COMPETITION ECONOMISTS GROUP

Asset betas for gas versus electricity businesses in the Commission's sample

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1 Executive summary

1. Both Oxera and TDB rely on the Commission's published asset betas to argue that gas businesses have significantly higher than average asset betas. Oxera proposes that this results in a gas WACC uplift while TDB proposes that this results in many gas businesses being removed from the sample (on the basis that their higher betas reflect higher risk associated with unregulated activities).

2. Both Oxera and TDB's statistical analysis is unreliable in that it is based on:

   - an invalid comparison across firms/subsamples without the appropriate adjustment for gearing and debt beta; and
   - only the most recent 5 year period.

3. When these are corrected (positive debt betas are used and a longer time period analysed) the Oxera and TDB's conclusions no longer hold. Specifically, there is no statistically significant difference between gas and electricity asset betas and the 'outliers' claimed by TDB disappear.

4. This does not necessarily imply that a WACC uplift for GPBs is inappropriate. For the reasons set out in our March 2016 report for Vector, GPBs appear to face higher stranding risk and the expected cost of this exposure must be compensated for even though it is not, or is not primarily, a systemic (beta) risk. In addition, there is other, New Zealand specific, information before the Commission supporting a higher asset beta for NZ GPBs than NZ EDBs.[1] This would not be expected to show up in the predominantly international measured comparator sample adopted by the Commission.

5. Separately, TDB applies a qualitative assessment of each firm in the Commission's sample in order to determine whether they should be included or excluded from the sample. TDB removes 66 of the 74 comparators in the Commission's sample but only provides a written discussion of this for a handful of the firms excluded.

6. We identify that TDB has not consistently applied the same logic to its sample selection process and the effect of these internal inconsistencies happens to be that the average asset beta in TDB's final sample is understated. Moreover, had TDB applied the same criteria universally its final sample would be an empty set (i.e., no comparators).

[1] For example, NZ elasticity of demand data surveyed by Houston Kemp in: Houston Kemp, Asset beta for gas pipeline businesses, May 2016.

7. In the process of performing this work we have also identified an error in the Commission's spread-sheet which raises average asset betas (according to the Commission's method) by a little over 0.01 on average.

2 Introduction

8. This report is provided as a cross-submission primarily in relation to submissions lodged by Contact Energy and First gas and the expert reports submitted by these parties (respectively by TDB and Oxera). The remainder of this report has the following structure.

9. This cross-submission is, naturally, focussed on the empirical analysis performed by Oxera and TDB using the Commission's comparator set. Of course, this does not imply that we believe that the Commission should focus solely on evidence from that comparator set when estimating the appropriate asset beta for EDBs and GPBs.

10. We do find in this report that there is no statistically significantly higher asset beta for gas only businesses in the Commission's sample of comparators. However, in relation to estimating an uplift to the WACC for GPBs, we note that, for the reasons set out in our March 2016 report for Vector, GPBs appear to face higher stranding risk and the expected cost of this exposure must be compensated for even though it is not, or is not primarily, a systemic (beta) risk. In addition, there is other, New Zealand specific, information before the Commission supporting a higher asset beta for NZ GPBs than NZ EDBs.[2] This would not be expected to show up in the predominantly international measured comparator sample adopted by the Commission.

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

12. Section 3 discusses why the comparisons of the Commission's asset beta made by TDB (across individual firms) and Oxera (across subsamples of firms) cannot meaningfully be done unless the firms/subsamples have the same gearing. This is not the case in the context of the TDB/Oxera analysis and, in order for it to proceed without error, debt betas must be estimated for individual firms. We illustrate that when plausible estimates of debt beta are used much of the apparent variation relied on by TDB and Oxera to reach their conclusions disappears.

13. Section 4 focuses on Oxera's analysis in support of an estimated higher asset beta for gas only businesses in the Commissions predominantly US sample. We demonstrate that the apparent differences in gas and electricity betas is largely a function of the use of zero debt betas (as explained in section 3) and the use of the most recent 5 year period. We demonstrate that there is no statistically significant difference between gas and electricity betas when a longer time horizon is examined. We explain why a longer time horizon is the only appropriate basis on which to perform such a test

[2] For example, NZ elasticity of demand data surveyed by Houston Kemp in: Houston Kemp, Asset beta for gas pipeline businesses, May 2016.

unless there was a credible a priori reason for assuming that gas businesses had only suddenly and recently become higher risk than electricity businesses.

14. Section 5 focuses on TDB's analysis and its rationale for removing 66 of the 74 comparators in the Commission's sample. We demonstrate that TDB's analysis of asset betas and its conclusion that some gas businesses appear to be 'outliers' is also dependent on the assumed zero debt betas (as explained in section 3) and the sole reliance on data from the last 5 years. Adjusting for debt beta and using a longer time horizon, TDB's rationale for identifying 'outliers', such as it was, is greatly reduced.

15. Section 5 also carefully critiques TDB's rationale for removing other firms from the sample. We identify that TDB has not consistently applied the same logic to its sample selection process and the effect of these internal inconsistencies happens to be that the average asset beta in TDB's final sample is understated. Specifically, had TDB applied the same criteria universally sample would be larger (with fewer firms excluded) or smaller (with more firms excluded). Indeed, a strict application of TDB's stated criteria would lead to an empty set – with all firms excluded. We explain why, in our view, the Commission's larger sample should be adopted – with the possible exception of two firms the removal of which does not have a material effect on the results.

16. Section 6 identifies what we believe is a spread-sheeting error in the Commission's model the correction of which has a modest increase in weekly asset betas of around 0.03 (leading to an increase of around 0.01 on average across weekly and four weekly asset betas).

17. Section 7 discusses sample average leverage and why adopting sample average leverage, and a zero debt beta, will tend to underestimate the true equity beta (by around 0.02).

3 Correctly adjusting for gearing in cross-sectional comparisons

18. The Commission's standard approach is to estimate asset betas assuming, for simplicity, that debt betas are zero. The Commission acknowledges that this is unlikely to be accurate but correctly states that inaccuracies in the sample average asset beta estimated will be largely "cancelled out" provided the sample average asset beta is re-levered back to the sample average gearing while also assuming a zero debt beta.

19. That is, errors created by de-levering equity beta assuming a zero debt beta are, on average, cancelled out, if the same 'zero beta' formula is used to re-lever the asset beta back to the sample average gearing. The Commission discusses precisely this issue under the heading "the leverage anomaly" starting on page 117 of Topic Paper 4. The Commission explains why it would not countenance adopting a higher leverage than sample average leverage for Transpower unless it also adopted a positive debt beta assumption to accurately account for the impact of differences in gearing between Transpower and the sample average.[3]

20. Precisely the same logic applies when attempting to compare asset betas for individual firms (or subsets of firms) within the wider sample. Asset betas for a firm with high gearing cannot be meaningfully compared to asset betas for a firm with low gearing unless a non-zero debt beta has been used in the de-leverage process.

21. By way of illustration, consider two otherwise identical firms with the same asset beta (of 0.40). Let the only difference be that one has zero debt and the other is 80% geared. The firm with zero debt has an asset beta equal to their equity beta (0.4 in this example) and no adjustment for debt beta is required to derive an asset beta. Let the 80% geared firm have high risk debt (consistent with high gearing) and a debt beta of 0.3. Applying the Commission's leverage formula at paragraph 288.1 of Topic Paper 4 this implies the highly geared firm will have an equity beta of 0.8 (=(0.4-0.3*0.80%)/(1-0.80%) which is double the equity beta of its 'twin' with zero gearing.

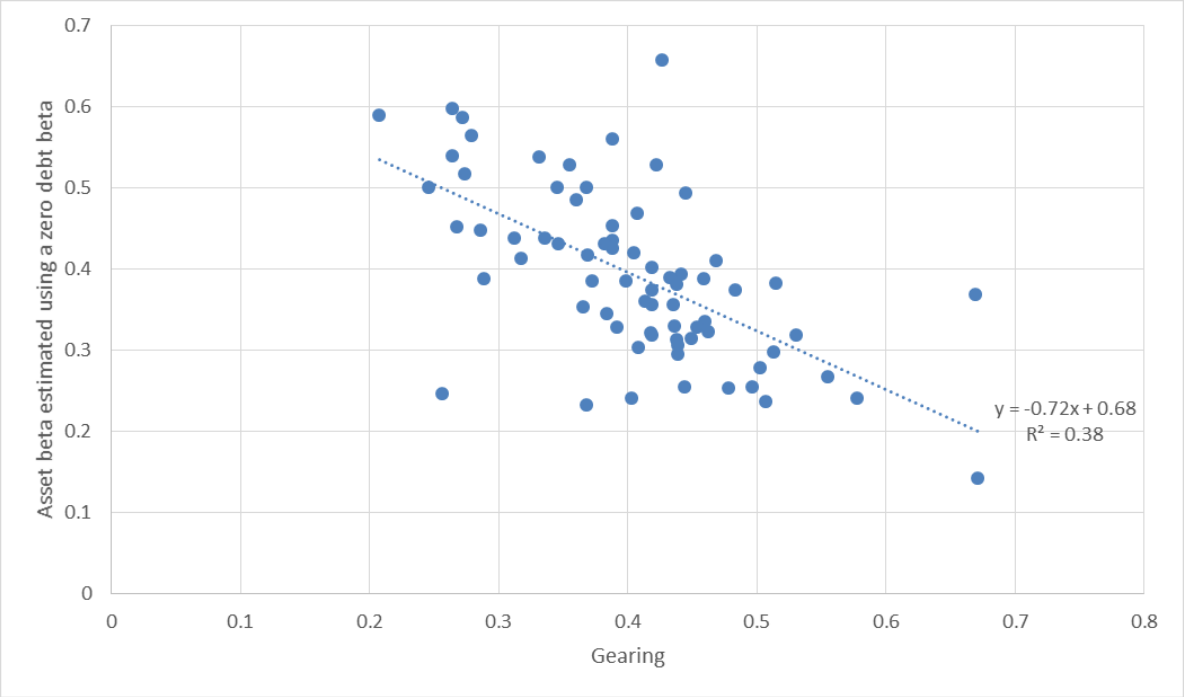
22. Now, let a researcher observe these two firms' equity betas and gearing and calculate an asset beta for each assuming a zero debt beta. If the researcher does so, then they will estimate an asset beta of 0.40 for the zero geared firm and an asset beta of 0.16 (=0.8*(1-0.8)) for the highly geared firm. The researcher may then conclude that the latter's asset beta is less than half the former's asset beta. However, this is a clear error. By construction in this example both firms have the same asset beta of 0.40.

[3] Paragraph 458 beginning on page 117 of Topic Paper 4.

23. Having made this error the researcher may then go onto speculate about fundamental reasons why one firm has lower risk than the other. However, such speculation would ultimately be guided by an unreliable empirical observation/comparison. The estimated difference in risk (one firm estimated to be less than half as risky as the other) is wholly artificial and created by the assumption of a zero debt beta.

24. We consider that this is, in large part, a valid criticism of both the Oxera and TDB reports. To illustrate the importance of accounting for a zero debt when making comparisons within the Commission's sample consider the following chart, for the 2011-16 period, showing the estimated daily asset beta on the vertical axis and the gearing on the horizontal axis. Each dot represents one of 72 firms.[4]

Figure 1: Asset beta estimated with zero debt beta vs gearing (daily estimates over 2011-16)



Source: Commerce Commission data, CEG analysis.

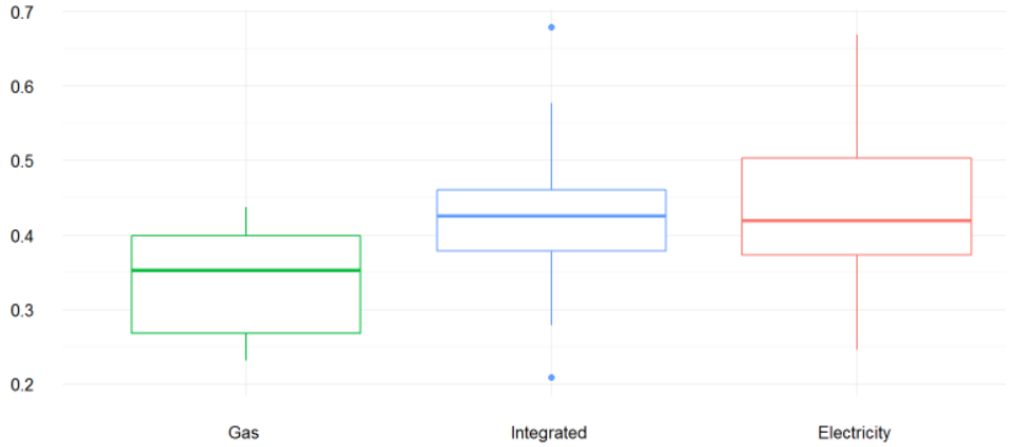
25. This illustrates a very strong and statistically significant negative relationship between gearing and asset beta (when the former is estimated assuming zero debt beta). Of course, there should be no relationship between asset beta and gearing because asset beta is, by definition, estimated in order to remove the impact of differences in gearing across businesses.

4 The chart excludes JEL and NFG consistent with the discussion in section 5.2.

26. The above figure strongly suggests that the differences in measured asset betas within the sample is largely explained by the failure to account for the impact of debt betas when estimating asset betas. Moreover, this underestimation of asset beta is strongest for firms outside the gas subsample because these firms happen to have the highest gearing. This is illustrated in Figure 2 below.

27. Figure 2 compares the distribution of gearing for the underlying gas, electricity and integrated samples. It can be seen that the average gearings for gas firms is lower than for electricity and integrated firms and that the 25th percentile (the bottom of the boxplot) is much lower for the gas sample than the electricity or the integrated samples. This indicates that the observed higher asset betas for gas firms could be attributed to the lower level of borrowings, instead of different exposure to systematic risks.

Figure 2: Average gearings adopted in calculating the recent five year asset betas for gas, electricity and integrated sub-samples



Bloomberg data, CEG analysis

28. The debt beta represents the amount of systemic risk that is transferred to debt holders when debt is raised. At low levels of debt this is very likely zero because debt holders are protected from the impact of a systematic shock hitting the firm by a large equity cushion. However, at higher leverage the equity cushion is reduced and the debt holders' exposure to systemic shocks hitting the debt issuer is increased. For this reason debt beta, just like equity beta, can be expected to increase with gearing.

29. In order to account for the potential impact of debt beta we have applied the following approach. We assume that, for each individual firm, its debt beta is zero if the gearing is less than 30%, and increases with gearing above 30% to a maximum of 0.3. The algebraic expression of the relationship between individual firms' debt beta and gearing is given by:

$$debt\ beta = \min(\max\left(\frac{0.5}{1-\text{gearing}} - \frac{0.5}{1-0.3}, 0\right), 0.3)$$

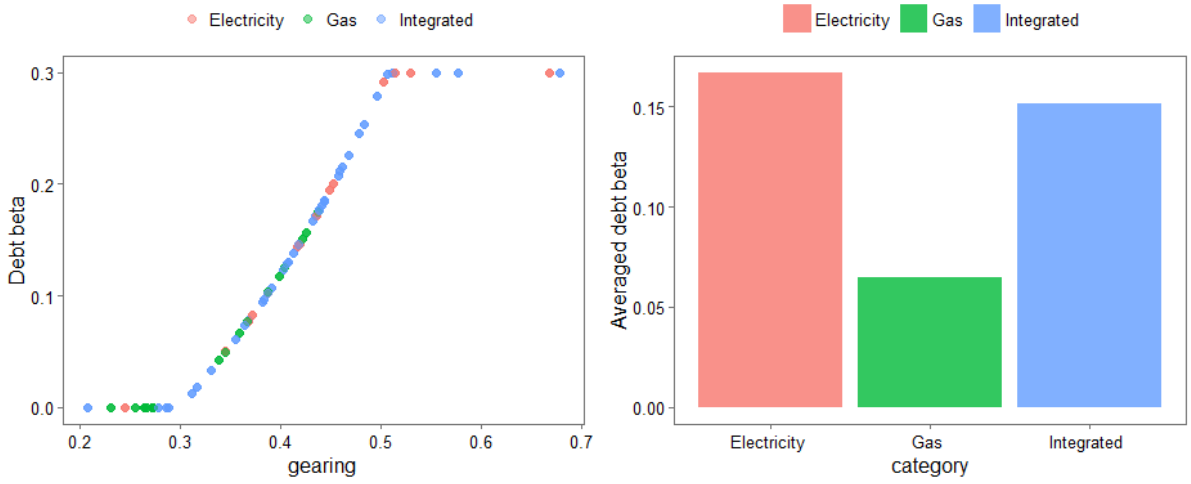
30. When this approach is adopted the average debt beta in the Commission's sample is 0.14 in the 2011-16 period but the distribution is from 0.00 to 0.30. This range is consistent with that nominated by Brealey and Myers as typical.[5]

> *Debt betas of large firms are typically in the range of .1 to .3.*

31. The fact that debt betas increase with leverage is also explained in a worked example by Brealey and Myers where a firm increases leverage from 30% to 40% and debt betas increase from 0.1 to 0.2.[6] This is roughly the same as the increase in debt beta we model for an increase in gearing from 30% to 40% (except we assume zero debt beta at 30% gearing).

32. In terms of further elaboration, the left scatter plot in Figure 3 shows the calculated debt beta against gearing for all the firms using the most recent five years of data. It can be seen that a number of electricity firms (red dots) are associated with higher debt beta, due to higher gearing; while most gas firms (green dots) reside in the left bottom corner which corresponds to low or zero debt betas resulted from lower gearing. The right bar plot in Figure 3 shows that the debt beta for electricity firms is 0.1 higher, on average, than for gas firms.

Figure 3: Assumed relationship between gearing and debt beta, 2011-2015 sample



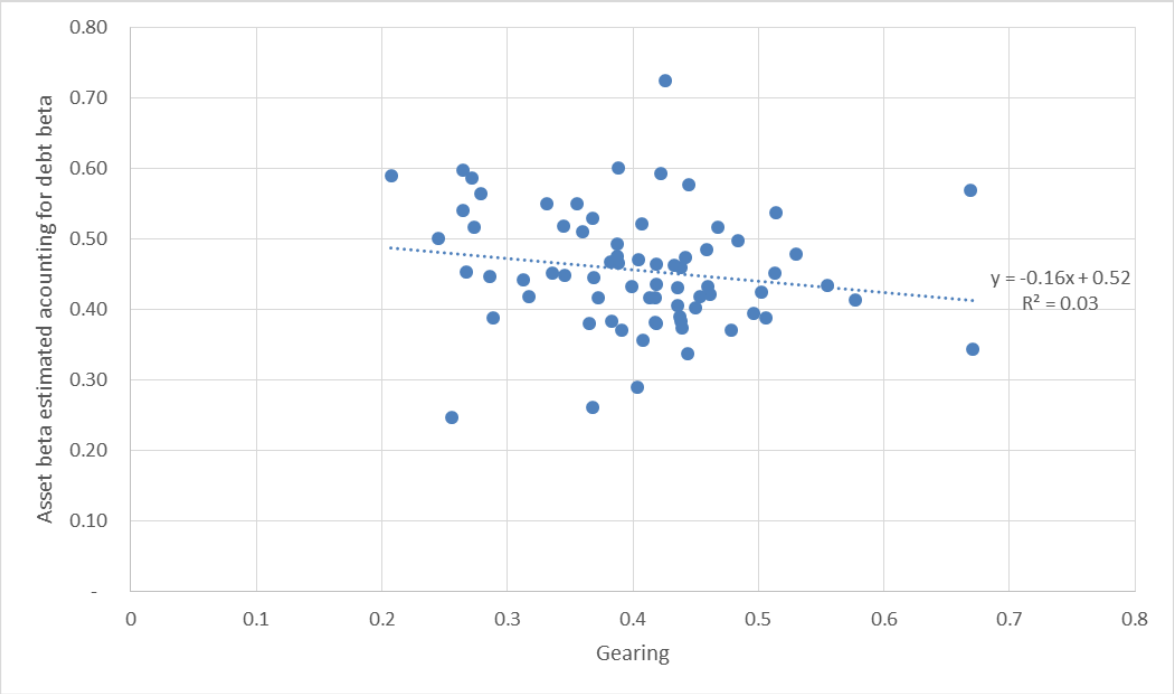
Bloomberg data, CEG analysis

5 Brealey and Myers, Principles of Corporate Finance, Tenth Edition, p. 427

6 Brealey and Myers, Principles of Corporate Finance, Tenth Edition, p. 426-428.

33. This relationship between debt beta and asset beta is adopted because it serves to largely eliminate the negative relationship between asset beta and gearing observed in Figure 1 above. That figure becomes transformed into Figure 4 below with our assumed debt betas.

Figure 4: Asset beta estimated with positive debt betas vs gearing (daily estimates over 2011-16)



Source: Commerce Commission data, CEG analysis.

34. Comparing Figure 1 and Figure 4 the negative relationship between asset beta and gearing is reduced by a factor of over 4 and gearing goes from explaining 38% of the variation in asset betas to just 3%. Given that, in theory, gearing should have no explanatory power over asset beta we consider that this is a significant improvement.

35. That said, we do not represent our assumed debt beta estimates as uniquely correct or necessarily the best possible estimates. Estimating debt betas is difficult, given the lack of reliable liquid prices for BBB corporate debt, which is why the Commission and other regulators tend not to do so. However, an estimate of debt beta is required if the Oxera/TDB style analysis is to be carried out (adopting a zero debt beta is not an option for this cross-sectional analysis). We consider that adopting our estimates of debt beta is a considerable improvement on the assumption that debt betas are zero – implicitly adopted by Oxera and TDB. We also note that any alternative estimates should have similar properties to ours in terms of largely eliminating the negative relationship between asset beta and gearing.

3.1 Impact on Oxera analysis

36. The following series of charts in Figure 5 and Figure 6 illustrate the differential impact of adjusting for debt betas on the comparison between gas and non-gas subsamples in the 2011-16 period. The first panel (Figure 5) shows asset betas estimated with a zero debt beta. The three charts correspond to different definitions of beta (daily, weekly, and 4-weekly ("monthly")). The green dots represent gas subsample firms while the blue/pink dots represent electricity/integrated firms. The left most panel has the same data as is in Figure 1 (i.e., daily betas for 2011-16).

37. The second panel (Figure 6) provides the corresponding estimates when asset beta is estimated using a positive debt beta. It can be seen that the asset betas of the firms with high gearing increase the most while those with low gearing rise by less (or do not rise at all if their debt beta is zero). The effect of this is to markedly reduce the difference between the average level of the green dots and the blue/pink dots.

Figure 5: Scatter plot of recent five year asset beta vs gearing by firm categories (2011-16)

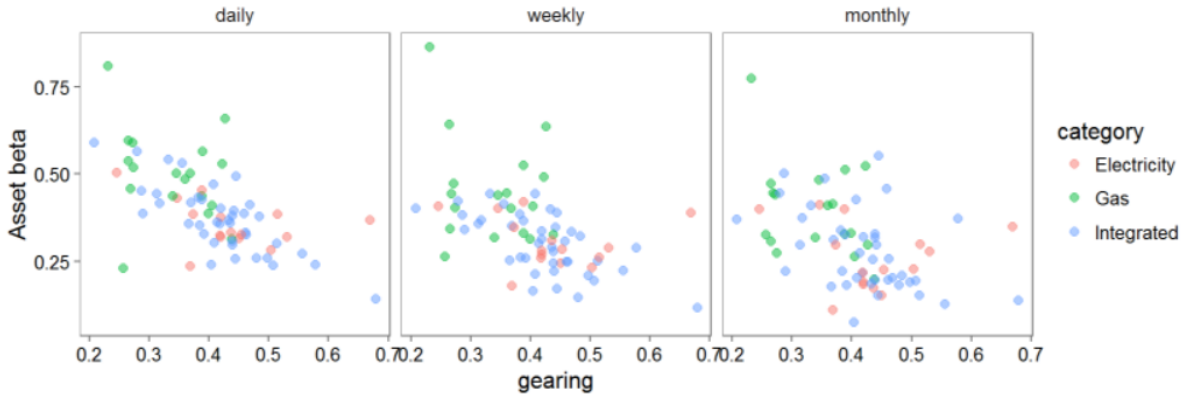
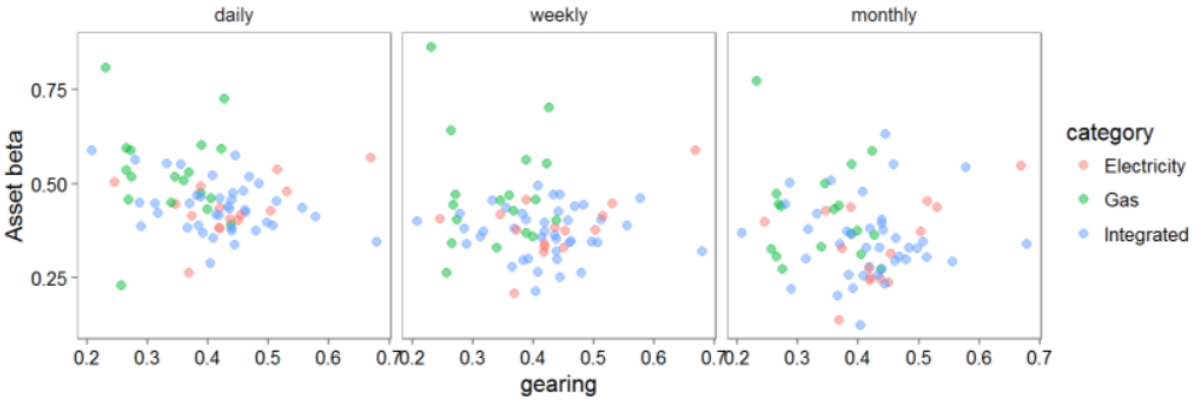


Figure 6: Scatter plot of recent five year asset beta vs gearing by firm categories after correction with debt betas (2011-16)



Bloomberg data, CEG analysis

38. The following table summarises the impact on the average asset beta in each subsample when positive debt betas are accounted for. The values in this table are for a sample of 72 firms – with JEL and NFG excluded consistent with the discussion in section 5.2 below.

Table 1: Impact of debt beta on difference between gas and electricity

Firm category	Firm category	Zero debt beta	Positive debt beta	Percentage decline in difference
Daily 2011-16	Electricity	0.36	0.44	
	gas	0.48	0.51	
	Difference	**0.12**	**0.07**	**43%**
Weekly 2011-16	Electricity	0.33	0.41	
	gas	0.47	0.50	
	Difference	**0.15**	**0.09**	**37%**
4 Weekly 2011-16	Electricity	0.27	0.36	
	gas	0.42	0.45	
	Difference	**0.15**	**0.10**	**36%**
Daily 2006-11	Electricity	0.40	0.49	
	gas	0.45	0.50	
	Difference	**0.05**	**0.01**	**79%**
Weekly 2006-11	Electricity	0.40	0.49	
	gas	0.47	0.51	
	Difference	**0.07**	**0.03**	**59%**
4 Weekly 2006-11	Electricity	0.40	0.48	
	gas	0.39	0.44	
	Difference	**-0.01**	**-0.05**	**788%**

Bloomberg data, CEG analysis

39. Clearly the apparent difference between gas and other subsamples is materially reduced for the most recent 5 year period and is actually made more negative in the previous 5 year period for 4 weekly estimates.

3.1 Impact on TDB analysis

40. TDB makes a different inference on the same data than does Oxera. While Oxera argues that high relative gas asset betas justify an uplift for predominantly US GPBs, TDB argues that high relative gas asset betas for some firms in the sample mean that they should be excluded. TDB's basis for this position is essentially two pronged:

- First, TDB presents charts that purport to identify gas asset betas that are outliers; and
- Second, TDB provides some qualitative discussion of the characteristics of these 'outlier' firms; characteristics which it purports to explain why they are higher risk than a standard regulated GPB/EDB.

41. We deal with the second prong of this argument in section 5 below. However, the first prong of TDB's argument is important because this analysis has the potential to play the role of 'softening up' the reader to accept that there must be a problem with the sample selection – to which TDB then proceeds to provide "the solution" by essentially removing high asset beta firms (gas and electricity).

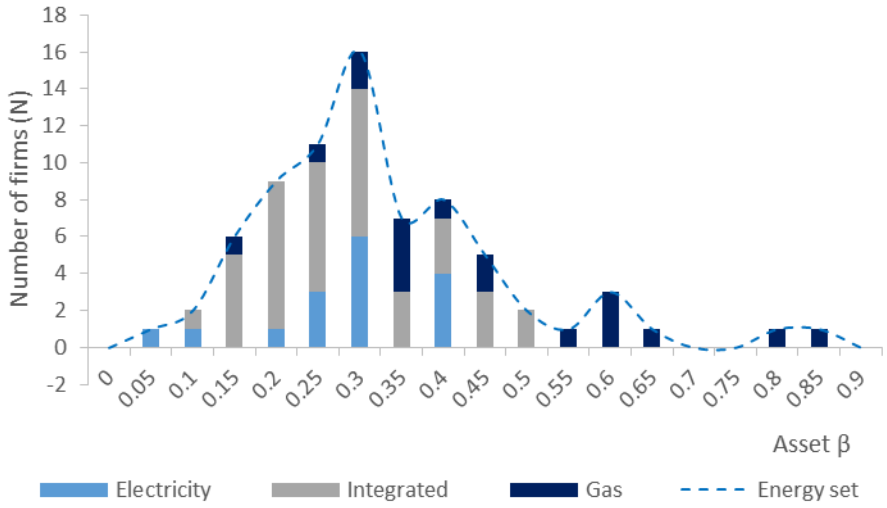
42. TDB does, correctly, state in relation to the first prong of its argument:

> *We do not want to overstate the statistical significance or reliability of the distribution analysis presented above. Our analysis is intended to indicate issues that may warrant further analysis by the Commission.*

43. However, TDB does not perform any analysis on the sensitivity of its distributional analysis to methodological choices it makes. In our view, the persuasiveness, such as it is, of TDB's presentation of distributional analysis is entirely dependent on the use of zero debt betas to derive asset betas and the sole reliance on the last 5 years of data.

44. TDB's core exhibit is its Figure 2 which is reproduced below.

Figure 7: Reproduction of TDB Figure 2



45. Before we proceed, it is relevant to note that the highest and lowest observations in the above figure are for JEL and NFG. For the reasons set out in section 5, we consider that both of these firms could reasonably be removed from the Commission's sample.

46. In relation to the above chart TDB states:

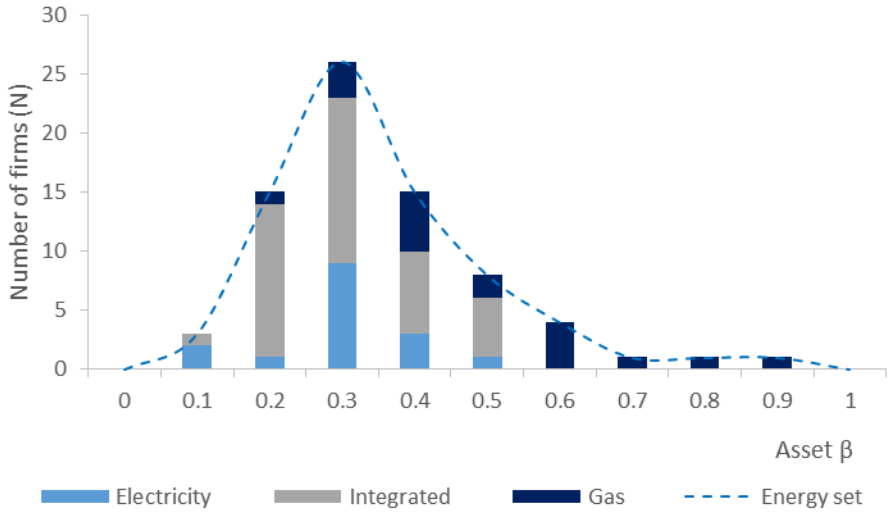
> *Figure 2 indicates that the distributions of the betas for the three industry sub-sets defined by the Commission may not be the same:*

- *the highest seven asset beta estimates belong to the gas industry;*
- *the electricity firm beta estimates appear to be skewed towards the lower end of the distribution; while*
- *the integrated firms seem to be fairly evenly spread across the distribution.*

47. The reader examining TDB's Figure 2 may be inclined to agree that the distribution looks 'odd' and not at all smooth in the manner of the text-book Gaussian (normal) distribution. Instead, it appears to have several 'humps' (at 0.3, 0.4, 0.6 and 08). Drawing of the blue dotted line accentuates this impression making it more difficult for the viewer to draw her own, smoother, distribution in their 'mind's eye'.

48. However, this lack of smoothness is a function of the presentation rather than the underlying data. If we insert larger increments in the frequency distribution (increasing in blocks of 0.10 instead of 0.05), as is appropriate when attempting to assess the distribution of a relatively small finite number of observations against the theoretical 'normal' distribution with infinite observations, then we do arrive at a relatively smooth looking distribution.

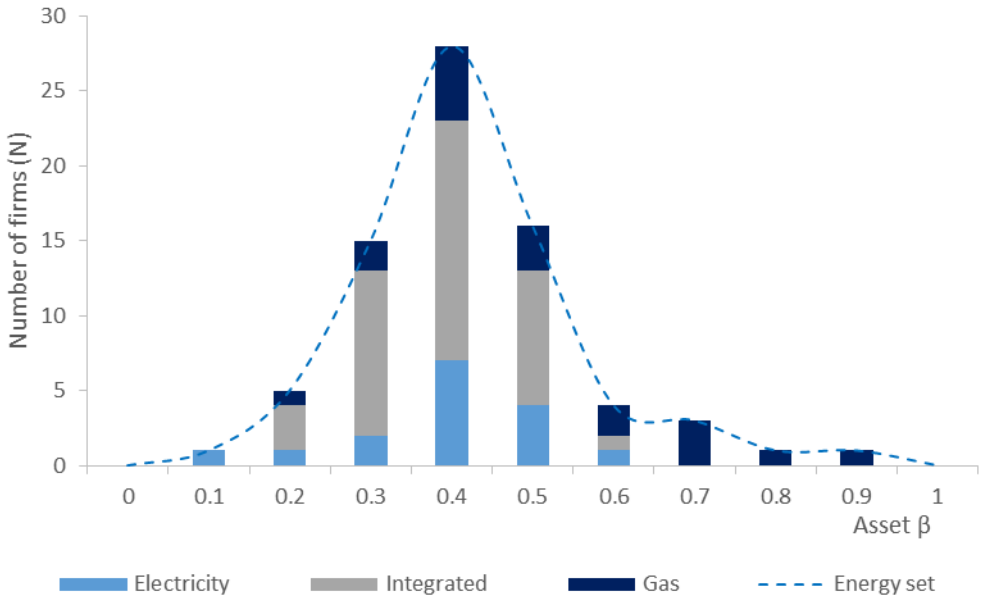
Figure 8: TDB's Figure 2 using asset beta increments of 0.10 instead of 0.05



49. The claimed "skew" for electricity betas, such as it was in TDB's Figure 2, is less apparent in this presentation. That said, it is still the case that gas asset betas dominate the right hand tail of the distribution and are hardly present on the left hand side of the distribution. However, that description depends critically on the use

of zero debt betas to arrive at asset betas. When positive debt betas are used the distribution alters materially as is shown in Figure 9.

Figure 9: TDB's Figure 2 using positive debt betas

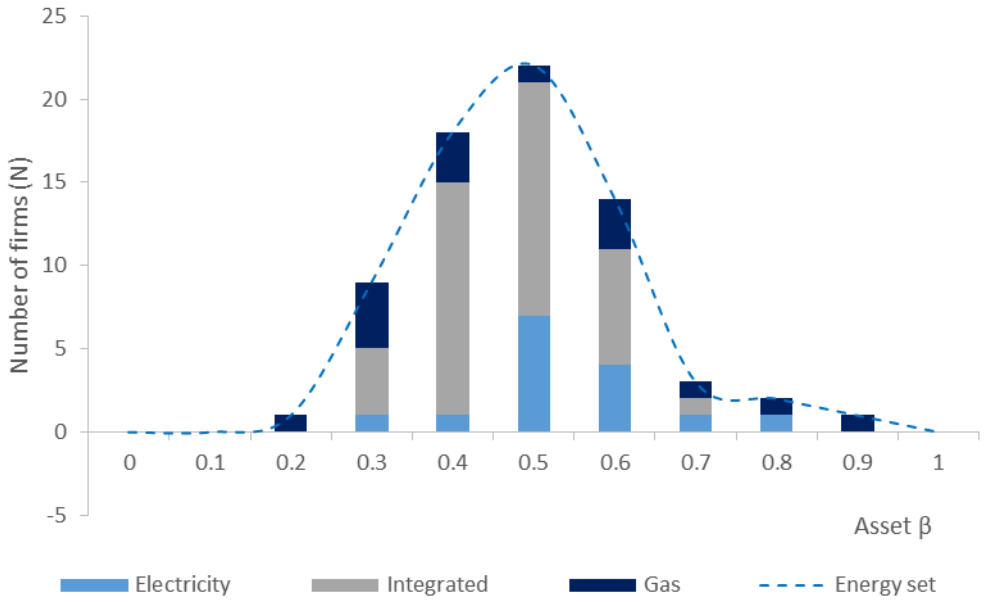


50. It can be seen that with positive debt betas the electricity and integrated firms with high gearing see their asset betas increase while the gas firms with low gearing have little or no increase. The effect is that the gas asset betas are now distributed more evenly throughout the distribution. Instead of having only one gas asset beta below the modal point there are now three. Instead of having only three at the modal point there are now 5. Equally, instead of having 14 above the modal point there are now only 10.

51. That said, it remains the case that gas asset betas are more heavily represented on the right hand side of this distribution than the left hand side (10 vs 3). However, this is only true in the 5 year period 2011- 2016. If, instead, the period 2006 to 2011 is examined the gas asset betas are over-represented in the left hand tail of the distribution rather than the right hand tail (8 observations below the modal point vs 6 observations above the modal point).[7] This is illustrated in Figure 10 below.

[7] The total number of firms is different in this Figure. KMI and WPZ are not included because, despite the Commission's spreadsheet assigning them zero asset betas in this period we are unable to obtain data for these firms in 2006-11. Obviously, including these firms with zero asset betas would add to the number of gas firms on the left of the observation. In addition, we remove NFG and JEL for the reasons discussed in section 5.2 below. The effect of this is to remove a low beta electricity observation and a high beta gas

Figure 10: TDB's Figure 2 using positive debt betas and the period 2006-11



52. It is also worth noting that, while the highest asset beta is still for a gas businesses, this is not amongst the gas businesses with high asset betas in 2011-16. The highest gas asset beta in 2006-11 is for STR (with an asset beta of 0.90) but STR had one of the lower asset betas in 2011-16 (0.32).[8]

53. In summary, it is our view that TDB's analysis of 'outliers' with higher risk than 'normal' regulated energy transport businesses is *ad hoc* and places too much emphasis on one estimate of asset beta (2011-16 asset betas estimated with a zero debt beta) to 'tell a story' without assessing whether the story is sensitive to the specific choice of asset beta measurement.

54. The above variety in STR's relative asset beta illustrates this point. Rather than the high 4-weekly asset beta in 2006-11 year period being strong evidence of a fundamentally risky business, a more plausible explanation is that this happens to be the natural result of volatility in beta estimates. When you have a sample of 70+ firms, one of them will have the highest asset beta (when measured in any particular way). It is a mistake to exclude that observation on the basis that the firm must be fundamentally different to the sample average. To do so will asymmetrically remove

observation. Were this done in TDB's 2011-16 charts the apparent difference between electricity and gas would be smaller in that period as well.

8 All numbers are based on 4-weekly asset betas as per TDB's own analysis.

the high asset beta observations and artificially depress the average of the remaining sample.

55. In reality, some firms will have high asset betas measured in some periods and low asset betas measured in others. To assume that high measured betas for a stock in one periods is strong evidence of high fundamental risk is to fail to appreciate the volatility of individual assets betas and to fail to understand the benefits of a large sample of comparators and a longer estimation period in the presence of such volatility.

4 Statistical tests for the difference in asset/equity betas between gas and electricity

56. In this section we carry out a number of standard statistical tests for difference in the average asset beta for gas and electricity businesses. For the reasons discussed at the end of this section we consider that these tests are biased to find statistically significant differences where none actually exist because they fail to take into account all of the relevant sources of variability/uncertainty. Even so, these tests do not find evidence of statistically significant differences between gas and electricity assets betas.

4.1 The test

57. A two-sample t-test is used to measure whether the observed difference between the gas/electricity asset betas, within their calculating frequencies (i.e. daily, weekly and monthly) and given standard deviations, are statistically significant. The procedure of a two-sample t-test for unpaired data is defined as:

$H_o: \mu_{gas} = \mu_{electricity}$

$H_a: \mu_{gas} \neq \mu_{electricity}$

$$Test\ statistic: T = \frac{\overline{beta_{gas}} - \overline{beta_{electricity}}}{\sqrt{\frac{s_{gas}^2}{N_{gas}} + \frac{s_{electricity}^2}{tricity}}}$$

where,

$\overline{beta_{gas}}$ *and* $\overline{beta_{electricity}}$ *are sample means;*

$s_{electricity}$ *are standard deviations; and*

N_{gas} *and* $N_{electricity}$ *are sample sizes.*

58. At 5% significance, the null hypothesis will be rejected if:

$$|T| > t_{0.05,v}$$

$$where\ \ v\ is\ degree\ of\ freedom\ for\ the\ critical\ value: v = \frac{\left(\frac{s_{gas}^2}{N_{gas}} + \frac{s_{electricity}^2}{N_{electricity}}\right)^2}{\frac{\left(\frac{s_{gas}^2}{N_{gas}}\right)^2}{N_{gas}-1} + \frac{\left(\frac{s_{electricity}^2}{N_{electricity}}\right)^2}{N_{electricity}-1}}$$

4.2 Results

59. This section steps through the results of application of this test to different time periods. We focus on the average of 4 weekly and weekly asset betas which follows the Commission's own focus. The sample of firms used for these tests excludes JEL and NFG consistent with the discussion in section 5.2 below.

60. First we report the results of these tests applied individually to each of the last three sets of 5 year regulatory periods – with and without a debt beta adjustment. In summary,

- The 2011-16 period has statistically significantly higher gas asset betas using a zero debt beta but not if positive debt betas are used;
- In 2001-06 gas asset betas are statistically significantly lower than electricity asset betas – even when no debt beta adjustment is applied;
- In the middle period (2006-11) there is no statistically significant different between gas and electricity assets betas – irrespective of whether a debt beta adjustment is applied.

Table 2: T-tests for discrete 5 year periods

Time period	Gas less electricity	P value	Gas less electricity	P value
	No debt beta adjustment		Debt beta adjustment	
2011-16	0.148	0.003	0.095	0.058
2006-11	0.010	0.854	-0.032	0.576
2001-06	-0.135	0.016	-0.160	0.009

Bloomberg data, CEG analysis

61. These periods are then combined in a number of different ways. All estimates using a positive debt beta find no statistically significant difference. Three out of four tests with a zero debt beta find no statistically significant difference. These results are summarised in Table 3.

Table 3: T-tests for 10 and 15 year periods

Beta estimates	Gas less electricity	P value	Gas less electricity	P value
	No debt beta adjustment		Debt beta adjustment	
2006-16				
Single 10 year regression	0.077	0.107	0.029	0.561
Average of two 5 year regressions	0.084	0.043	0.037	0.393
2001-16				
Single 15 year regression	0.035	0.454	-0.011	0.821
Average of three 5 year regressions	0.030	0.441	0.021	0.638

Bloomberg data, CEG analysis

62. The first row of Table 3 shows the results when asset betas are estimated in a single regression over the entire 10 year period 2006 to 2016. These estimates are then averaged across the gas and electricity subsamples and the mean values compared in the t-test. The second row uses the same data but instead of a single regression two 5 year regressions are run and each firm's asset beta is set equal to the average across the two regression results. These estimates are then averaged across the gas and electricity subsamples and the mean values compared in the t-test. The last two rows repeat these two approaches but over a 15 year period.

63. The only test which finds a statistically significant difference occurs where no debt beta adjustment is made and only in one of the four tests (where the 10 year period is broken into two five year periods and betas are separately estimated from these periods and then averaged).

4.3 The longest time period is most reliable

64. Unless there is a credible *a priori* reason for believing that GPBs have only recently, in the last 5 years, become higher risk than EDBs then a longer time period should be used to test for a difference in asset betas. We are unaware of any credible argument to support such an *a priori* view and, therefore, consider that a longer period should be used.

65. We consider that it would be a mistake to rely on the most recent 5 year period while disregarding previous periods. Examining only the most recent estimates of beta will leave relevant information out of the assessment and make the application of any statistical test subject to bias and error. Indeed, the finding of a statistically significant difference between variables in one period is invalid if data from adjacent periods are excluded without a valid reason. This is because the p-values for

statistical tests are only meaningful if all of the relevant information is included. If some relevant information is excluded then the estimated p-values cannot be attributed their standard meaning (they become invalid).

66. This fact is, somewhat humorously, explained in the "jelly bean fallacy"[9] which describes a process whereby scientists test whether different colour jelly beans cause acne. The scientists test 25 different colours and find no statistically significant affect. However, on the 26th test they find that green jelly beans do cause acne with a greater than 95% confidence. This leads to headlines in newspapers touting this finding and claiming only a "5% chance of coincidence".

67. The point of this example is that, if there is no credible *a priori* basis for believing that the colour of a jelly bean might be the cause of acne, then the methodology followed by the scientists is effectively continually reapplying the same test until a "statistically significant" relationship is found. Of course, with enough applications of the test this will give rise to such a finding eventually – purely by chance. The scientists' conclusion, on the 26th test, that green jelly beans cause acne with 95% confidence is invalid because they fail to incorporate the information from the previous 25 tests which found no relationship between jelly beans of other colours and acne.

68. In our example, adjacent time periods are the equivalent of different colour jelly beans. Unless there is a credible reason to believe that the effect we are interested in (whether predominantly US GPBs have higher risk than predominantly US EDBs) only materialised in the most recent period then all of the data must be used to test the proposition. The finding of statistical significance in a subset of the available data is not statistically valid.

69. This is more or less the same conclusion that Commission arrives at when it notes that the average gas asset beta is not consistently higher than electricity asset betas overtime. In some periods the gas beta is higher than the electricity beta, but in other periods the electricity beta is higher than the gas beta. In light of this, the Commission concluded that[10]:

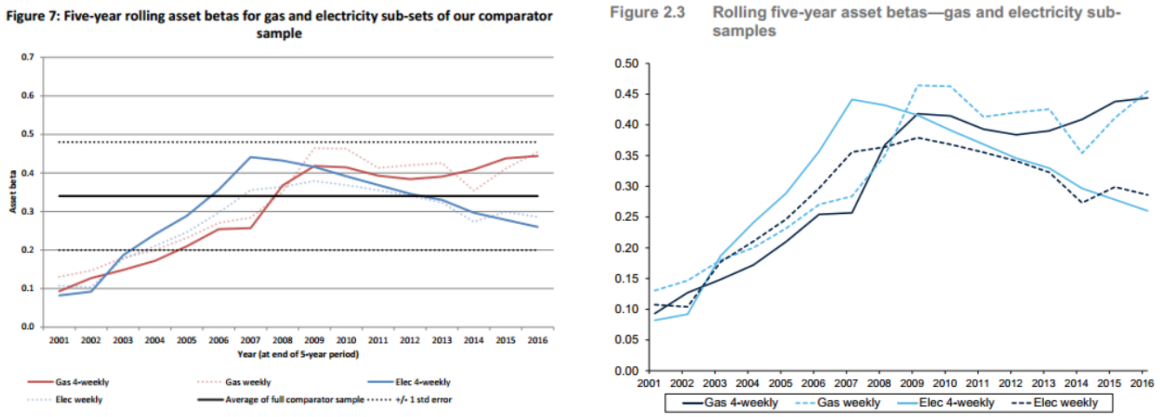
> *observed differences in asset betas between electricity and gas are more likely to reflect measurement error than a systematic difference over time; and therefore the empirical evidence in support of using a higher asset beta for GPBs is relatively weak*

9 Available at this link https://xkcd.com/882/. Cartoon is reproduced in Appendix B.

10 Commerce Commission, *Input methodologies review draft decision topic paper 4 cost of capital issues,* June 2016, p.97

70. Both Figure 7 from the Commission's draft[11] decision and Figure 2.3 from Oxera's report[12], as shown below, illustrate that the observed difference in asset betas between gas and electricity firms are inconsistent overtime.

Figure 11: Five-year rolling asset betas for gas and electricity firms, results from the Commission and Oxera



Source: CC draft decision Figure 7; Oxera report Figure 2.3

71. It is also important to note that the tests that we have performed in this section only account for variation/uncertainty within the specific asset beta estimate being examined. This means that each test fails to account for the variation/uncertainty associated with the other, equally valid, approaches to estimating asset beta. Similarly, each individual asset beta is itself estimated with uncertainty – uncertainty which is not accounted for in the above t-tests (i.e., the firm specific asset betas used as inputs to the t-test are treated as values known with certainty when, in reality, they are only estimates). In addition, that fact that integrated businesses have similar asset betas to electricity businesses is not accounted for. On this basis it is reasonable to treat the t-test as more likely to incorrectly estimate a statistically significant difference than the reverse because the tests do not capture all the relevant uncertainty surrounding the estimates.

[11] Commerce Commission, *Input methodologies review draft decision topic paper 4 cost of capital issues,* June 2016, p.98

[12] Oxera, *Asset beta for gas pipelines in New Zealand,* Aug 2016, p. 10

5 TDB's sample selection

72. Section 3.1 addresses the problems with TDB's distributional analysis where it purports to identify, using asset betas estimated with zero debt betas over 2011-16, some firms that have a different risk profile to the average for the sample as a whole. For the reasons set out in that section we do not consider that this conclusion is sound. In this section we address the second prong of TDB's analysis which is to remove the vast majority of the firms from the Commission's sample based on a qualitative assessment of characteristics of each firm

5.1 TDB's qualitative assessment is opaque

73. TDB proposes the removal of 66 of the 74 comparators in the Commission's original sample. TDB purports to remove firms that:

- Are exposed to commodity price risk which TDB attributes to unregulated production/processing of natural gas and other liquids and operation of gathering pipelines.[13]

  > *The increased risk (as noted previously) appears to stem primarily from commodity price risk exposure for firms which produce natural gas and own and operate gathering pipelines.*

- Have large other unrelated/unregulated business segments;
- Have significant business segments that are not related to transmission or distribution.

74. TDB does not provide any sort of metric which it has used to make these determinations and TDB describes the basis of their decisions as follows.[14]

> *Our assessment is based on an analysis of each firm's 10-K and Annual Report. It is important to note that through this process we have used our best judgment when classifying each firm. There are areas where the firms and the regulations they are subject to is unclear and where firms' business segments are highly complicated. For instance, in the U.S. most firms we looked at have rate-regulated generation functions under FERC. However, some firms declare unregulated generation functions. In these cases, it is unclear whether the revenue was generated by the firm outside the US or if some states have overridden FERC. Another point to note relates to the regulation surrounding gathering and production of natural gas and*

[13] TDB, pp. 28-29

[14] TDB p. 35.

related NGLs. In most cases this is reported as unregulated revenue but this does not always appear to be the case. However, as demonstrated in Appendix 4, a conservative sensitivity analysis indicates there are not large discrepancies if 10% of the highest beta firms are misclassified at each step.

75. Notwithstanding the reference to data within annual reports and 10-K forms, very few actual references to this data are provided and there is certainly no systematic basis upon which any data relied on by TDB is presented. In order to assess the reasonableness of TDB's judgement we have examined a subset of the firms included and excluded by TDB and attempted to assess the consistency or otherwise of TDBs approach.

5.1.1 Vector and DUET vs Cleco

76. TDB includes Vector and DUET in its proposed sample but excludes Cleco. DUET/Vector have average asset betas over the last 10 years using the Commission methodology of 0.14/0.21 compared to Cleco's 0.35.

77. Cleco's annual report states that of total property plant and equipment of 4.51bn 4.50bn was regulated in 2014 – i.e., 99.7% regulated.[15] By contrast, Vector's annual report states that 85% of assets (and only 64% of revenue) is regulated.[16] DUET has substantial contracted (as opposed to regulated) revenues from its interest in the Dampier to Bunbury Pipeline and DDG ($321m in revenues out of $854m total revenues in 2015) and even its electricity/gas distribution business has 8%/5% unregulated revenues.[17]

78. Cleco is as close to a 100% pure play regulated asset as exists in the Commissions sample yet TDB excludes Cleco. No specific description of the reasons for Cleco's exclusion are provided with the only explanation in the form of the Table in Appendix 3 where Cleco is removed from the sample in the last column of the table – signifying that Cleco is excluded on the basis that it is not a "pure play distribution/transmission firm".

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15 Cleco, 2014 Annual Report, p. 71. Cleco also reports total assets on p. 57. These include current assets of 0.5bn which is attributable to its regulated activity (e.g., unbilled revenues, fuel and inventory etc.) as well as $0.7bn in non-PP&E assets that are also clearly related to its regulated activity (e.g., $0.6bn in assets specifically nominated at 'regulatory'.

16 Vector 2015 Annual Report, p. 21.

17 DUET, 2015 Annual Report, p.93 and p. 3. In addition DUET acquired Energy Developments Limited with $448m of revenue in 2015 (not included in the previous total).

79. This is technically correct in that Cleco does have generation assets. However, as is clear in Cleco's annual report, these activities are overwhelmingly regulated.[18] TDB provides no reason to believe that regulated generation activities involve different asset beta risk to regulated transmission or distribution activities – especially where the regulation of revenues earned from each asset is equivalent (i.e., the same regulated return and price path is applied to the asset whether it is generation, transmission or distribution).

80. Moreover, the only rational basis to exclude Cleco but include Vector and DUET, is if TDB believes the regulated generation assets of Cleco are a worse proxy for a regulated firm's risk than the unregulated activities of Vector and DUET. No such justification is provided by TDB.

5.1.2 DUET vs APA

81. Similarly, TDB excludes APA group (average asset beta using the Commission methodology of 0.28) on the basis that:

> *Other firms that are removed include APA group from Australia which operates for the most part in contracted pipelines and not regulated pipelines.*

82. However, if the same test was applied to DUET it would be excluded because 96% of the revenues from the DBP pipeline (which contributes 41% of total DUET EBITDA) are also contracted.[19]

5.1.3 US gas transmission pipelines

83. TDB approach to the exclusion of gas transmission businesses is also deeply flawed. WPZ can be used as a case study of TDB's ad hoc approach to qualitative data when excluding firms from the sample. TDB states that

> *As recognised by the Bloomberg description, WPZ is heavily involved in gathering and generation of raw materials. Furthermore, it is involved in the transportation of crude oil and NGL, as well as natural gas. It is unclear how much of the transportation operation of WPZ is fee for contract and how much is for WPZ's product and the products of WPZ's subsidiaries.*
>
> *WPZ's service lines that exceed 10% of consolidated revenue by segment have no natural gas distribution revenues. Service revenues make up 70%*

[18] In 2013 Cleco did have $0.27bn in unregulated PP&E generation assets (6.6% of total PP&E) but these assets were incorporated into its regulated assets in the following year and, moreover, would have, even when unregulated, been contracted for in a manner providing revenue streams equivalent to regulation.

[19] DUET, 2015 Annual Report, p. 3.

> *of the firm's total revenues. However, it is unclear what "service revenue" consists of. The company's business segments also have fee-for-contract transportation of oil and NGL as well as gathering and processing components. However, according to Bloomberg research approximately 30% of U.S. gas volumes touch WPZ's systems, which includes all aspect of the gas value chain as depicted in Figure 6.*

84. TDB excludes WPZ on the basis that it is a 'commodity exposed firm'. However, WPZ's advice to analysts, available on its website, is that 88% of its gross margin is contributed by fee based services (29% of which is regulated and 60% is contractual – with a significant proportion of this on a 'cost of service' regulatory style price adjustment).[20] The exclusion of firms that build and operate gas transmission pipelines where the majority of the revenues from the pipeline are governed by foundation contracts will mean that most, if not all, transmission pipelines would be excluded from the sample. This is despite the revenues from such contracts having very similar properties to regulated revenues (if anything one might reasonably believe lower risk). It is our understanding that, at least in Australia, such contracts account for the majority of gas transport volumes even on 'regulated' pipelines (i.e., where access to spare capacity is regulated).

85. WPZ does state that 11% of margins are classified as deriving from commodity margins.[21] However, while it may be ideal to have 100% regulated/contracted revenues, imposing such a restriction will ultimately leave the Commission with a sample of close to zero (or maybe one if a 99% threshold is applied (e.g., Cleco described above)).

86. TDB excludes KMI on the same basis as WPZ. TDB states:

> *KMI's Consolidated Income Statement show that approximately 62% of KMI's revenue is attributed to 'services'. There is no obvious further break down of the services component. As specified in the business segments reporting, it is likely to be some weighting of pipeline transportation of natural gas, NGL and crude oil, tanker transportation of oil, frication and processing services and possibly marketing of CO2. As is consistent in this more detailed analysis, the other revenue generating activities include 'product sales' and 'natural gas sales'.* ***This indicates that KMI, while owning pipelines for natural gas, is a natural gas generator, processor and wholesaler, rather than a gas pipeline business which charges a fee for the transportation of a third party's product.***

[20] WPZ, May 2015, Analyst Day presentation, slide G-5 (page 72 of the PDF).

[21] WPZ, May 2015, Analyst Day presentation, slide G-5 (page 72 of the PDF).

87. On this basis, TDB excludes the largest natural gas pipeline network in North America from the sample of comparators. While it is true that KMI has some contribution from non-fee based margins it is also clear that this is small. In a presentation to investors, available on KMI's website, KMI makes clear that 91% of its EBDA is fee-based revenues and that 74% of that is in the form of 'take or pay' contracts/regulation.[22]

5.1.4 TDB's final sample

88. In addition to DUET and Vector, there are 6 other firms in TDB's preferred sample. All of these firms also have sources of revenue other than fees for infrastructure services. We discuss each below and, in our view, this discussion makes clear the problem with TDB's approach. Specifically, the criteria used to eliminate other firms from the sample would, if applied consistently, eliminate all of the remaining firms in TDBs sample.

- AusNet, had $152m revenue for its "Select Solutions" segment that provides "specialist metering, asset intelligence and telecommunication solutions". This revenue is similar in magnitude to the revenue earned from gas distribution ($189m). [23]
- Spark Infrastructure states that semi-regulated and unregulated revenue was $0.36bn compared to distribution and metering revenue of $1.05bn (or roughly 30%).[24]
- Unitil states that 8.7% of profits in 2015 were contributed by business segments other than regulated gas and electricity segments.[25]
- Northwest Natural Gas Company reports that one of its core businesses is unregulated gas storage which its 10k form states accounts for 8.5% of assets.[26]
- Spire reports that its Gas Marketing and Other revenue was 10% of Gas Utility revenues averaged over 2013 to 2015.[27]

22 Kinder Morgan, presentation "Run for Shareholders, by Shareholders" 18 August 2016.

23 In 2015/16 AusNet AusNet annual report, 2015/16, p. 35.

24 SKI's 2015 Annual Report (p. 51).

25 Unitil's 2015 Annual Report (p. 63).

26 NW Natural gas Company, Section 1: 10-K (FORM 10-K) For the fiscal year ended December 31, 2015, p.5

27 Laclede Group 2015 Annual Report, p. 10.

- ITC reports that its 36% of net assets are held outside the regulated operating subsidiaries in "ITC Holdings and other"[28] which it describes as "focused primarily on business development activities".[29]

89. It is far from clear that these firms are superior comparators than the average of the firms that have been excluded. Certainly, the criteria applied to arrive at these firms in TDB's final sample do not appear to have been applied consistently. Equally certainly, TDBs final sample is small and the average measured beta from this sample is, even if it is not *a priori* biased,[30] subject to a great deal of imprecision.

90. We also note that, even if there was a more concerted and disciplined attempt at an internally consistent and rationale approach to the 'whittling down' of the Commission's sample it would, inevitably, involve the application of 'judgment'. This is problematic in the context where:

- historical asset betas are already known; and
- the submitting parties involved have clear vested interests.

91. In this context, it would be more appropriate for parties to submit on what they believe the best adjustment to the broad comparator sample is at the next IM review (rather than the current IM review). Given the volatility of firm specific betas, that would largely eliminate any incentive or ability of parties to game the sample selection process. It would also lay bare the problem with choosing a very small sample (such as chosen by TDB) for which the future average asset beta will be highly volatile.

5.2 Two firms that could be removed

92. In our review of TDB's exclusions, we have identified two firms that could potentially be removed from the sample. These are NFG (National Fuel Gas Company) and JEL (Jersey Electricity). NFG has exploration and production activities that, in terms of their contribution to EBITDA over the period 2012 to 2015, exceeded gas pipeline activities (gathering, transmission and storage).[31] This is the only firm in the Commission's sample we have identified where non-fee based infrastructure activities form the majority of the activities by value. NFG has had consistently high asset betas in both the 2011-16 and 2006-11 periods (averaging 0.78 according to the Commission estimates and methodology).

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28 ITC 2015 Form 10-K, p.100

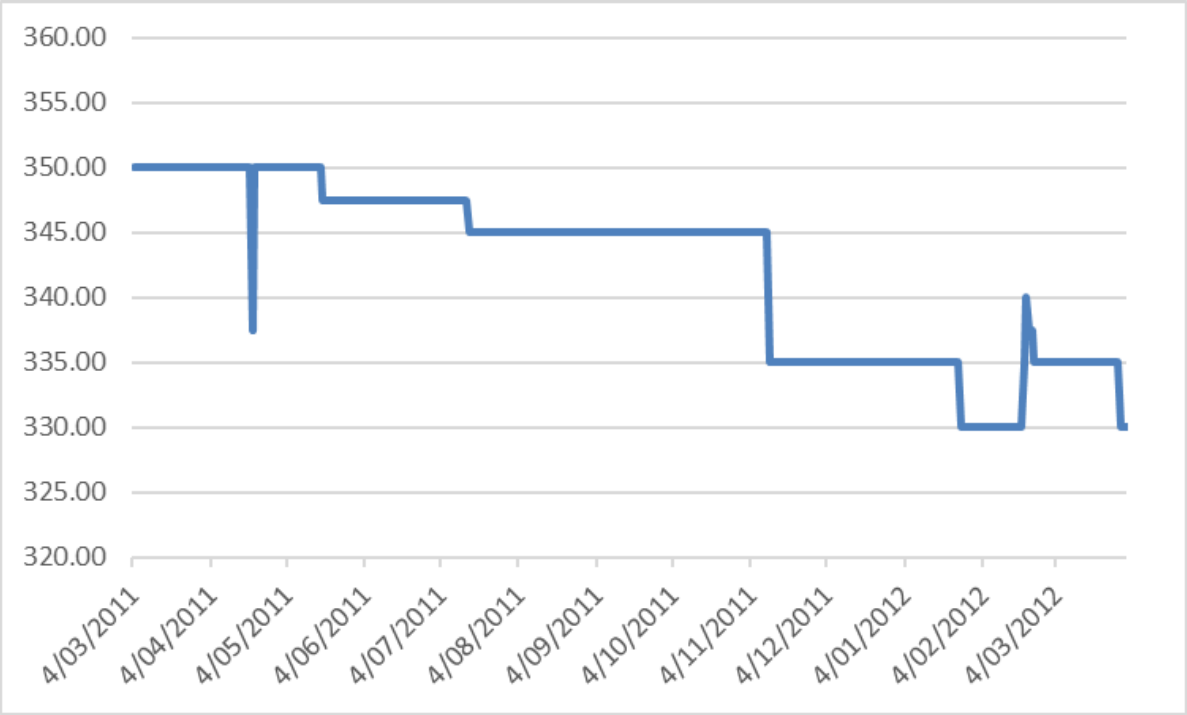
29 ITC Form 10-K, p. 6

30 That is, expected to result in too high/low a beta in some period for which data is not already known.

31 NFG, Investor Presentation, Q3 Fiscal 2016 Update, August 2016, slide 45.

93. We consider that JEL could also be excluded on the basis that the JEL share price data is clearly illiquid – changing sometimes less than once per month. Consistent with this JEL has an average asset beta of -0.01 (according to the Commission estimates and methodology). By way of illustration of this illiquidity, Figure 12 below shows JEL's share price remained unchanged on the vast majority of days/weeks over 2011/12.

Figure 12: JEL Share price in 2011/12



94. Given that the average asset beta for these two firms is just 0.38, and they are only 2 out of 74, firms the removal of these firms has no material effect on the Commission's average asset beta estimate of 0.34. In other words, while removal of these firms is potentially justifiable the existence of a large sample means that doing so would not have any material effect on the average asset beta estimated across the sample (and in this sense is unnecessary).

6 Correcting a Commission spread-sheeting error

95. The Commission has provided the spreadsheet it used to calculate its daily, weekly and 4-weekly asset betas for the comparator sample. We note that there appear to be an error in the calculation of weekly stock returns.

96. Specifically, running the macro for the weekly estimation would result in incorrect referencing for weekly returns for each individual stock (column G, Q, AA, etc.). In calculating the percentage returns, instead of dividing the difference in stock prices by the earlier price as:

$$Return = \frac{P_2 - P_1}{P_1}$$

The Commission has instead estimated:

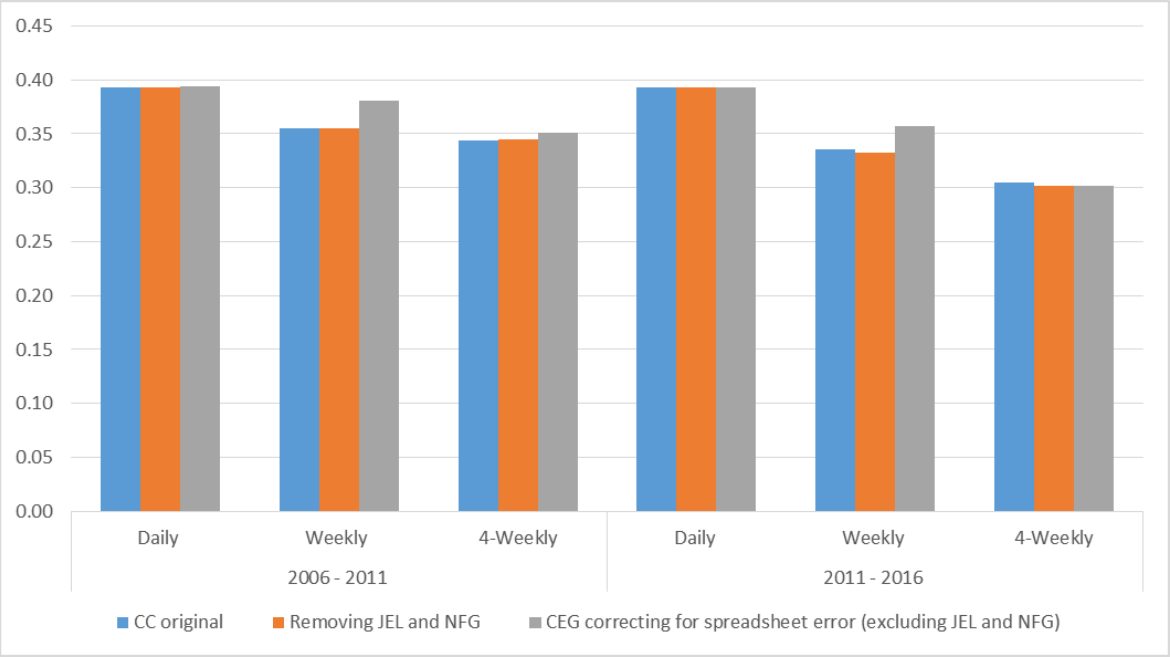
$$Return = \frac{P_2 - P_1}{P_3}$$

$$where\ P_3\ is\ the\ stock's\ ending\ price\ 21\ days\ prior\ to\ the\ date\ of\ P_1$$

97. The presence of this error for all weekly beta estimations has resulted in a downward bias to the average asset betas (as is to be expected stock returns are misestimated). The corrected weekly average asset beta is 0.03 (0.02) above the Commission's estimates for the five year period from 2011 to 2016 (2006 to 2011).

98. We have included our replication of the Commission's Table 29 in 7 for comparison. The daily and monthly estimates are not affected by this error. Consistent with this, only the weekly estimates are materially different. The impact of the error on weekly betas is illustrated graphically in Figure 13 below. It can be seen that we replicate the Commission's daily and 4-weekly estimates very closely but our weekly estimates are materially higher.

Figure 13: Daily, weekly and 4 weekly asset betas (zero debt beta)



7 Sample average leverage and the leverage anomaly

7.1 Sample average gearing

99. Removing JEL and NFG from the sample would increase sample average gearing over the 10 years from 2006 to 2016 from 40.6% to 41.6%. Once more, this is not a material change (although it is larger for asset betas due to JEL's estimated negative gearing). It also appears that the Commission has inadvertently included gearing data for KMI and WPZ despite Bloomberg not having stock data for these firms in 2006-11. When these firms are excluded from the gearing calculation for the earlier period the average gearing rises to 42.0%.

7.2 The leverage anomaly and positive debt betas

100. The Commissions standard approach of calculating asset betas assuming zero debt premium and re-levering to the sample average gearing ensures that most of the errors associated with assuming a zero debt beta cancel out in the de-levering and re-levering process. That is, the average asset beta is underestimated by assuming zero debt betas for all firms. However, this error is largely cancelled out by re-levering that asset beta using a zero debt beta to the sample average.

101. This approach would be perfect (the errors would cancel out perfectly) if all firms had the same debt beta. However, if debt betas increase with gearing, as they must, then the underestimate of asset beta in the de-levering process will be less than fully cancelled out by a re-levering of asset beta to the sample average gearing.

102. By way of illustration consider a minor amendment to the example at paragraph 21 above. In that example there are two otherwise identical firms with the same asset beta (of 0.4) but one has zero debt (and zero debt beta) and the other is 80% geared (and has a 0.3 debt beta). Sample average gearing is 40% and let this be associated with a sample average debt beta of 0.15.

103. Based on these assumptions the observed equity beta for each firm will be 0.40 and 0.80.[32] Now, let the Commission calculate an asset beta for each firm assuming a zero debt beta. In which case the estimated asset betas will be 0.40 (=0.40*(1-0%)) and 0.16 (=0.8*(1-80%)) with an average asset beta of 0.28. If the Commission re-levers this asset beta with a zero debt beta it will estimate a re-levered equity beta of 0.47

[32] Applying the Commission's leverage formula at paragraph 288.1 of Topic Paper 4 the equity beta of a firm with a 0.4 asset beta and a 0.3 debt beta will be of 0.8 (=(0.4-0.3*0.80%)/(1-0.80%).

(=0.28/(1-40%)). However, the correct re-levered equity beta[33] will be 0.57 (=(0.40-0.15*40%)/(1-40%)). Thus, the re-levered equity beta is underestimated by 0.10.

104. Of course, this is a stylised example and the magnitude of the error depends heavily on the fact that there are only two observations – each one very different to the average. If there are a large number of firms more heavily clustered around the average the bias will be smaller. We estimate, based on the Commission's sample and our assumptions about debt beta, that that this source of bias causes the re-levered equity beta to be underestimated by around 0.02. Once more, this is a relatively small effect.

33 Applying the Commission's leverage formula at paragraph 288.1 of Topic Paper 4.

Appendix A CEG replication of the Commission's Table 29

Table 4: CEG replication of the Commission's Table 29

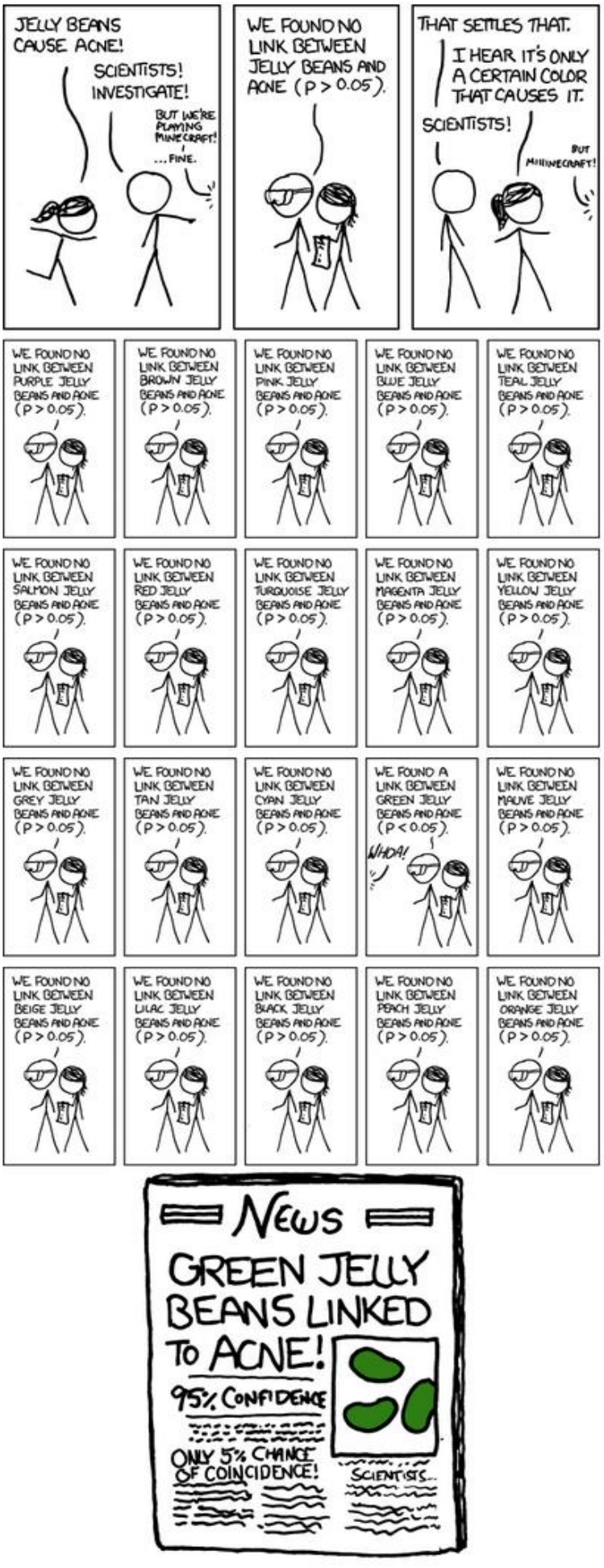
stock	2001 - 2006			2006 - 2011			2011 - 2016		
	Daily	Weekly	4-Weekly	Daily	Weekly	4-Weekly	Daily	Weekly	4-Weekly
AEE US Equity	0.29	0.28	0.25	0.40	0.41	0.42	0.36	0.32	0.26
AEP US Equity	0.40	0.44	0.55	0.35	0.33	0.30	0.32	0.28	0.20
AES US Equity	0.40	0.46	0.64	0.52	0.52	0.56	0.37	0.40	0.37
ALE US Equity	0.52	0.54	0.56	0.47	0.46	0.51	0.43	0.40	0.40
APA AU Equity	0.21	0.18	0.25	0.28	0.22	0.24	0.39	0.32	0.33
AST AU Equity	NA	NA	NA	0.16	0.09	0.09	0.24	0.24	0.27
ATO US Equity	0.35	0.30	0.26	0.30	0.31	0.32	0.44	0.39	0.31
AVA US Equity	0.34	0.32	0.36	0.34	0.33	0.36	0.40	0.35	0.30
BKH US Equity	0.37	0.48	0.58	0.52	0.50	0.58	0.49	0.43	0.47
BWP US Equity	NA	NA	NA	0.39	0.47	0.26	0.41	0.41	0.51
CMS US Equity	0.24	0.30	0.47	0.26	0.25	0.24	0.30	0.26	0.17
CNL US Equity	0.41	0.49	0.63	0.47	0.38	0.37	0.42	0.39	0.28
CNP US Equity	0.18	0.27	0.40	0.27	0.30	0.28	0.41	0.39	0.29
CPK US Equity	0.09	0.12	0.20	0.54	0.51	0.36	0.54	0.32	0.26
D US Equity	0.31	0.31	0.34	0.38	0.36	0.31	0.33	0.28	0.17
DGAS US Equity	0.00	0.04	0.08	0.12	0.22	0.25	0.23	0.28	0.32
DTE US Equity	0.22	0.19	0.22	0.33	0.34	0.32	0.36	0.32	0.23
DUE AU Equity	0.11	0.05	0.06	0.14	0.14	0.17	0.14	0.13	0.12
DUK US Equity	0.44	0.59	0.72	0.37	0.35	0.30	0.26	0.21	0.13
ED US Equity	0.27	0.21	0.18	0.28	0.27	0.22	0.24	0.17	0.05
EDE US Equity	0.29	0.27	0.32	0.35	0.33	0.35	0.38	0.30	0.23
EE US Equity	0.36	0.28	0.26	0.43	0.41	0.44	0.38	0.32	0.27
EEP US Equity	0.16	0.19	0.07	0.40	0.53	0.52	0.49	0.57	0.61
EIX US Equity	0.33	0.28	0.32	0.48	0.48	0.43	0.32	0.29	0.26
ES US Equity	0.19	0.18	0.17	0.30	0.30	0.28	0.36	0.32	0.25
ETR US Equity	0.27	0.29	0.36	0.45	0.39	0.39	0.28	0.25	0.22
EXC US Equity	0.31	0.26	0.36	0.66	0.60	0.50	0.35	0.29	0.18
FE US Equity	0.25	0.21	0.26	0.42	0.39	0.34	0.27	0.22	0.12
GAS US Equity	0.35	0.36	0.36	0.36	0.38	0.33	0.31	0.26	0.12
GXP US Equity	0.28	0.37	0.42	0.32	0.35	0.44	0.32	0.32	0.30
HE US Equity	0.40	0.41	0.43	0.39	0.44	0.44	0.51	0.46	0.36
IDA US Equity	0.30	0.36	0.43	0.35	0.33	0.29	0.45	0.39	0.38
ITC US Equity	0.43	0.54	0.53	0.43	0.48	0.49	0.32	0.28	0.19

KMI US Equity	NA	NA	NA	NA	NA	NA	0.53	0.60	0.55
SR US Equity	0.40	0.36	0.29	0.44	0.35	0.13	0.44	0.35	0.30
LNT US Equity	0.29	0.33	0.28	0.49	0.47	0.42	0.42	0.38	0.31
MGEE US Equity	0.62	0.43	0.33	0.47	0.38	0.26	0.59	0.39	0.31
NEE US Equity	0.31	0.31	0.29	0.45	0.42	0.35	0.33	0.31	0.25
NFG US Equity	0.31	0.36	0.40	0.75	0.76	0.76	0.81	0.90	0.81
NG LN Equity	0.29	0.24	0.30	0.32	0.29	0.27	0.31	0.27	0.26
NI US Equity	0.27	0.25	0.31	0.33	0.34	0.36	0.38	0.36	0.22
NJR US Equity	0.41	0.38	0.27	0.48	0.42	0.27	0.59	0.46	0.35
NWE US Equity	0.18	0.21	0.38	0.36	0.37	0.38	0.40	0.32	0.30
NWN US Equity	0.34	0.29	0.19	0.42	0.35	0.22	0.39	0.30	0.24
OGE US Equity	0.28	0.24	0.27	0.50	0.49	0.49	0.54	0.55	0.46
OKE US Equity	0.34	0.37	0.36	0.49	0.50	0.56	0.66	0.73	0.57
PCG US Equity	0.52	0.48	0.55	0.37	0.28	0.27	0.30	0.25	0.26
PEG US Equity	0.27	0.29	0.37	0.54	0.47	0.40	0.44	0.39	0.23
PNM US Equity	0.37	0.38	0.60	0.38	0.42	0.43	0.39	0.32	0.29
PNW US Equity	0.33	0.38	0.50	0.32	0.34	0.33	0.39	0.36	0.29
PNY US Equity	0.41	0.39	0.36	0.49	0.42	0.24	0.50	0.45	0.46
POM US Equity	0.23	0.22	0.29	0.34	0.37	0.33	0.24	0.23	0.19
PPL US Equity	0.32	0.34	0.51	0.49	0.41	0.34	0.26	0.24	0.19
SCG US Equity	0.27	0.28	0.29	0.33	0.31	0.32	0.33	0.28	0.25
SE US Equity	NA	NA	NA	0.61	0.61	0.63	0.56	0.57	0.46
SJI US Equity	0.25	0.24	0.23	0.46	0.38	0.27	0.53	0.45	0.43
SKI AU Equity	NA	NA	NA	0.28	0.22	0.21	0.39	0.30	0.20
SO US Equity	0.26	0.17	0.11	0.30	0.24	0.22	0.24	0.19	0.09
SRE US Equity	0.43	0.47	0.57	0.54	0.54	0.52	0.43	0.41	0.38
SSE LN Equity	0.36	0.29	0.30	0.47	0.43	0.36	0.45	0.44	0.44
STR US Equity	0.45	0.51	0.63	1.10	1.06	0.91	0.52	0.50	0.32
SWX US Equity	0.28	0.25	0.22	0.43	0.40	0.40	0.50	0.40	0.38
TCP US Equity	0.18	0.24	0.17	0.32	0.46	0.53	0.46	0.58	0.60
TE US Equity	0.27	0.35	0.39	0.42	0.40	0.42	0.37	0.37	0.20
UGI US Equity	0.29	0.31	0.24	0.37	0.34	0.29	0.47	0.49	0.44
UTL US Equity	0.04	0.06	0.03	0.08	0.12	0.15	0.33	0.21	0.15
VCT NZ Equity	0.44	0.54	0.33	0.24	0.21	0.27	0.26	0.20	0.21
VVC US Equity	0.32	0.35	0.32	0.34	0.33	0.29	0.43	0.39	0.39
WEC US Equity	0.21	0.21	0.19	0.28	0.27	0.25	0.36	0.27	0.15
WGL US Equity	0.43	0.38	0.31	0.49	0.39	0.27	0.56	0.45	0.39
WPZ US Equity	NA	NA	NA	0.33	0.49	0.32	0.60	0.84	0.83
WR US Equity	0.26	0.25	0.25	0.36	0.36	0.33	0.33	0.30	0.26
XEL US Equity	0.31	0.27	0.49	0.31	0.27	0.25	0.30	0.24	0.17

Bloomberg data, CEG analysis

Appendix B Jelly bean fallacy

105. See overleaf cartoon available at https://xkcd.com/882/.


JELLY BEANS CAUSE ACNE!
SCIENTISTS! INVESTIGATE!
BUT WE'RE PLAYING MINECRAFT!
... FINE.
WE FOUND NO LINK BETWEEN JELLY BEANS AND ACNE (P > 0.05).
THAT SETTLES THAT.
I HEAR IT'S ONLY A CERTAIN COLOR THAT CAUSES IT.
SCIENTISTS!
BUT MINECRAFT!
WE FOUND NO LINK BETWEEN PURPLE JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN BROWN JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN PINK JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN BLUE JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN TEAL JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN SALMON JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN RED JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN TURQUOISE JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN MAGENTA JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN YELLOW JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN GREY JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN TAN JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN CYAN JELLY BEANS AND ACNE (P > 0.05).
WE FOUND A LINK BETWEEN GREEN JELLY BEANS AND ACNE (P < 0.05).
WHOA!
WE FOUND NO LINK BETWEEN MAUVE JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN BEIGE JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN LILAC JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN BLACK JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN PEACH JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN ORANGE JELLY BEANS AND ACNE (P > 0.05).
NEWS
GREEN JELLY BEANS LINKED TO ACNE!
95% CONFIDENCE
ONLY 5% CHANCE OF COINCIDENCE!
SCIENTISTS...