COMPETITION
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GROUP

Regression estimates of equity beta

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1 Executive summary

1. CEG has been asked by DBP to examine the Economic Regulation Authority's (ERA) analysis estimating betas for companies with regulated assets using historical stock market data.

1.1 Unable to replicate ERA results

2. We have been unable to replicate the ERA's beta estimates. In particular, when we attempt to follow the ERA's methodology, there are significant differences between the ordinary least squares (OLS) beta estimate we derive for DUET (0.32 vs 0.17) and SP AusNet (0.27 vs 0.05). Primarily as a consequence of this difference we estimate higher average OLS betas when we attempt to replicate the ERA's analysis. Specifically, 0.56 versus 0.50 across the average of the ERA's sample of firms. For the reasons set out in section 3.2, we consider OLS beta estimates are the most reliable of all the regression methodologies used by the ERA. Consequently, this difference is material and should be investigated further.

1.2 Suggested amendment to ERA sampling interval

3. We recommend that the ERA adapt its methodology to estimate betas over a range of different sampling interval. The ERA creates a single return series based on measuring weekly returns from Friday of one week to Friday of the next week. This is a somewhat arbitrary way of creating a return series and the ERA could just as easily define returns as from Monday to Monday or Tuesday to Tuesday (etc.).

4. To the extent that the results are invariant to such arbitrary distinctions then the choice of one or the other sampling interval would not matter. However, the results are highly sensitive to the choice of sampling interval. For example, the impact of defining weekly returns over the week from Monday to Monday raises the average beta for the firms in the ERA sample from 0.56 to 0.62 (0.06 higher). Using daily sampling intervals the average beta is 0.67. If we use monthly returns, the average beta can be as high as 0.94 and as low as 0.29 depending on what day of the month is used to measure returns.

5. There are an extremely large number of possible sampling intervals that can be used to estimate beta and there is no *a priori* reason to believe that one sampling interval is better than another. In this report we estimate betas for 26 different sampling intervals - consistent with the 5 possible definitions of a weekly return, the single possible definition of daily returns, and 20 different possible definitions of monthly returns. This is a very small subset of the possible sampling intervals (which could be defined in terms of number of trading days instead of number of calendar weeks/months etc.) .

1.3 Assessment of uncertainty in the beta estimate

6. There is a very large degree of uncertainty around the best estimate of beta, especially using only Australian data – and much larger than the confidence intervals that the ERA reports in the Explanatory Statement.

7. The ERA uses standard regression statistics to calculate a 95% confidence interval around its beta estimates. For the OLS regression based on an equally weightedportfolio of all six stocks this range is 0.37 to 0.61. In our view this is a considerable overestimate of the true statistical precision of the beta estimates as a proxy for investors' forward looking beta estimates – which is, in our view, what must be estimated under the Rules. This is because the regression confidence intervals rely, amongst other things, on the following assumptions about how investors' form their forward-looking beta estimates:

   - That investors form their expectations of forward-looking beta risk on the basis of regression analysis;
   - That investors only have regard to betas estimated using 'week ended Friday' return series;
   - That investors only have regard to the time period 4/01/2002 to 19/04/2013;
   - That investors only have regard the average behaviour of beta in that period (i.e., that investors believe that beta is stable over time); and
   - That investors only have regard to the betas for the 6 proxy firms examined by the ERA.

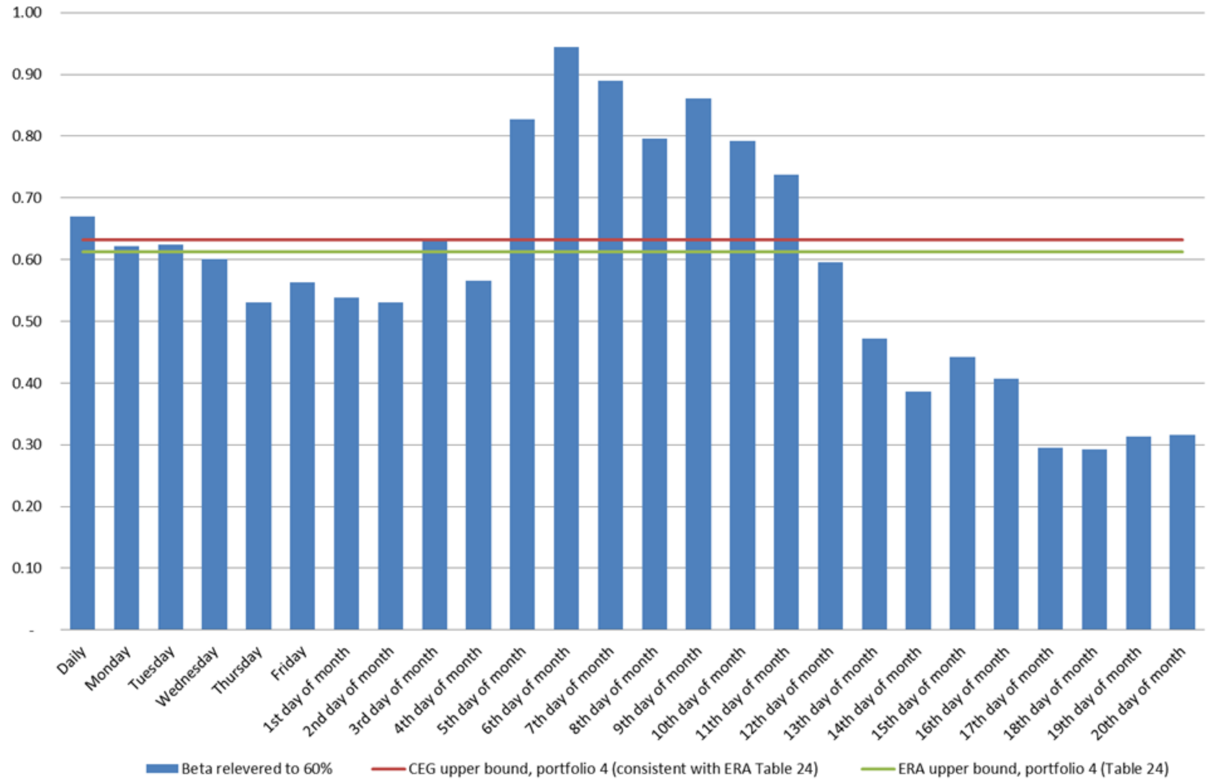
8. Even if there is no a priori reason to believe that relaxing each of these assumptions will raise/lower the best estimate of beta, there is a strong basis to conclude that relaxing these assumptions will increase the width of the confidence interval around any estimate of beta.

9. By way of illustration we can simply relax the second of the assumptions above. Figure 1 below shows the average beta (averaged across the ERA's six proxy companies) for each of the 26 sampling intervals described in the previous subsection.

10. The bar on the far left hand side of Figure 1is the average daily beta, the next five bars represent the average weekly betas (one bar for each possible definition of a week (week ended Monday first, then week ended Tuesday etc.). The next 20 bars each represent different definitions of a month. The first monthly bar represents the beta associated with measuring returns to the first week day of each month. The second monthly bar represents the beta associated with measuring returns to the second week day of each month, etc... There are only 20 monthly beta estimates defined in this manner because there are only 20 week days in February.

11. The horizontal lines in Figure 1 show the upper bound beta as estimated by the ERA (green line) and by CEG following the 'week ended Friday' ERA methodology (red line) for the equally weighted portfolio that includes all stocks (P_4).

Figure 1: Australian OLS beta estimates associated with different sampling intervals



Source: Bloomberg, CEG analysis

12. If the upper bound estimates were reliable, we would expect to only see around 2.5% of average beta estimates exceed the upper bound (and 2.5% below the lower bound – not shown). In reality, there are 9 observations in Figure 1 that are above the CEG upper bound (the upper bound estimated by CEG following ERA methodology) and 11 above the ERA upper bound. That is, almost half (42%) of all observations are above the ERA 97.5% upper bound.

13. This demonstrates a clear problem with the methodology underpinning the upper bound estimate. Relaxing just one of the assumptions listed above (week ended Friday returns interval) results in most beta estimates falling outside the ERA's confidence interval. This is in large part due to the fact that, because the ERA restricts itself to examining only Australian regulated firms, there are just 6 observations in the ERA sample. For this reason, and the additional reasons described in sections 4.1 4.2 4.3 and 4.4, relaxing all of the assumptions implicit in

the ERA confidence interval estimate would result in a 95% confidence interval that extends well above 1.0.

1.4 Using US betas to increase sample size and improve beta estimate accuracy

14. Any estimate of beta based on a sample of only six firms is bound to be imprecise and will be inherently unreliable. This problem can be addressed by including regulated businesses from other countries in the sample. CEG has separately identified a sample of 56 US businesses with at least 50% of total assets subject to regulation.[1] CEG chose the 50% threshold based on analysis showing that, above 50% regulated assets, there was no statistical relationship between historical regression beta and the percentage of regulated assets. That is, all US businesses with more that 50% regulated assets have similar asset betas and, therefore, the non-regulated assets are not biasing the estimated beta for this sample. As discussed below, US historical betas are highly relevant to forming an estimate of investors' forward looking beta estimates for Australian utilities.

15. For this sample of 56 companies, the sensitivity of the US results to the sampling interval is much lower due to the larger number of firms in the sample. The range between the maximum and minimum average betas in Figure 1 (the Australian sample) is 0.65 (from 0.29 to 0.94) while the equivalent range for the US sample is 0.39 (0.63 to 1.02).

16. We have assessed whether there is any reason to believe that US regulated utilities are higher risk than Australian utilities and have found that, if anything, the opposite is true. Therefore, we consider that each US regulated utility beta should be given the same weight as an Australian regulated utility beta.

17. However, we recognise that one might want to take a cautious route and give less than equal weight to US observations. This is the approach taken by SFG in their recent report for the ENA where they decided to give twice the weight to Australian observations.[2]

18. This approach involves a significant loss of accuracy and precision in the final estimate. It is equivalent to not using half of the available US observations. This could be justified if there was strong evidence that US betas were a biased estimate of the forward-looking beta perceived by investors in Australian utilities. However, in our view there is no reliable evidence to this effect. Certainly, the lower average betas for the small sample of Australian utilities do not provide such evidence.

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1 CEG, Information on equity beta from US companies, A report for the ENA, June 2013.

2 See page 16 of, SFG, *Regression-based estimates of risk parameters for the benchmark firm*, 24 June 2013.

Consequently, giving lower weight to US beta estimates results in a sacrifice of both precision and accuracy.

19. Moreover, a consistent logic should be applied when considering the weight given to US betas and when considering the weight given to observations within Australian beta set. For example, DBP is a gas transmission asset and only two firms in the ERA sample are primarily gas transmission businesses (APA and HDF). While DUET is a part owner of DBP[3] it derives most of its revenues from gas and electricity distribution in Victoria.) The average re-levered beta of APA and HDF across all sampling intervals is 0.94. These are the two highest betas in the sample and their average is more than double the average of the remaining four companies.

20. One could take the view that US betas were not directly comparable to Australian betas solely on the basis that US betas tended to be higher than the average of the small Australian sample (in the period under consideration). One could then conclude that US betas should be given low or zero weight. However, if one did reach this conclusion then internal consistency would suggest that the same logic be applied to weighting within the Australian sample. Specifically, DUET, SP AusNet, Spark Infrastructure and Envestra should be given low or zero weight when estimating beta for DBP – as these companies are not predominantly gas transmission pipeline operators and have substantially lower betas than the predominantly gas transmission pipelines in the sample.

21. In our view this conclusion would be wrong because it is based on too small a sample to be reliable. But, for precisely the same reason, it would be wrong to give zero weight to US beta estimates.

3 60% prior to 2011 and 80% since.

2 Introduction

22. DBP has asked CEG to provide a replication and analysis of the ERA's beta estimates in section 12.3 of the August 2013 *Explanatory Statement for the Draft Rate of Return Guidelines: Meeting the requirements of the National Gas Rules*.

23. Under the National Gas Rules the ERA is required to make its decisions consistent with the "allowed rate of return objective". That is defined in Rules 87(3) and (4) to be:

- Commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to the service provider in the provision of reference services; and
- A weighted average of the return on equity for the access arrangement period in which that regulatory year occurs and the return on debt for that regulatory year.

24. The remainder of this report has the following structure.

- Section 3 describes data sources used and provides our attempt to replicate the ERA's results; and
- Section 4 summarises the sensitivity of beta estimates to different estimation methodologies and:
  - describes the implication of this for estimates of confidence intervals around the beta estimates;
  - describes how increasing the sample size by including US betas can help address the statistical uncertainty.

3 Replication of ERA results

25. We have attempted to replicate the ERA's results as reported in Tables 19 to 25 of the Explanatory Statement. We have been unable to replicate the ERA's results. The main conclusions of this section are:

- That we consider the ordinary least square regression provide more reliable estimates of beta than "robust regressions" (i.e., regressions that are robust to 'outliers');
- We estimate significantly higher OLS betas for DUET and SPN than the ERA (SPN (0.27 vs 0.05) and DUET (0.32 vs. 0.17)). Our estimates are consistent with those produced by Bloomberg over the same time period and also those estimated by SFG over a similar time period.[4] Our higher estimates for these firms are largely why we estimate higher average OLS betas.
- We do not estimate higher robust regression betas for DUET and SPN. This suggests that there may be some unusual returns in the ERA's data set that are not in our dataset (the effect of which lowers the OLS betas estimated by the ERA but not the robust regressions). Conceivably, this could be due to inappropriate treatment of rights offerings in the ERA's return series (we note that both DUET and SPN had discounted rights offers during the period).
- Table 18 and Table 19 of the ERA Explanatory Statement provide different OLS and LAD estimates that both seem to relate to the same ERA analysis (2013 study). It is unclear why these figures are different. Notwithstanding differences in individual beta estimates, the average across all firms is similar in Table 18 and Table 19 (0.51 in Table 18 and 0.50 in Table 19). In what follows where we compare our estimates to the ERA we compare to Table 19 not Table 18.
- The ERA's Table 23 reports values for the number of observations used that suggest that the ERA did not use the data range set out earlier in Table 17. For example, based on Table 17 there should be 590 observations for both Envestra and APA.[5] However, Table 23 reports only using 261. It is possible that the reporting of 261 is a typographical error.

26. The remainder of this chapter has the following structure:

- In section 3.1 we describe our data sources and estimation methodology;
- In section 3.2 we describe why we prefer the OLS regression to the regressions that are robust to outliers;

4 See appendix 8 of SFG, Cost of capital parameter estimates for energy networks, June 2013.

5 From the 4/01/2002 (the earliest date in the Table 17 data range reported for both Envestra and the All ordinary index) to 19/04/2013 there are 590 weekly returns.

- In section 3.3 to section 3.8 we provide our own regression estimates and a comparison of these to the ERA's estimates. Each section has the same structure showing first our estimates and then presenting a table showing our estimates less the ERA's estimates.

3.1 Data sources

27. We collected total return indices based on price changes and reinvested dividends from Bloomberg for each individual stock as well as for the US and Australian markets. Indices for the total return on each stock were sourced from Bloomberg using the Total Return Index (Net Dividends) field. We used the Australian Stock Exchange Accumulation All Ordinaries Index (ASA30 index) for the Australian market and the S&P 500 Total Return Index (SPXT index) for the US market.

28. Market capitalisation and net debt data were used to calculate the gearing for each stock and to weight stocks in weighted portfolios. For market capitalisation, we sourced Bloomberg's Current Market Cap data which gives the market value of all of a company's outstanding shares. We used Bloomberg's Net Debt data which gives the company's overall debt situation by netting the value of a company's liabilities and debts with its cash and other similar liquid assets.

29. Our estimates for gearing for the Australian firms were very similar to the ERA's estimates and for ease of comparison we used the ERA estimates to lever and de-lever all Australian equity beta estimates. We also used the same leverage formula used by the ERA.

3.1.1 Missing data

30. We do not have price data for individual stocks and/or the market for some weekdays in the analysis period due to public holidays and halted trading. In this circumstance. We calculated returns using the nearest weekday before the date in question which has data for both the stock and the market. An individualised market return series was created for each stock such that stock and market returns used in beta estimates were for comparable periods.

3.1.2 Sampling interval

31. In this report, we present daily[6], weekly and monthly betas. There are many ways in which weekly and monthly returns can be calculated. In this report we present betas

[6] We note that daily betas have the potential for being downward biased if there is illiquid trading in the stock in question. We note that SFG has separately examined the liquidity of both the Australian and the US stocks used in this report, and have rejected a conclusion that they are illiquid. (See page 11 of SFG *Regression-based estimates of risk parameters for the benchmark firm*, June 2013). In any event, daily betas are not lower than betas with longer time periods.

based on Monday to Monday through to Friday to Friday weekly returns. For monthly betas, returns were calculated from one weekday to the same weekday in the previous month. For example, from the first weekday on September to the first weekday of August. We present monthly betas for returns for the first through to the 20th weekday of each month. The 20th weekday is the maximum examined because the returns series can only be calculated for February if the maximum is 20 week days or less.

3.1.3 US betas

32. We also estimate betas for a sample of 56 US regulated utilities. This sample is discussed in more detail in section 4.4.1 below. In summary, CEG has separately identified US businesses with at least 50% of total assets subject to regulation.[7]

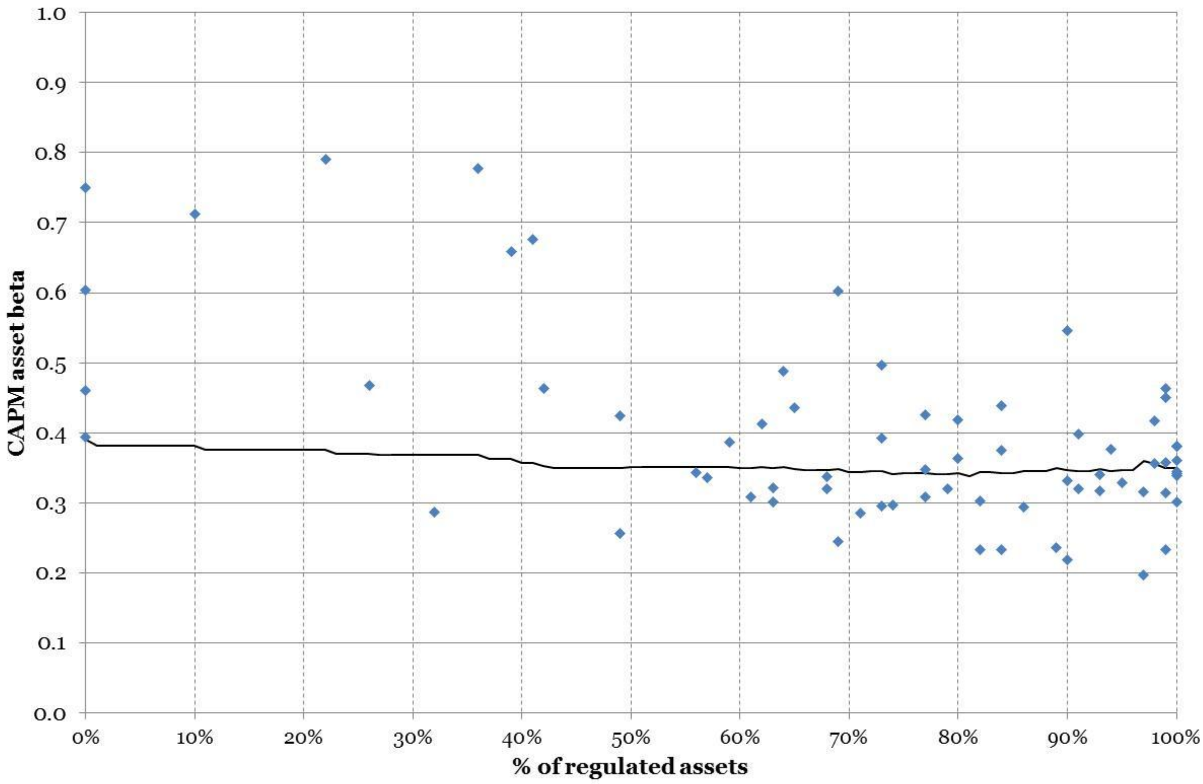
33. CEG chose the 50% cut threshold based on analysis showing that, above 50%, there was no statistical relationship between historical regression beta and the percentage of regulated assets. The basis for this conclusion can be seen in Figure 2 below.[8] The black line illustrates the sample average assuming the threshold has been set at a given point. For example, if the threshold was set at zero regulated assets the black line shows the average for all of the 70 points shown in each chart. This average is just below 0.4 for the unlevered asset beta (predicted relative risk).

34. Figure 2 illustrates that, when the percentage of regulated gas/electricity assets make up less than 50% of total assets, beta estimates are highly dispersed (and some are relatively high). However, for businesses with a percentage of regulated gas/electricity assets as a proportion of total assets greater than 50%, this dispersion is smaller and there is no obvious relationship with the estimated asset beta. This is consistent with the average asset beta (black line) being more or less the same as the threshold for inclusion in the sample is increased beyond 50% of regulated assets. Indeed, predicted CAPM relative risk is almost identical when the threshold is set at 90% as when the threshold is set at 50% (both 0.35). FFM relative risk is actually higher (0.38 vs. 0.37)

7 CEG, Information on equity beta from US companies, A report for the ENA, June 2013.

8 This figure has been taken from Figure 1 in CEG, Information on equity beta from US companies, A report for the ENA, June 2013.

Figure 2: CAPM asset beta vs. percentage of regulated assets



Source: Figure 1 in CEG, Information on equity beta from US companies, A report for the ENA, June 2013

35. The betas (re-levered to 60% gearing) for the 56 companies with regulated assets greater than 50% are reported in Table 1 below. The betas reported in Table 1 have been estimated using the ERA data period (4/01/2002 to 19/04/2013) and using the sampling intervals described in the previous section. The reported betas are averages across all 26 sampling intervals (from daily to monthly). Notwithstanding the slight difference in methodology, the average of all these re-levered betas is the same as the average of the re-levered betas reported in our June report for the ENA.[9]

9 CEG, Information on equity beta from US companies, A report for the ENA, June 2013. The average asset beta in that report was 0.35 which, when re-levered to 60%, is 0.87

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Table 1: US regulated utilities OLS beta (re-levered to 60%) averaged across 26 sampling intervals

	Average OLS beta over 26 different sampling intervals		Average OLS beta over 26 different sampling intervals
SO	0.54	EE	1.00
ED	0.52	ETR	0.88
LG	0.52	IDA	0.79
UNS	0.60	EDE	0.86
WEC	0.59	NWE	0.92
NWN	0.61	AEE	1.12
NU	0.70	EIX	0.96
SJI	0.81	LNT	0.96
WGL	0.78	PNW	0.85
NJR	0.82	PCG	0.69
POM	0.80	PEG	0.92
WR	0.77	AEP	0.75
CNP	0.69	TE	0.93
DTE	0.83	ITC	1.13
MGEE	0.76	UIL	0.97
SCG	0.79	TEG	1.21
NVE	0.68	DUK	0.66
PNY	0.77	OGE	1.19
ATO	0.81	CNL	0.87
GAS	0.84	GXP	1.03
CMS	0.56	PNM	1.18
VVC	0.77	SRE	1.20
FE	0.81	BKH	1.32
SWX	0.98	ALE	1.26
AVA	0.88	OTTR	1.80
NI	0.86		
PPL	0.78		
POR	1.00		
CHG	0.84		
XEL	0.59		
NEE	0.87		
Average			**0.87**

Source: Bloomberg, CEG

3.2 Why we focus on OLS estimates

36. Any reasonable understanding of finance theory indicates that 'robust regressions' are inappropriate as a basis for estimating beta. 'Robust regressions' such as Least Absolute Deviations (LAD) regressions give limited weight to observations that are 'unusual'.[10] While this may be appropriate in some other circumstances it is not appropriate when estimating beta. Giving low weight to unusual observations can be appropriate where there are measurement errors (i.e., the unusual observation is likely to be due to a measurement error) or where the researcher is only interested in estimating the relationship between variables that "usually" exists.

37. By contrast, there should be no significant measurement error when estimating beta for modern, reasonably liquid stocks. Moreover, the theory underpinning the CAPM is that investors care about the relationship between a stock return and the market return across *all* market circumstances.

38. For example, it may be that in 95% of circumstances a stock return tends to move more or less in line with the market return. However, in the other 5% of circumstances (say when large financial shocks are having a large impact on the economy and stock market) the stock may tend to move in a ratio of 3 to 1 with the market return. That is, in most market circumstances the firm has a beta of 1.0 but in other circumstances, when there are large movements in the market, it has a beta of 3.0.

39. In this scenario, a robust regression will give low (and even near zero) weight to the data points associated with financial shocks (when the firm has a high beta). This is because these are unusual (associated with a beta of 3 rather than 1) and because they are associated with large market movements (and therefore are a 'long way' off the regression line through the 95% of observations associated with a beta of 1.0).

40. However, unless there is a reason to believe that investors do not care about the behaviour of the stock during periods when large financial shocks hit the market the weight given to these observations should not be reduced. Investors will rationally form their opinion about beta risk for all periods in which the stock was held - including such shocks (and possibly even to give them more weight than other observations if exposure to these shocks is more problematic to investors than exposure to more mundane variations in the value of the market).

41. Put simply, robust regressions will tend to give less weight to periods when market returns are unusually positive/negative. However, there is no *a priori* assume that investors give less weight to such events when assessing a particular stock's risk and, indeed, they may well rationally give such observations more weight.

10 And which would otherwise exert a high level of weight on the regression coefficient relative to other observations

42. Consistent with the above, is the empirical evidence that robust regression will bias downwards the estimate of beta for all but the largest stocks. This fact is comprehensively set out in a recent report by SFG in relation to the LAD regression procedure.[11] That report demonstrates that LAD biases down the estimate of beta relative to OLS for all but the largest 20 stocks (and does not bias those stocks up – so the net effect is a market beta of less than 1.0).

3.3 Table 19 replication and reconciliation

43. As in each of the following subsections, we first set out CEG's attempt to replicate the ERA table in question (in this case Table 19 from the ERA Explanatory Statement) and then presenting a table showing the ERA's estimates less our estimates.

44. Table 19 of the ERA Explanatory Statement provides beta estimates for each firm the ERA sample (using a week ended Friday sampling interval). It can be seen that we estimate materially higher average OLS betas than does the ERA and that this is primarily due to higher betas for DUET (DUE) and SP AusNet (SPN).

Table 2: CEG replication of ERA Table 19

	APA	DUE	ENV	HDF	SKI	SPN	Average
Gearing	0.5418	0.742	0.6884	0.3936	0.4436	0.6107	0.5700
OLS	0.6253	0.3206	0.3867	1.2332	0.5419	0.2728	0.5634
LAD	0.5984	0.2461	0.3494	0.9097	0.4467	0.2818	0.472
Robust MM	0.6181	0.2882	0.3357	0.9066	0.4948	0.3425	0.4976
Theil Sen	0.5434	0.2959	0.3268	0.8751	0.4424	0.3235	0.4678
Average	0.5963	0.2877	0.3496	0.9812	0.4814	0.3052	0.5002

Source: Bloomberg, CEG analysis

Table 3: CEG comparison to ERA Table 19

	APA	DUE	ENV	HDF	SKI	SPN	Average
Gearing	0	0	0	0	0	0	0
OLS	-0.0323	-0.146	0.0558	-0.0362	0.0013	-0.2238	-0.0635
LAD	-0.0435	-0.013	0.094	0.1957	-0.0799	-0.0255	0.0213
Robust MM	0.0153	-0.0375	0.114	0.0949	-0.0147	-0.0382	0.0223
Theil Sen	0.0209	-0.0303	0.1188	0.1303	-0.0509	-0.1014	0.0146
Average	-0.0099	-0.0567	0.0957	0.0961	-0.036	-0.0973	-0.0013

Source: Bloomberg, CEG analysis

[11] SFG, *Comparison of OLS and LAD regression techniques for estimating beta* (2013).

3.4 Table 21 replication and reconciliation

45. Table 21 of the ERA Explanatory Statement provides beta estimates for each equal weighted portfolio (using a week ended Friday sampling interval). Once again, a reconciliation to the ERA's table 21 shows that we estimate materially higher OLS betas for the portfolios with DUE and SPN (P2 to P4).

Table 4: CEG replication of ERA Table 21

	P0	P1	P2	P3	P4	Average
Gearing	0.6187	0.631	0.6752	0.6046	0.5854	0.6230
OLS Beta	0.4964	0.4983	0.4234	0.5869	0.5384	0.5087
LAD Beta	0.5173	0.5422	0.4119	0.5387	0.5542	0.5129
MM Beta	0.4833	0.4926	0.4176	0.5559	0.5106	0.492
Theil-Sen Beta	0.4418	0.462	0.4056	0.5331	0.5057	0.4696
Average	0.4964	0.4983	0.4234	0.5869	0.5384	0.5087
Observations	590	503	453	436	383	

Source: Bloomberg, CEG analysis

Table 5: CEG comparison to ERA Table 21

	P0	P1	P2	P3	P4	Average
Gearing	0	0	0	0	0	0
OLS Beta	-0.0072	-0.0045	-0.0364	-0.0372	-0.0469	-0.0264
LAD Beta	0.0162	0.0009	0.0004	0.0417	0.0361	0.019
MM Beta	0.003	0.0054	-0.0072	0.0235	0.0538	0.0157
Theil-Sen Beta	-0.0067	-0.0028	-0.008	0.013	0.0197	0.0031
Average	-0.0104	0.0002	-0.0216	-0.023	0.0045	-0.0101
Observations	-1	0	0	-21	-21	

Source: Bloomberg, CEG analysis

3.5 Table 22 replication and reconciliation

46. Table 22 of the ERA Explanatory Statement provides beta estimates for each value weighted portfolio (using a week ended Friday sampling interval). Once again, a reconciliation to the ERA's table 22 shows that we estimate materially higher OLS betas for the portfolios with DUE and SPN (P2 to P4).

Table 6: CEG replication of ERA Table 22

	P0	P1	P2	P3	P4	Average
Gearing	0.5929	0.6093	0.6638	0.6319	0.6002	0.6196
OLS Beta	0.5378	0.5344	0.4392	0.517	0.4622	0.4981
LAD Beta	0.583	0.5933	0.4419	0.4677	0.4842	0.514
MM Beta	0.5314	0.5338	0.4361	0.4946	0.4689	0.493
Theil-Sen Beta	0.4861	0.4994	0.4255	0.487	0.4622	0.472
Average	0.5378	0.5344	0.4392	0.517	0.4622	0.4981
Observations	590	503	453	436	383	

Source: Bloomberg, CEG analysis

Table 7: CEG comparison to ERA Table 22

	P0	P1	P2	P3	P4	Average
Gearing	0	0	0	0	0	0
OLS Beta	-0.0101	-0.007	-0.0405	-0.0437	-0.0633	-0.0329
LAD Beta	-0.0275	-0.0418	-0.0057	0.0442	0.023	-0.0015
MM Beta	-0.0035	-0.0017	-0.004	0.0154	0.0247	0.0061
Theil-Sen Beta	-0.0132	-0.0114	-0.0112	0.0074	-0.0081	-0.0072
Average	-0.0168	-0.0096	-0.0189	-0.0196	0.0013	-0.0127
Observations	-1	0	0	-21	-21	

Source: Bloomberg, CEG analysis

3.6 Table 23 replication and reconciliation

47. Table 23 of the ERA Explanatory Statement provides confidence intervals around the point estimates for each individual firm reported in Table 19. A reconciliation to the ERA's table 23 shows that we estimate smaller confidence intervals (lower standard errors) for DUE and SPN. This suggests that there are more 'unusual' data observations (outliers) in the ERA data series for these companies.

48. We present two different versions of our own estimate of Table 23 below. The first uses the same number of observations as set out by the ERA in the second last row of Table 23. This is smaller than the full data set. We also use the full data set to attempt to replicate the ERA's results.

Table 8: CEG replication of ERA Table 23 (using same N as ERA Table 22)

	APA	DUE	ENV	HDF	SKI	SPN
OLS method						
OLS t-stat	7.6456	4.9151	6.0602	4.8432	4.4575	3.7217
OLS Beta Upper Bound	0.7664	0.4029	0.5563	1.7921	0.7392	0.4057
OLS Beta Lower Bound	0.4537	0.1732	0.2844	0.7595	0.2877	0.1258
LAD method						
LAD t-stat	7.1891	5.3508	10.6496	10.2311	3.8548	4.7226
LAD Beta Upper Bound	0.739	0.3546	0.5275	1.2437	0.6369	0.5205
LAD Beta Lower Bound	0.4348	0.1381	0.3539	0.7287	0.1641	0.2146
Robust MM method						
Robust MM t-stat	9.1386	6.3488	8.348	8.4753	4.5789	5.8086
Robust MM Beta Upper Bound	0.7725	0.3259	0.5323	1.181	0.6132	0.4726
Robust MM Beta Lower Bound	0.4997	0.1722	0.3299	0.7374	0.2456	0.2341
Theil-Sen method						
Theil-Sen Upper Bound	0.7215	0.3754	0.5431	1.2587	0.5977	0.4963
Theil-Sen Lower Bound	0.4131	0.176	0.2982	0.7063	0.1434	0.1999
N	261	261	261	240	261	261
R-Square (OLS)	0.1841	0.0853	0.1242	0.0897	0.0713	0.0508

Source: Bloomberg, CEG analysis

Table 9: CEG comparison to ERA Table 23 (same N as ERA)

	APA	DUE	ENV	HDF	SKI	SPN
OLS method						
OLS t-stat	-0.571	-3.1035	0.0185	-0.9674	-1.4716	-3.4179
OLS Beta Upper Bound	-0.0092	-0.0394	0.0288	0.0102	0.1606	-0.0409
OLS Beta Lower Bound	-0.025	-0.1875	0.0154	-0.1678	-0.1011	-0.3927
LAD method						
LAD t-stat	1.22	0.2211	11.4573	9.289	0.8074	-0.9796
LAD Beta Upper Bound	-0.0548	-0.0395	-0.0448	-0.0273	-0.1159	-0.13
LAD Beta Lower Bound	-0.0092	0.013	0.0502	0.2657	0.0485	-0.0925
Robust MM method						
Robust MM t-stat	-0.2041	-0.1631	-0.1152	-0.1713	0.4813	-1.4335
Robust MM Beta Upper Bound	-0.0002	0.0042	0.0244	0.0569	0.0529	-0.0319
Robust MM Beta Lower Bound	-0.0053	-0.001	0.0127	0.0277	0.0486	-0.0661
Theil-Sen method						
Theil-Sen Upper Bound	-0.0022	-0.0027	0.0327	0.0355	0.0364	-0.1043
Theil-Sen Lower Bound	-0.0143	-0.012	0.0192	0.0111	0.0125	-0.1522
N	0	0	0	0	0	0
R-Square (OLS)	-0.0222	-0.0728	0.0007	-0.0303	-0.038	-0.0504

Source: Bloomberg, CEG analysis

Table 10: CEG replication of ERA Table 23 (using all data)

	APA	DUE	ENV	HDF	SKI	SPN
OLS method						
OLS t-stat	10.2828	7.1978	8.5938	6.714	5.9312	4.5604
OLS Beta Upper Bound	0.7445	0.4079	0.4749	1.5932	0.7209	0.3901
OLS Beta Lower Bound	0.5061	0.2333	0.2985	0.8732	0.3628	0.1556
LAD method						
LAD t-stat	9.6356	5.4602	8.4335	11.2979	4.525	4.4312
LAD Beta Upper Bound	0.7411	0.3814	0.432	1.0782	0.6539	0.4949
LAD Beta Lower Bound	0.4395	0.1564	0.2201	0.6288	0.2357	0.1767
Robust MM method						
Robust MM t-stat	11.9729	8.3968	10.5496	11.3403	6.6919	6.7779
Robust MM Beta Upper Bound	0.7193	0.3555	0.3981	1.0633	0.6397	0.4416
Robust MM Beta Lower Bound	0.5169	0.2209	0.2733	0.7499	0.3498	0.2435
Theil-Sen method						
Theil-Sen Upper Bound	0.6669	0.3832	0.4071	1.0838	0.6171	0.4492
Theil-Sen Lower Bound	0.4175	0.2074	0.2418	0.669	0.2624	0.201
N	590	453	590	415	383	383
R-Square (OLS)	0.1524	0.103	0.1116	0.0984	0.0845	0.0518

Source: Bloomberg, CEG analysis

Table 11: CEG comparison to ERA Table 23 (all data)

	APA	DUE	ENV	HDF	SKI	SPN
OLS method						
OLS t-stat	-3.2082	-5.3862	-2.5151	-2.8382	-2.9453	-4.2566
OLS Beta Upper Bound	0.0127	-0.0444	0.1102	0.2091	0.1789	-0.0253
OLS Beta Lower Bound	-0.0774	-0.2476	0.0013	-0.2815	-0.1762	-0.4225
LAD method						
LAD t-stat	-1.2265	0.1117	13.6734	8.2222	0.1372	-0.6882
LAD Beta Upper Bound	-0.0569	-0.0663	0.0507	0.1382	-0.1329	-0.1044
LAD Beta Lower Bound	-0.0139	-0.0053	0.184	0.3656	-0.0231	-0.0546
Robust MM method						
Robust MM t-stat	-3.0384	-2.2111	-2.3168	-3.0363	-1.6317	-2.4028
Robust MM Beta Upper Bound	0.053	-0.0254	0.1586	0.1746	0.0264	-0.0009
Robust MM Beta Lower Bound	-0.0225	-0.0497	0.0693	0.0152	-0.0556	-0.0755
Theil-Sen method						
Theil-Sen Upper Bound	0.0524	-0.0105	0.1687	0.2104	0.017	-0.0572
Theil-Sen Lower Bound	-0.0187	-0.0434	0.0756	0.0484	-0.1065	-0.1533
N	-329	-192	-329	-175	-122	-122
R-Square (OLS)	0.0095	-0.0905	0.0133	-0.039	-0.0512	-0.0514

Source: Bloomberg, CEG analysis

3.7 Table 24 replication and reconciliation

49. Table 24 of the ERA Explanatory Statement provides confidence intervals around the point estimates for each equally weighted portfolio reported in Table 21. A reconciliation to the ERA's table 24 shows that we estimate smaller confidence intervals (lower standard errors) for the portfolios with DUE and SPN (P2, P3 and P4). This suggests that there are more 'unusual' data observations (outliers) in the ERA data series for these companies.

Table 12: CEG replication of ERA Table 24

	P0	P1	P2	P3	P4
OLS method					
OLS Standard Error	0.0383	0.04	0.0339	0.0485	0.0476
OLS t-stat	12.9721	12.4636	12.4741	12.1009	11.3194
OLS Beta Upper Bound	0.5714	0.5767	0.49	0.682	0.6316
OLS Beta Lower Bound	0.4214	0.42	0.3569	0.4918	0.4452
LAD method					
LAD Standard Error	0.043	0.0413	0.0306	0.0308	0.0334
LAD t-stat	12.0358	13.1262	13.4708	17.4894	16.6081
LAD Beta Upper Bound	0.5766	0.6176	0.5036	0.6495	0.6265
LAD Beta Lower Bound	0.3947	0.4488	0.3299	0.4763	0.4237
Robust MM method					
Robust MM Standard Error	0.0312	0.0321	0.0274	0.0325	0.0346
Robust MM t-stat	15.4944	15.3407	15.2501	17.0845	14.7499
Robust MM Beta Upper Bound	0.5444	0.5555	0.4712	0.6197	0.5784
Robust MM Beta Lower Bound	0.4221	0.4296	0.3639	0.4921	0.4428
Theil-Sen method					
Theil-Sen Upper Bound	0.5183	0.539	0.4729	0.6135	0.5889
Theil-Sen Lower Bound	0.3629	0.3805	0.3372	0.4564	0.4213
N	590	503	453	436	383
R-Square (OLS)	0.2225	0.2367	0.2565	0.2523	0.2517

Source: Bloomberg, CEG analysis

Table 13: CEG comparison to ERA Table 24

	P0	P1	P2	P3	P4
OLS method					
OLS Standard Error	0.0044	0.0034	0.0086	0.0109	0.0141
OLS t-stat	-1.5021	-1.0936	-3.3741	-2.8409	-3.3494
OLS Beta Upper Bound	0.0014	0.0023	-0.0197	-0.0158	-0.0192
OLS Beta Lower Bound	-0.0158	-0.0113	-0.0533	-0.0585	-0.0745
LAD method					
LAD Standard Error	-0.0107	-0.0075	0.0058	0.0105	0.0103
LAD t-stat	4.4742	2.9338	-2.1408	-3.4194	-3.0981
LAD Beta Upper Bound	0.0202	-0.0082	-0.02	0.0118	0.0494
LAD Beta Lower Bound	0.0755	0.0281	0.0111	0.0233	0.081
Robust MM method					
Robust MM Standard Error	0.0022	0.0014	0.0013	0.0032	0.0049
Robust MM t-stat	-0.9344	-0.4607	-0.9501	-0.8345	-0.4499
Robust MM Beta Upper Bound	0.0073	0.0081	-0.0046	0.0296	0.0633
Robust MM Beta Lower Bound	-0.0013	0.0028	-0.0098	0.0174	0.0442
Theil-Sen method					
Theil-Sen Upper Bound	-0.0015	-1E-04	-0.0053	0.0227	0.033
Theil-Sen Lower Bound	-0.0118	-0.0066	-0.0105	0.0027	0.0006
N			Not reported by the ERA		
R-Square (OLS)			Not reported by the ERA		

Source: Bloomberg, CEG analysis

3.8 Table 25 replication and reconciliation

50. Table 25 of the ERA Explanatory Statement provides confidence intervals around the point estimates for each value weighted portfolio reported in Table 22. A reconciliation to the ERA's table 25 shows that we estimate smaller confidence intervals (lower standard errors) for the portfolios with DUE and SPN (P2, P3 and P4). This suggests that there are more 'unusual' data observations (outliers) in the ERA data series for these companies.

Table 14: CEG replication of ERA Table 25

	P0	P1	P2	P3	P4
OLS method					
OLS Standard Error	0.0389	0.0391	0.0285	0.0446	0.0475
OLS t-stat	12.9104	12.3892	12.1469	12.5489	10.5189
OLS Beta Upper Bound	0.5815	0.5633	0.4118	0.6276	0.6313
OLS Beta Lower Bound	0.4289	0.4102	0.3	0.4526	0.445
LAD method					
LAD Standard Error	0.0437	0.0403	0.0257	0.0283	0.0334
LAD t-stat	15.9989	18.0614	14.3552	17.172	15.623
LAD Beta Upper Bound	0.5869	0.6032	0.4232	0.5977	0.6262
LAD Beta Lower Bound	0.4017	0.4383	0.2773	0.4383	0.4235
Robust MM method					
Robust MM Standard Error	0.0317	0.0314	0.023	0.0299	0.0346
Robust MM t-stat	15.3253	15.0725	14.9141	15.676	13.0172
Robust MM Beta Upper Bound	0.554	0.5426	0.3961	0.5703	0.5782
Robust MM Beta Lower Bound	0.4296	0.4196	0.3059	0.4529	0.4425
Theil-Sen method					
Theil-Sen Upper Bound	0.5275	0.5265	0.3975	0.5646	0.5886
Theil-Sen Lower Bound	0.3693	0.3716	0.2835	0.42	0.4211
N	590	503	453	436	383
R-Square (OLS)	0.2209	0.2345	0.2465	0.2662	0.2251

Source: Bloomberg, CEG analysis

Table 15: CEG comparison to ERA Table 25

	P0	P1	P2	P3	P4
OLS method					
OLS Standard Error	0.008	0.0085	0.0168	0.0067	0.013
OLS t-stat	-1.6604	-1.3192	-3.3469	-3.3189	-3.9189
OLS Beta Upper Bound	0.0382	0.0575	0.0757	-0.0538	-0.1138
OLS Beta Lower Bound	0.0068	0.0239	0.01	-0.0798	-0.1646
LAD method					
LAD Standard Error	-0.0016	0.0026	0.0073	0.0054	0.0008
LAD t-stat	-2.7889	-5.2214	-1.1452	-1.972	-0.773
LAD Beta Upper Bound	0.051	0.0325	0.0778	-0.0198	-0.052
LAD Beta Lower Bound	0.0714	0.0291	0.0942	0.0076	0.0168
Robust MM method					
Robust MM Standard Error	0.0048	0.0046	0.0072	0.0033	0.005
Robust MM t-stat	-0.8753	-0.2725	-0.5841	-0.326	-0.5372
Robust MM Beta Upper Bound	0.0455	0.06	0.0951	0.0048	-0.007
Robust MM Beta Lower Bound	0.0267	0.042	0.0671	-0.008	-0.0264
Theil-Sen method					
Theil-Sen Upper Bound	0.0243	0.0441	0.0866	0.0277	0.011
Theil-Sen Lower Bound	0.0056	0.0243	0.0547	0.0074	-0.0143
N	Not reported by the ERA				
R-Square (OLS)	Not reported by the ERA				

Source: Bloomberg, CEG analysis

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4 Accuracy of beta estimates

51. Historical estimates of beta are based on regressing the returns on a particular stock (or portfolio of stocks) against the return on the market portfolio of stocks. In order to perform this analysis it is necessary to define, amongst other things:

- The data period that will be used (e.g., the last five or ten years of stock market data); and
- How returns will be estimated from within that data. This is known as the sampling interval (e.g., daily returns, monthly returns).

52. The ERA has chosen to use data from 4/01/2002 to 19/04/2013 (see Table 17 of the Explanatory Statement). The ERA has also chosen to perform all of its analysis on the basis of weekly sampling intervals where the week is defined as the return from the end of one Friday to the end of the Friday of the following week. Having made these decisions, the ERA proceeded to use the data in regression analysis in order to estimate betas for its sample of 6 proxy firms (and portfolios thereof) – see Tables 19, 21 and 22 of the Explanatory Statement. The ERA used the same regressions in order to estimate the 95% upper and lower bound confidence levels of its beta estimates (see Tables 23, 24 and 25).

53. The ERA's conclusion was that, for OLS regressions, the average upper bound estimates of beta for each of its six proxy firms (0.80 calculated from Table 23) was 0.30 above the average point estimate (0.50 reported in Table 19).

54. Notwithstanding that this difference suggests a material lack of precision in the beta estimates, this is a considerable overestimate of the true statistical precision of the beta estimates as a proxy for investors' forward looking beta estimates – which is what the ERA is required to estimate under the Rules. This is because these confidence intervals rely, amongst other things, on the following assumptions about how investors' form their forward-looking beta estimates:

- That investors form their expectations of forward-looking beta risk on the basis of regression analysis;
- That investors only have regard to betas estimated using 'week ended Friday' return series;
- That investors only have regard to the time period 4/01/2002 to 19/04/2013;
- That investors only have regard the average behaviour of beta in that period (i.e., that investors believe that beta is stable over time); and
- That investors only have regard to the betas for the 6 proxy firms examined by the ERA.

55. Even if there is no *a priori* reason to believe that relaxing each of these assumptions will raise/lower the best estimate of beta, there is a strong basis to conclude that relaxing these assumptions will increase the width of the confidence interval around any estimate of beta.

4.1 Allowing for the fact that investors may not give 100% weight to regression analysis

56. The first point is a general one. It must be noted that investors almost certainly have regard to information other than historical beta when forming their forward looking assessment of risk. We cannot be certain what that information is and, *a priori*, whether it raises or lowers the best estimate of the forward-looking beta. However, we can be confident that allowing for this likelihood increases the uncertainty bounds around the ERA's regression results.

4.2 Allowing for the fact that 'week ended Friday' is only one of many sampling intervals

57. Each of the ERA's estimates of statistical uncertainty are taken from a single regression for each stock using week ended Friday sampling interval of returns over the period 4/01/2002 to 19/04/2013 (up to 11.3 years if data is available for that long). However, this is only one of the many possible sampling intervals the ERA could have examined.

58. Consider for the sake of illustration, the impact on beta estimates of adopting precisely the same data period but instead defining weekly returns over the week from Monday to Monday. Because we cannot replicate the ERA's beta estimates we start with our estimate of the average beta for the week ended Friday of 0.56. But if we simply measure returns from Monday to Monday (changing nothing else in our analysis) our average beta is estimate is 0.62 (0.06 higher). If we use daily returns our average beta is 0.67 (0.11 higher). If we use monthly returns, the average beta estimate can be as high as 0.94 (0.38 higher if betas are estimated from/to the 6th trading day in each month) and as low as 0.29 (0.27 lower if betas are estimated from/to the 17th trading day in each month).

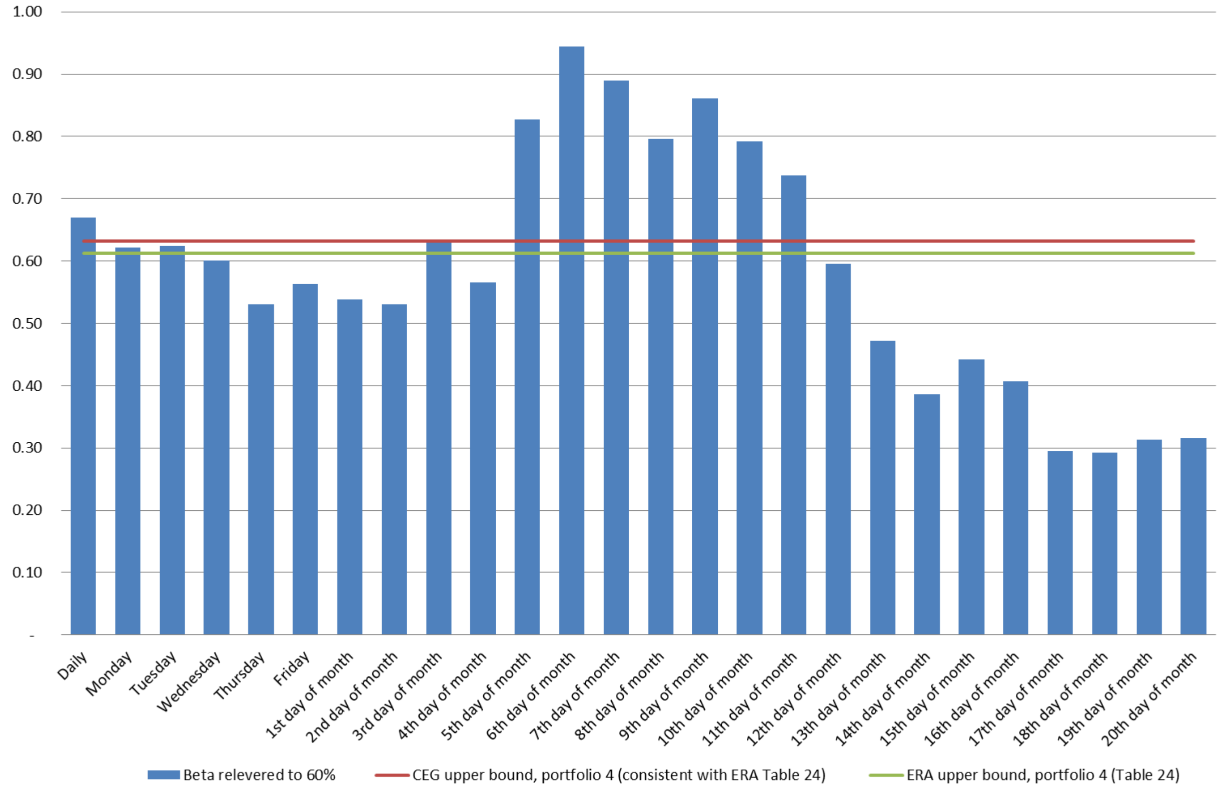
59. These and other results are set out in Figure 3 below. Figure 3 shows the average beta (averaged across the ERA's six proxy companies) using the ERA's data period but simply varying the sampling interval.

60. The bar on the far left hand side of Figure 3 is the average daily beta, the next five bars represent the average weekly betas (one bar for each possible definition of a week (week ended Monday first, then week ended Tuesday etc.). The next 20 bars each represent different definitions of a month. The first monthly bar represents the beta associated with measuring returns to the first trading day of each month.

The second monthly bar represents the beta associated with measuring returns to the second trading day of each month, etc. There are only 20 monthly beta estimates defined in this manner because there are only 20 trading days in February.

61. The horizontal lines in Figure 1 show the upper bound beta as estimated by the ERA (green line) and by CEG following the ERA 'week ended Friday' methodology (red line – as reported in section 3.7 above) for the equally weighted portfolio that includes all stocks (P_4).

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



Source: Bloomberg, CEG analysis

62. If the upper bound estimates were reliable then we would expect to only see around 2.5% of average beta estimates exceed the upper bound (and 2.5% below the lower bound – not shown). In reality, there are 9 observations above the CEG upper bound (the upper bound estimated by CEG following ERA methodology) and 11 above the ERA upper bound. That is, almost half (42%) of all observations are above the ERA 97.5% upper bound.

63. This demonstrates a clear problem with the methodology underpinning the upper bound estimate. The ERA upper bound estimate is based on a single regression

where it is assumed that the data used in that regression represents all of the available information. In effect, it assumes that investors form their beta estimate solely based on the confidence interval around the estimation of betas using a "week ended Friday" sampling interval for returns.

64. In reality, the underlying data is far richer and more varied than this. A 'week ended Friday' sampling interval is ultimately arbitrary (as are all of the sampling intervals in Figure 3). Even if investors were to solely inform their forward-looking beta estimates by reference to historical betas using the ERA's sample of firms and using the same 11.3 years of data as used by the ERA, it is reasonable to assume that they might adopt a different sampling interval to the ERA.

65. In reality, any one of the beta estimates in Figure 3 is equally as likely to be the 'true beta' estimate that informs investors' valuations. In which case, a better estimate of the 97.5 upper bound is one that takes account of the different sampling assumptions that might inform investors' forward-looking beta estimates. In this context, the 97.5th percentile of the 26 different beta estimates derived above provides a better estimate than the 97.5th upper bound estimate of the (single) beta regression coefficient using week ended Friday return sampling. The 97.5th percentile from the above sample is 0.91.

66. However, even this upper bound is unrealistically low. This is because it assumes that investors:

- assume that the beta estimated over this 11.3 year period is constant and is equal to the forward-looking beta; and
- solely have regard to the six firms in the ERA sample.

67. Relaxing any of these assumptions will further materially increase the width of the true confidence interval that can be estimated using the historical beta estimates for the six firms in the ERA sample.

4.3 Allowing for the fact that betas may not be constant through time

68. The ERA uses a particular period to estimate returns (11.3 years for Envestra and APA, shorter for the other four firms who were listed at a later date) and estimates a single beta over that entire period. It is possible that this is the way investors inform a forward-looking beta estimate. However, it is also possible that they give different weight to different periods within that data set. For example, it is plausible that investors give weight to beta estimates derived using shorter (or longer) periods. It is plausible that investors give less weight to particular past periods that they perceive least likely to be representative of the expected future. Once more, we cannot necessarily strongly reason, *a priori*, that these possibilities will raise or lower the best estimate of the forward-looking beta. However, we can reason that

these possibilities will increase the bounds of uncertainty around an estimate of beta that is based on only one such possibility (i.e., that investors focus only on the average beta over the longest period of data availability).

69. Put simply, underpinning the ERA's regression estimates is the assumption that there is a single beta for each firm (over the entire 11.3 year period and into the future) and that variations from that single beta observed in the historical data are 'noise' rather than a time varying beta for the six firms in question. This is a strong assumption which is almost certainly violated in reality.

70. The relationship between stock prices and the market almost certainly depends on the kind of shocks that are affecting the market portfolio. The beta of a stock during a financial crisis is likely different to the beta of a stock during a commodity boom etc. If one believes that beta varies through time (i.e., beta depends on the forces expected to impact the economy and financial markets) then investors' forward-looking estimate of beta will be dependent on the nature of the market environment expected over the relevant period.

71. It is possible to perform statistical tests for whether the underlying coefficient of a regression (in this case beta) is constant through time. We have performed three of these tests within R statistical software and find strong support for time variation of the equal weighted portfolio betas.

72. The results are reported below. The F Stats test is designed to test a hypothesis that there are only two different values of the coefficient (a single shift) while the cumulative sum of errors (CUSUM) and recursive estimates tests allow for the possibilities of more than just two values of the coefficient over time. In the test based on the F-statistic a statistic (Chow statistic) is computed for each conceivable breakpoint and looks at the distribution of the maximum F statistic. The leading and trailing 10% of the observations were not considered as possible break points. The recursive estimates test is the fluctuation test given by Ploberger et. al. (1989).[12] All three tests were implemented using the strucchange package in R

73. P-values for these tests applied to each of the ERA's five equal weighted portfolios are given below. The lower the p-value the stronger the conclusion that beta is not constant over time. Using the F-Test the hypothesis that there is a single shift in beta over the time period is only accepted at between the 80% and 5% significance level (depending on the portfolio). However, using the CUSUM and Recursive Estimates tests the hypothesis that beta takes on multiple values of beta over time can be accepted at the 5% confidence level for portfolios P0 P1 and P4 using both tests. The hypothesis can be accepted for portfolios P2 and P3 at the 10% level using the CUSUM test (but only at the 15% confidence interval using the Recursive Estimates Test).

12 Ploberger, Kramer, and Kontrus (1989) "A new test for structural stability in the linear regression model." Journal of Econometrics, 40, 307-318.

Table 16: P-values in tests for time variation in beta

	F stats test (Chow)	CUSUM	Recursive estimates
P0	0.1178	0.0427	0.0438
P1	0.1179	0.0213	0.0422
P2	0.165	0.059	0.115
P3	0.049	0 .007	0.013
P4	0.157	0.024	0.048

74. Once more, we may not know whether investors' forward-looking beta over the relevant future horizon is higher or lower than the historical average. However, the fact that investors may reasonably expect market conditions that differ from the historical average suggests the confidence interval around the historical average must be greater. This is especially true when the historical average:

- is based on only seven years of data for the full set of six firms; and
- covers a period of unusual market circumstances – including the global financial crisis of 2008/09 and a commodity 'super cycle' that drove the Australian stock market in the years leading up the GFC.

75. This is consistent with the finding in Diamond (2013)[13]. In that study the authors find that, for a sample of 9 firms, the average difference in beta estimates between two different 10 year periods is around 0.24 to 0.62.[14] The differences are even larger over five year periods.

76. Moreover, this source of variability is in addition to the variability described in Figure 3 (associated with different sampling intervals). The combined level of uncertainty relaxing both assumptions[15] underpinning the ERA's confidence intervals will almost certainly be materially greater than the level of uncertainty derived relaxing only one such assumption.

4.4 Allowing for the small sample size

77. The ERA's proxy firms for the estimation of beta include only six firms (and one of these has been delisted). Moreover, there is cross ownership between these firms (APA owns 33% of Envestra and has fully merged with HDF) which reduces the true number of independent proxies.

78. Diamond (2013) examines the impact of sample size on the precision of beta estimates. They estimate that if 9 firms are randomly selected from an industry to

13 Diamond *et. al., Assessing the reliability of regression-based estimates of risk* (2013)

14 Diamond *et. al.,* see Table 4, Panel B on page 13.

15 That investors' forward looking betas are formed only on week ended Friday beta regressions and that investors believe the true beta is constant through time equal to the historical average beta over the ERA's estimation period.

be the proxy sample, the standard error[16] of the mean beta estimate ranges from 0.15 to 0.22 across different industries.[17] The authors show that this standard error falls dramatically with a larger data set – more than halving when the number of firms is increased from 9 to 36. While not reported, the level of inaccuracy associated with a sample of 6 firms (the ERA's sample) will be higher still than with 9 firms.

79. This suggests that the reliability of the beta estimate would be increased dramatically if the sample size could be increased.

4.4.1 US regulated businesses as additional proxy betas

80. CEG has separately identified a sample of 56 US businesses with at least 50% of total assets subject to regulation.[18] CEG chose the 50% cut threshold based on analysis showing that, above 50%, there was no statistical relationship between historical regression beta and the percentage of regulated assets.

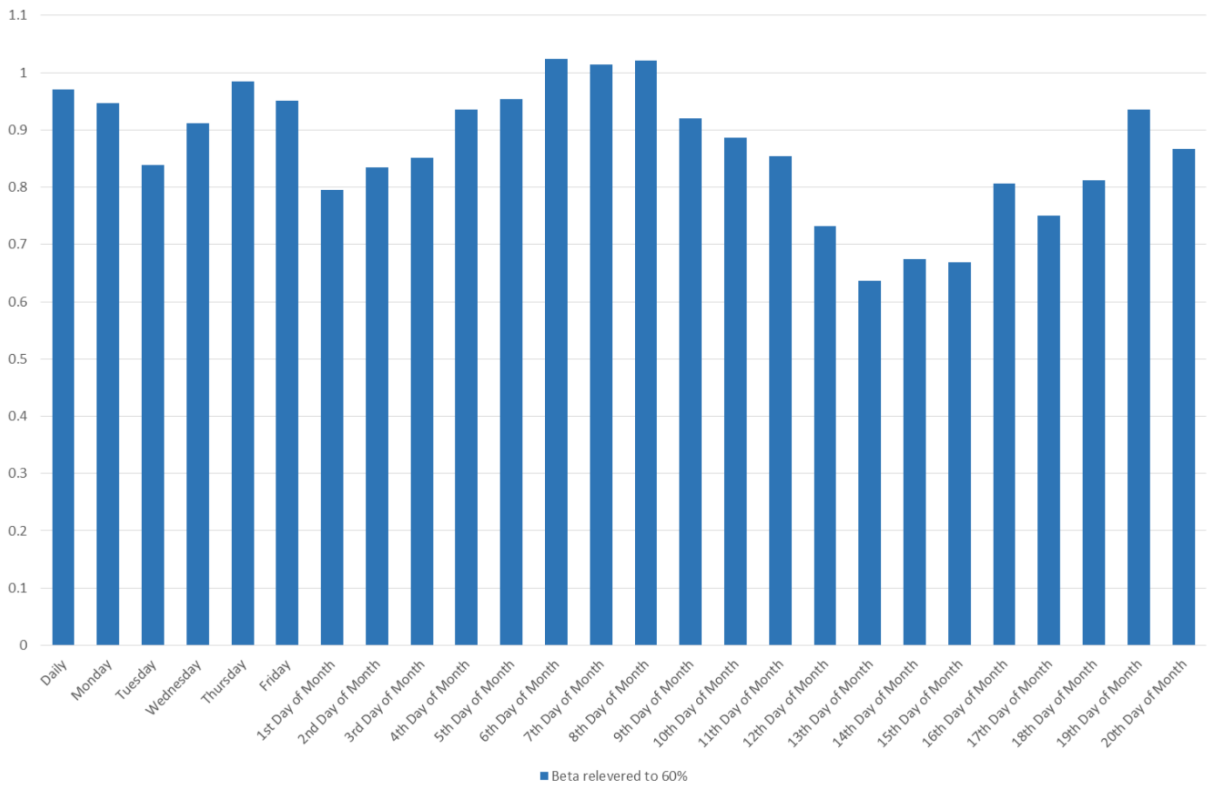
81. Figure 4. below is a direct reproduction of Figure 3 above except that average US rather than Australian betas have been estimated for each sampling interval.

16 This is narrowly defined in terms of the standard error associated with sampling from estimated historical equity betas. It is not a measure of the dispersion in the possible forward-looking betas perceived by investors.

17 Diamond *et. al.* (*op cit*) See Table 2, Panel F on page 11.

18 CEG, Information on equity beta from US companies, A report for the ENA, June 2013.

Figure 4: US OLS beta estimates associated with different sampling intervals



Source: Bloomberg, CEG.

82. Comparing Figure 3 and Figure 4 it is noticeable that the dispersion in Figure 4 is much lower – as would be expected with a larger sample of companies. The range between smallest and largest estimate for the US sample is 0.39 (0.63 to 1.02) while for the Australian sample it is 0.65 (0.29 to 0.94).

83. The fact almost half the Australian estimates and all the US estimates of beta (each one averaged across 56 firms) are above the ERA's upper bound estimates (0.61)[19] is further evidence that that upper bound is not, in reality, a reliable reflection of the true uncertainty that surrounds the ERA point estimate. Indeed, only 16% of all the individual US beta estimates are below the ERA upper bound.[20]

84. Provided that US regulated assets have similar (do not have very dissimilar) CAPM risk to Australian regulated businesses then including these 56 companies would dramatically improve the accuracy of the ERA's proxy sample. Having regard to US

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19 0.61 is the portfolio 4 upper bound for the OLS regression (the same regression used to generate the US betas).

20 There are 56*26 individual beta estimates underpinning the US results (26 for each company reflecting the 26 different sampling intervals). Of these, only 234 have a beta that is less than 0.6124.

beta estimates will tend to raise the ERA's point estimate and likely lower the ERA's upper bound.

85. In the same report referred to above, CEG examined the question of comparability of US and Australia equity betas. There is no *a priori* reason to believe that investing in US regulated businesses will be higher risk than investing in Australian regulated businesses. In fact, it has been standard practice by many regulators and academics to assume precisely the opposite – on the grounds that US regulation tended have lower powered incentives thereby reducing risk (upside and downside) for investors.

86. Alexander, Mayer and Weeds (1996) found that high-powered incentive schemes such as price cap regulation resulted in higher risks relative to low-powered incentive schemes such as rate-of-return regulation (but as discussed below, we do not):[21]

> *The results show a clear pattern at the level of individual utility sectors and for regulatory regimes as a whole. Regimes with low-powered incentives tend to co-exist with low asset beta values, while high-powered incentives imply a significantly higher beta values. These results, in accordance with existing comparisons of regulatory regimes, seem to imply that companies under RPI-X regulation are exposed to much higher levels of systematic risk in comparison with those under rate-of-return regulation, and that the cost of capital for these forms is therefore likely to be higher.*

87. The findings of Alexander et al. are referred to approvingly by the New Zealand Commerce Commission's adviser Dr Lally, who notes that[22]:

> *Firms subject to "rate of return regulation" (price regulation with frequent resetting of prices) should have low sensitivity to real GNP shocks, because the regulatory process is geared towards achieving a fixed rate of return.*

88. Dr Lally recommended an upward adjustment to account for the incentive based regulatory regime in New Zealand and the length of time between price resets when he estimated betas in 2005 for electricity distribution businesses and in 2004 and 2008 for gas pipeline businesses.[23]

89. In addition, CEG has separately shown why the higher rates of company tax in the US will tend to lower measured betas for highly geared companies (such as utilities)

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21 Alexander, Mayer & Weeds (1996) *Regulatory structure and risk: An international comparison,* The World Bank.

22 Lally (2005) *The weighted average cost of capital for electricity lines businesses,* Victoria University of Wellington, p. 37

23 New Zealand Commerce Commission (2010) *EDB and GPB Input Methodologies Reasons Paper,* p. 531

– meaning a like-for-like comparison would involve an upward adjustment to US utility betas if they were to be used in Australia. [24]

90. The New Zealand Commerce Commission however, in its recent Input Methodologies Paper, concluded, on the basis of empirical evidence it reviewed, that it was not necessary to make an adjustment to the asset beta estimate to account for different levels of systematic difference due to regulatory policy.[25] The New Zealand Commerce Commission set beta based almost entirely on US betas without any adjustment for differences in risk.

91. If one accepts that US utilities are actually lower (or the same) risk as Australian utilities then the only reasonable conclusion is that the sampling of Australian betas suffers from sampling bias. This sampling bias may be due to the small number of proxy firms in the ERA sample (6 firms) or the relatively small amount of time analysed (the overlapping data for all 6 firms in less than 7 years in total).

92. A definitive empirical examination of this issue is hindered by precisely the same factors that raise the question in the first place (namely a small sample of Australian firms). However, there is evidence that the patterns of beta across industries appear to be similar in the US to Australia. That is, industries with high/low beta in the US tend to have high/low beta in Australia.[26]

93. In our view, in order for any estimate of beta to be consistent with the allowed rate of return objective in the Rules, weight must be given to the large dataset of historical betas for US regulated utilities.

24 CEG, Information on equity beta from US companies, A report for the ENA, June 2013. See section 5.3.1.

25 New Zealand Commerce Commission (2010) *EDB and GPB Input Methodologies Reasons Paper*, p. 542

26 CEG, Information on equity beta from US companies, A report for the ENA, June 2013. See section 5.3.2.