Beta estimation issues

Report for Energy Networks Australia | December 2025

Frontier Economics Pty Ltd is a member of the Frontier Economics network, and is headquartered in Australia with a subsidiary company, Frontier Economics Pte Ltd in Singapore. Our fellow network member, Frontier Economics Ltd, is headquartered in the United Kingdom. The companies are independently owned, and legal commitments entered into by any one company do not impose any obligations on other companies in the network. All views expressed in this document are the views of Frontier Economics Pty Ltd.

Contents

1 Executive Summary

1. Frontier Economics has been retained by Energy Networks Australia to provide advice on two technical aspects of beta estimation and to compile a series of equity beta estimates for the benchmark energy network that is the subject of the AER's 2026 RoRI review.

Re-levering

2. We explain why re-levering to reflect a common level of gearing is an essential part of beta estimation. In particular, we explain that, under the CAPM, the definition of beta itself requires that gearing is properly reflected in the calculations and we present a simple numerical example to demonstrate the point. It is for this reason that re-levering is a standard part of regulatory and commercial practice when estimating equity beta.

3. In our view, it is not an open question as to whether or not re-levering should be performed or how re-levering should be performed. The formula for the very definition of beta under the CAPM requires that re-levering be performed in the manner that is industry standard.

Debt beta

4. We use a simple illustrative example to show that:
   a. Under the CAPM, positive debt betas only arise when there is a positive probability of default;
   b. Other things being equal, a higher debt beta implies a higher probability of default; and
   c. The debt beta and default probability jointly determine the debt risk premium (**DRP**), which constrains the reasonable range of debt betas. Thus, any proposed debt beta should be checked to ensure that it does not imply an unreasonably high DRP or default probability.

5. We conclude that, like any WACC parameter, a proposed debt beta should be checked to ensure that it doesn't have implausible implications.

Equity beta estimates

6. We perform a large number of equity beta estimations that vary:
   a. The sets of comparator firms;
   b. The length of the period of historical data;
   c. The frequency of return observations; and
   d. The debt beta that is used in the re-levering process.

7. For each of our estimation 'runs' we report the interquartile range of the estimates of equity beta, re-levered to 60% using the Brealey-Myers re-levering formula.

8. Our comparator sets include domestic and international firms that own and operate energy networks.

9. Across a large number of estimations using various combinations of the estimation choices set out above, the outcomes are:
   a. The lower bound of the interquartile range is most commonly in the order of 0.6 or above; and

b. The upper bound of the interquartile range is most commonly in the order of 0.8 or above.

10. In our view, a range of 0.6 to 0.8 represents a conservative interpretation of the currently available market evidence.

2 Beta estimation and results

Approach to estimating equity beta for individual comparators

11. The standard approach to estimating equity beta involves an Ordinary Least Squares (**OLS**) regression analysis to quantify the relationship between stock returns and market returns using a sample of comparator firms. For each comparator firm, a series of historical stock returns is regressed against a corresponding series of returns from a broad stock market index, such as the ASX 200 index in Australia or the S&P 500 index in the United States. The slope of the regression line is an estimate of the equity beta for that comparator.

12. In the analysis that follows, we consider comparators from a number of markets. The market indices that we use in our analysis, including the relevant Bloomberg index codes, are set out in Table 1 below.

Table 1: Market Indices used in the analysis

Market	Index	Index ticker
Australia	ASX 200	AS51 Index
Canada	S&P/TSX Composite Index	SPTSX Index
Italy	FTSE MIB	FTSEMIB Index
New Zealand	S&P/NZX 50 Index	NZSE Index
Spain	IBEX 35	IBEX Index
United Kingdom	FTSE 100 Index	UKX Index
United States	S&P 500	SPX Index

Source: Bloomberg.

13. We have computed beta estimates using different historical periods (e.g., the longest period of data available for each firm and data for the 10-year period from 2015-2025) and different return frequencies (e.g., weekly and monthly data).

14. Our primary results are based on weekly returns for the longest period available, so we focus our explanation below on that case.

15. This requires a series of weekly total returns (i.e., returns series that include dividends and capital gains) data for each stock over the longest period available to 30 September 2025.

16. We obtain the following data from Bloomberg for each comparator:[1]

    a. Total returns index (TOT_RETURN_INDEX_NET_DVDS);

    b. Total debt (SHORT_AND_LONG_TERM_DEBT);

    c. Historic market capitalisation (HISTORICAL_MARKET_CAP); and

[1] Bloomberg codes in parentheses.

d. Turnover (TURNOVER).[2]

17. We also obtain the total returns index for each market index.

18. To account for the well-known sensitivity of beta estimates to the reference day,[3] when estimating beta at the weekly frequency we perform the estimation separately for each of the five reference days (i.e., weekly over Monday to Monday periods, Tuesday to Tuesday periods, and so on). We then average across the estimates from each of the five reference days.

19. When estimating beta at the monthly frequency we adopt a similar process, using the returns as at the first calendar day of the month, and repeating the process for the second through to 31st day of the month.[4]

20. Next, we applied a series of data quality filters. We screened the data for periods of illiquidity because it is well-recognised in the finance literature that thin trading can bias beta estimates.

21. We apply the Amihud measure, which is designed to quantify the price impact of illiquidity – when a stock is thinly traded, a large transaction can have a material temporary effect on prices as it is absorbed by the market.[5] The Amihud filter seeks to identify observations where the price change is large relative to the liquidity in the market at the time – such observations being more likely to reflect price dislocation from an order being absorbed into a relatively illiquid market. We drop any observations if the associated Amihud measure exceeds 25 over the returns window.[6] This approach was recently adopted by IPART.[7]

22. We also required that each weekly interval used must have returns data for at least two trading days within that interval (identified as days with positive turnover).[8] When using monthly intervals we require trading on eight days during the month.

23. Any returns intervals that failed to satisfy both of these liquidity requirements were excluded from the historical period used to estimate beta.

24. For each week used in the estimation, we find gearing, measured as total debt divided by total debt plus market capitalisation.[9]

25. Using the observations that remain, we estimate the raw beta using ordinary least squares regression, with the returns calculated as the log difference between the start and end of the week.[10] The gearing is taken as the average gearing over all observations used in the regression.

---

2 Obtained in USD for all firms to facilitate the performance of the Amihud filter in a consistent manner.

3 The risk of estimation error due to the choice of reference day is known in the empirical finance literature as 'reference day risk.'

4 If the calendar month does not have 31 days, the last day is used. Similarly, for 29th and 30th reference days.

5 Amihud, Y (2002), "Illiquid and stock returns: cross-section and time-series effects," *Journal of Financial Markets*, Volume 5, pp. 31-56.

6 For each day with positive turnover, we find the daily Amihud measure, calculated as the absolute value of the daily return divided by turnover (expressed as billions of USD). We then average over the days with positive turnover within the week. For example, when using Friday as the reference day, the Amihud index for the week ending 26 September 2025 would average the daily Amihud index over the five trading days 22 September through 26 September 2025.

7 IPART, *Estimating Equity Beta for the Weighted Average Cost of Capital, Final Report*, August 2020.

8 Consistent with the IPART requirement for liquidity.

9 For SKI AU Equity, we manually impose the gearing (on an annual basis) as per the AER annual rate of return update. See Table 2 of AER, *Rate of Return Annual Update 2024*, December 2024.

10 For example, when using Friday as the reference day, the firm returns for the week ending 26 September 2025 would be the logarithm of the returns index as at 26 September 2025, subtracting the logarithm of the returns index as at 19 September 2025.

26. We then average the raw equity betas and gearing over the five possible reference days.[11]

27. Finally, we applied a data sufficiency filter. In order for a firm to remain within the sample, it was required to have at least 30 valid weekly returns over the estimation window.[12]

28. All beta estimates are re-levered to 60% gearing (the AER's benchmark figure) using the approach and for the reasons explained in Section 3 below.

Comparator sets

29. We have compiled a number of comparator sets, all of which include domestic and international firms that own and operate energy networks. In particular, we have included all domestic firms that are currently listed and all that have de-listed within the last 10 years (that is, APA Group, AusNet Services, Spark Infrastructure and DUET Group). That is, we have not included any comparator firms that have not existed for over a decade. We combine these domestic comparators with a number of different sets of international comparators is as follows:

- The set that the AER has traditionally used in its annual rate of return updates (**AER 1**);[13]
- The filtered set that the AER has recently developed and made available (**AER 2**);[14]
- The set adopted by the New Zealand Commerce Commission (**NZCC**); [15]
- The set adopted by the ERA (**ERA**);[16] and
- A combined set consisting of the aggregate of the above sets (**ALL**).

Estimation results

30. Table 2 and Figure 1 through Figure 4 below set out the interquartile range for various comparator sets, periods and frequencies, all re-levered to 60% using a debt beta of zero. We then present similar sets of results for alternative debt betas.

[11] We also average the number of valid weeks used in the estimation. We note that there is minimal variation across reference days in the number of valid weeks and gearing.

[12] For the avoidance of doubt, this is an average of at least 30 weeks across the five reference days. Only CNL US Equity failed the data sufficiency requirement, with 8 valid weeks after applying the liquidity filters. We note that RGCO US Equity, EE US Equity, NU US Equity and TE US Equity had 80, 180, 198 and 233 valid weeks respectively. All other international comparators considered had at least 400 valid weeks in the estimation period.

[13] See Table 20 of CEG, Information on equity beta from US companies, June 2013.

[14] See "List.xlsx", provided by the AER in October 2025.

[15] See Commerce Commission, Cost of capital topic paper - Part 4 Input Methodologies Review 2023 - Final decision, December 2013.

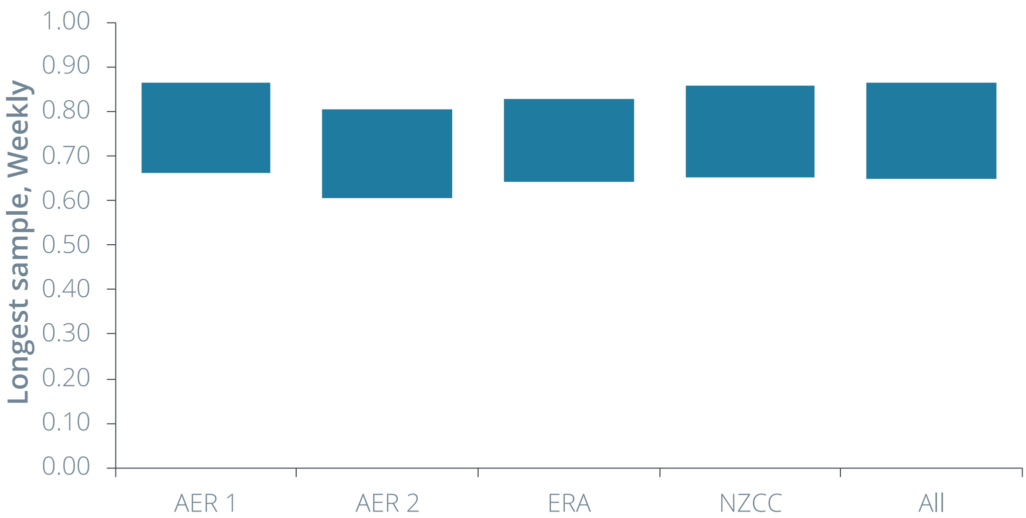
[16] See ERA, Explanatory statement for the 2022 final gas rate of return instrument, December 2022.

Table 2: Equity beta estimates – re-levered to 60% with debt beta of 0

	Number	Longest	Longest	10-years	10-years
		Weekly	Monthly	Weekly	Monthly
AER 1 + dom	60	0.66-0.86	0.66-0.82	0.59-0.96	0.53-0.96
AER 2 + dom	52	0.61-0.80	0.50-0.78	0.63-0.83	0.53-0.81
ERA + dom	62	0.64-0.83	0.54-0.80	0.65-0.96	0.57-0.91
NZCC + dom	58	0.65-0.86	0.66-0.83	0.66-0.95	0.59-0.93
All + dom	91	0.65-0.86	0.61-0.84	0.63-0.96	0.56-0.98

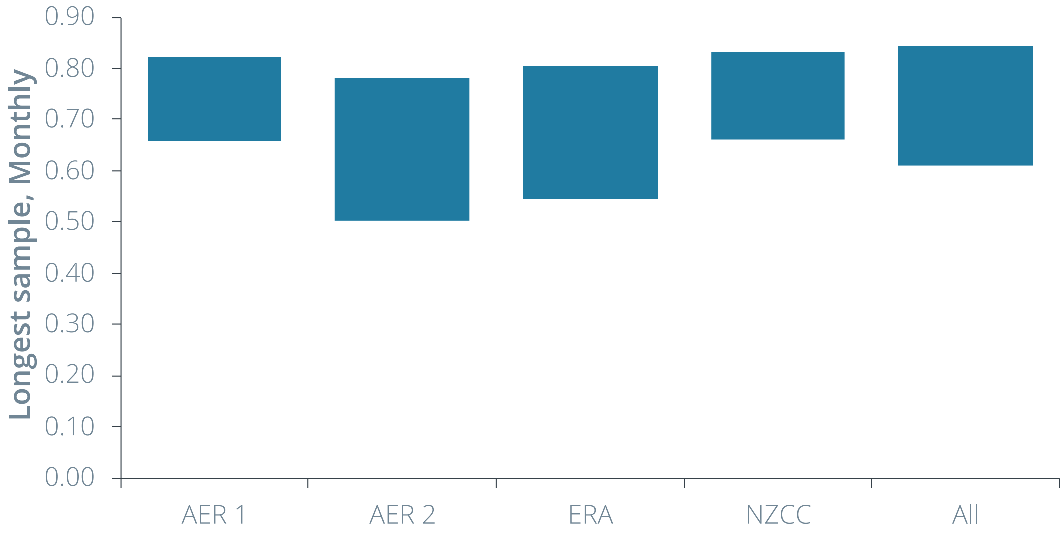
Source: Frontier Economics analysis of Bloomberg data.

Figure 1: Equity beta estimates – weekly returns – longest available period – re-levered to 60% with debt beta of 0



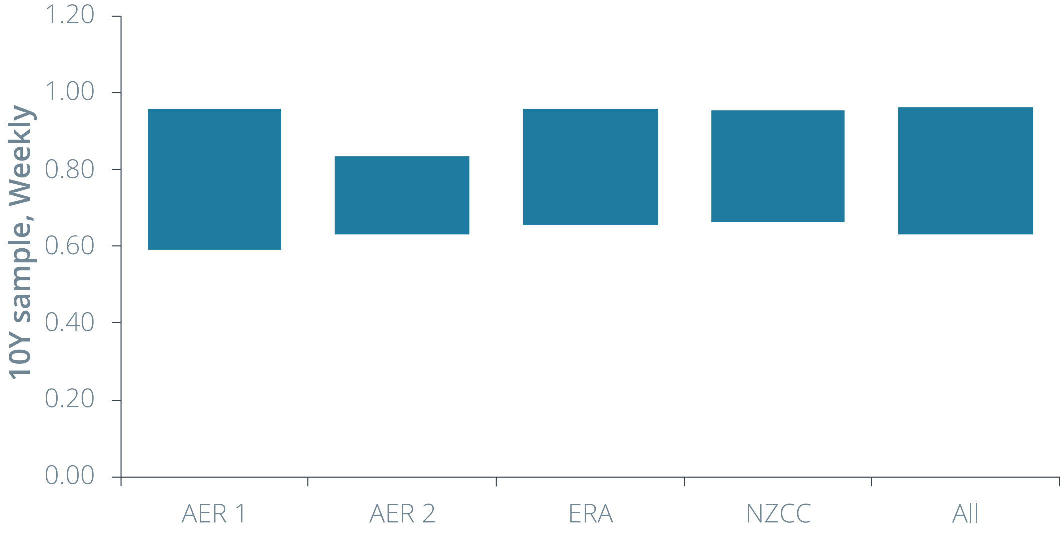
Source: Frontier Economics analysis of Bloomberg data.

Figure 2: Equity beta estimates – monthly returns – longest available period – re-levered to 60% with debt beta of 0



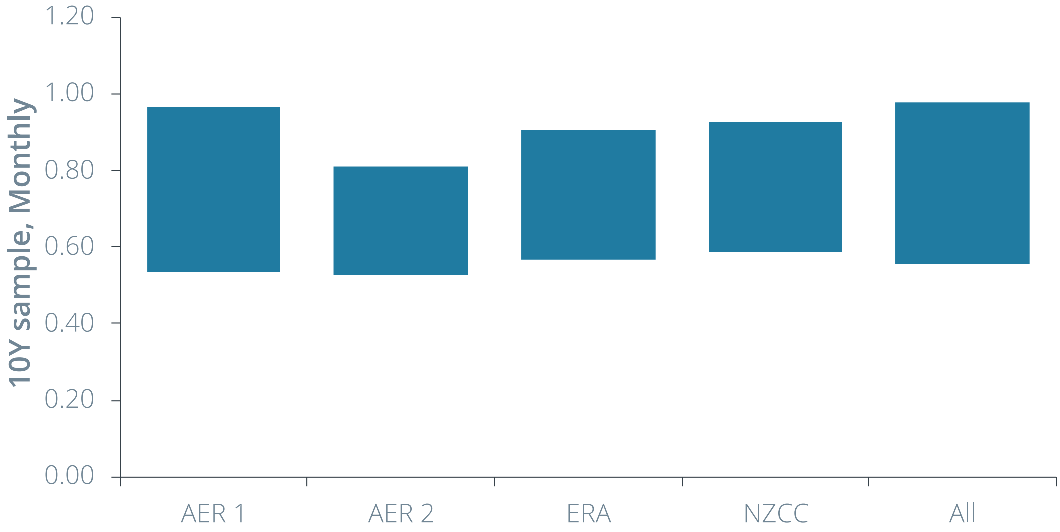
Source: Frontier Economics analysis of Bloomberg data.

Figure 3: Equity beta estimates – weekly returns – 10 years to September 2025 – re-levered to 60% with debt beta of 0



Source: Frontier Economics analysis of Bloomberg data.

Figure 4: Equity beta estimates – monthly returns – 10 years to September 2025 – re-levered to 60% with debt beta of 0



Source: Frontier Economics analysis of Bloomberg data.

31. The interquartile ranges of equity beta estimates adopting a debt beta of 0.05, 0.075 and 0.1 are presented in Table 3 through Table 5 below.

Table 3: Equity beta estimates – re-levered to 60% with debt beta of 0.05

	Number	Longest	Longest	10-years	10-years
		Weekly	Monthly	Weekly	Monthly
AER 1 + dom	60	0.65-0.84	0.64-0.81	0.57-0.91	0.51-0.95
AER 2 + dom	52	0.59-0.78	0.49-0.75	0.62-0.80	0.51-0.77
ERA + dom	62	0.62-0.81	0.53-0.78	0.64-0.93	0.55-0.88
NZCC + dom	58	0.64-0.83	0.64-0.81	0.64-0.93	0.56-0.91
All + dom	91	0.63-0.84	0.59-0.82	0.61-0.94	0.54-0.95

Source: Frontier Economics analysis of Bloomberg data.

Table 4: Equity beta estimates – re-levered to 60% with debt beta of 0.075

	Number	Longest	Longest	10-years	10-years
		Weekly	Monthly	Weekly	Monthly
AER 1 + dom	60	0.64-0.83	0.63-0.80	0.56-0.90	0.51-0.94
AER 2 + dom	52	0.58-0.77	0.48-0.74	0.61-0.79	0.51-0.76
ERA + dom	62	0.62-0.80	0.53-0.78	0.63-0.92	0.53-0.87
NZCC + dom	58	0.63-0.82	0.63-0.80	0.63-0.91	0.55-0.90
All + dom	91	0.63-0.82	0.58-0.80	0.59-0.94	0.53-0.94

Source: Frontier Economics analysis of Bloomberg data.

Table 5: Equity beta estimates – re-levered to 60% with debt beta of 0.1

	Number	Longest	Longest	10-years	10-years
		Weekly	Monthly	Weekly	Monthly
AER 1 + dom	60	0.63-0.82	0.61-0.78	0.55-0.89	0.50-0.92
AER 2 + dom	52	0.58-0.76	0.47-0.73	0.60-0.77	0.50-0.74
ERA + dom	62	0.61-0.79	0.52-0.77	0.62-0.91	0.52-0.86
NZCC + dom	58	0.63-0.81	0.61-0.79	0.63-0.90	0.54-0.89
All + dom	91	0.62-0.81	0.56-0.80	0.58-0.93	0.52-0.94

Source: Frontier Economics analysis of Bloomberg data.

Rolling equity beta estimates

32. To illustrate the importance of the length of the data period when estimating beta, we consider, as an example, rolling 5-year and 10-year beta and gearing estimates for the two domestic comparators for which the required data is recently available. Figure 5 below shows the variation in the rolling 5-year beta estimate and gearing for APA, AusNet Services and Spark Infrastructure.[17]

33. All other domestic comparators either had no, or insufficient, data available within the last 15 years.

34. In Figure 5, we set all series to start at 1 to make clear the relative volatility in equity beta and gearing estimates. The figure shows that:

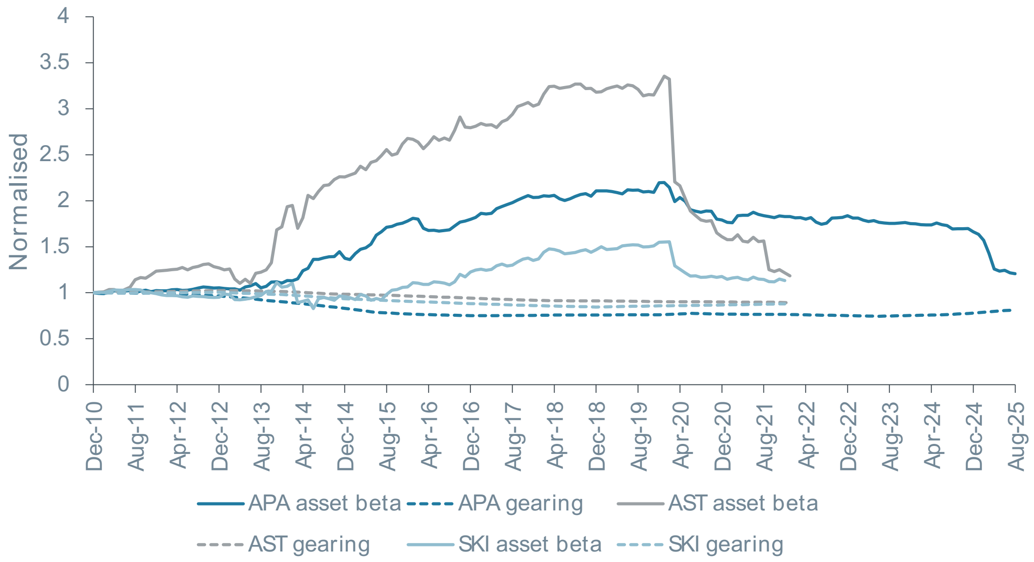
    a. The 5-year equity beta estimates are extraordinarily volatile – doubling or tripling and then halving again even within a relatively short period; and

[17] Estimates for Spark Infrastructure and AusNet Services end in 2022 due to these firms delisting at that time.

b. Gearing exhibits much more stability over time.

35. These two observations together imply that 5-year equity and asset betas both exhibit pronounced volatility over time. Indeed, the volatility in these estimates is so pronounced as to make them essentially unusable in our view.

Figure 5: 5-year rolling estimates – weekly frequency



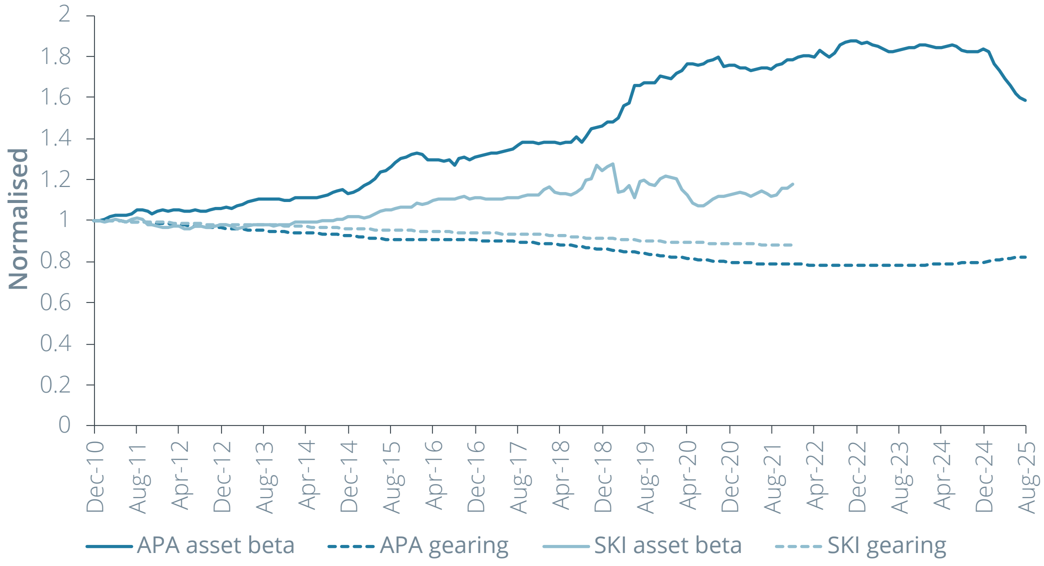
Source: Frontier Economics analysis of Bloomberg data.

36. Figure 6, below shows the variation in the rolling 10-year beta estimate and gearing for APA and Spark Infrastructure – there being insufficient data for AusNet Services over this period.

37. Although there is lower volatility in the beta estimates (than in the case of the 5-year estimates above), there remains very significant variation over time. As for the 5-year estimates above, gearing is more stable than the equity beta estimates, implying that 10-year equity and asset betas both exhibit pronounced volatility over time.

38. It is for this reason that our focus in the analysis above is on estimates form the longest available period.

39. Figure 6: 10-year rolling estimates – weekly frequency



Source: Frontier Economics analysis of Bloomberg data.

3 Debt betas: The systematic risk of debt under the CAPM

3.1 Overview

40. This section explains the role of a debt beta within the context of the CAPM.

41. We use a simple illustrative example to show that:

    a. Under the CAPM, positive debt betas only arise when there is a positive probability of default;

    b. Other things being equal, a higher debt beta implies a higher probability of default; and

    c. The debt beta and default probability jointly determine the debt risk premium (**DRP**), which constrains the reasonable range of debt betas. Thus, any proposed debt beta should be checked to ensure that it does not imply an unreasonably high DRP or default probability.

42. We conclude that, like any WACC parameter, a proposed debt beta should be checked to ensure that it doesn't have implausible implications.

3.2 The systematic risk of debt under the CAPM

43. The CAPM is a one-period model under which all investments have an initial cost at the beginning of the period and produce a payoff at the end of the period.

44. If the end-of-period payoff is certain or uncorrelated with the return on the market (i.e., with the change in aggregate wealth), it will have a required return equal to the risk-free rate. In particular, an investment with an uncertain end-of-period payoff will have a required return equal to the risk-free rate if that uncertainty is uncorrelated with the return on the market. An investment will only have a positive beta to the extent that its end-of-period payoffs are correlated with the market.

45. For a debt instrument in the CAPM, the only uncertainty pertains to the risk of default. At the end of the period, the debt instrument will either pay off the agreed amount or it will default and pay a lower amount. If that possibility of default is uncorrelated with the return on the market, the expected return will be equal to the risk-free rate.

46. In this case, the *yield* on the debt instrument will be higher than the risk-free rate, such that the *expected return* is equal to the risk-free rate. To see this, consider a simple example where:

    a. The risk-free rate is 5%;

    b. There is a 99% chance that the bond will not default and pay the full promised yield;

    c. There is a 1% chance that the debt instrument will default and pay back only half of the invested capital such that the investor receives a return of -50% (i.e., loss of half of the invested capital; and

    d. Defaults are entirely uncorrelated with market returns – no more or less likely to occur when the market is up or down.

47. In this example, the yield (*y*) will be set to ensure that the expected return is equal to the risk-free rate:

$$0.99 \times y + 0.01 \times (-50\%) = 5\%$$

in which case the yield is 5.56% and the debt risk premium (**DRP**) is 0.56%.

48. That is, the yield is higher than the risk-free rate and there is a positive DRP in this case where there is no systematic risk and no debt beta. In this case, the *yield* is higher than the risk-free rate just to ensure that the *expected return* is equal to the risk-free rate.

49. Thus, a debt beta cannot be reverse-engineered from the yield or the DRP – only from the expected return. This makes debt beta notoriously difficult to estimate because one needs to know the probability of default and the recovery rate (i.e., payoff on debt) in the event of default to derive the expected return.

50. Now consider the case where there *is* a correlation between defaults and market returns – for example, where a default is more likely in circumstances where the market is down than when it is up. In such a case, there will be systematic risk, debt beta will be positive, and the required return will be higher than the risk-free rate.

51. In this case, the required return will be higher than the risk-free rate to compensate for the systematic risk. Consequently, the yield and DRP will be higher than in the previous case. In such cases:

    a. Part of the DRP is just sufficient to ensure that the expected return is equal to the risk-free rate – which depends only on the probability and severity of defaults; and

    b. Part of the DRP is compensation for the systematic risk of defaults – which depends on the extent to which defaults are correlated with market returns.

52. The estimation of debt beta requires an (internally consistent) allocation between those components of the DRP.

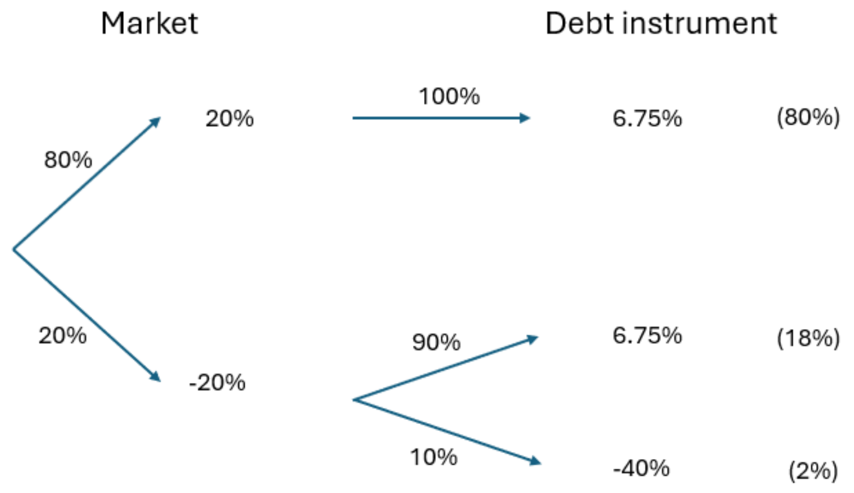
3.3 An illustrative example

53. In this sub-section, we present a simple numerical example to illustrate that only part of the DRP relates to systematic risk and debt beta.

54. As noted above, the CAPM is a one-period model in which a debt investment either pays off the contracted amount or something less (i.e., a default occurs). Systematic risk arises only to the extent that a default is more likely in a scenario where the broad market is down. Importantly, there is no systematic risk unless there is some risk of default and where such a default is more likely to occur when the market is down than when it is up.

55. Consider the simple numerical example set out in Figure 7 below where there are two possible market 'states' (up or down) and where there is some chance of the firm defaulting, but only in the state where the market is down. In particular, there is a 2% probability of default and all defaults occur in the state when the market is down.

Figure 7: Illustrative example – debt beta



Source: Frontier Economics.

56. In this example:

   a. The expected market return is 12%;[18]

   b. The risk-free rate is 5%;

   c. The market risk premium is 7%;[19]

   d. The yield (promised return) on the debt instrument is 6.75%, implying a debt risk premium of 1.75%;

   e. When a default occurs, the recovery rate is 60% of the principal such that a default produces a return of -40%;

   f. The expected return on debt is 5.82%;[20] and

   g. The beta of debt is 0.12.[21]

57. If it had been a case where defaults were unrelated to the state of the market, the debt beta would be zero and there would be no premium for systematic risk. In such a case, the expected return on debt would be equal to the risk-free rate and the yield on debt would be 5.94% such that:

$$E[r_d] = 0.98 \times 5.94\% + 0.02 \times (-40\%) = 5.00\%.$$

58. Thus, a DRP of 0.94% is required to compensate for the purely statistical probability of default.

59. However, in the case above, there *is* a correlation between defaults and the state of the market, such that the debt beta is 0.2. Investors will require compensation for that systematic risk in the form of a higher required return:

$$E[r_d] = r_f + \beta_d \times MRP = 5\% + 0.12 \times 7\% = 5.82\%.$$

[18] $0.8 \times 20\% + 0.2 \times (-20\%)$.

[19] $12\% - 5\%$.

[20] $0.8 \times 6.75\% + 0.18 \times 6.75\% + 0.02 \times (-40\%)$.

[21] $[0.8 \times (20\% - 12\%)(6.75\% - 5.82\%) + 0.18 \times (-20\% - 12\%)(6.75\% - 5.82\%) + 0.02 \times (-20\% - 12\%)(-40\% - 5.82\%)] \div [0.8 \times (20\% - 12\%)^2 + 0.18 \times (-20\% - 12\%)^2 + 0.02 \times (-20\% - 12\%)^2]$.

60. In this case, the premium for systematic risk is 0.82% – arising because defaults only occur in a down market.

61. Thus, the promised yield is 6.75%, such that the DRP is 1.75%. The DRP consists of:

    a. 0.94% to compensate for the statistical probability of default; and

    b. A further 0.82% to compensate for the systematic risk of that default – the fact that defaults only occur when the market is down.

62. This simple example makes two important points:

    a. Under the Sharpe-Lintner CAPM, if there is no chance of default, there is no debt beta; and

    b. Debt beta cannot be derived by assuming that the entire debt risk premium is compensation for systematic risk – part of the debt risk premium is compensation for the statistical probability of default.

63. In the example above, the DRP could be allocated between (a) the statistical probability of default and (b) the systematic nature of those defaults because we had full information about every possible state of the world. In practice, of course, that will not be the case. Moreover, because defaults occur so infrequently we don't have sufficient empirical data to reliably estimate default probabilities and correlations. For these reasons, it is notoriously difficult to estimate debt betas in practice.

64. What we can conclude from the above example is:

    a. Under the CAPM, positive debt betas only arise when there is a positive probability of default;

    b. Other things being equal, a higher debt beta implies a higher probability of default; and

    c. The debt beta and default probability jointly determine the DRP, which constrains the reasonable range of debt betas. Thus, any proposed debt beta should be checked to ensure that it does not imply an unreasonably high DRP or default probability.

65. We conclude that, like any WACC parameter, a proposed debt beta should be checked to ensure that it doesn't have implausible implications.

66. For example, debt betas up to 0.3 were contemplated in the AER's recent *Eligible Experts' Report*.[22] Debt betas of that magnitude require implausibly large default probabilities and it is immediately obvious that they are inconsistent with observed DRPs.

67. To see this, note that a MRP of 6.4% and a debt beta of 0.3 implies that the expected return on debt is 1.9% above the risk-free rate. The yield on debt would then require a further addition of a similar magnitude to account for the statistical probability of default (as explained above). The result is a total DRP (i.e., difference between the yield and the risk-free rate) that is an order of magnitude higher than what is observed in market data.

68. We suggest that this is why debt betas of that magnitude are not used in regulatory or commercial practice.

[22] *Eligible Experts' Report* at paragraphs 174 and 228.

4 Why re-levering is essential

4.1 Overview

69. In the AER's recent *Eligible Experts' Report*, Associate Professor Partington questioned whether the re-levering process is "worthwhile":

> *Given the pitfalls and potential inaccuracies in making the unlevering and relevering adjustments I question whether the whole exercise is worthwhile. You take an estimate of beta, which likely has a relatively high standard error, and subject it to an adjustment which can give varied outcomes depending on what you do and for which there is no guarantee of getting the adjustment right. Is this just an exercise in spurious precision?*
>
> *It is true that the making of such leverage adjustments is commonplace. This is not surprising. The relation between beta and leverage is well established theoretically, so you are open to challenge if you do not adjust for leverage. Consequently, there is pressure to do something even if it might be just as good, or better, to do nothing.* [23]

70. This section explains why re-levering to reflect a common level of gearing is an essential part of beta estimation. Under the CAPM, beta depends (among other things) on the standard deviation of returns to equity holders. That standard deviation is affected in a mechanical way by gearing. Other things being equal, higher gearing means a higher standard deviation of returns and therefore a higher beta.

71. That is, the definition of beta itself requires that gearing is properly reflected in the calculations.

72. It is for this reason that re-levering is a standard part of regulatory and commercial practice when estimating equity beta.

73. In our view, it is not an open question as to whether or not re-levering should be performed or how re-levering should be performed. The formula for the very definition of beta under the CAPM requires that re-levering be performed in the manner that is industry standard.

4.2 The economic role of re-levering

74. The systematic risk (equity beta) that an investor bear as an equity holder depends on two things:

    a. **The risk of the operations of the firm**

    Some firms operate in industries that are inherently riskier than others. For example, airlines and high-end electronics tend to be volatile and cyclical – during periods of strong economic growth there is more business travel, overseas holidays and sales of whitegoods and entertainment systems. The opposite occurs during recessions. By contrast, supermarkets are much less cyclical as their products and services are required during economic booms and recessions alike. That is, some industries are inherently more exposed to systematic risk.

    b. **Leverage / gearing**

    Because debt ranks ahead of equity, at the end of each year, the firm must first pay debt holders everything they are due. Anything remaining can then be used to pay a return to

[23] *Eligible Experts' Report* at paragraphs 249-250.

equity holders. Other things being equal, if there are more debt holders with a claim that ranks ahead of equity, the (residual) equity claim will be more risky.

75. When we compile a set of beta comparators, we control for the first element – we deliberately select firms that are in the same industry as the target firm and subject to the same operations/business risk.

76. But it is possible that those firms have capital structures (i.e., leverage) that differs from the firm in question. Re-levering controls for those differences and enables like-with like comparisons to be made.

77. It is important to note that the increase in the risk to equity holders does not arise from the prior-ranking debt increasing the prospect of bankruptcy or insolvency. Even if the prior-ranking debt is risk-free (i.e., no chance of default – even in the worst possible state of the world), the existence of that debt still 'levers up' the returns to equity and increases the required rate of return. This is illustrated in the illustrative example that follows.

4.3 An illustrative example

A simple economy

78. Consider the single-period economy set out in Figure 8 in which:

    a. The risk-free rate is 6%;

    b. There is an 80% probability that the market will be up 20%; and

    c. There is a 20% chance that the market will be down 20%; such that

    d. The expected return on the market is 12% and the MRP is 6%.

79. Consider an unlevered firm that has $100 of assets where the return on those assets is identical to the return on the market portfolio:

    a. In the state where the market is up 20%, the assets if the firm are also up 20%; and

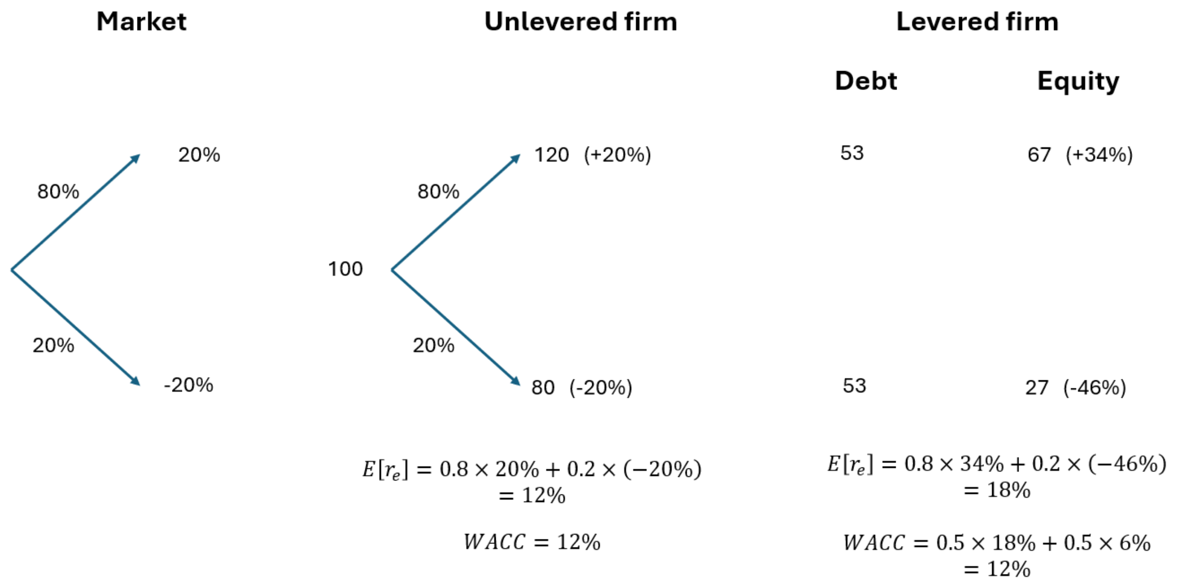
    b. In the state where the market is down 20% the assets of the firm are also down 20%.

80. Because the returns to that firm are always identical to the returns on the market portfolio in every state of the world, it has a beta of 1. That is, a stock that always mimics the market will have a beta of 1.

81. Figure 8 below shows that the expected return on that stock is 12%, which is consistent with the CAPM:

$$E[r_e] = r_f + \beta_e \times MRP = 6\% + 1 \times 6\% = 12\%.$$

Figure 8: Illustrative example – re-levering



Source: Frontier Economics.

82. Now suppose that the firm levers up to 50% debt / 50% equity. Specifically, suppose the firm borrows $50 at 6% p.a. and uses that to pay out equity.

83. Figure 8 shows that:

    a. The debt holders have a first-ranking claim to be paid $53, being their $50 of invested capital plus the promised 6% return;

    b. Debt holders will receive the full amount they are due in both states – because the value of the assets is more than enough to pay the debtholders, even in the bad state of the world; and

    c. Because there is zero risk of default, the return on debt is equal to the risk-free rate in this case.

84. Figure 8 then shows that the equity holders have a residual claim that entitles them to whatever remains after payment to the first-ranking debt holders. The result is a higher positive return (on the $50 of equity capital) in the up state and a larger negative return in the down state.

85. In particular, the range of potential returns is materially wider: (+20% or -20%) in the first case and (+34% or -46%) in the second case. Hence the terms 'leverage' or 'gearing'.

86. Figure 8 further shows that:

    a. The expected return on equity in this case has increased to 18%; and

    b. The WACC is unchanged at 12%.

How does gearing affect beta?

87. We begin by noting that beta is defined in terms of the standard deviation of the returns on the stock, the standard deviation of the returns on the market, and the correlation between those two things:

$$\beta_i = \frac{\rho_{i.M}\,\sigma_i}{\sigma_M}.$$

88. Because the unlevered firm and the market both have the same set of potential returns, correlation is 1 and both have the same standard deviation given by:

$$\sigma_e = \sqrt{0.8(0.20-0.12)^2 + 0.2(-0.20-0.12)^2} = 16\%$$

in which case, the beta for the unlevered firm is:

$$\beta_U = \frac{\rho_{U.M}\,\sigma_U}{\sigma_M} = \frac{1\times 0.16}{0.16} = 1.$$

89. Similarly, the standard deviation of equity returns for the levered firm is given by:

$$\sigma_e = \sqrt{0.8(0.34-0.18)^2 + 0.2(-0.46-0.14)^2} = 32\%.$$

in which case, the beta for the levered firm is:

$$\beta_L = \frac{\rho_{L.M}\,\sigma_L}{\sigma_M} = \frac{1\times 0.32}{0.16} = 2.$$

90. Note that the returns here are all consistent with the CAPM:

$$E[r_U] = r_f + \beta_U \times MRP = 6\% + 1.0\times 6\% = 12\%$$

and:

$$E[r_L] = r_f + \beta_L \times MRP = 6\% + 2.0\times 6\% = 18\%.$$

91. Finally, note that the standard re-levering formula can be used to convert one beta into the other. For example, we can un-lever the second beta as follows:

$$\beta_U = \beta_L \times \frac{E}{V} = 2.0 \times \frac{50}{100} = 1.0.$$

5 Appendix: Comparator sets

Table 6: Identification of comparator sets

Ticker	Company	Market	AER	CEG	ComCom	ERA
AEE US Equity	AMEREN CORPORATION	United States	1	1	1	1
AEP US Equity	American Electric Power	United States	1	1	1	0
AES US Equity	AES Corp	United States	0	0	1	0
AGR US Equity	Avangrid Inc	United States	1	0	1	1
ALA CN Equity	ALTAGAS LTD	Canada	0	0	0	1
ALE US Equity	ALLETE INC	United States	0	1	1	1
APA AU Equity	APA Group	Australia	1	1	1	1
AQN CN Equity	ALGONQUIN POWER & UTILITIES	Canada	1	0	0	1
ASC IM Equity	Ascopiave SpA	Italy	1	0	0	0
AST AU Equity	AusNet Services	Australia	1	1	1	1
ATO US Equity	ATMOS ENERGY CORP	United States	1	1	1	1
AVA US Equity	AVISTA CORP	United States	1	1	1	1
BKH US Equity	BLACK HILLS CORP	United States	1	1	1	1
CHG US Equity	CH Energy Group	United States	0	1	0	0

Ticker	Company	Market	AER	CEG	ComCom	ERA
CMS US Equity	CMS ENERGY CORP	United States	1	1	1	1
CNA LN Equity	Centrica PLC	United Kingdom	0	0	1	0
CNL US Equity	Cleco Corporation	United States	0	1	0	0
CNP US Equity	CENTERPOINT ENERGY INC	United States	1	1	1	1
CPK US Equity	Chesepeake Utilities Corp	United States	0	0	1	1
CU CN Equity	CANADIAN UTILITIES LTD-A	Canada	1	0	0	1
D US Equity	Dominion Energy Inc	United States	1	0	1	1
DTE US Equity	DTE ENERGY COMPANY	United States	0	1	1	1
DUE AU Equity	DUET Group	Australia	1	1	1	1
DUK US Equity	DUKE ENERGY CORP	United States	1	1	1	1
ED US Equity	CONSOLIDATED EDISON INC	United States	1	1	1	1
EDE US Equity	Empire District Electric Company	United States	0	1	0	0
EE US Equity	El Paso Electric Company	United States	0	1	0	0
EIX US Equity	EDISON INTERNATIONAL	United States	1	1	1	1
EMA CN Equity	EMERA INC	Canada	1	0	0	1
ENB CN Equity	ENBRIDGE INC	Canada	0	0	0	1

Ticker	Company	Market	AER	CEG	ComCom	ERA
ENG SM Equity	Enagas SA	Spain	1	0	0	0
ES US Equity	Eversource Energy	United States	1	0	1	1
ETR US Equity	ENTERGY CORP	United States	1	1	1	1
EVRG US Equity	Evergy Inc	United States	1	0	1	1
EXC US Equity	Exelon Corp	United States	1	0	1	1
FE US Equity	FIRSTENERGY CORP	United States	1	1	1	1
FTS CN Equity	FORTIS INC	Canada	1	0	0	1
GAS US Equity	AGL Resources Inc	United States	0	1	0	0
GXP US Equity	Great Plains Energy	United States	0	1	0	0
H CN Equity	HYDRO ONE LTD	Canada	1	0	0	1
HE US Equity	Hawaiiian Electric Inds	United States	1	0	1	1
HER IM Equity	Hera SpA	Italy	1	0	0	0
IDA US Equity	IDACORP INC	United States	1	1	1	1
ITC US Equity	ITC Holdings Corporation	United States	0	1	0	0
KMI US Equity	Kinder Morgan Inc	United States	0	0	1	1
LG US Equity	Laclege Group	United States	0	1	0	0
LNT US Equity	ALLIANT ENERGY CORP	United States	1	1	1	1

Ticker	Company	Market	AER	CEG	ComCom	ERA
MGEE US Equity	MGE ENERGY INC	United States	1	1	1	1
NEE US Equity	NEXTERA ENERGY INC	United States	1	1	1	1
NFG US Equity	National Fuel Gas Co	United States	0	0	1	1
NG/ LN Equity	National Grid PLC	United Kingdom	1	0	1	1
NI US Equity	NISOURCE INC	United States	1	1	1	1
NJR US Equity	NEW JERSEY RESOURCES CORP	United States	0	1	1	1
NU US Equity	Northeast Utilities	United States	0	1	0	0
NVE US Equity	NV Energy	United States	0	1	0	0
NWE US Equity	NORTHWESTERN CORP	United States	1	1	1	1
NWN US Equity	NORTHWEST NATURAL HOLDING CO	United States	1	1	1	1
OGE US Equity	OGE ENERGY CORP	United States	0	1	1	1
OGS US Equity	One Gas Inc	United States	1	0	1	1
OKE US Equity	OneOK Inc	United States	0	0	1	0
OTTR US Equity	Otter Tail Corporation	United States	0	1	0	0
PCG US Equity	P G & E CORP	United States	1	1	1	1
PEG US Equity	PUBLIC SERVICE ENTERPRISE GP	United States	0	1	1	1

Ticker	Company	Market	AER	CEG	ComCom	ERA
PNM US Equity	PNM RESOURCES INC	United States	0	0	0	0
PNW US Equity	PINNACLE WEST CAPITAL	United States	1	1	1	1
PNY US Equity	Piedmont Natural Gas Company	United States	0	1	0	0
POM US Equity	Pepco Holdings Inc	United States	0	1	0	0
POR US Equity	PORTLAND GENERAL ELECTRIC CO	United States	1	1	1	1
PPL US Equity	PPL CORP	United States	1	1	1	1
RGCO US Equity	RGC Resources Inc	United States	1	0	1	1
SCG US Equity	SCANA Corporation	United States	0	1	0	0
SJI US Equity	SOUTH JERSEY INDUSTRIES	United States	0	1	1	1
SKI AU Equity	Spark Infrastructure Group	Australia	1	1	1	1
SO US Equity	SOUTHERN CO/THE	United States	1	1	1	1
SR US Equity	Spire Inc	United States	1	0	1	1
SRE US Equity	SEMPRA ENERGY	United States	1	1	1	1
SSE LN Equity	SSE PLC	United Kingdom	0	0	1	1
SWX US Equity	SOUTHWEST GAS HOLDINGS INC	United States	0	1	1	1

Ticker	Company	Market	AER	CEG	ComCom	ERA
TE US Equity	TECO Energy Inc	United States	0	1	0	0
TEG US Equity	Integrys Energy Group	United States	0	1	0	0
TRN IM Equity	Terna SpA	Italy	1	0	0	0
TRP CN Equity	TC ENERGY	Canada	0	0	0	1
UIL US Equity	UIL Holdings Corporation	United States	0	1	0	0
UNS US Equity	UNS Energy Corp	United States	0	1	0	0
UTL US Equity	Unitil Corp	United States	1	0	1	1
VCT NZ Equity	Vector Ltd	New Zealand	0	0	1	1
VVC US Equity	Vectren Corporation	United States	0	1	0	0
WEC US Equity	WEC ENERGY GROUP INC	United States	1	1	1	1
WGL US Equity	WGL Holdings	United States	0	1	0	0
WR US Equity	Westar Energy Inc	United States	0	1	0	0
XEL US Equity	XCEL ENERGY INC	United States	1	1	1	1
TXNM US Equity	TXNM Energy Inc	United States	1	1	1	1

Source: AER, CEG, Commerce Commission, ERA.

Note: We replace PNM US Equity with TXNM US Equity due to a ticker change.

Frontier Economics

Brisbane | Melbourne | Singapore | Sydney

Frontier Economics Pty Ltd
395 Collins Street Melbourne Victoria 3000

Tel: +61 3 9620 4488
www.frontier-economics.com.au

ACN: 087 553 124 ABN: 13 087 553 124