheutrim, G., (1998), *Systematic Risk Characteristics of Corporate Equity*, Research Discussion Paper 9802, Reserve Bank of Australia, Sydney.

Application of the Vasicek adjustment

The Vasicek adjustment has been proposed as an alternative to Blume, and is used by some professional 'beta-book providers' such as the London Business School. The Vasicek adjustment is based on a Bayesian framework and draws the beta of a stock closer to the prior belief about the beta of that stock depending on the uncertainty about the estimated beta relative to the uncertainty surrounding the estimate of the prior belief. Under the Vasicek adjustment, the company j's beta (β_j) is estimated as:

$$\beta_j^v = \beta_p(1 - x_j) + x_j \hat{\beta}_j$$

where

$\hat{\beta}_j$ is the OLS estimate of j's beta,

β_p is the mean of the prior belief about β_j exclusive of $\hat{\beta}_j$;

$x_j = \dfrac{\sigma_p^2}{\sigma_p^2 + s^2(\hat{\beta}_j)}$; and

σ_p^2 and $s^2(\hat{\beta}_j)$ are the estimated variances for the prior belief and the new beta estimate, respectively.

The Vasicek has a number of desirable aspects compared to the Blume adjustment when determining a beta for regulatory purposes. First, it is clear that the Vasicek adjustment is motivated only by the relative precision of the 'prior belief' and the raw beta estimate, and hence removes the doubt that some or all of the adjustment may be irrelevant to regulated entities. Secondly, the extent of the adjustment is sensitive to the precision of the new information, rather than being predetermined and potentially no longer relevant.

The difficult question for the Vasicek adjustment is the prior belief that is formed for the estimate and the level of precision assumed for that prior belief. While the adjustment assumes that the prior belief would reflect the average beta across a set of comparable entities and the variance term reflects the dispersion across those point estimates, different views on the appropriate set of comparable entities exists. As we noted in our report to the ACCC in 2002:[49]

- the Ibbotson cost of capital service uses an industry group to inform the prior belief (which for gas and electricity is the Electric, Gas and Sanitary Services industry); whereas
- the London Business School uses the market as a whole to inform the prior belief.

We note that Vasicek himself appeared to assume that an industry group would be used to inform the prior belief for utility stocks, as follows:[50]

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49 ACG (2002), p.23.

50 Vasicek, O. (1973), "A note on using cross-sectional information in Bayesian estimation of security betas, *Journal of Finance*, Vol. 28, p.1237.

> Thus, if a utility stock is considered and it is known from previous measurements that betas are centered around 0.8, with a dispersion of 0.3, the estimate β_j is adjusted toward 0.8 by the formula...

In our own previous advice, we have assumed that the prior belief would be informed by the average beta from a set of comparable entities, and concluded this would add little if the same set of entities was used as the set of comparable entities when estimating the beta for the regulated activities. Having said that, in the time that we have been advising on equity betas for regulatory purposes, the reliability and stability of the beta estimates in Australia has remained depressingly poor, notwithstanding our predictions that the situation would improve.[51]

In our view, it cannot be rejected that the Vasicek adjustment may provide valid information that a regulator may consider when determining the equity beta for regulatory purposes. We also consider that the only practicable prior belief is one that is informed by beta estimates for the market as a whole, following the method applied by the London Business School.

The specification of the prior belief – and the level of precision of that information – is not an exact science. Accordingly, we have reported results for our base case using a prior of a 60 per cent geared equity beta of 1, with the precision of the prior belief taken as the dispersion of observed beta estimates. We have also tested the sensitivities of two other approaches to estimating the precision of this prior belief, namely that:

- the dispersion in beta estimates is calculated placing more weight assigned on the betas of larger firms, which we have done by estimating the dispersion of beta estimates for the largest 100 firms only; and
- the dispersion in beta estimates is calculated placing more weight assigned on the betas that are more precisely estimated, which we have done by estimating the dispersion of beta estimates for the top 100 firms ranked by the precision of their estimated betas.

While it may be argued that a prior of an equity beta of 1will bias upwards the beta estimate, we do not consider there to be strong grounds for this view. While Vasicek seemed to assume that a prior belief of 0.80 was appropriate for utilities, we note that the average US utility has a much lower level of gearing than their Australian counterparts, and that the 0.80 would translate into a 60 percent geared equity beta of about 1 when adjusted for the gearing levels. More generally, the regulatory benchmark level of gearing for Australian energy utilities of 60 per cent debt-to-assets is approximately twice that of the average listed firm – so that a prior of a 60 per cent geared equity beta of 1 still implies that regulated utilities are materially less risky than the average firm.

3.8 Testing for differences between US and Australian betas

As discussed above, we believe that it is appropriate to give weight to betas estimated for comparable foreign firms, although caution should be exercised. In this report, we have tested three factors that may cause betas for the same activity to differ between Australia and the US, which are:

- the weights of the various sectors in the different stock exchanges;

[51] See ACG (2002), p.6.

- the effects of differences in the average level of gearing between Australia and the US; and
- the effect of the different forms of regulation applied in Australia and the US.

Our method for testing for the effect of these factors is set out below.

Effect of different market weights of industry sectors

It is plausible that beta estimates could vary between countries if the weight of the different industry sector differed. In particular, if the industries that were sensitive to the same macroeconomic factors as the firm in question have a small weight on its home stock exchange but a larger weight in Australia, then all else constant the beta should be higher for the same activity in Australia. Lally (2004) suggested that foreign betas should be re-estimated with the Australian industry sector weights substituted. However, this approach had already been undertaken in relation to an Australian regulatory case by the US-based Brattle Group, which in 1999 produced beta estimates for five US companies engaged in gas pipeline operations as comparables for the Dampier to Bunbury Natural Gas Pipeline (DBNGP).[52]

In its analysis the Brattle Group had mapped a 'US ASX-Weighted Index', which was based on year-end market weights for 1993 to 1998 taken from the AGSM's Risk Management Service (RMS). The methodology was to:

- Take the 29 sectors identified in the Australian Graduate School of Management Risk Management Service Index and match them against the larger set of US industry sectors for which Standard & Poor's (S&P) published a sectoral index;
- Multiply the monthly returns for each S&P sector by the weight accorded to that sector in the Australian ASX market;
- Sum the weighted S&P (Australian market weighted) sector returns to derive a 'US ASX-Weighted Index' return for each month; and
- To use the 'US ASX-Weighted Index' in beta estimation.

The Brattle Group found that a sensitivity analysis applying four alternative versions of the mapping framework resulted in only minor differences in the estimated betas.

We have applied the Brattle method, with only minor changes. In particular, while Brattle constructed the 'US ASX- Weighted Index' based on year-end market weights, we have used the monthly weights.

For the purposes of this study, we constructed the relevant indices using market weight and market return information from Standard & Poor's GISC industry groups.

52 The Brattle Group (October 1999), *The Cost of Capital for the Dampier to Bunbury Natural Gas Pipeline*, prepared for Epic Energy.

Adjustment for foreign market gearing

It has been suggested that differences in the average leverage of home share markets could affect the interpretation of international beta proxies, and that an adjustment for this factor should be undertaken.[53] That is, if the beta is measured against a market that has a higher level of gearing than the home market, the resulting asset beta estimate would need to be adjusted upwards when applied to the home market. The adjustment formula, consistent with the general re-leveraging formula we have applied to test the materiality of this factor is:[54]

$$\beta_{a,h} = \beta_{a,f} \frac{\left[1 + \frac{L_f}{(1-L_f)}\right]}{\left[1 + \frac{L_h}{(1-L_h)}\right]}$$

where,

$\beta_{a,h}$ and $\beta_{a,f}$ are asset betas of the comparator firm with respect to the home and foreign markets respectively; and

L_h and L_f are leverage (Debt / Enterprise Value) of the home and foreign markets respectively.

Testing for the effect of the form of regulation

It has often been proposed that US rate of return regulation has a dampening effect on beta compared with incentive-based regulation (or CPI-X regulation). Since incentive regulation typically sets parameters for five years, the regulated business is able to pursue efficiencies in operations or financing, but is exposed for that period to revenue and cost uncertainty. With traditional US rate of return regulation the option exists for the business to return to the regulator (or for the regulator to reopen controls) at more frequent intervals to adjust regulated prices if earnings depart from the cost of capital.

Empirical evidence on the influence of type of regulation was presented by Alexander, Mayer and Weeds in 1996.[55] They compared betas of the regulated electricity, gas, water and telecoms industries in the UK (i.e. 'high powered' CPI-X regulated) and rate of return regulated businesses in the same sectors in the US (i.e. 'low powered' rate of return regulated). The simple differences in asset beta were in the order of 0.30 (in the case of electricity) to 0.64 (in the case of gas) higher in the high-powered (CPI-X) regulated businesses in the UK compared with the same industry in the US. The full differential was put down to the nature of regulation.

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[53] Lally, Martin (2002), "Betas and Market Leverage", *Accounting Research Journal*, Vol. 15 No. 1, pp.91-97.

[54] Note that the adjustment formula suggested by Lally includes tax terms. We have eliminated these for consistency with our use of the simple levering formula, but have also calculated sensitivities.

[55] See Alexander, I., C. Mayer and H. Weeds (1996), *Regulatory Structure and Risk: An International Comparison*, prepared for the World Bank.

There are several potential problems in attempting to compare the impact of regulation across different countries. In particular, it would be necessary to control for such differences as market structure and market gearing, which have been discussed above. The best methodological approach, which holds constant any market differences, would be to compare alternative regulatory approaches in the same industry sector, in the same country.

The United States is the only country where there are sufficient numbers of listed regulated businesses with a sufficient diversity of regulatory approach for such an analysis can be undertaken. We therefore have analysed the effect of the form of regulation on beta by researching the form of regulation applied to our US comparable entities, and to examine for any difference in the measured beta.

As shown in Table 3.1 below, we were able to find evidence of incentive regulation being applied to five of the 21 US energy transmission and distribution businesses in our sample. The sources that we relied upon for this purpose are shown in the table.

Table 3.1

US ENERGY DISTRIBUTION AND TRANSMISSION: INCENTIVE REGULATION

Incentive Based Companies	Incentive	Source
AGL Resources	Performance-based rates with Virginia State Corporate Commission	AGL Resources website
Consolidated Edison	-Revenue per customer cap with earnings sharing -Rate moratorium -Rate freeze for distribution and transmission services	The Electricity Journal, October 2001
NICOR Inc	Performance-based rates trial	NICOR website
NSTAR	Rate freeze for distribution services	The Electricity Journal, October 2001
WGL Holdings, Inc	Rate plan incorporating earnings sharing above established targets	WGL Holdings website

Source: As presented

Chapter 4

Empirical beta estimates

4.1 Introduction

In this chapter we summarise the empirical results for the selection of companies and method described in Chapters 2 and 3. The results for the portfolios are summarised in Table 4.1 below.

Table 4.1

PORTFOLIOS: FULL MONTHLY BETA ESTIMATES (1990-1998 AND 2002-2008)

Sample	N	OLS			Re-weighted OLS			LAV		
		L	M	H	L	M	H	L	M	H
Full period excluding Technology Bubble:										
Australia										
Average portfolio	174	0.43	**0.72**	1.02	0.40	**0.65**	0.90	0.50	**0.80**	1.10
Median portfolio	174	0.42	**0.72**	1.03	0.39	**0.65**	0.92	0.56	**0.87**	1.18
United States										
Average portfolio	177	0.52	**0.68**	0.85	0.47	**0.61**	0.75	0.46	**0.58**	0.71
Median portfolio	177	0.50	**0.65**	0.81	0.49	**0.63**	0.78	0.33	**0.54**	0.75
Last 5 years of data:										
Australia										
Average portfolio	60	0.46	**0.65**	0.85	0.45	**0.65**	0.85	0.40	**0.64**	0.88
Median portfolio	60	0.36	**0.65**	0.94	0.36	**0.64**	0.93	0.32	**0.68**	1.04
United States										
Average portfolio	60	0.65	**0.97**	1.29	0.63	**0.95**	1.27	0.21	**0.65**	1.09
Median portfolio	60	0.66	**1.05**	1.43	0.63	**0.99**	1.36	0.15	**0.72**	1.29

Note: L denotes lower 95%CI, M denotes mean estimate and H denotes upper 95%CI. N denotes number of monthly observations

- For the **Australian firms**, the average geared beta for the whole period (excluding the technology bubble, which we defined as between 1 July, 1998 and 31 December, 2001) ranged between 0.65 and 0.9 depending on the estimation technique. Upper bounds of the 95 per cent confidence intervals ranged between 0.9 and 1.2. The results for the most recent five years were central beta estimates of 0.65 to 0.7 across all three estimation techniques, with the upper bounds of the 95 percent confidence intervals ranging from 0.85 to 1.

- For the **US firms**, the average geared beta for the whole period (excluding the technology bubble) ranged between 0.5 and 0.7, with all the upper bounds of 95 per cent confidence intervals between 0.7 and 0.9. The betas measured over the most recent five years were materially higher, ranging between 0.65 and 1.05, with all of these estimates having upper bounds of 95 percent confidence interval greater than 1.

4.2 Australia

Table 4.2 shows the results for the longest period of monthly data that we were able to obtained from Bloomberg. The maximum number of months of observations is 174 for the portfolios. In all tables we have excluded the 'technology bubble' period.

Table 4.2

AUSTRALIAN ENERGY RELATED SECURITIES: FULL MONTHLY BETA ESTIMATES (1990-1998 AND 2002-2008)

Stock	N	OLS			Re-weighted OLS			LAV		
		L	M	H	L	M	H	L	M	H
AAN	68	0.02	**0.81**	1.60	0.17	**0.90**	1.62	0.22	**0.95**	1.68
AGL	155	0.43	**0.84**	1.26	0.32	**0.67**	1.02	0.17	**0.84**	1.51
APA	77	0.22	**0.68**	1.14	0.26	**0.70**	1.15	0.43	**0.81**	1.20
GAS	59	0.00	**0.38**	0.77	-0.02	**0.31**	0.64	-0.04	**0.34**	0.72
ENV	78	0.00	**0.36**	0.73	-0.01	**0.33**	0.67	-0.31	**0.04**	0.40
DUE	36	0.12	**0.38**	0.65	0.13	**0.30**	0.47	0.02	**0.38**	0.73
HDF	41	-0.10	**0.54**	1.17	0.10	**0.64**	1.19	0.13	**0.80**	1.46
SPN	27	-0.12	**0.25**	0.61	-0.11	**0.23**	0.57	-0.71	**0.06**	0.83
SKI	29	0.24	**0.57**	0.91	0.23	**0.56**	0.89	0.09	**0.59**	1.09
Portfolios:										
Average	174	0.43	**0.72**	1.02	0.40	**0.65**	0.90	0.50	**0.80**	1.10
Median	174	0.42	**0.72**	1.03	0.39	**0.65**	0.92	0.56	**0.87**	1.18

Note: L denotes lower 95%CI, M denotes mean estimate and H denotes upper 95%CI. N denotes number of monthly observations. Newey-West Standard Errors used to calculate confidence intervals.

The central estimate of the portfolio beta based on the maximum number of monthly observations (174) lies between 0.7 (OLS average portfolio) and 0.9 (LAV median portfolio); however there are wide confidence intervals around these levels. Important for the discussion below, the upper bound of the 95 percent confidence interval for the estimate exceeds 1 for 4 of the 6 portfolio estimates.

The OLS results also indicate that 4 out of 9 individual stocks had a lower 95 percent confidence interval that is either zero or negative. Since it is unreasonable to expect a zero or negative beta for a 60 percent geared electricity or gas transmission or distribution business (which would imply a business with zero systematic risk), this finding is an artefact of the quality of the data and the inherent imprecision of beta estimates and exemplifies the limited capacity of statistical analysis to adequately describe the level of uncertainty around the estimates.

The portfolio OLS estimates, at 0.7, are around 10 points higher than for the results we obtained in our 2007 for the ESC using an earlier dataset, while the LAV portfolio estimates are 10 to 25 points higher.

Table 4.3 shows our results based on the last 5 years (60 months) of observations when they were available ending in May, 2008. The last 60 months average and median portfolio estimates of beta are either the same (for Re-weighted OLS) or 7 to 19 points lower (for OLS and LAV) than for the whole period sample. However, portfolio estimates for the last 60 months are approximately 0.7. Again, the 95 percent confidence intervals are wide, and the upper bound of the 95 per cent confidence interval for the portfolio is between 0.9 and 1, and greater than 1 in half of the individual estimates.

Again, the lower bounds of the 95 percent confidence interval of beta estimates for some individual stocks are zero or negative, indicating the inherent imprecision of beta estimates and exemplifies the limited capacity of statistical analysis to adequately describe the level of uncertainty around the estimates.

Table 4.3

AUSTRALIAN ENERGY RELATED SECURITIES: LATEST 5 YEAR MONTHLY BETA ESTIMATES (2003-2008)

Stock	N	OLS			Re-weighted OLS			LAV		
		L	M	H	L	M	H	L	M	H
AAN	51	0.15	**1.29**	2.43	0.16	**1.26**	2.35	0.16	**1.29**	2.41
AGL	41	-1.15	**0.57**	2.29	-1.59	**-0.39**	0.81	-1.43	**0.13**	1.69
APA	60	0.42	**0.87**	1.33	0.44	**0.89**	1.34	0.35	**0.85**	1.34
DUE	42	-0.04	**0.51**	1.06	-0.07	**0.42**	0.91	-0.23	**0.27**	0.78
ENV	60	0.15	**0.51**	0.87	0.13	**0.46**	0.80	0.22	**0.61**	1.00
GAS	36	0.12	**0.38**	0.65	0.13	**0.30**	0.47	0.02	**0.38**	0.73
HDF	41	-0.10	**0.54**	1.17	0.10	**0.64**	1.19	0.13	**0.80**	1.46
SPN	27	-0.12	**0.25**	0.61	-0.11	**0.23**	0.57	-0.71	**0.06**	0.83
SKI	29	0.24	**0.57**	0.91	0.23	**0.56**	0.89	0.09	**0.59**	1.09
Portfolios:										
Average	60	0.46	**0.65**	0.85	0.45	**0.65**	0.85	0.40	**0.64**	0.88
Median	60	0.36	**0.65**	0.94	0.36	**0.64**	0.93	0.32	**0.68**	1.04

Note: L denotes lower 95%CI, M denotes mean estimate and H denotes upper 95%CI. N denotes number. Newey-West Standard Errors used to calculate confidence intervals.

The updated results for the latest 5 years are markedly higher than in our 2007 study for the ESC. The portfolio average OLS beta estimate rose from 0.3 previously to 0.65 currently, the portfolio average re-weighted OLS rose from 0.2 previously to 0.65 currently, while the portfolio average LAV beta rose from 0.3 to 0.64 currently.

Tables 4.4 and 4.5 show the effect of applying the Blume and Vasicek adjustments for the whole period and the last five years beta estimates. As discussed in Chapter 3, the different Vasicek adjustments reflect a prior belief of an equity beta of 1 (at 60 percent gearing) with different assumed precisions and weightings of the prior beliefs, reflecting:

- the standard deviation of beta estimates for all firms listed on the Australian stock exchange, which was 0.797, corresponding to a weighting of the prior belief for the average and median portfolio beta estimates of 1.5 to 1.7 per cent (Vasicek (1));
- the standard deviation of the beta estimates for only the largest 100 firms, which was 0.572, corresponding to a weighting of the prior belief for the average and median portfolio beta estimates of about 3 per cent (Vasicek (2)); and
- the standard deviation of the beta estimates for only 100 firms with the most precise beta estimates, which was 0.345, corresponding to a weighting of the prior belief for the average and median portfolio beta estimates of about 8 per cent (Vasicek (3)).

While the Blume adjustment had a material (upward) effect on the interpretation of the raw beta estimates, the Vasicek adjustment had little effect on the portfolio estimates for any of the methods for defining the precision of the prior belief. The average of the betas for the five entities that have the most trading history increased by slightly more than the portfolio estimates, but not by a sufficient margin to change the interpretation of the raw beta estimates. The limited effects of the Vasicek adjustment arise from the prior being not substantially different from the average of the raw beta estimates (a prior of an equity beta of 1 at 60 per cent gearing compared with average and median raw beta estimates of about 0.72) and the limited weight assigned to the prior (between 1.5 and 8 per cent). The values applied in this study to both the prior and the weights assigned to the prior are not uniquely correct and different values would give rise to different Vasicek-adjusted results.

Table 4.4

AUSTRALIAN ENERGY RELATED SECURITIES: WHOLE PERIOD MONTHLY BETA ESTIMATES – OLS BLUME AND VASICEK (1990-1998 AND 2003-2008)

		Average Portfolio	Median Portfolio
	L	0.43	0.42
OLS	**M**	**0.72**	**0.72**
	H	1.02	1.03
	L	0.62	0.61
Blume	**M**	**0.82**	**0.81**
	H	1.01	1.02
	L	0.44	0.43
Vasicek (1)	**M**	**0.73**	**0.73**
	H	1.02	1.03
	L	0.45	0.43
Vasicek (2)	**M**	**0.73**	**0.73**
	H	1.02	1.03
	L	0.47	0.46
Vasicek (3)	**M**	**0.75**	**0.75**
	H	1.03	1.04

Note: L denotes lower 95%CI, M denotes mean estimate and H denotes upper 95%CI.

Table 4.5

AUSTRALIAN ENERGY RELATED SECURITIES: LATEST 5 YEAR PERIOD MONTHLY BETA ESTIMATES – OLS BLUME AND VASICEK (2003-2008)

		Average Portfolio	Median Portfolio
	L	0.46	0.36
OLS	**M**	**0.65**	**0.65**
	H	0.85	0.94
	L	0.64	0.57
Blume	**M**	**0.77**	**0.77**
	H	0.90	0.96
	L	0.46	0.38
Vasicek (1)	**M**	**0.66**	**0.66**
	H	0.86	0.95
	L	0.47	0.39
Vasicek (2)	**M**	**0.66**	**0.67**
	H	0.86	0.95
	L	0.48	0.42
Vasicek (3)	**M**	**0.67**	**0.69**
	H	0.87	0.97

Note: L denotes lower 95%CI, M denotes mean estimate and H denotes upper 95%CI.

4.3 US gas and electricity

Table 4.6 reports the results for the longest available period (excluding the ‘technology bubble’) for 21 US gas and/or electricity transmission and/or distribution businesses drawn from the UBS Utilities Index. The sample of 21 stocks is more than twice as large as the 9 stock sample employed in our earlier study, which focused on gas-only distribution and transmission businesses.

The estimates of the portfolio betas estimated over the whole period vary between 0.5 and 0.7, with a simple average of the betas across firms of 0.7 irrespective of the estimation method employed. These estimates are approximately 10 points higher than the beta estimates we undertook for the ESC in 2007 using an earlier period and gas-only sample (although a majority of the gas-only stock betas also rose when the sample period was extended to the most recent period). The upper 95 per cent confidence intervals all exclude 1.

Table 4.6 reports our beta estimates for the same firms over the latest 5 year period of monthly observations up to May 2008. It is clear from the table that the estimated betas are considerably higher than for the whole period, with four of the six portfolio beta estimates at or above 1, and all of the simple averages of the betas across firms at or above 1, irrespective of the estimation method employed. In addition, in contrast to the whole of period results, the upper 95 per cent confidence intervals for all of the beta estimates exceed 1, and by a substantial margin.

Table 4.6

US ENERGY TRANSMISSION AND DISTRIBUTION SECURITIES: FULL PERIOD MONTHLY BETA ESTIMATES EXCLUDING TECHNOLOGY BUBBLE PERIOD (1990-1998 AND 2003-2008)

Stock	N	OLS			Re-weighted OLS			LAV		
		L	M	H	L	M	H	L	M	H
ATG	177	0.40	**0.61**	0.82	0.41	**0.62**	0.83	0.22	**0.56**	0.90
ATO	177	0.10	**0.55**	1.00	0.25	**0.54**	0.83	0.07	**0.41**	0.75
CHG	177	0.40	**0.68**	0.96	0.52	**0.72**	0.92	0.51	**0.81**	1.12
CNP	177	0.43	**0.91**	1.40	0.45	**0.71**	0.97	0.18	**0.51**	0.85
EAS	177	0.56	**0.76**	0.96	0.53	**0.68**	0.83	0.41	**0.62**	0.83
ED	177	0.44	**0.75**	1.05	0.52	**0.80**	1.09	0.53	**0.76**	1.00
GAS	177	0.40	**1.17**	1.94	0.31	**0.72**	1.12	0.40	**0.94**	1.48
ITC	33	0.47	**1.56**	2.65	0.50	**1.60**	2.69	-0.60	**1.66**	3.91
IG	177	0.16	**0.40**	0.65	0.16	**0.39**	0.61	0.02	**0.42**	0.82
NI	177	0.52	**0.76**	1.00	0.53	**0.76**	0.99	0.28	**0.61**	0.95
NJR	177	0.08	**0.42**	0.76	0.10	**0.42**	0.74	0.18	**0.41**	0.64
NST	77	0.40	**0.75**	1.10	0.57	**0.84**	1.12	0.50	**0.86**	1.22
NU	177	0.19	**0.48**	0.77	0.34	**0.53**	0.73	0.14	**0.38**	0.62
NWN	177	0.05	**0.41**	0.76	0.14	**0.42**	0.69	-0.04	**0.39**	0.83
PNY	177	0.37	**0.66**	0.96	0.34	**0.60**	0.86	0.27	**0.63**	0.99
POM	69	0.40	**0.67**	0.95	0.32	**0.55**	0.78	-0.02	**0.38**	0.78
SJI	177	0.15	**0.39**	0.62	0.19	**0.43**	0.67	0.04	**0.36**	0.69
SRP	77	0.87	**1.57**	2.26	0.81	**1.11**	1.41	0.87	**1.26**	1.64
SWX	153	0.10	**0.36**	0.62	0.06	**0.31**	0.56	0.01	**0.27**	0.53
UIL	177	0.44	**0.72**	1.00	0.43	**0.65**	0.88	0.32	**0.64**	0.96
WGL	177	0.41	**0.70**	0.98	0.41	**0.70**	0.98	0.46	**0.71**	0.95
Average			**0.73**			**0.67**			**0.65**	
Portfolios:										
Average	177	0.52	**0.68**	0.85	0.47	**0.61**	0.75	0.46	**0.58**	0.71
Median	177	0.50	**0.65**	0.81	0.49	**0.63**	0.78	0.33	**0.54**	0.75

Note: L denotes lower 95%CI, M denotes mean estimate and H denotes upper 95%CI. N denotes number. Newey-West Standard Errors used to calculate confidence intervals.

Table 4.7

US ENERGY TRANSMISSION AND DISTRIBUTION SECURITIES: LATEST 5 YEAR PERIOD MONTHLY BETA ESTIMATES - (2003-2008)

Stock	N	OLS			Re-weighted OLS			LAV		
		L	M	H	L	M	H	L	M	H
ATG	60	0.02	**0.52**	1.01	0.06	**0.52**	0.98	-0.48	**0.11**	0.71
ATO	60	0.48	**0.99**	1.50	0.56	**1.05**	1.54	0.39	**1.02**	1.65
CHG	60	0.74	**1.49**	2.24	1.09	**1.77**	2.45	0.37	**1.32**	2.26
CNP	60	0.21	**0.56**	0.92	0.22	**0.57**	0.92	0.15	**0.77**	1.39
EAS	60	-0.08	**0.29**	0.65	-0.17	**0.21**	0.59	-0.51	**0.19**	0.89
ED	60	0.09	**0.78**	1.46	0.08	**0.67**	1.26	-0.12	**0.47**	1.05
GAS	60	0.33	**1.37**	2.40	0.24	**1.04**	1.84	0.26	**1.36**	2.47
ITC	33	0.47	**1.56**	2.65	0.50	**1.60**	2.69	-0.60	**1.66**	3.91
IG	60	0.59	**1.17**	1.75	0.59	**1.16**	1.73	0.06	**0.97**	1.89
NI	60	0.10	**0.59**	1.09	0.40	**0.82**	1.24	-0.24	**0.40**	1.04
NJR	60	0.47	**1.08**	1.68	0.50	**1.08**	1.65	0.21	**0.98**	1.74
NST	60	0.31	**0.88**	1.45	0.33	**0.89**	1.44	-0.11	**0.62**	1.36
NU	60	0.35	**0.96**	1.57	0.34	**0.94**	1.54	0.50	**1.04**	1.58
NWN	60	0.60	**1.25**	1.90	0.53	**1.16**	1.78	-0.21	**0.72**	1.65
PNY	60	0.44	**0.90**	1.37	0.43	**0.88**	1.32	0.00	**0.69**	1.39
POM	60	0.31	**0.77**	1.23	0.36	**0.71**	1.06	-0.28	**0.35**	0.97
SJI	60	0.43	**0.97**	1.52	0.41	**0.89**	1.38	0.35	**1.02**	1.69
SRP	60	0.71	**1.23**	1.76	0.75	**1.25**	1.75	0.26	**0.80**	1.34
SWX	60	0.26	**0.70**	1.14	0.18	**0.59**	0.99	0.19	**0.71**	1.23
UIL	60	0.88	**1.61**	2.35	0.89	**1.56**	2.23	0.56	**1.73**	2.89
WGL	60	0.74	**1.33**	1.93	0.74	**1.29**	1.84	0.51	**1.21**	1.90
Average			**1.00**			**0.98**			**0.86**	
Portfolios:										
Average	60	0.65	**0.97**	1.29	0.63	**0.95**	1.27	0.21	**0.65**	1.09
Median	60	0.66	**1.05**	1.43	0.63	**0.99**	1.36	0.15	**0.72**	1.29

Note: L denotes lower 95%CI, M denotes mean estimate and H denotes upper 95%CI. N denotes number. Newey-West Standard Errors used to calculate confidence intervals.

The results for the most recent period for the US firms are also materially higher than what we reported in our work for the ESC in 2007. At that time, the beta estimates for the gas-only sample ranged between 0.5 and 0.8 for the portfolio estimates, and were less than 0.6 for the simple averages of firm betas, irrespective of the estimation method that was employed.

Tables 4.8 and 4.9 show the effects of the Blume and Vasicek adjustments for the US firms, again with the three methods for deriving the precision of the prior belief summarised above.

Table 4.8

US ENERGY RELATED SECURITIES: WHOLE PERIOD MONTHLY BETA ESTIMATES – OLS BLUME AND VASICEK (1990-1998 AND 2003-2008)

		Average Portfolio	Median Portfolio
	L	0.52	0.50
OLS	**M**	0.68	0.65
	H	0.85	0.81
	L	0.68	0.66
Blume	**M**	0.79	0.77
	H	0.90	0.87
	L	0.52	0.50
Vasicek (1)	**M**	0.69	0.66
	H	0.86	0.81
	L	0.52	0.50
Vasicek (2)	**M**	0.69	0.66
	H	0.86	0.81
	L	0.53	0.51
Vasicek (3)	**M**	0.70	0.66
	H	0.86	0.82

Note: L denotes lower 95%CI, M denotes mean estimate and H denotes upper 95%CI.

Table 4.9

US ENERGY RELATED SECURITIES: LATEST 5 YEAR PERIOD MONTHLY BETA ESTIMATES – OLS BLUME AND VASICEK (2003-2008)

		Average Portfolio	Median Portfolio
	L	0.65	0.66
OLS	**M**	0.97	1.05
	H	1.29	1.43
	L	0.77	0.77
Blume	**M**	0.98	1.03
	H	1.19	1.29
	L	0.66	0.67
Vasicek (1)	**M**	0.97	1.04
	H	1.28	1.41
	L	0.66	0.67
Vasicek (2)	**M**	0.97	1.04
	H	1.28	1.41
	L	0.67	0.69
Vasicek (3)	**M**	0.97	1.04
	H	1.27	1.39

Note: L denotes lower 95%CI, M denotes mean estimate and H denotes upper 95%CI.

Again, while the Blume adjustment had a material effect for the whole of period results, none of the Vasicek adjustments had a material effect on the interpretation of the raw beta estimates.

4.4 Additional sensitivities

In this section we report the additional sensitivities described in Chapter 3, namely the effects of three factors that may affect the interpretation of US betas, and sensitivities around the method we have employed to adjust betas for leverage.

Tests for the appropriateness of US betas

Market gearing – sensitivity of results

Table 4.10 shows how our beta estimates for the US would be reinterpreted if an explicit adjustment was made for the differences in gearing between countries using the method described in Chapter 3. We found that over the past 5 years the weighted gearing level of the US S&P500 Index was 40 percent, while the corresponding gearing level of the Australian ASX 200 Index was only 34 percent. The 60 percent geared US beta estimate of 1 for the last five years that was reported earlier would increase to 1.1 if differences in country gearing only are taken into account.[56]

We conclude, therefore, that adjusting for differences in market gearing alone would add approximately 10 per cent to the beta that is observed from the US.

Market weights

As discussed in Chapter 3, we have applied the Brattle Group method for testing the effect of sectoral weights on beta estimates. In particular, we have re-estimated the betas for US firms against the US share market, but re-weighted to resemble the Australian market.

The results of this analysis are set out in Table 4.11. This table shows that, using the last five years of results, the 60 percent geared beta of 1 previously reported falls to 0.81 when measured against the re-weighted US index. However, if the combined effects of market weight and market gearing are taken into account, the re-levered beta rises to 0.89, and so the effects of these two adjustments are substantially offset. While we note that the (downward) effect of the change in market weights *appears* to be more material than the (upward) effect of the adjustment for market gearing, we are more confident in the latter adjustment, given its strong theoretical basis. Accordingly, we conclude that the differences in market gearing and market weights between the Australian and US share markets are unlikely to have a material effect on betas when considered in combination.

[56] If the levering and re-levering formulas include tax terms and an assumption of 39 percent tax in the US and 15 percent tax in Australia, the adjusted beta becomes 1.07.

Table 4.10

US MONTHLY BETA: LAST 5 YEARS PERIOD, SENSITIVITY TO COUNTRY GEARING

Stock	Raw Be (SP500)	Gearing (D/V)	Raw Be geared to 60%	Ba with US gearing	Ba with Aust gearing	Be geared to 60%
ATG	0.34	0.40	0.52	0.21	0.23	0.57
ATO	0.73	0.45	0.99	0.40	0.44	1.09
CHG	0.83	0.28	1.49	0.60	0.66	1.64
CNP	0.73	0.69	0.56	0.23	0.25	0.62
EAS	0.23	0.51	0.29	0.11	0.13	0.32
ED	0.53	0.42	0.78	0.31	0.34	0.85
GAS	0.74	0.26	1.37	0.55	0.60	1.50
ITC	1.04	0.40	1.56	0.62	0.69	1.72
IG	0.82	0.43	1.17	0.47	0.52	1.29
NI	0.49	0.52	0.59	0.24	0.26	0.65
NJR	0.61	0.29	1.08	0.43	0.47	1.18
NST	0.67	0.47	0.88	0.35	0.39	0.97
NU	0.87	0.56	0.96	0.38	0.42	1.05
NWN	0.78	0.36	1.25	0.50	0.55	1.37
PNY	0.53	0.32	0.90	0.36	0.40	0.99
POM	0.71	0.57	0.77	0.31	0.34	0.85
SJI	0.60	0.35	0.97	0.39	0.43	1.07
SRP	1.47	0.66	1.23	0.49	0.54	1.36
SWX	0.62	0.55	0.70	0.28	0.31	0.77
UIL	1.06	0.39	1.61	0.64	0.71	1.77
WGL	0.79	0.33	1.33	0.53	0.59	1.46
Average	0.72	0.44	1.00	0.40	0.44	1.10
Portfolio Average	0.69	0.44	0.97	0.39	0.43	1.07
Portfolio Median	0.73	0.42	1.05	0.42	0.46	1.15

Source: Bloomberg and ACG analysis

Table 4.11

US MONTHLY BETA: LAST 5 YEARS PERIOD, MARKET WEIGHTS AND COUNTRY GEARING ADJUSTED– TAX IGNORED

Stock	Raw Be (SP500)	Gearing (D/V)	Raw Be Geared to 60%	Re-Weighted Be (Brattle)	Re-weighted Be, 60% gearing	Re-weighted Be, 60% gearing market gearing corrected
ATG	0.34	0.40	0.52	0.40	0.60	0.66
ATO	0.73	0.45	0.99	0.69	0.94	1.04
CHG	0.83	0.28	1.49	0.62	1.12	1.23
CNP	0.73	0.69	0.56	0.49	0.38	0.42
EAS	0.23	0.51	0.29	0.09	0.11	0.12
ED	0.53	0.42	0.78	0.34	0.50	0.55
GAS	0.74	0.26	1.37	0.62	1.15	1.26
ITC	1.04	0.40	1.56	0.75	1.13	1.24
IG	0.82	0.43	1.17	0.72	1.03	1.13
NI	0.49	0.52	0.59	0.56	0.67	0.73
NJR	0.61	0.29	1.08	0.43	0.76	0.84
NST	0.67	0.47	0.88	0.45	0.59	0.65
NU	0.87	0.56	0.96	0.63	0.70	0.76
NWN	0.78	0.36	1.25	0.72	1.15	1.26
PNY	0.53	0.32	0.90	0.43	0.74	0.81
POM	0.71	0.57	0.77	0.50	0.54	0.59
SJI	0.60	0.35	0.97	0.47	0.76	0.84
SRP	1.47	0.66	1.23	1.16	0.97	1.07
SWX	0.62	0.55	0.70	0.52	0.58	0.64
UIL	1.06	0.39	1.61	0.88	1.34	1.48
WGL	0.79	0.33	1.33	0.72	1.20	1.32
Average	0.72	0.44	1.00	0.58	0.81	0.89
Portfolio Average	0.69	0.44	0.97	0.56	0.78	0.86
Portfolio Median	0.73	0.42	1.05	0.60	0.87	0.95

Source: Bloomberg and ACG analysis

Form of regulation

Table 4.12 below shows the results of comparing the US betas estimated earlier, based on the form of regulation applied, as discussed in Chapter 3. Our results show that the group of businesses with some form of incentive regulation had an estimated average beta that was approximately the same as the average estimated beta of the purely rate of return regulated group. Therefore, we conclude that we have been unable to find support for the hypothesis that the beta risk of US firms varies materially with the form of regulation.

Table 4.12

US MONTHLY BETA: IMPACT OF INCENTIVE REGULATION ON BETAS FOR LATEST 5 YEARS

	60% geared vs S&P500 Index
ATG	0.52
ED	0.78
GAS	1.37
NST	0.88
WGL	1.33
Average Incentive regulated	**0.98**
ATO	0.99
CHG	1.49
CNP	0.56
EAS	0.29
ITC	1.56
LG	1.17
NI	0.59
NJR	1.08
NU	0.96
NWN	1.25
PNY	0.90
POM	0.77
SJI	0.97
SRP	1.23
SWX	0.70
UIL	1.61
Average rate of return regulated	**1.01**

Source: FERC trade and finance literature, company websites

Levering methods

In Table 4.13 we show the sensitivity of our estimates to the gearing factor that has been applied in this report. As discussed in Chapter 3, we have applied the simplest of levering formulae as our base case, which ignores both tax and the possibility that debt has material systematic risk, which is labelled 'Levering 1' in the table below. The other endpoint of the plausible set of levering formulae includes both tax terms (at the marginal company tax rate) and a debt beta, for the latter we have assumed 0.10, which is labelled 'Levering 2'.

Table 4.13

US MONTHLY BETA: WHOLE PERIOD VS S&P500 INDEX – SENSITIVITY TO RELEVERING METHOD

Stock	OLS raw beta	Gearing (D/V)	60% relevered: Levering 1	60% relevered: Levering 2
Australia				
Portfolio of average returns	0.49	0.41	0.72	0.67
Portfolio of median returns	0.49	0.41	0.72	0.67
US				
Portfolio of average returns	0.50	0.45	0.68	0.75
Portfolio of median returns	0.46	0.43	0.65	0.70

Source: Bloomberg and ACG analysis

The combined changes to the levering method again have an effect on the equity beta that is derived, with the beta for Australian firms falling somewhat, and the betas for US rising slightly. Noting that none of the levering methods can claim to be correct, we conclude that it is appropriate to continue to use the simplest levering method that is described in Chapter 3.

Scholes-Williams beta

We noted in Chapter 3 that the AGSM has calculated an LM statistic of 0.022 for Envestra, indicating the potential for thin trading bias. We applied the Scholes-Williams methodology as a sensitivity to the last 60 months of observations and found that the central estimate increased slightly (from 0.52 to 0.55), while the upper 95 percent confidence interval increased markedly from 0.91 under OLS to 1.68 under Scholes-Williams.

4.5 Summary of results

The results set out in Chapter 4 for the portfolio estimates can be summarised as follows.

- For the **Australian firms**, the average geared beta for the whole period (excluding the technology bubble, which we defined as between 1 July, 1998 and 31 December, 2001) ranged between 0.7 and 0.9 depending on the estimation technique. In addition, 4 out of 6 of the estimates have an upper 95 percent confidence interval that was greater than or equal to 1. The results for the most recent five years were central beta estimates of 0.65 across all three estimation techniques, with the 95 percent confidence interval ranging from 0.9 to 1.

- For the **US firms**, the average geared beta for the whole period (excluding the technology bubble) ranged between 0.5 and 0.7, with all the upper 95 per cent confidence intervals being between 0.7 and 0.9. However, the betas measured over the most recent five years were materially higher, ranging between 0.7 and 1.1, with all of these estimates having an upper 95 percent confidence interval greater than 1.

The most striking feature of these results, however, is the change that has occurred in the period since we undertook a major study for the ESC. For the Australian firms, the only difference in method was the addition of another 16 months of observations since January 2007 (which was the cut-off date for the earlier study).[57] A larger sample was employed for the US firms – this time covering electricity utilities as well as gas utilities. Compared to the results described above, the equivalent results in our previous report found:

- for **Australian firms over the longest period**, a range of 0.6 to 0.7 (cf. 0.7 to 0.9), with only 1 estimate having an upper 95 per cent confidence interval above 1;
- for **Australian firms over the recent period**, a range of 0.2 to 0.4 (cf. 0.7), with none of the estimates having an upper 95 per cent confidence interval above 1;
- for **US firms over the longest period**, a range of 0.4 to 0.6 (cf. 0.5 to 0.7); and
- for **US firms over the recent period**, a range of 0.5 to 0.8 (cf. 0.7 to 1.1), with only two of the estimates having an upper 95 per cent confidence interval above 1.

In our view, the fact that the estimates of betas for similar or the same firms can change so materially in such a short period underscores the high degree of imprecision of estimates of beta. It also underscores the inadequacy of traditional measures of statistical precision to account fully for the uncertainty in beta estimation.

Market influences on measured betas and confidence intervals

There is a range of factors that may affect the precision of beta estimates. Traditional statistical measures of uncertainty show the extent of confidence as to whether a particular relationship existed over a historical period. However, the beta of concern is the *expected* beta not a *measured* beta, which will only coincide if the market conditions during the period of the study correspond to what investors expect to occur in the future.

A number of plausible hypotheses could be advanced as to why the future may differ to the past. With the benefit of today's perspective, it would appear that the period of unusually low market volatility observed in the 5 years to the beginning of 2007 (which constituted the period of data for our previous study) was a short-term aberration. The average 5-year market volatility of the ASX since 1980 was 13.7 percent. But the lowest point of this series was reached late in 2005, and at the beginning of 2007, was still much lower than the 28 year average. Since mid-2007 the 5-year average market volatility has increased markedly, and this has coincided with the rise in the beta estimates for energy transmission and distribution in both Australia and the US.

[57] We also added 13 months of observations at the beginning of the data period, which was for AGL.

We have noted in our previous advice that low levels of market volatility make it more difficult to estimate betas – and result in wider statistical confidence intervals – as regression techniques rely on variation in the key inputs. However, it is also possible that the low level of volatility may have led to a downward bias in betas over that period if the absence of volatility was due to the absence of macroeconomic factors that have a particular impact on utilities. Equally, however, coinciding with the return to normal market volatility has been a sharp increase in interest rates and an increase in interest rate volatility, which may have a more pronounced effect on utilities and be over-represented in current observations.

In our view, a proper assessment of the true level of uncertainty in beta estimates needs to take account of the potential for the change in the mix of macroeconomic events between periods to have a material effect on betas, which implies the true level of uncertainty would be materially higher than what is implied by statistical confidence intervals.

4.6 Conclusion

We have been asked to form an opinion on whether the empirical evidence provides persuasive evidence that the equity beta for a regulated electricity transmission or distribution business should be moved from the currently applied regulatory equity beta of 1.

Of the results for Australian firms summarised above, a beta of 1 is within the 95 per cent interval in a significant proportion of the estimates. In addition, even though all of the estimates for the US firms using the whole period of data would appear to reject the proposition that the 60 percent geared beta is 1, this is not the case for the latest period, where none of the estimates reject the proposition that the 60 percent geared equity beta is 1. The contradictory implications of these confidence intervals highlight the fact that conventional statistical tests of the reliability of the data are flawed.

There is a great deal of uncertainty about the equity beta for regulated electricity transmission or distribution business that is currently expected by the market, which makes it difficult to form a strong view about what is the best estimate of that equity beta. The estimation of beta for the Australian regulated energy sector has been hampered by a paucity of data over a long period, but the material rise in the estimates of beta observed for the Australian portfolio data since our last report in 2007 due to the addition of a relatively small number of months of data gives even greater cause for concern about the reliability of the estimates than had previously existed.

In conclusion, having analysed the available evidence, we do not consider that the evidence in this report provides convincing or persuasive evidence that the equity beta for a regulated electricity transmission or distribution business is different from 1.

Appendix A

Bloomberg ticker-codes

Stock	Bloomberg Ticker
Australia	
Australian Gas Light	AGL
Alinta	AAN
Envestra	ENV
Australian Pipeline Trust	APA
GasNet	GAS
DUET	DUE
SP AusNet	SPN
Spark Infrastructure	SKI
Hastings Funds Management	HDF
United States	
AGL Resources	ATG
Atmos Energy	ATO
CH Energy Group Inc	CHG
CentrePoint Energy	CNP
Energy East	EAS
Consolidated Edison	ED
NICOR Inc	GAS
ITC Holding Corp	ITC
Laclede Group	LG
NiSource Inc	NI
New Jersey Resources	NJR
NSTAR	NST
Northeast Utilities	NU
Northwest Natural Gas	NWN
Piedmont Natural Gas	PNY
Pepco Holdings	POM
South Jersey Industries	SJI
Sierra Pacific	SRP
Southwest Gas	SWX
UIL Holdings Corp	UIL
WGL Holdings Inc	WGL

Source: Bloomberg

Appendix B

Methodology for Bloomberg downloads

B.1 Bloomberg methodology

We downloaded almost all of the data applied in estimating betas in this study from Bloomberg. An exception was the net debt information for Spark Infrastructure due to the need to adjust for loan notes within the stapled securities structure. This Net debt information was provided by the management of Spark Infrastructure.

During the course of this study, we discovered discrepancies between the newly downloaded Bloomberg data and the archived data set that was used in our previous study. Bloomberg advised that its data are adjusted over the course of time for in-specie dividends or other dilution effects. Consequently, in order to maintain data consistency, we constructed a new database based on the current information available on Bloomberg.

This Appendix sets out the steps required to construct the data sets used by us for the purposes of this study.

Company Data – Price, Dividend, Net Debt, Market Capitalisation and Gearing

Bloomberg fields used are as follows:

PX_LAST (Last price), HISTORICAL_MARKET_CAP (Historical market cap), CUR_MKT_CAP (Current market cap), NET_DEBT (Net debt), DIV_HIST_ALL (Dividend history)

Current market cap information from Bloomberg was available only back to May 2002 as at the time of data download. Historical market cap information was used for periods before May 2002.

Net debt and historical market cap information are reported figures available in the database at the date of financial statements. A linear interpolation of net debt and historical market cap information was undertaken for the months in between reporting periods.

Interpolation of net debt was based on the following formula:

$$\frac{NetDebt(t+1) - NetDebt(t)}{12} \times NumOfMonths$$

Interpolation of market cap can be broken down to the following sub-steps:

1. Calculate the number of shares based on reported historical market cap and last price

$$NumOfShares(t) = \frac{HistoricalMarketCap(t)}{Last\,Price}$$

2. Interpolate the number of shares in between reporting periods

$$\frac{NumOfShares(t+1) - NumOfShares(t)}{12} \times NumOfMonths$$

3. Calculate the market cap for the period based on the last price for the period and the corresponding interpolated number of shares.

$$MarketCap(t) = NumofShares(t) \times LastPrice(t)$$

Gearing is defined as $\dfrac{NetDebt}{NetDebt + MarketCap}$

Market Gearing

In order to avoid interpolation of net debt for the months in between reporting periods, we back-calculated net debt information from Bloomberg data that are available at least on a monthly basis such as current market cap, debt to market cap, cash and equivalents per share on Bloomberg.

Bloomberg fields used are as follows:

CUR_MKT_CAP (Current market cap), PX_LAST (Last price),
DEBT_TO_MKT_CAP (Debt to market cap ratio),
CASH_AND_EQUIV_PER_SH (Cash and equivalents per share)

Market gearing for period *t* is defined as the sum of net debt divided by the sum of market cap and net debt for all the companies in the market.

$$MarketGearing(t) = \frac{\sum_{i=1}^{i=n} NetDebt(i,t)}{\sum_{i=1}^{i=n} MarketCap(i,t)}$$

where:

i = company i

$NetDebt(i,t) = Debt(i,t) - CashAndEquiv(i,t)$

$Debt(i,t)$ = debt of company i for the period t

$CashAndEquiv(i,n)$ = cash and equivalent for company i for the period t

Company debt information was calculated from current market cap and debt to market cap ratio.

$$Debt(i,t) = CurMktCap \times DebtToMktCapRatio$$

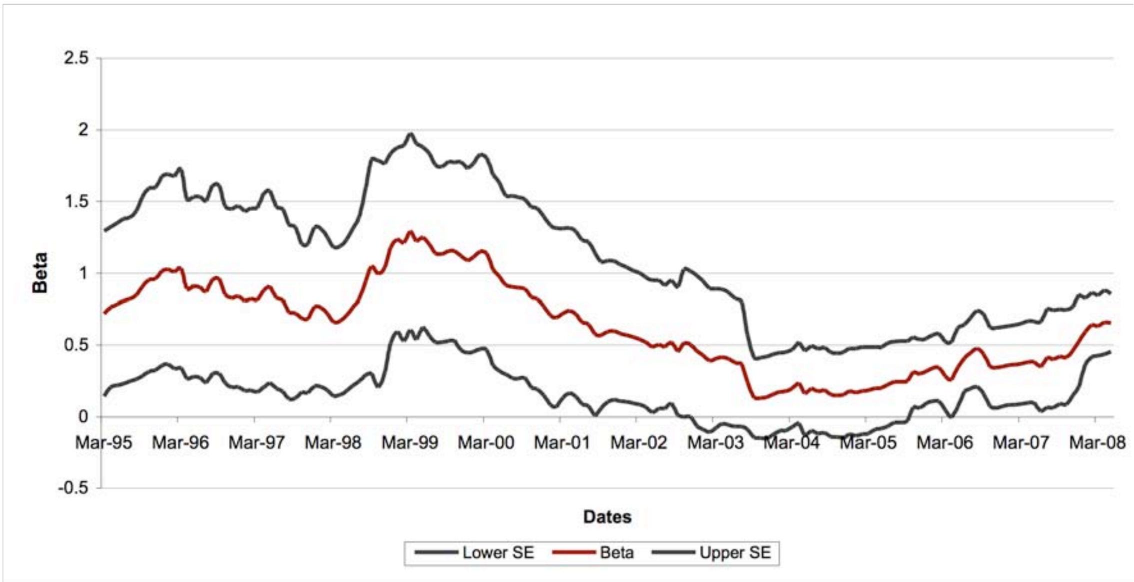
Cash and equivalent was calculated from cash and equivalent per share ratio, current market cap and last price

$$CashAndEquiv(i,t) = CashAndEquivPerShare(i,t) \times \frac{MarketCap(i,t)}{LastPrice(i,t)}$$

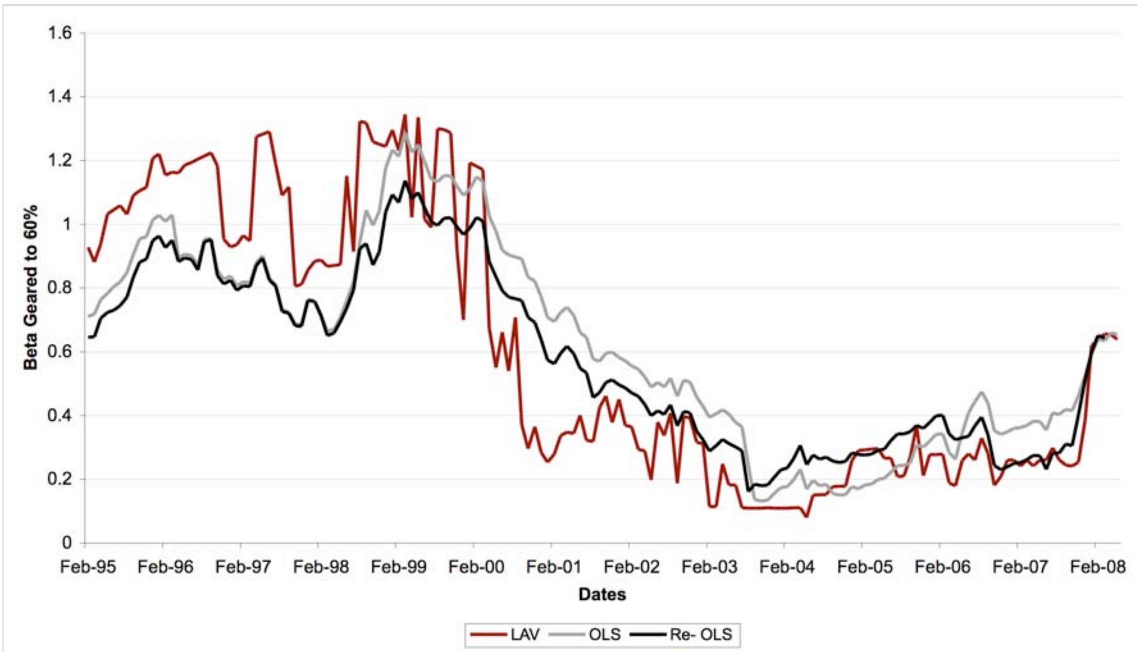
Appendix C

Rolling Beta Estimates

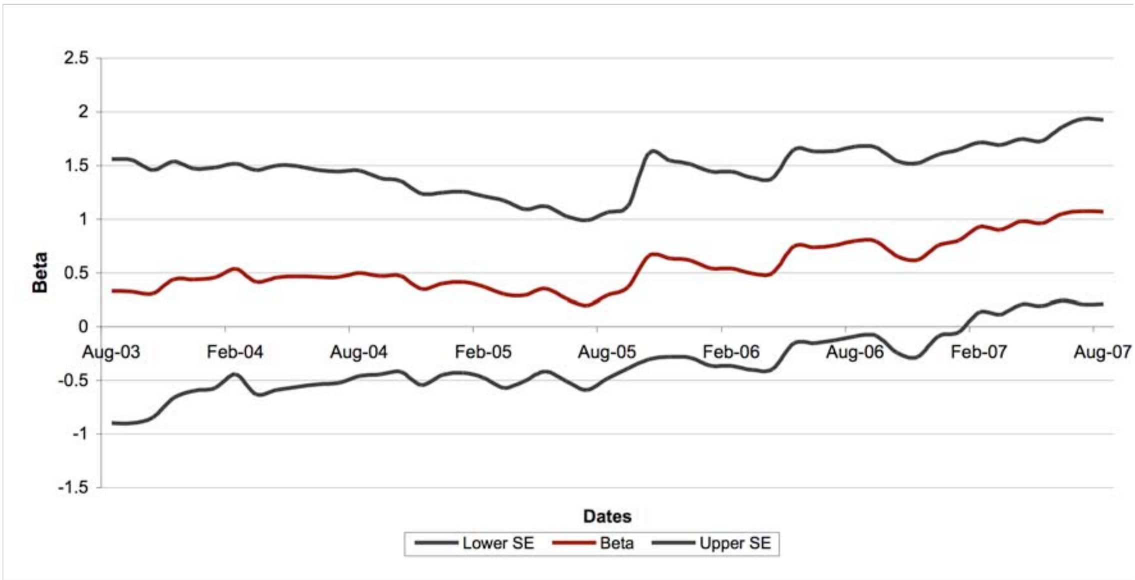
C.1 Australian average portfolio – OLS



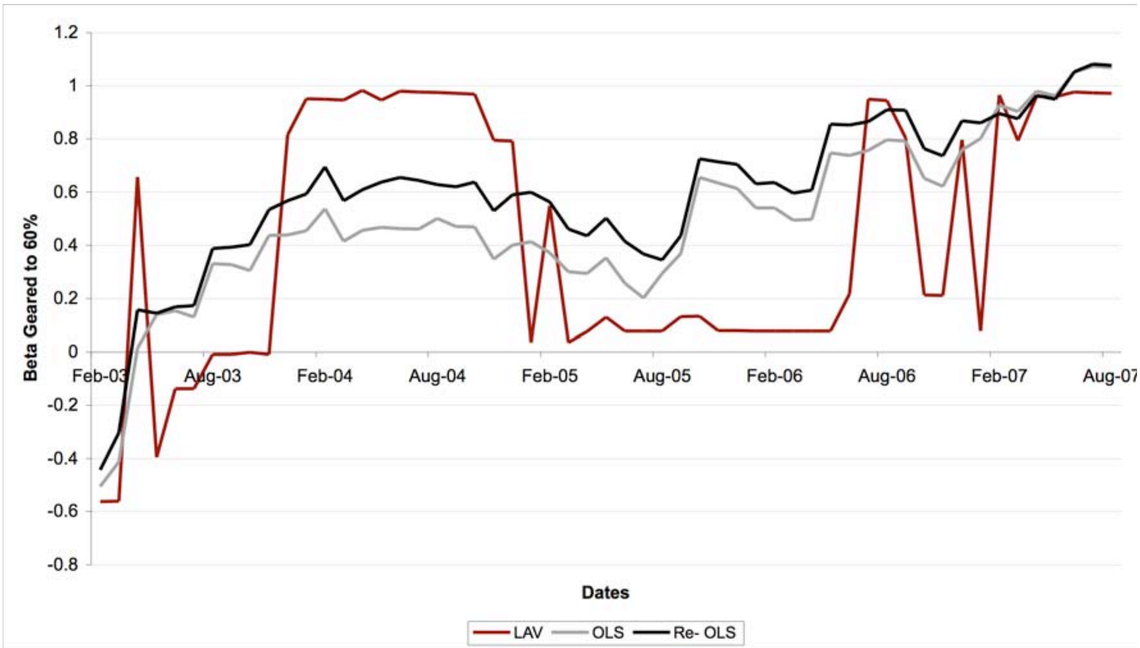
C.2 Australian average portfolio – OLS Re- OLS LAV



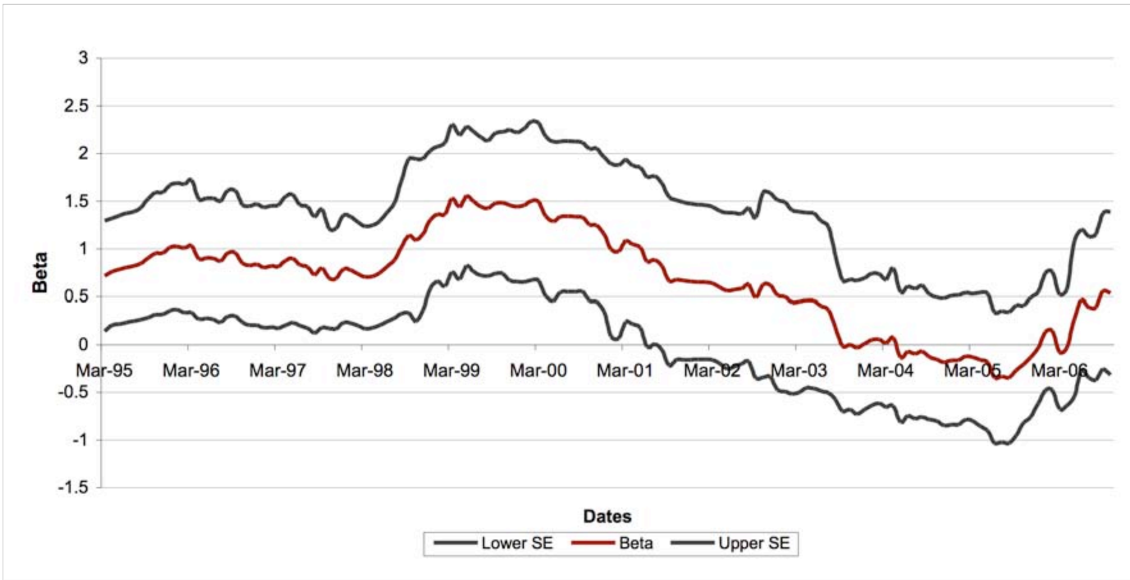
C.3 Alinta Holdings – OLS



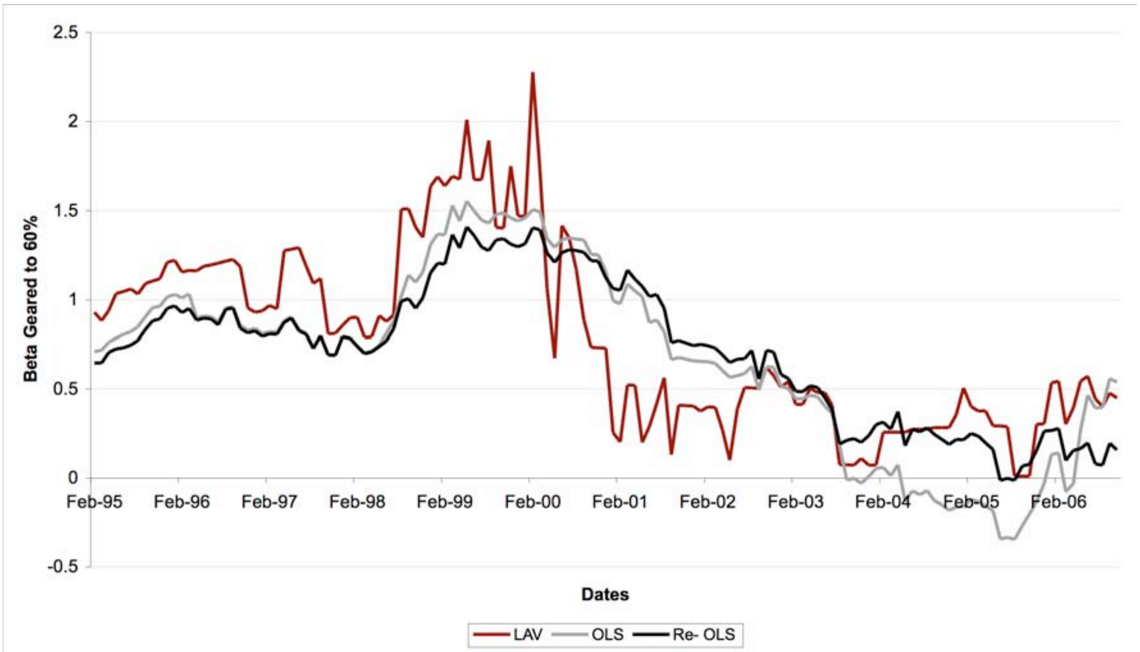
C.4 Alinta Holdings – OLS Re- OLS LAV



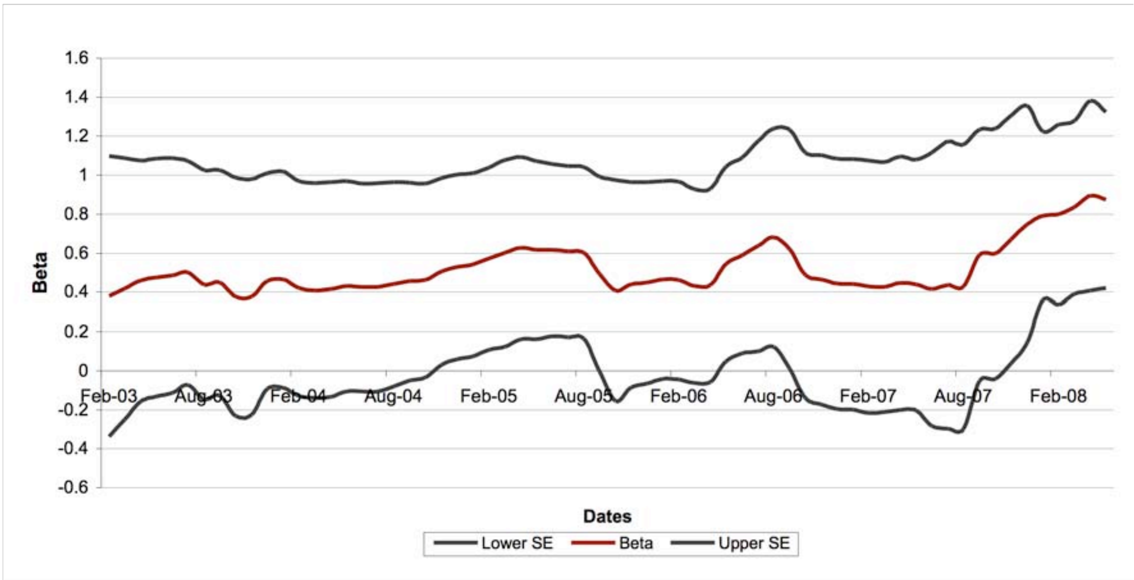
C.5 AGL – OLS



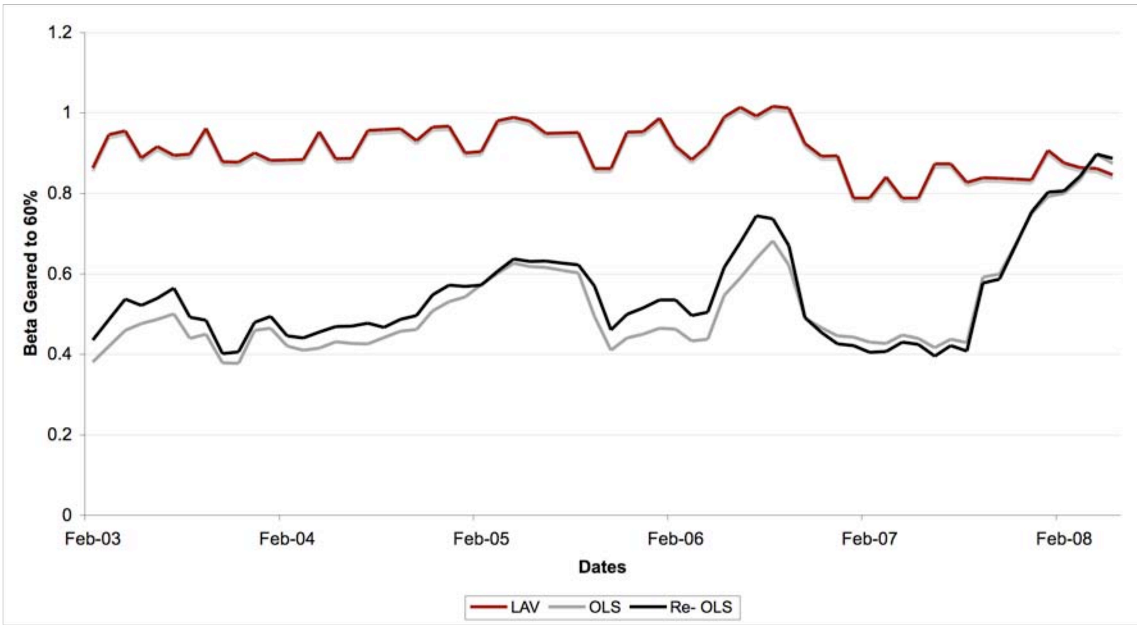
C.6 AGL – OLS Re- OLS LAV



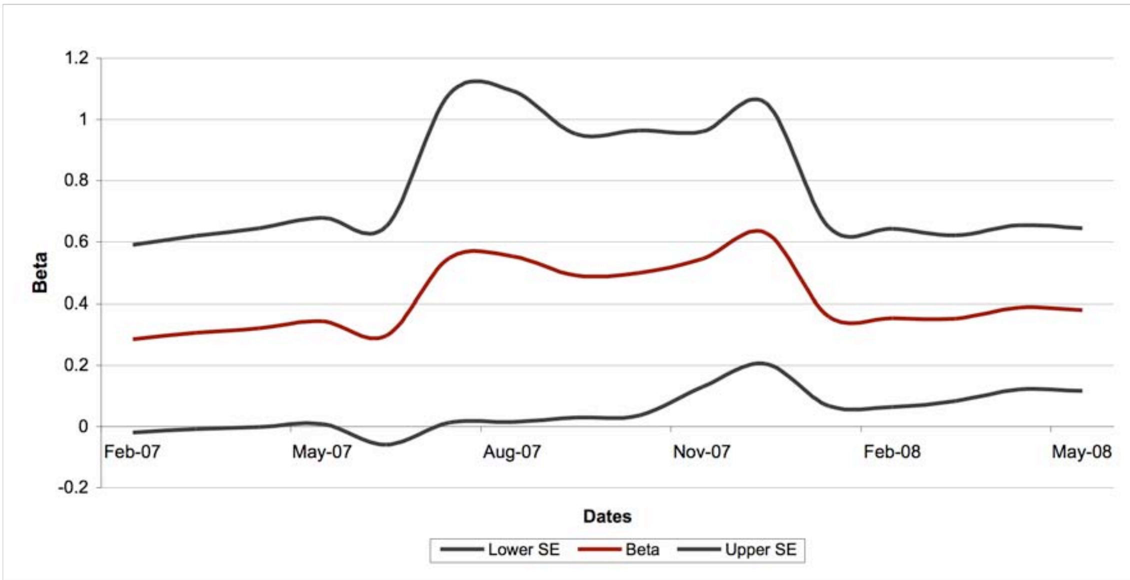
C.7 Australian Pipeline Trust – OLS



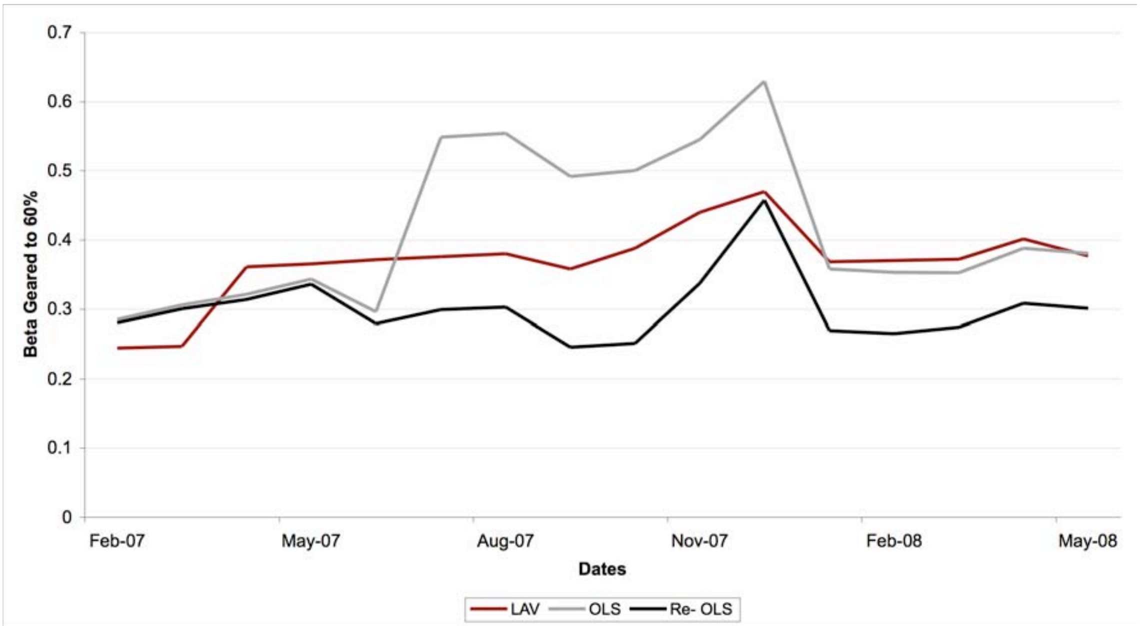
C.8 Australian Pipeline Trust – OLS Re- OLS LAV



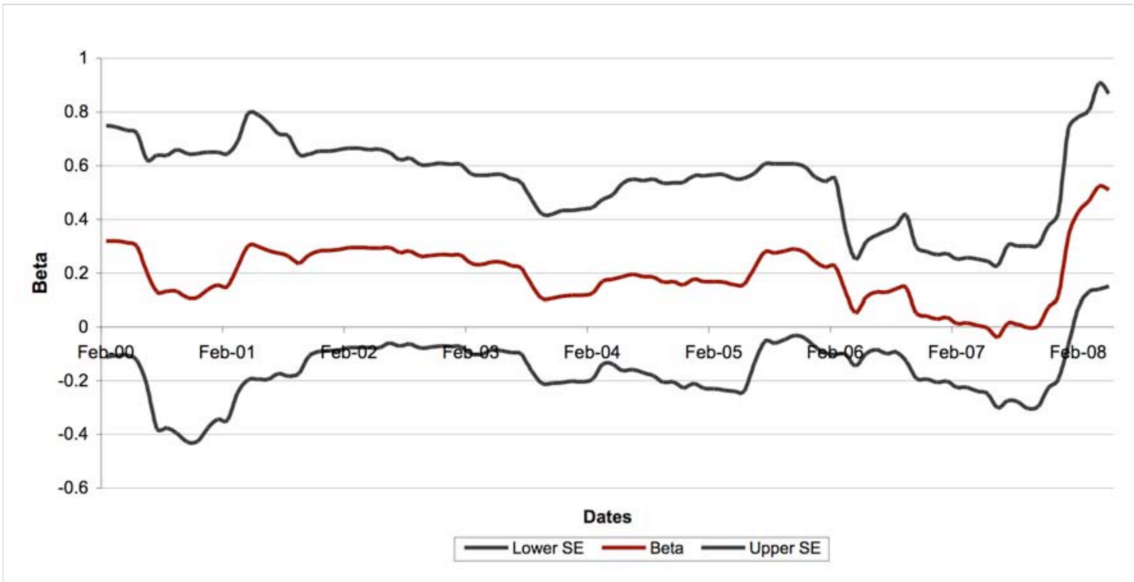
C.9 Diversified Utilities Energy Trust – OLS



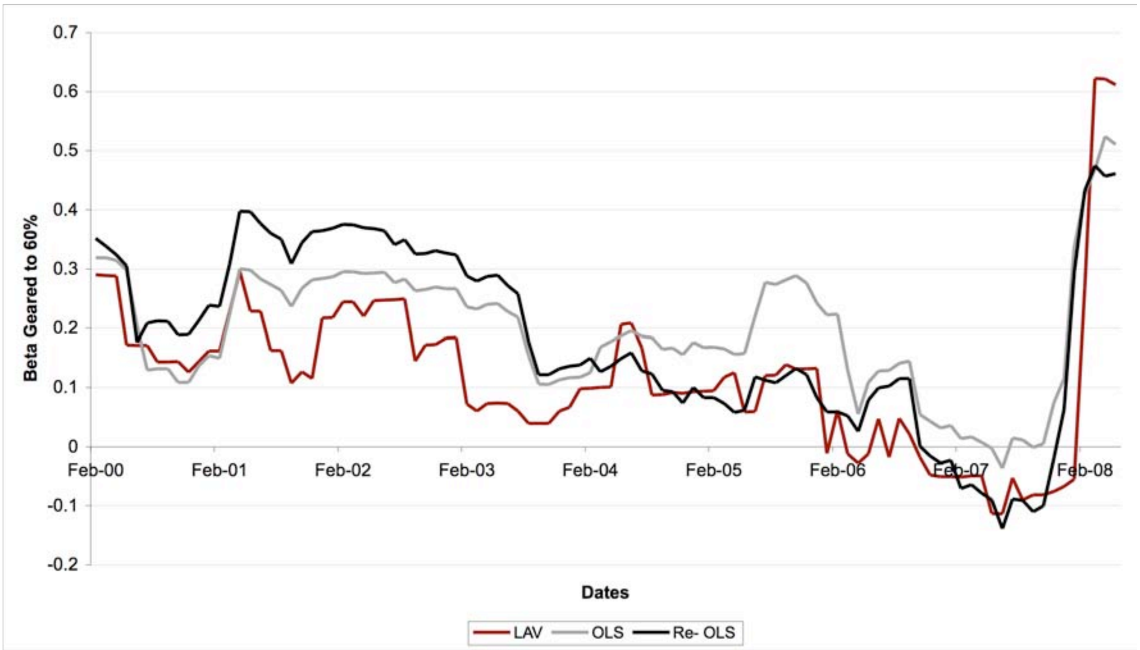
C.10 Diversified Utilities Energy Trust – OLS Re- OLS LAV



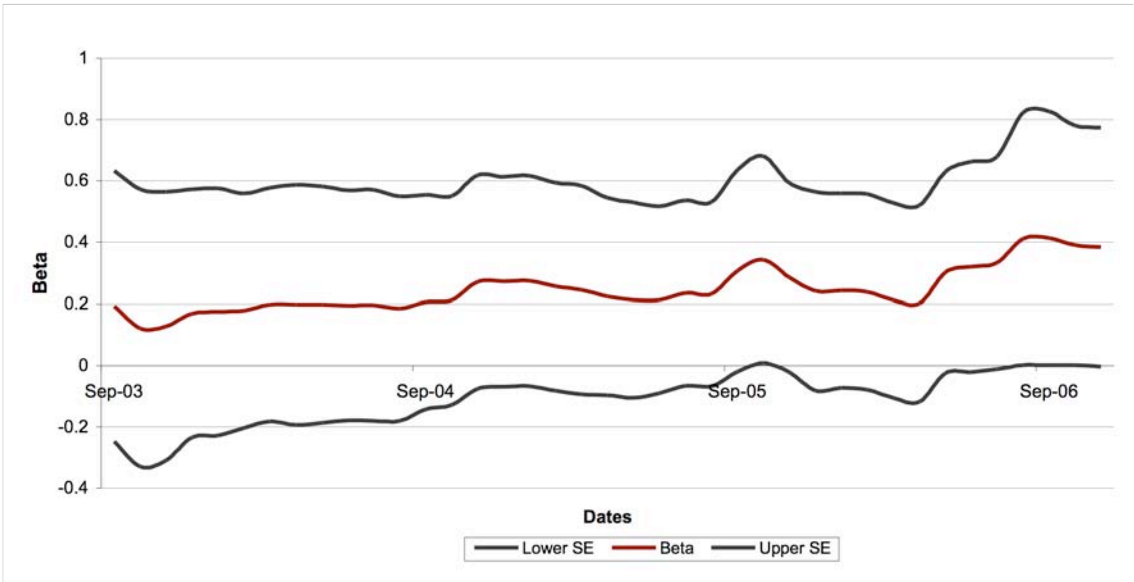
C.11 Envestra – OLS



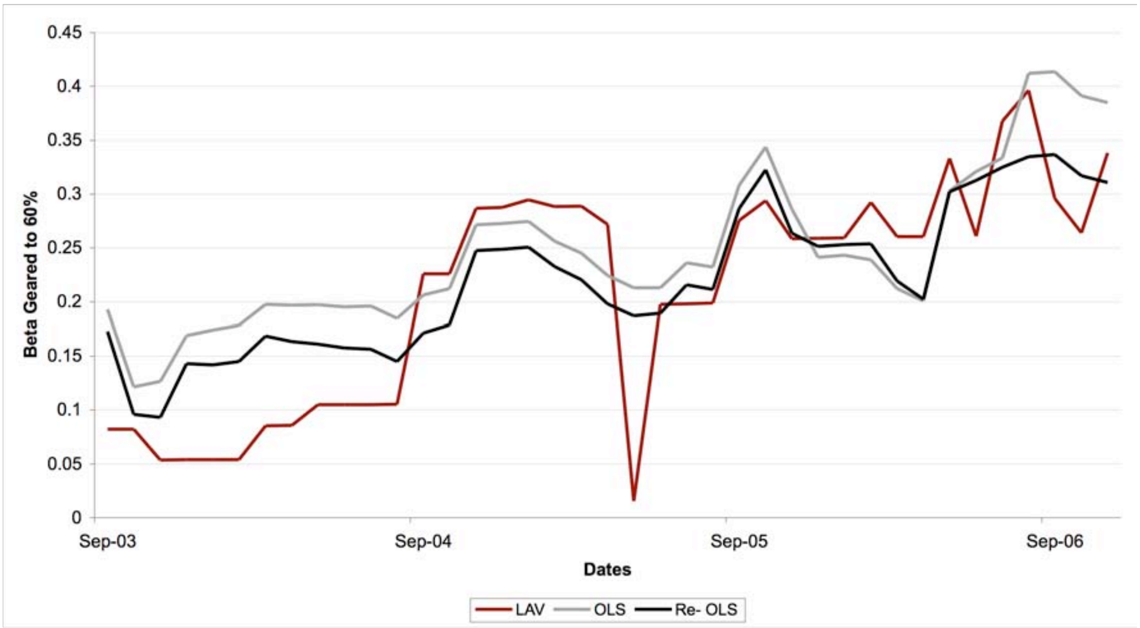
C.12 Envestra – OLS Re-OLS LAV



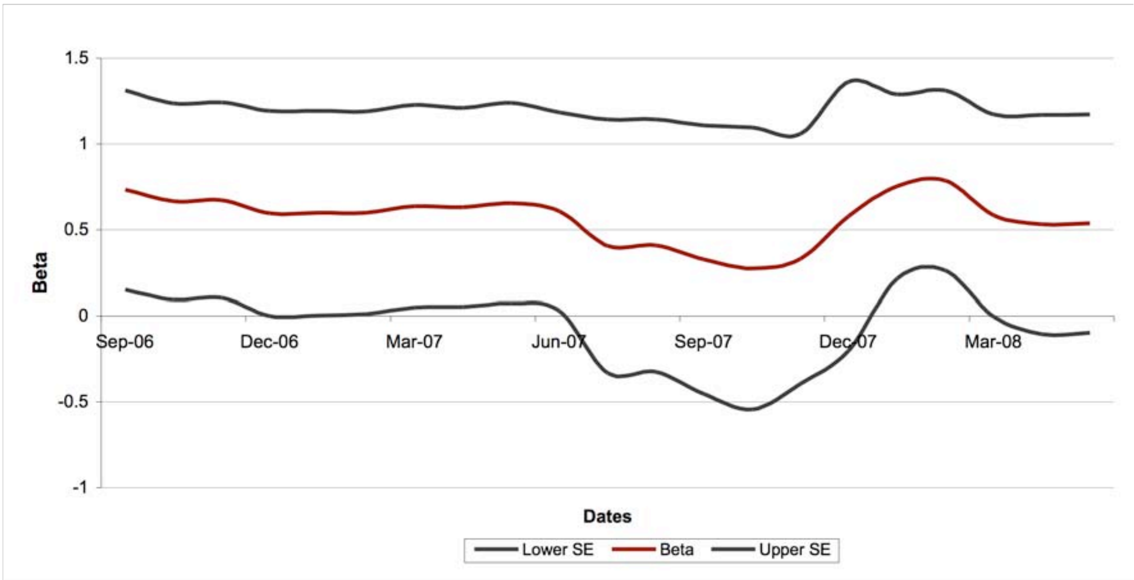
C.13 GasNet Holdings – OLS



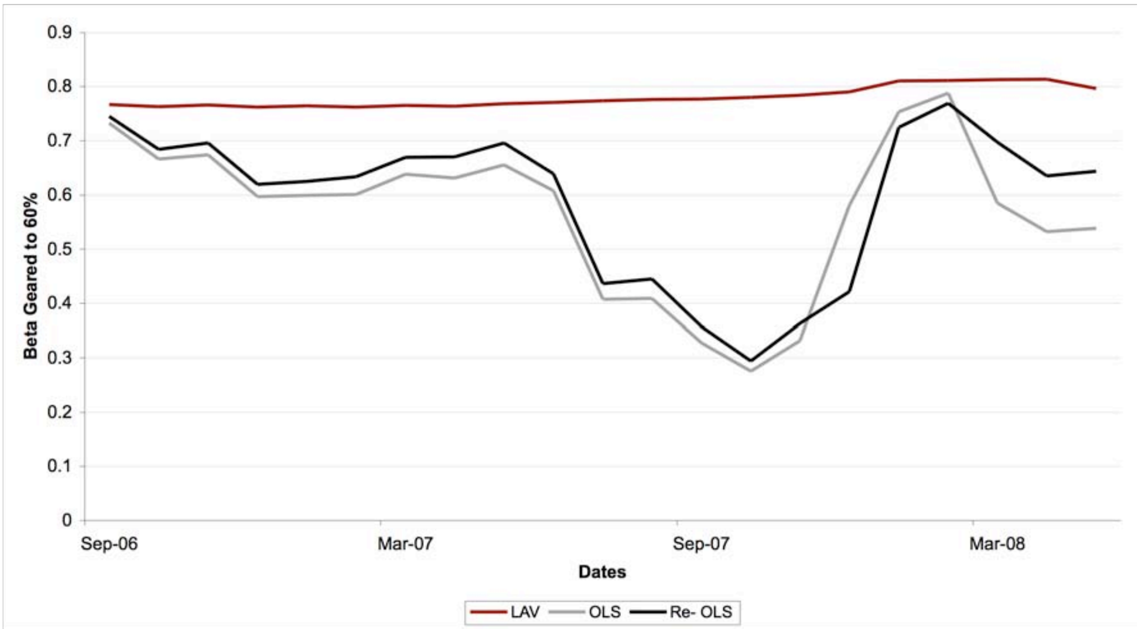
C.14 GasNet Holdings – OLS Re-OLS LAV



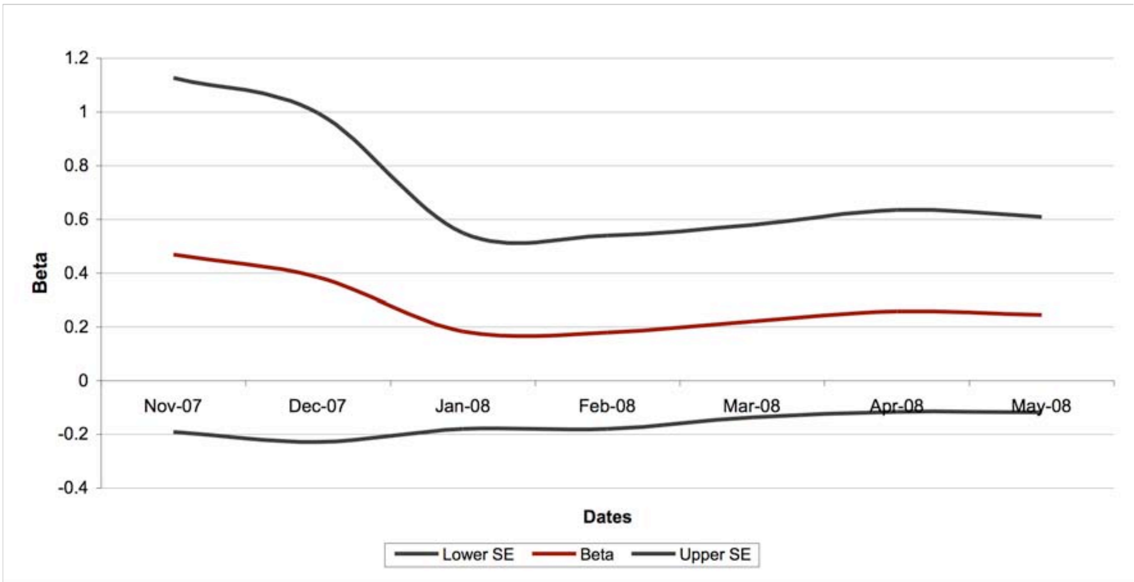
C.15 Hastings Diversified Fund – OLS



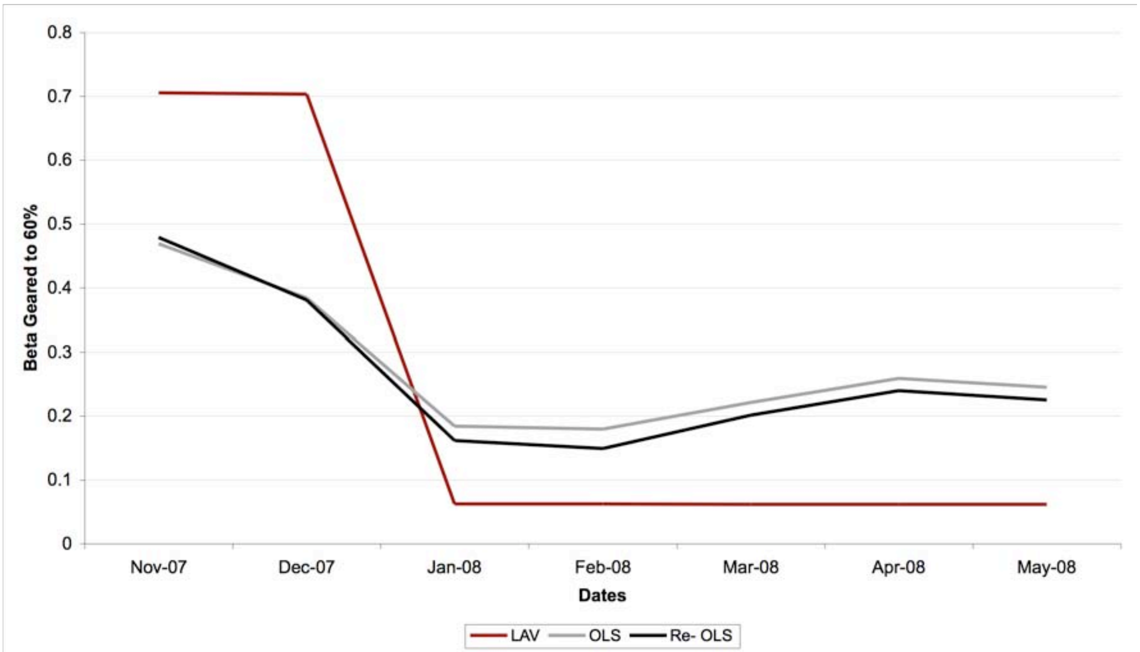
C.16 Hastings Diversified Fund – OLS Re- OLS LAV



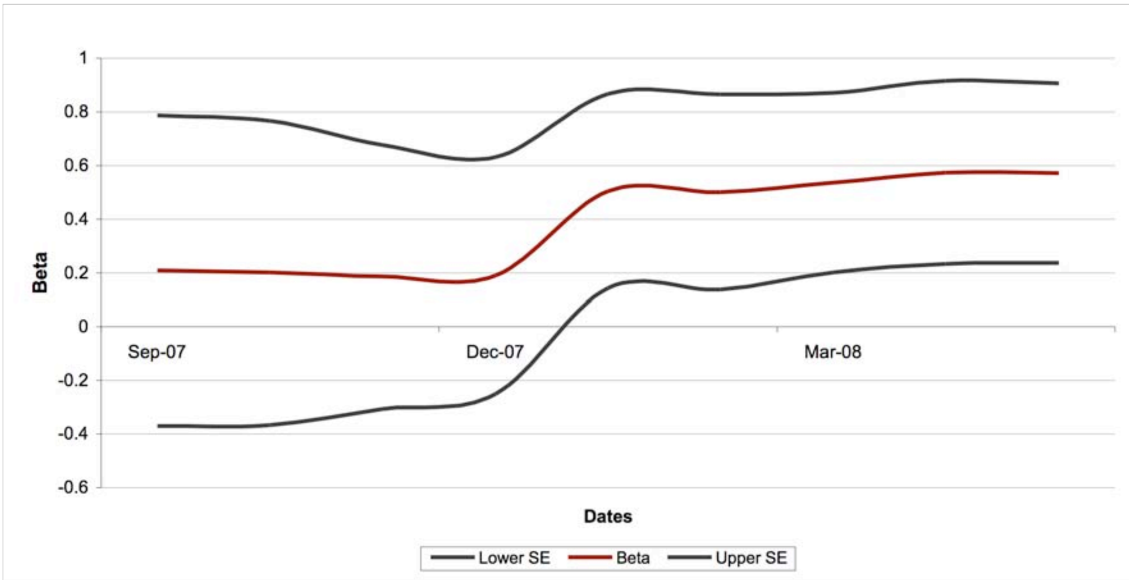
C.17 SP AusNet – OLS



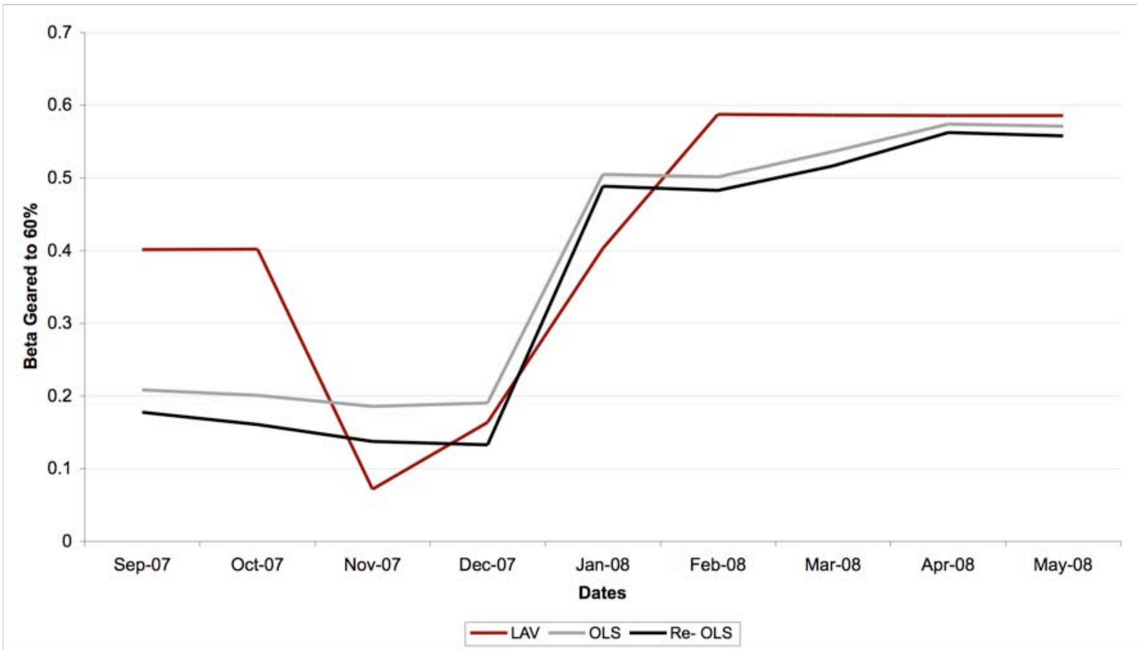
C.18 SP AusNet – OLS Re- OLS LAV



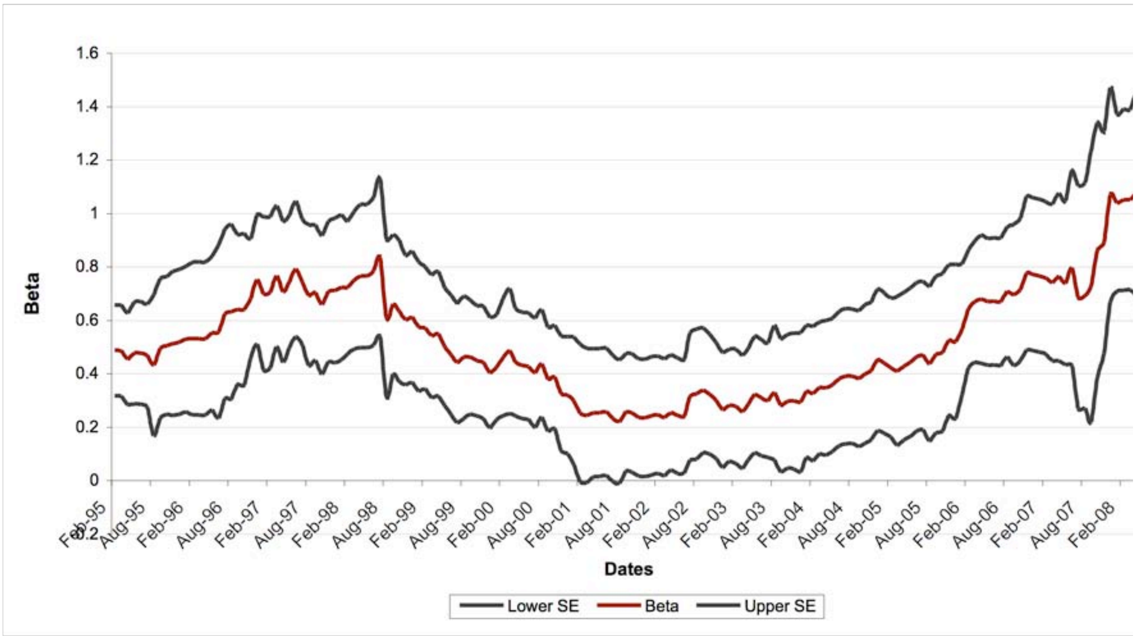
C.19 Spark Infrastructure - OLS



C.20 Spark Infrastructure – OLS Re- OLS LAV



C.21 United States average portfolio – OLS



C.22 United States average portfolio – OLS Re- OLS LAV