Estimation of beta for Australian water networks

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1. Executive summary

1.1 Objective

SFG Consulting has been engaged by State Water to advise on an estimate of equity beta for a regulated water network in Australia. The equity beta is an input into the Capital Asset Pricing Model ("CAPM") adopted by regulators for setting the required return to equity holders.

To place this issue in context, in the Australian Capital Territory the regulator adopted an estimate of 0.90 for regulation of Actew (ICRC, 2008). In New South Wales, the regulator adopted an estimate within the range of 0.80 to 1.00 for the regulation of State Water (IPART, 2010) and an estimate within the range of 0.60 to 0.80 for the Sydney Desalination Plant (IPART, 2011). In the latter case, the asset is characterised by contractual terms which transfer risk away from the plant and to the plant operator. In Queensland, the regulator has adopted an equity beta estimate of 0.66 (QCA, 2011).

Hence, regulators have adopted point estimates for the equity beta of a regulated water business within the range of 0.66 to 0.90.[1] These conclusions reflect both differing interpretations of the returns-based evidence from listed water utilities, and analysis of asset-specific information.

1.2 Method

Our estimates rely upon the relationship between excess stock returns and excess market returns for listed firms, computed using ordinary least squares ("OLS") regression. All our calculations are based upon four-weekly returns and are the result of performing the analysis 20 times, and computing average values. The 20 sets of analysis correspond to 20 different start points at which we can compute four-weekly returns. We observe substantial fluctuations in beta estimates depending upon start dates, so minimise estimation error by repeating the analysis in this manner. This calls into question the reliability of beta estimation which does not account for alternative start points.

We also consider whether firm characteristics other than industry sectors – market capitalisation, book-to-market ratio and debt-to-equity ratio – provide additional information about the empirical relationship between stock returns and market returns. In this analysis, the percentile ranks of these characteristics for each firm itself are incorporated into the regression. We perform this analysis separately on Australian-listed firms and an overseas sample of US-listed firms and five UK-listed firms. The Australian sample comprises 2400 firms and an average 323,061 returns observations, an average of approximately 10 years' worth of four-weekly returns for each firm. The US- and UK-listed sample comprises 1508 firms and an average 467,398 returns observations, an average of approximately 20 years' worth of four-weekly returns for each firm.[2]

An alternative technique to account for firm characteristics in beta estimation is to first compute OLS beta estimates on a firm-specific basis, and then regress these beta estimates against variables which measure these characteristics. We take the predicted beta estimates for each firm from this regression, and then compute the mean beta estimates for each industry.

In short, we compile beta estimates using three alternative techniques to account for firm characteristics – *OLS* estimates by firm, *pooled* estimates which account for firm characteristics in the returns regression itself, and *fitted* regression estimates in which we compile the OLS beta estimates which are predicted by firm characteristics.

[1] When we refer to point estimates in this sentence, we take the mid-point of IPART's ranges as its point estimates.

[2] There is an "average" of 323,061 and 467,398 observations because we repeat our analysis 20 times.

It is important to emphasise that this analysis of characteristics relies upon what relationships are present in the data itself. We do not impose a relationship between these characteristics and returns or beta estimates. If firm characteristics are independent of systematic risk, then incorporating these characteristics into the analysis should not impact on the conclusions. In small samples we could observe relationships due to random chance. But we have a large sample of firms. In fact, this analysis relies upon a sample of firms which is far greater than typically analysed when only a narrowly-defined industry is taken into consideration.

In addition, we analyse two plausible sets of comparator firms. We consider the evidence for (1) nine Australian-listed energy network firms which have previously been relied upon by the Australian Energy Regulator ("the AER"); and (2) 17 water utilities listed in the United States ("US") and the United Kingdom ("US"). These are the same firms we analysed in our previous advice to IPART with respect to the Sydney Desalination Plant (SFG, 2011).[3] These samples are drawn from broader samples of 2400 Australian-listed firms and 1518 US- and UK-listed firms. We use market- and accounting-based information from these larger samples to inform our beta estimates for the smaller sub-samples.

1.3 Equity beta estimates

The equity beta estimates resulting from this analysis are summarised below. These beta estimates have not been adjusted for differences in leverage between listed firms and the 60% gearing assumption typically adopted by regulators. We consider the impacts of leverage in Sub-section 1.4. Our beta estimates are presented in Table 1, with 90% confidence intervals presented in brackets where these have been compiled.

- **Australian-listed energy networks.** The mean OLS beta estimate for nine energy network firms is 0.54, the mean predicted value from the pooled regression is 0.87 and the mean fitted estimate is 0.82. The beta estimates from the pooled and fitted analysis are higher for two main reasons. First, firms with higher debt-to-equity ratios have lower OLS beta estimates, but the OLS beta estimates for the listed energy networks are much lower than other firms with the same amount of leverage. Second, other firms classified according to the same industry sub-sectors have higher beta estimates.

- **US- and UK-Listed water utilities.** The mean OLS beta estimate for 17 firms in the ICB Sub-Sector 7577 Water is 0.49, the mean predicted value from the pooled regression is 0.83 and the mean fitted estimate is 0.52.

These figures suggest that the weights placed on different samples of "comparable" firms and the weights placed upon alternative estimation techniques, will be crucial in compiling a suitable beta estimate. If we were to rely exclusively on OLS estimation, the data is consistent with a beta estimate of 0.54 for Australian-listed energy networks and 0.49 for US- and UK-listed water utilities. But these figures are estimated with considerable imprecision. The 90% confidence intervals around these estimates are 0.41 to 0.67 for Australian-listed energy networks and 0.38 to 0.59 for US- and UK-listed water utilities. If we account for firm characteristics in the analysis the data is consistent with point estimates of 0.87 & 0.82 for Australian-listed energy networks, and 0.83 & 0.52 for US- and UK-listed water utilities.

[3] One firm, Northumbrian Group, represents two observations because there are two distinct returns series available for different time periods.

Table 1. Summary of beta estimates

Sample	Equity beta			Asset beta			Re-levered to 60%		
	OLS	Pooled	Fitted	OLS	Pooled	Fitted	OLS	Pooled	Fitted
Au. energy net.	0.54 (0.41–0.67)	0.87 (0.73–1.00)	0.82 (0.71–0.94)	0.37 (0.27–0.46)	0.53 (0.44–0.63)	0.51 (0.42–0.59)	0.59 (0.39–0.79)	0.93 (0.73–1.13)	0.88 (0.77–0.99)
US & UK water	0.49 (0.38–0.59)	0.83 (0.80–0.86)	0.52 (0.45–0.59)	0.39 (0.30–0.48)	0.61 (0.57–0.66)	0.39 (0.33–0.45)	0.64 (0.46–0.83)	1.10 (1.00–1.20)	0.65 (0.57–0.73)

1.4 Leverage impacts

Our analysis highlights a limitation of the conventional un-levering/re-levering approach to equity beta estimation for the purposes of regulation. In the Australian data, it is the firms with high leverage that have relatively lower OLS beta estimates. But in the US and UK data, there is a positive relationship between leverage and OLS beta estimates.[4] This occurs because firms decide to take on debt with an understanding of their business risks, so increased leverage could be a signal of higher or lower risk. In other words, if two firms have the same underlying business risk and one takes on more leverage, the firm with more leverage will end up being the riskier firm. But we only get to observe the amount of leverage and not the underlying business risk. So it is also likely that when we see a firm with high leverage, it is a signal that risk is low and this low risk allowed the firm to take on higher debt.

Nevertheless, we need to conduct our analysis under an assumed capital structure and we have adopted the standard 60% gearing ratio adopted by Australian regulators. Assuming a debt beta of 0.15,[5] a corporate tax rate of 30% and 60% benchmark gearing, we have the following estimates for asset betas and re-levered equity betas:

- **Australian-listed energy networks.** The asset beta estimated from OLS regression is 0.37, the pooled estimate is 0.53 and the fitted estimate is 0.51. In turn, this implies re-levered equity beta estimates of 0.59 for OLS estimation, a pooled estimate of 0.93 and a fitted estimate of 0.88.

- **US- and UK-listed water utilities.** The asset beta estimated from OLS regression is 0.39, the pooled estimate is 0.61 and the fitted estimate is 0.39. This implies re-levered equity beta estimates of 0.64, a pooled estimate of 1.10 and a fitted estimate of 0.65.

1.5 Interpretation

Having compiled a series of point estimates and confidence intervals we need to interpret that evidence in a systematic manner. In doing so, there are two issues to consider.

First, there is the issue of the reliability of OLS beta estimates as an estimate of systematic risk. While it is standard practice to estimate risk in this manner, the empirical evidence suggests that we need to exercise caution in interpreting the results. If OLS beta estimates, when incorporated into the CAPM provide reliable estimates of equity holders' required returns then on average we should observe a positive association between expected returns and realised returns. In other work (Gray, Hall, Klease and McCrystal, 2009) we document the limited reliance which can be placed upon equity beta estimates

[4] Specifically, across the 2400 Australian-listed firms, the median firm has a debt-to-equity ratio of 0.07 and the firm at the 75th percentile has a debt-to-equity ratio of 0.32. The beta estimate of the more highly geared firms is expected to be 0.02 lower than the firm with less financial risk. Across the 1508 US- and UK-listed firms, the median firm has debt-to-equity of 0.22 and the firm at the 75th percentile has a debt-to-equity ratio of 0.51. In this sample, the beta estimate of the more highly geared firm is expected to be 0.02 higher than the firm with less financial risk.

[5] We adopt the figure of 0.15 from Davis (2005, Table II, p.39) which is an estimate of the beta for 10-year Australian government bonds. Increasing or decreasing the debt beta assumption impacts differently upon the beta estimates from different sub-samples and estimation techniques.

derived from historical returns and do not repeat that discussion in this paper. This conclusion is not unique in the literature. OLS beta estimates and the CAPM itself are used largely for convenience as summarised by Fama and French (2004) who state that "[t]he attraction of the CAPM is that it offers powerful and intuitively pleasing predictions about how to measure risk and the relation between expected return and risk. Unfortunately, the empirical record of the model is poor. (p.25)."

This limited reliability has been verified in other recent studies. In a recent US paper, the authors could find no association between OLS beta estimates and average stock returns over a 38-year period from 1970 to 2008 in a sample which averaged 1,738 stocks per month (Da, Guo and Jagannathan, 2012). In Australia, researchers found that simply assuming a beta of one for all stocks was a better predictor of next period's OLS beta than the prior OLS beta (Brimble and Hodgson, 2007). Hence, we would not place full weight on OLS estimates. Some weight can be placed on the market beta of one, because the further a beta estimate is from the market beta, the greater the probability this has occurred because of estimation error (Vasicek, 1973).[6]

The point is that we can use OLS estimates to some degree in arriving at the cost of capital but need to exercise caution against placing too much weight on these estimates. That is why we have performed analysis using a very large sample of data and incorporated information other than industry groupings into the analysis. Even with this information there remains the chance that the sample of firms we can observe is not representative of the risks of a regulated water network in Australia, the chance that the returns we have observed historically are not representative of what we expect to observe and the chance that our estimation techniques are not entirely reliable.

Second, there is the issue of whether the sample of listed firms analysed appropriately captures the systematic risk of a representative regulated water network in Australia. There are no Australian-listed water utilities, so we analyse 17 listed water businesses from overseas and nine Australian-listed energy network businesses. Australian water networks share a characteristic of the energy network businesses, in that they are operators of network businesses subject to a similar regulatory regime. But revenue for these comparator firms is driven by an entirely different product. Australian water networks also share a characteristic of the listed water utilities overseas, namely a similar customer base and product, but operate in a different market under different regulation. What is unclear is just how similar the systematic risk of an Australian water network is to either comparator group we have employed.

We have refined the technique used in prior analysis of the Sydney Desalination Plant for the Independent Pricing and Regulatory Tribunal ("IPART") (SFG, 2011). Rather than rely upon monthly returns, we rely upon four-weekly returns and repeat the analysis 20 times with start points at each day of the four-weekly period. This mitigates estimation error associated with a randomly selected start point. The comparable firm set is the same. We document that OLS beta estimates can vary substantially, contingent upon the start point. The presumption in analysing these firms is that differences in markets, regulation and cost structures across firms, on average, cancel out so that the average firm faces similar risks to a representative regulated Australian water network. In a small sample of listed firms there is no guarantee that this is the case.

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[6] Davis (2011) queries whether a prior estimate of one is appropriate. He states that "the rationale for such an adjustment, particularly using a long data sample of specifically chosen water utility stocks is not strong (p.2)." Davis refers to Vasicek (1973) himself who provided the example that "if a utility stock is included, and it is known from previous measurements that betas of utilities are centered around 0.8 with a dispersion of 0.3, the estimated [β] is adjusted toward 0.8…with [βPrior] = 0.8 and [Std error of βPrior] = 0.3." The issue is that, prior to conducting the regression analysis, we do not have information which suggests that our prior estimate should be different from the average stock in the market. To adopt a prior expectation different from one, we would need evidence aside from the returns information, which supports this prior expectation. It is possible to argue that the beta estimate for an ungeared utility will be lower than the beta estimate for an ungeared stock in another industry, on the basis of the stability of the revenue stream and if there is quantitative information to support this view. But this does not tell us whether the relatively high leverage of the utility will result in an equity beta estimate which differs from one.

To arrive at a final estimate we have placed weights on each of the six re-levered equity beta estimates from our analysis. In determining these weights we adopted the following rationale.

- In terms of estimation techniques, we placed 50% weight on the pooled analysis and 25% weight on each of the OLS and fitted OLS estimates. The fitted OLS estimates rely upon each firm's OLS estimate as a starting point, and we shift these OLS estimates according to industry groupings and firm characteristics. So we are basically placing half the weight on the pooled estimation technique and half the weight on OLS estimation.

- In terms of samples, we placed two thirds weight on estimates from US & UK listed water utilities, on third weight on estimates derived from Australian-listed energy networks.

In aggregate, this means we apply the following weights to the re-levered equity beta estimates presented in the right of Table 1.

Table 2. Weights applied to beta estimates (%)

	Estimation Technique			
Sample	OLS	Pooled	Fitted	Total
Australian-listed energy networks	8%	17%	8%	33%
US- & UK-listed water utilities	17%	33%	17%	67%
Total	25%	50%	25%	100%

Applying the weights presented above to the re-levered equity beta estimates implies an estimate of 0.86, which we round to 0.9 for the purposes of discussion. This estimate lies within the 90% confidence interval for two of our six estimates, below the confidence interval for one estimate and above the confidence interval for three estimates.

Estimates within range of 0.8 to 1.0 would be consistent with the analysis. Of all the confidence intervals presented the range with the lowest upper bound is that of the fitted estimates for US & UK-listed water utilities. The upper bound of this interval is 0.73. The confidence interval with the highest lower bound is that of the pooled estimates for the US- and UK-listed water utilities. The lower bound of this interval is 1.00.

1.6 Conclusion

In deriving an equity beta estimate for a regulated water network in Australia we have attempted to overcome an important sample limitation – there are no pure-play listed water utilities in Australia. Hence, we have derived beta estimates using a large sample of Australian-listed firms across industries, and small samples of Australian-listed energy networks and US- and UK-listed water utilities. In addition, the standard technique of computing industry means ignores important firm-specific information relating to market capitalisation, book-to-market ratio and leverage, which are associated with stock returns and allow us to mitigate firm-specific estimation error.

All of this information, from different samples and estimation techniques, is informative about the appropriate beta estimate. There is no reason to place sole reliance on one particular sample or estimation technique. The only question is just how much relative weight should be placed on particular samples and estimation techniques.

Our conclusion is that an equity beta of 0.9 is appropriate and that a range of 0.8 to 1.0 is consistent with the evidence and reasonable weights placed on alternative estimation techniques. Our estimate is consistent with decisions made by regulators in NSW and the ACT, but above the figure of 0.66 adopted in Queensland.

2. Methodology

2.1 Introduction

We compile beta estimates according to three estimation techniques. First, we compile OLS beta estimates by firm, and report mean estimates across firms for two sub-samples – Australian-listed energy networks and US- and UK-listed water utilities. Second, we incorporate firm characteristics directly into a pooled regression. There are three accounting and market-based characteristics – market capitalisation, book-to-market ratio and debt-to-equity ratio – along with industry classifications. Thus, we compile predicted beta estimates from the regression. Third, we regress OLS estimates against these same firm characteristics, where each firm comprises one observations. We compile fitted beta estimates from this cross-sectional regression.

2.2 Ordinary least squares regression

We compiled OLS beta estimates for individual firms and an equal-weighted index according to the following equation on four-weekly excess returns, where excess returns refers to stock or market returns minus the risk-free rate. Our analysis is repeated 20 times using different start points for four-weekly returns, and we take average values from the 20 sets of analysis.

$$r_{i,t} - r_{f,t} = \alpha + \beta\left(r_{m,t} - r_{f,t}\right) + \varepsilon_{i,t}$$

where:

$r_{i,t}$, $r_{m,t}$ and $r_{f,t}$ = return on stock *i*, the return on the equity market and the risk-free rate, respectively in period *t*; and
$\varepsilon_{i,t}$ = an error term for stock *i* during period *t*.

2.3 Incorporating firm characteristics directly into beta estimates

The beta estimates from this regression technique result from what are termed "interactive" variables, in the sense that we interact (that is, multiply) the firm characteristics with the excess market returns. We convert these firm characteristics to percentile ranks in order to mitigate against the influence of extreme observations. Our regression equation is presented below.

$$r_{i,t} - r_{f,t} = \alpha + \gamma_1 MC_i \times \left(r_{m,t} - r_{f,t}\right) + \gamma_2 B/M_i \times \left(r_{m,t} - r_{f,t}\right) + \gamma_3 D/E_i \times \left(r_{m,t} - r_{f,t}\right) + \sum_{n=1}^{40} \delta_n Industry_i \times \left(r_{m,t} - r_{f,t}\right) + \varepsilon_{i,t}$$

where:

MC_i = the percentile rank of the average market capitalisation for firm *i* minus 0.5;
B/M_i = the percentile rank of the average book-to-market equity ratio for firm *i* minus 0.5;
D/E_i = the percentile rank of the average book-to-market equity ratio for firm *i* minus 0.5;
$Industry_i$ = an indicator variable (that is, 1 or 0) according to 40 different ICB sector classifications (referred to as industry fixed effects in the paper); and
$\varepsilon_{i,t}$ = an error term.

As mentioned above, this is a pooled regression in which each four-weekly return for each firm is an observation. The analysis is performed on a pooled basis because the firm characteristics will be relatively stable over time. In other words, each firm will have a relatively stable value for market capitalisation, book-to-market ratio, debt-to-equity ratio and industry classification over time. So it is not feasible to run the regression for each firm. This would be basically multiplying the excess market returns by a series of constant values.

The important issue to understand is that, if industry is the only characteristic which has information for beta estimations, the coefficients on market capitalisation, book-to-market ratio and debt-to-equity ratio will be zero. The beta estimate for each industry will be the same as if we ran a pooled regression of excess stock returns on excess market returns for separately for each industry. But if the three accounting and market based characteristics do have information which is relevant for beta estimation, then this will mitigate against some of the estimation error associated with consideration only of industry.

We can interpret the coefficients as follows. For each industry the coefficient on the industry variable (delta or δ) is the beta estimate for a firm in that industry with median values across the entire sample for market capitalisation, book-to-market ratio and debt-to-equity ratio. The coefficients on the other variables represent the incremental contribution to the beta estimate for the firm with the smallest value to the firm with the largest value. For example, the coefficient on market capitalisation percentile (gamma 1 or γ_1) represents how much the beta estimate would differ for the largest market capitalisation firm compared to the smallest market capitalisation firm.

2.4 Fitting regression-based beta estimates according to firm characteristics

In this analysis, we first estimate the beta for each firm using all available stock returns for that firm. These beta estimates then become the dependent variable in a regression on firm characteristics. The assumption underlying this analysis is that there is random estimation error in the beta estimate for each firm, but that, on average, the regression-based estimates appropriately measure the systematic risk for a firm with specified firm characteristics. An example of this application in the literature is the paper by Brimble and Hodgson (2007). Amongst other conclusions they find that OLS beta estimates are positively associated with market capitalisation and interest coverage. In a multivariate regression, we also find that OLS beta estimates are positively associated with market capitalisation and inversely related to leverage (that is, more financing risk is associated with lower beta estimates, consistent with the interest coverage ratio finding).

A simplified version of this analysis would be to partition the sample into a number of sub-samples according to cut-offs for the accounting and market-based characteristics and the industry groupings, and then simply compute the mean or median beta estimates within those sub-samples. All that the regression analysis does is perform the same task but with continuous variables rather than partitioning the sample into cohorts.

We report results in which the dependent variable is the percentile rank of the regression-based beta estimate. Hence our regression equation is as follows.

$$\beta_i = \alpha + \gamma_1 MC_i + \gamma_2 B/M_i + \gamma_3 D/E_i + \sum_{n=1}^{40} \delta_n Industry_i + \varepsilon_i$$

where:

β_i = either the percentile rank of the OLS beta estimate; and
other variables are as defined in the previous equation.[7]

[7] Note that when reporting beta estimates based upon the percentile rank we use the 1st and 99th percentiles of the beta estimates as lower and upper bounds so that our fitted values do not take on extreme estimates.

2.5 Leverage

For the purposes of computing asset betas and re-levered equity betas we use the following equation:

$$\beta_e = \beta_a \times \left[1 + \frac{D}{E} \times (1 - \tau)\right] - \beta_d \times \frac{D}{E} \times (1 - \tau)$$

where:

β_e, β_a, and β_d = the equity beta, asset beta and debt beta respectively;
D/E = the market value debt-to-equity ratio; and
τ = the corporate tax rate.

3. Data

3.1 Introduction

We separately analyse data for Australian-listed firms and US- and UK-listed firms. Ideally, we would analyse data for a large sample of Australian-listed water utilities. However, there are no pure-play Australian-listed water utilities, let alone a large sample of such firms. So we analyse data for 2400 Australian-listed firms (nine of which have previously been adopted by the AER in decision-making; and a sample of 1508 US- and UK-listed firms. The Australian sample comprises all firms for which sufficient data was available. The US and UK sample comprises firms in the S&P1500 plus five UK-listed water utilities. All returns and firm characteristic variables have been converted to US dollars in this sample.

We use firm characteristics to mitigate estimation error in OLS beta estimation, namely market capitalisation, book-to-market ratio, debt-to-equity ratio and 40 ICB Sub-sector classifications. In short, we use alternative statistical techniques to estimate the systematic risk of each firm according to the beta estimates of all firms with similar firm characteristics.

3.2 Australian-listed firms

We analysed four-weekly returns on 2400 Australian-listed firms from January 1976 to May 2012, a period of 39 years and four months. The analysis begins in January 1976 because this is the first period in which required data is available for analysis. We restrict our analysis to firms in which at least 13 four-week periods of returns are available for analysis. On average each firm contributes 134 four-weekly returns to the sample, which is equivalent to 10 years of returns.

We do not require market capitalisation and accounting data for the entire period for which returns are available. Accounting information is only available from 1980 onwards so we estimate mean leverage and book-to-market equity ratios for each firm using data from this year onwards. Market capitalisation figures have been converted to March 2012 dollars using the Consumer Pricing Index as reported by the Reserve Bank of Australia. Accounting and market information is from Datastream. From June 1992 the index used to compute beta estimates is the All Ordinaries Index. Total returns are not available on this index prior to this date, so from January 1976 to May 1992, we use the Datastream Total Market Index for Australia.

In Table 3 we present descriptive statistics. The mean OLS beta estimate is 1.09 with a standard deviation of 0.84 and 90% of estimates lie within the range of 0.17 to 2.22. As we discuss later, small firms are characterised by relatively higher beta estimates. If the beta estimates are weighted by average market capitalisation, the mean OLS beta estimate is 0.95. The median firm has market capitalisation of $47 million, book-to-market equity ratio of 0.68 and debt/equity of 0.07. We excluded firms with book value of equity less than or equal to zero.

Table 3. Descriptive statistics for Australian-listed firms

Rate	Mean	Median	Std Dev	Min	5th perc	95th perc	Max
Beta	1.09	1.04	0.84	-16.04	0.17	2.22	12.46
Market cap (A$m)	506	47	2673	1.19	5	1905	74299
Book/Market	0.89	0.68	1.25	0.002	0.16	1.95	33.89
Debt/Equity	0.34	0.07	1.25	0.000	0.00	1.22	39.49

3.3 United States- and United-Kingdom-listed firms

In the US and the UK we analysed 1500 firms using data from January 1973 to December 2012, a period of 40 years. As with the Australian sample we restrict our analysis to firms in which at least 13 four-week periods of returns are available for analysis. On average each firm contributes 310 four-weekly returns to the sample, which is equivalent to 24 years of returns. As with the Australian sample, accounting information is available from 1980 onwards and this has been converted to October 2012 dollars using the respective consumer price indices in the US and UK. We use the Datastream Total Market Indices for the US and UK to compute market returns.

These firms have a mean OLS beta estimate of 1.11 with a standard deviation of 0.44 and 90% of estimates lie within the range of 0.48 to.1.90. The median firm has market capitalisation of US$1.5 billion, book-to-market equity ratio of 0.55 and debt/equity of 0.23. The lower dispersion of OLS estimates compared to the Australian sample can be attributed to the longer trading history of the US- and UK-listed firms. The higher book-to-market equity ratio of the US- and UK-listed firms reflects the different industry composition and reinvestment policies of firms in those the markets.

Table 4. Descriptive statistics for United States- and United Kingdom-listed firms

Rate	Mean	Median	StdDev	Min	5th perc	95th perc	Max
Beta	1.11	1.07	0.44	-2.86	0.48	1.90	3.07
Market cap (US$b)	6.2	1.5	17.2	0.4	2.7	22.9	230.1
Book/Market	0.56	0.55	0.27	0.02	0.20	0.96	4.23
Debt/Equity	0.38	0.23	0.49	0.00	0.00	1.21	7.67

4. Results

4.1 Introduction

There is considerable estimation error associated with the conventional technique used to estimate the systematic risk of equity in a given firm. There is a small sample problem, both in terms of the number of firms available for analysis and the time period over which we can observe their returns. Hence, there is a high probability that the OLS beta estimates are not representative of the systematic risk we would expect to be incorporated into the required returns to equity holders for the firms analysed. Furthermore, even if the risk of those firms could be analysed with precision, there is a high probability that the firms analysed are not representative of the risk of a regulated water network in Australia.

The most troubling aspect of the industry analysis is that it ignores firm characteristics which empirical evidence and theory implies are associated with equity returns. The two most commonly-used firm characteristics used to by portfolio managers and academics to benchmark firms according to risk are market capitalisation and the book-to-market ratio. On average, small firms and high book-to-market firms earn higher returns than large firms and firms with low book-to-market ratios. This result is not specific to any individual national market.

A third characteristic, the debt-to-equity ratio, is directly addressed in cost of capital estimation. This is done by assuming that each firm analysed has the same systematic risk in its underlying assets (an asset beta is estimated by "unlevering" the equity beta estimate of listed firms) and the risk to equity holders is estimated under the assumption of benchmark gearing (the equity beta of the firm of interest is determined by "relevering" the asset beta). So the standard technique relies upon a relationship between leverage and equity risk. But if this is true, we can minimise estimation error by examining the relationship between leverage and equity beta for a large number of firms.

So in our analysis we take into consideration not just industry, but market capitalisation, book-to-market ratio and debt-to-equity ratio in equity beta estimation. This is done using two forms of regression analysis. First, we incorporate these four characteristics directly into the regression estimate of beta itself. It is a pooled analysis in which each four-week return is an individual observation. It will generate a beta estimate for each firm with any specified industry, market capitalisation, book-to-market ratio and debt-to-equity ratio.

Second, we measure regression-based estimates for each firm and then compile fitted estimates for firms with the same characteristics. This is analogous to the standard technique in which the fitted estimate is the same value for firms within the same industry. The incremental difference is that our fitted estimate is the same value for firms within the same industry *and* with the same market capitalisation, book-to-market ratio and debt-to-equity ratio.

4.2 Australian-listed firms

4.2.1 Regression incorporating firm characteristics

In Table 5 we present pooled regression results for Australian-listed firms. The coefficients, adjusted r-squared figures and number of observations represent mean values resulting from performing the regression 20 times. This is the information we will subsequently use to compile beta estimates for Australian-listed energy networks.

The sectors of interest are those which span the nine listed energy network businesses which have been previously relied upon by the AER. The sectors are 7530 Electricity (25 firms including Spark Infrastructure and SP Ausnet), 7570 Gas, water & multi-utilities (9 firms including Alinta and Duet Group), and 570 Oil equipment, services & distribution (11 firms including Gasnet, APA Group and

Hastings Diversified Utilities Fund). Of these three sectors, there is one with a sector beta estimate significantly below one. The Gas, water & multi-utilities sector has a beta estimate of 0.74, within a 90% confidence interval of 0.64 to 0.85 based upon its standard error of 0.06. This sector has the 30th highest beta estimate. The other two sectors have beta estimates of 1.08 and 1.21, respectively, both of which are close to one in a statistical sense. The implication of this analysis is that, all else being equal, a firm assigned to the Gas, water & multi-utilities sector has an equity beta estimate below one.

Expressed as an equation, according to the regression estimates the expected excess return for an Gas, water & multi-utilities firm would be given according to the equation below (recalling that MC, B/M and D/E are percentile ranks scaled within the range of –0.5 to +0.5 with ranks computed across the entire sample):

$$r_{i,t} - r_{f,t} = 0.01 + 0.04 \times MC_i \times (r_{m,t} - r_{f,t}) - 0.05 \times \frac{B}{M_i} \times (r_{m,t} - r_{f,t}) - 0.29 \times \frac{D}{E_i} \times (r_{m,t} - r_{f,t}) + 0.74 \times (r_{m,t} - r_{f,t})$$

We reiterate the importance of performing the analysis 20 times and reporting mean values. For the Gas, water & multi-utilities sector, across the 20 sets of analysis the minimum beta estimate was 0.62 and the maximum beta estimate was 0.90. Put another way:

- Had we run the analysis just once and selected the fourth Thursday of the month as the start point, the computed 90% confidence interval would have been 0.84 to 0.96.
- Alternatively, had we run the analysis just once and selected the first Thursday of the month as the start point, the computed 90% confidence interval would have been 0.48 to 0.77.

These differences result purely from the selection of the day at which the four-weekly returns are computed, and there is no reason to believe that one start point will be more reliable than another start point.

4.2.2 Regressions with OLS estimates as the dependent variable

The alternative way to account for the association between firm characteristics and systematic risk is to first estimate OLS beta estimates, and then to estimate fitted OLS values according to those characteristics. We present these regression results in Table 6. The dependent variable is the percentile rank of the OLS beta estimates, because this mitigates against the noise associated with extreme beta estimates. We compile fitted percentile ranks and then convert these to beta estimates in the final step. We repeated our analysis using OLS beta estimates as the dependent variable. There is a reduction in explanatory power but the directional results are consistent.

We also present results including and excluding the industry fixed effects, and include the other firm characteristics separately as dependent variables. This is presented to show how the inter-relationships between the firm characteristics impact upon the analysis.

Table 5. Regression analysis incorporating firm characteristics into beta estimates

	Coefficient	Standard error	Two-tailed *p*-value
Intercept	0.01	0.00	0.00
Market capitalisation	0.04	0.07	0.59
Book-to-market	-0.05	0.10	0.59
Debt-to-equity	-0.29	0.09	0.00
530 Oil & gas producers	1.29	0.05	0.00
570 Oil equipment, services & dist.	1.21	0.19	0.27
580 Alternative energy	1.31	0.18	0.08
1350 Chemicals	0.73	0.09	0.00
1730 Forestry & paper	0.86	0.11	0.22
1750 Industrial metals & mining	1.49	0.06	0.00
1770 Mining	1.28	0.03	0.00
2350 Construction & materials	0.89	0.07	0.09
2710 Aerospace & defence	1.13	0.30	0.67
2720 General industrials	0.62	0.08	0.00
2730 Electronic & electrical equipment	0.93	0.09	0.40
2750 Industrial engineering	0.88	0.11	0.26
2770 Industrial transportation	0.85	0.09	0.09
2790 Support services	1.00	0.05	0.97
3350 Automobiles & parts	0.79	0.15	0.17
3530 Beverages	0.58	0.09	0.00
3570 Food producers	0.65	0.06	0.00
3720 Household goods & home const.	0.85	0.10	0.14
3740 Leisure goods	0.73	0.16	0.09
3760 Personal goods	0.66	0.13	0.01
3780 Tobacco	0.47	0.05	0.00
4530 Health care equip. and services	0.81	0.07	0.00
4570 Pharmaceutical and biotechnology	1.11	0.10	0.27
5330 Food & drug retailers	-1.41	1.96	0.22
5370 General retailers	0.77	0.06	0.00
5550 Media	0.91	0.11	0.41
5750 Travel & leisure	0.78	0.08	0.01
6530 Fixed line communications	1.15	0.13	0.22
6570 Mobile communications	1.08	0.16	0.62
7530 Electricity	1.08	0.12	0.53
7570 Gas, water & multi-utilities	0.74	0.06	0.00
8350 Banks	0.89	0.06	0.05
8530 Nonlife insurance	0.70	0.08	0.00
8570 Life insurance	0.77	0.23	0.32
8630 Real estate investment & services	0.90	0.08	0.17
8670 Real estate investment trusts	0.99	0.08	0.89
8770 Financial services	0.88	0.06	0.03
8980 Equity investment instruments	0.65	0.08	0.00
9530 Software & computer services	1.10	0.08	0.20
9570 Technology hardware & equip.	1.05	0.13	0.70
Observations		323,061	
Adjusted R-squared		2.9	

Table 6. Regression analysis with percentile rank of OLS estimates as the dependent variable

	Coefficient				Standard error				Two-tailed *t*-test *p*-value				A-Rsq
	Int	MC	B/M	D/E	Int	MC	B/M	D/E	Int	MC	B/M	D/E	(%)
Panel A: No industry fixed effects													
OLS	0.54	-0.07			0.01	0.02			0.00	0.00			0.5
	0.57		-0.13		0.01		0.02		0.00		0.00		1.6
	0.63			-0.27	0.01			0.02	0.00			0.00	6.9
	0.65	0.00	-0.07	-0.25	0.02	0.02	0.02	0.02	0.00	0.88	0.00	0.00	7.2
Panel B: Industry fixed effects													
OLS		0.04				0.02				0.04			80.0
			-0.05				0.02				0.03		80.0
				-0.07				0.02				0.00	80.1
		0.05	-0.03	-0.07		0.02	0.02	0.03		0.02	0.22	0.00	80.1

The regression results show, in the absence of industry fixed effects, firm characteristics are able to explain approximately 7% of the variation in the percentile ranks of beta estimates (see the last column in the fourth row of Panel A). This is primarily attributable to a statistically significant inverse relationship between the debt-to-equity ratio and the beta estimates. In a given sample, it is unclear whether we would expect to observe a positive or negative relationship between leverage and the beta estimate. If two firms have the same systematic risk at an operational level (that is, the same asset beta), we would expect an increase in financial risk to be associated with higher beta estimates. However, if firms with low operational risk use relatively more debt to finance their operations, but the low operational risk and high financing risk are not entirely offsetting, then we will observe an inverse relationship between beta estimates and gearing.

In the multiple regression analysis, there is a statistically significant positive relationship between market capitalisation and OLS beta estimates (see the fourth row of Panel B). All three coefficients on accounting and market-based characteristics are in the same direction as for the pooled regression analysis.

The industry coefficients are not presented in the table. But the corresponding coefficients for the industries of interest are 0.49 for 570 Oil equipment, services & distribution, 0.54 for 7530 Electricity and 0.25 for 7570 Gas, water & multi-utilities. Recall that these represent percentile ranks. The corresponding beta estimates associated with these percentile ranks are 1.03 for 570 Oil equipment, services & distribution, 1.10 for 7530 Electricity and 0.68 for 7570 Gas, water & multi-utilities.

So for example we have the following equation for the percentile rank of an OLS equity beta of a firm in the Gas, water and multi-utilities sector (where MC, B/M and D/E represent percentile ranks:

$$\beta_e Pctl = 0.25 + 0.05 \times MC - 0.03 \times \frac{B}{M} - 0.08 \times \frac{D}{E}$$

4.2.3 Beta estimates

In this sub-section we present all three sets of beta estimates – OLS estimates, pooled estimates from the returns regression and fitted estimates from the beta regression, and corresponding asset betas. In Table 7 we present estimates for the nine energy network businesses and in Table 8 we present estimates for all 2400 firms grouped according to ICB Sectors. For the energy network businesses we also present re-levered equity betas under the assumption of 60% leverage.

Table 7. Beta estimates for listed energy networks

	Means			Percentiles			OLS estimates			Asset betas			Re-levered betas		
Firm	MC	B/M	D/E	MC	B/M	D/E	OLS	Pooled	Fitted	OLS	Pooled	Fitted	OLS	Pooled	Fitted
Spark	1632	0.46	0.93	0.95	0.30	0.92	0.43	0.98	1.05	0.32	0.66	0.70	0.50	1.19	1.27
SPAus	2717	1.06	1.62	0.97	0.78	0.96	0.23	0.95	1.03	0.19	0.52	0.56	0.23	0.92	0.99
APA	1418	0.72	1.26	0.94	0.55	0.95	0.60	1.10	0.95	0.39	0.65	0.58	0.64	1.18	1.02
HDUF	594	0.86	0.90	0.88	0.65	0.92	0.91	1.10	0.94	0.61	0.73	0.64	1.10	1.34	1.15
Gasnet	432	0.64	1.96	0.85	0.48	0.97	0.28	1.09	0.94	0.20	0.55	0.48	0.26	0.96	0.83
AGL	7182	0.88	0.25	0.99	0.67	0.69	0.68	0.70	0.64	0.60	0.61	0.57	1.08	1.10	1.01
Alinta	6475	0.53	0.92	0.99	0.37	0.92	0.54	0.64	0.63	0.39	0.45	0.44	0.64	0.77	0.75
Envestra	807	0.37	2.93	0.90	0.22	0.98	0.56	0.63	0.62	0.28	0.31	0.30	0.42	0.47	0.47
Duet	1571	0.78	3.21	0.94	0.60	0.98	0.62	0.61	0.60	0.29	0.29	0.29	0.44	0.44	0.44
Mean	2536	0.70	1.55	0.93	0.51	0.92	0.54	0.87	0.82	0.37	0.53	0.51	0.59	0.93	0.88
Median	1601	0.71	1.41	0.94	0.53	0.93	0.55	0.91	0.88	0.34	0.54	0.53	0.55	0.95	0.94

For the energy network businesses, the table shows that the mean OLS beta estimate is 0.54. However, the estimates are considerably higher if we condition upon firm characteristics. This sub-sample of firms is relatively large, with high gearing and typical book-to-market ratio, as exhibited by average percentile ranks of 93% and 92% for market capitalisation and debt-to-equity ratio, and 51% for book-to-market ratio. According to firm and industry characteristics, the mean pooled estimate is 0.87 and the mean fitted estimate is 0.82. The corresponding mean asset beta estimates are 0.37, 0.53 and 0.51, respectively; and the mean re-levered equity beta estimates are 0.59, 0.93 and 0.88.

Table 8. Beta estimates according to ICB sector

		Means			Percentiles			Equity betas			Asset betas		
	n	MC	B/M	D/E	MC	MC	B/M	OLS	Pool.	Fit.	OLS	Pool.	Fit.
530 Oil & gas	153	284	0.77	0.08	0.48	0.49	0.36	1.35	1.33	1.27	1.15	1.08	1.01
570 Oil equip.	11	960	0.67	0.55	0.79	0.49	0.73	1.07	1.16	0.97	0.84	0.90	0.77
580 Alt. eng.	14	51	0.61	0.09	0.42	0.43	0.39	1.36	1.34	1.22	1.31	1.29	1.17
1350 Chem.	26	590	0.80	0.31	0.58	0.49	0.58	0.83	0.71	0.82	0.76	0.52	0.63
1730 Forestry	15	303	1.57	0.46	0.67	0.76	0.77	0.80	0.78	0.80	0.76	0.65	0.72
1750 Ind. met.	141	370	0.80	0.13	0.44	0.50	0.36	1.51	1.53	1.40	1.37	1.28	1.17
1770 Mining	689	265	0.70	0.07	0.42	0.47	0.32	1.35	1.33	1.25	1.20	1.13	1.06
2350 Constr.	67	723	1.09	0.50	0.63	0.56	0.71	0.94	0.83	0.90	0.84	0.66	0.74
2710 Aero.	5	68	1.31	0.51	0.47	0.45	0.59	1.12	1.10	1.09	1.13	0.85	0.88
2720 Gen. Ind.	14	1133	0.93	0.31	0.70	0.60	0.68	0.48	0.57	0.55	0.57	0.53	0.61
2730 Elec.	39	81	1.25	0.28	0.38	0.55	0.60	0.93	0.89	0.87	0.77	0.75	0.76
2750 Ind. eng.	34	173	0.91	0.41	0.57	0.62	0.69	1.01	0.82	0.97	0.83	0.65	0.75
2770 Ind. tran.	29	1348	0.95	0.64	0.69	0.64	0.76	0.82	0.78	0.80	0.70	0.63	0.69
2790 Support sv.	96	193	0.71	0.34	0.52	0.48	0.62	0.91	0.97	0.91	0.73	0.77	0.77
3350 Auto.	12	131	1.02	0.60	0.49	0.62	0.78	0.79	0.70	0.79	0.67	0.61	0.68
3530 Bev.	23	741	0.96	0.44	0.56	0.52	0.71	0.50	0.52	0.58	0.49	0.45	0.52
3570 Food	64	316	1.08	0.59	0.54	0.58	0.70	0.61	0.59	0.65	0.60	0.55	0.61
3720 H'hold.	19	223	1.30	0.38	0.62	0.65	0.68	0.76	0.79	0.78	0.69	0.65	0.66
3740 Leisure gds.	10	102	0.75	0.37	0.44	0.50	0.69	0.81	0.67	0.81	0.80	0.62	0.71
3760 Pers. gds	14	322	1.21	1.43	0.55	0.69	0.68	0.86	0.60	0.86	0.77	0.58	0.74
3780 Tobacco	2	1359	0.54	0.04	0.93	0.39	0.41	0.56	0.52	0.55	0.78	0.43	0.47
4530 Health care	71	278	0.57	0.18	0.44	0.34	0.49	0.87	0.81	0.85	0.76	0.70	0.75
4570 Pharm.	76	236	0.40	0.05	0.43	0.26	0.34	1.20	1.16	1.14	1.08	1.04	1.04
5330 Food & drug	8	3072	0.98	0.39	0.75	0.51	0.74	-1.48	-1.47	0.58	-0.75	-0.87	0.50
5370 Gen. ret.	62	625	0.87	0.42	0.62	0.49	0.66	0.78	0.73	0.81	0.76	0.61	0.70
5550 Media	55	559	0.75	0.34	0.56	0.46	0.63	0.95	0.88	0.95	0.79	0.73	0.82
5750 Tr. & leis.	63	670	0.87	0.42	0.57	0.55	0.64	0.72	0.74	0.76	0.62	0.62	0.65
6530 Fix. comm.	20	4523	0.81	0.11	0.56	0.49	0.50	1.17	1.16	1.13	0.94	0.92	0.94
6570 Mob. comm.	15	121	0.88	0.08	0.39	0.57	0.43	1.12	1.09	1.06	0.92	1.01	0.90
7530 Elec.	25	364	0.73	0.41	0.46	0.50	0.54	1.13	1.06	1.05	1.00	0.93	0.90
7570 Gas, wat. ut.	9	2439	0.63	1.01	0.70	0.47	0.71	0.61	0.69	0.62	0.68	0.54	0.65
8350 Banks	16	8904	0.67	1.38	0.89	0.49	0.87	0.73	0.80	0.74	0.65	0.55	0.66
8530 Nonlife ins.	11	2530	3.10	0.25	0.82	0.57	0.61	0.91	0.68	0.88	0.85	0.65	0.79
8570 Life ins.	5	7813	0.72	0.66	0.87	0.48	0.73	0.73	0.72	0.80	0.81	0.58	0.70
8630 Real est.	72	468	1.32	1.25	0.60	0.71	0.78	0.77	0.81	0.74	0.61	0.65	0.62
8670 REIT	74	1288	2.35	1.55	0.74	0.82	0.84	0.89	0.88	0.87	0.59	0.63	0.63
8770 Fin. sv.	155	351	1.06	0.68	0.50	0.58	0.49	0.92	0.88	0.89	0.77	0.77	0.78
8980 Equity inv.	79	233	1.19	0.47	0.57	0.76	0.34	0.76	0.69	0.73	0.63	0.69	0.64
9530 Soft. & comp.	87	100	0.66	0.14	0.47	0.42	0.47	1.16	1.11	1.07	0.99	0.94	0.93
9570 Tech. hard	20	260	0.94	0.53	0.50	0.52	0.56	1.23	1.03	1.02	0.89	0.74	0.80
Mean	2400	506	0.89	0.34	0.50	0.52	0.49	1.09	1.06	1.04	0.95	0.89	0.88
Median		47	0.68	0.07	0.51	0.52	0.49	1.04	1.07	1.04	0.85	0.87	0.87

4.3 United States- and United Kingdom-listed firms

4.3.1 Regression incorporating firm characteristics

In Table 9 we present pooled regression results for 1508 US- and UK-listed firms, including 47 firms listed in the Sector 7570 Gas, water & multi-utilities (23 Water, 15 Gas distribution and 9 Multi-utilities). The coefficient labelled "7570 Gas, water & multi-utilities" represents the estimated equity beta for a firm in the sample with median market capitalisation, book-to-market and debt-to-equity. The estimate is 0.85 with a standard error of 0.07, which implies a 90% confidence interval of 0.70 to 0.96.

Expressed as an equation, according to the regression estimates the expected excess return for a sample firm in this sector would be given according to the equation below (recalling that *MC, B/M* and *D/E* are percentile ranks scaled within the range of –0.5 to +0.5:

$$r_{i,t} - r_{f,t} = 0.01 + 0.08 \times MC_i \times (r_{m,t} - r_{f,t}) + 0.14 \times \frac{B}{M_i} \times (r_{m,t} - r_{f,t}) - 0.41 \times \frac{D}{E_i} \times (r_{m,t} - r_{f,t}) + 0.85 \times (r_{m,t} - r_{f,t})$$

As with the Australian-listed firms, this information is used subsequently to compile the beta estimates for a given firm. We incorporate that firm's percentile rank for market capitalisation, book-to-market ratio and debt-to-equity ratio into the equation above to compile its pooled beta estimate.

4.3.2 Regressions with OLS estimates as the dependent variable

In Table 10 we present the regression analysis where the dependent variable is the percentile rank of the OLS beta estimates. In the multiple regression analysis, there is a statistically significant positive relationship between market capitalisation and OLS beta estimates and a significantly negative inverse relationship with leverage (see the fourth row). In this instance there is a positive association between the debt-to-equity ratio and the beta estimate. As mentioned above, it is not obvious whether we will observe a positive, negative or zero relationship between risk and leverage, because an increase in leverage will cause an increase in risk (holding constant the business risk) or an increase in leverage could be the outcome of management's view that the business has low risk.

Table 9. Regression analysis incorporating firm characteristics into beta estimates

	Coefficient	Standard error	Two-tailed *p*-value
Intercept	0.01	0.00	0.00
Market capitalisation	0.08	0.04	0.05
Book-to-market	0.14	0.05	0.00
Debt-to-equity	-0.41	0.05	0.00
530 Oil & gas producers	1.09	0.06	0.14
570 Oil equipment, services & dist.	1.00	0.06	0.95
580 Alternative energy	1.00	0.18	0.99
1350 Chemicals	1.07	0.07	0.32
1730 Forestry & paper	1.04	0.15	0.78
1750 Industrial metals & mining	1.00	0.10	1.00
1770 Mining	0.94	0.11	0.59
2350 Construction & materials	1.10	0.06	0.11
2710 Aerospace & defence	1.15	0.09	0.10
2720 General industrials	1.02	0.07	0.84
2730 Electronic & electrical equipment	1.08	0.05	0.11
2750 Industrial engineering	1.15	0.05	0.00
2770 Industrial transportation	1.21	0.08	0.01
2790 Support services	0.99	0.06	0.90
3350 Automobiles & parts	0.97	0.08	0.69
3530 Beverages	1.00	0.10	0.99
3570 Food producers	1.10	0.06	0.07
3720 Household goods & home const.	1.06	0.06	0.35
3740 Leisure goods	1.07	0.10	0.49
3760 Personal goods	1.05	0.08	0.56
3780 Tobacco	1.29	0.16	0.07
4530 Health care equip. and services	1.07	0.04	0.10
4570 Pharmaceutical and biotechnology	1.08	0.05	0.11
5330 Food & drug retailers	1.00	0.08	0.99
5370 General retailers	1.09	0.04	0.01
5550 Media	1.21	0.07	0.00
5750 Travel & leisure	1.13	0.07	0.05
6530 Fixed line communications	1.40	0.19	0.04
6570 Mobile communications	1.22	0.08	0.01
7530 Electricity	0.96	0.05	0.38
7570 Gas, water & multi-utilities	0.85	0.07	0.03
8350 Banks	1.09	0.04	0.02
8530 Nonlife insurance	1.17	0.07	0.02
8570 Life insurance	1.06	0.11	0.55
8630 Real estate investment & services	1.04	0.09	0.63
8670 Real estate investment trusts	1.03	0.05	0.58
8770 Financial services	1.08	0.06	0.20
8980 Equity investment instruments	0.87	0.20	0.52
9530 Software & computer services	1.11	0.05	0.03
9570 Technology hardware & equip.	1.10	0.04	0.02
Observations		467,398	
Adjusted R-squared		7.7	

Table 10. Regression analysis with percentile rank of OLS estimates as the dependent variable

	Coefficient				Standard error				Two-tailed *t*-test *p*-value				A-Rsq
	Int	MC	B/M	D/E	Int	MC	B/M	D/E	Int	MC	B/M	D/E	(%)
Panel A: No industry fixed effects													
OLS	0.50	0.02			0.01	0.02			0.00	0.51			0.0
	0.50		-0.06		0.01		0.02		0.00		0.02		0.3
	0.50			-0.22	0.01			0.02	0.00			0.00	4.9
	0.50	0.07	0.12	-0.29	0.02	0.02	0.02	0.02	0.00	0.01	0.01	0.01	4.7
Panel B: Industry fixed effects													
OLS		0.03				0.02				0.13			85.9
			0.02				0.02				0.00		86.2
				0.13				0.03				0.00	86.1
		0.06	0.12	0.06		0.02	0.03	0.03		0.01	0.00	0.06	86.3

4.3.3 Beta estimates

As with the data for Australian-listed firms, in this sub-section we present all three sets of beta estimates – OLS estimates, pooled estimates from the returns regression and fitted estimates from the beta regression. In Table 11 we present estimates for each individual US- and UK-listed water utility.
The mean OLS beta estimate is 0.49, the mean pooled estimate is 0.83 and the mean fitted estimate is 0.52. The corresponding asset beta estimates are 0.39, 0.61 and 0.39. These transferred to re-levered beta estimates of 0.64, 1.10 and 0.64.

Table 11. Beta estimates for US & UK-listed water utilities

		Means			Percentiles			Equity betas			Asset betas			Re-levered betas		
Firm	N	MC	B/M	D/E	MC	B/M	D/E	OLS	Pool	Fit	OLS	Pool	Fit	OLS	Pool	Fit
Cons Wt	227	214	0.51	0.11	0.03	0.45	0.30	0.85	0.99	0.32	0.80	0.93	0.31	1.49	1.75	0.47
Northumbrian 1	109	2,971	0.26	1.55	0.68	0.11	0.98	0.34	0.71	0.47	0.24	0.42	0.30	0.33	0.70	0.47
Pennichuck	235	74	0.62	0.70	0.00	0.62	0.83	0.19	0.79	0.49	0.18	0.58	0.38	0.21	1.03	0.62
SJW	519	282	0.79	0.55	0.06	0.84	0.76	0.50	0.85	0.54	0.41	0.66	0.43	0.67	1.20	0.72
American Wat Wks	59	4,191	1.04	1.39	0.74	0.97	0.97	0.41	0.84	0.68	0.28	0.50	0.42	0.42	0.87	0.70
Artesian Res.	190	97	0.63	1.09	0.00	0.63	0.93	0.28	0.75	0.50	0.22	0.49	0.35	0.30	0.85	0.56
Cadiz	356	188	0.27	0.51	0.01	0.12	0.75	1.23	0.75	0.32	0.94	0.59	0.27	1.78	1.06	0.41
Northumbrian 2	80	1,499	1.26	0.39	0.49	0.99	0.68	0.83	0.94	0.62	0.69	0.77	0.52	1.25	1.43	0.90
United Utilities	292	7,447	0.70	0.73	0.83	0.73	0.84	0.47	0.87	0.62	0.36	0.62	0.46	0.58	1.12	0.78
Severn Trent	292	5,517	0.83	0.64	0.79	0.88	0.80	0.39	0.90	0.64	0.32	0.67	0.49	0.50	1.21	0.85
Pennon Group	292	2,387	0.92	0.75	0.63	0.94	0.85	0.40	0.88	0.64	0.31	0.63	0.47	0.49	1.13	0.81
Cal Water	514	508	0.59	0.56	0.17	0.58	0.77	0.40	0.82	0.50	0.33	0.63	0.40	0.52	1.14	0.66
American States	511	331	0.75	0.79	0.08	0.80	0.86	0.43	0.81	0.54	0.33	0.57	0.40	0.51	1.02	0.67
Aqua Am.	519	1,216	0.60	0.76	0.44	0.59	0.85	0.46	0.81	0.53	0.35	0.58	0.40	0.56	1.04	0.66
York	211	154	0.44	0.44	0.01	0.36	0.71	0.36	0.80	0.37	0.31	0.65	0.32	0.48	1.17	0.49
Connecticut	479	143	0.67	0.76	0.01	0.69	0.85	0.36	0.79	0.50	0.29	0.57	0.38	0.43	1.01	0.62
Middlesex	511	145	0.71	0.82	0.01	0.75	0.87	0.38	0.79	0.52	0.29	0.56	0.39	0.44	0.99	0.63
Mean	317	1,610	0.68	0.74	0.29	0.65	0.80	0.49	0.83	0.52	0.39	0.61	0.39	0.64	1.10	0.65
Median	292	331	0.67	0.73	0.08	0.69	0.84	0.40	0.81	0.52	0.32	0.59	0.40	0.50	1.06	0.66

Northumbrian Group has two separate returns series spanning different time periods so is included as two individual observations.

Table 12. Beta estimates according to ICB sector

		Means			Percentiles			Equity betas			Asset betas		
	n	MC	B/M	D/E	MC	MC	B/M	OLS	Pool.	Fit.	OLS	Pool.	Fit.
530 Oil & gas	44	12.0	0.63	0.37	0.09	0.11	0.10	1.07	1.17	1.04	0.89	0.97	0.86
570 Oil equip.	38	4.7	0.64	0.29	0.03	0.07	-0.03	1.21	1.13	1.16	1.05	0.99	1.00
580 Alt. eng.	3	4.5	0.36	0.09	0.02	-0.25	-0.24	1.55	1.16	1.49	1.48	1.11	1.41
1350 Chem.	41	5.2	0.53	0.33	0.00	-0.01	0.06	1.12	1.14	1.08	0.94	0.97	0.92
1730 Forestry	9	2.3	0.82	0.54	-0.16	0.24	0.21	1.29	1.08	1.23	0.97	0.84	0.95
1750 Ind. met.	20	3.6	0.71	0.30	0.02	0.16	0.02	1.46	1.11	1.38	1.25	0.96	1.18
1770 Mining	10	3.6	0.46	0.40	0.05	-0.10	0.10	1.07	0.99	1.05	0.86	0.83	0.87
2350 Constr.	35	1.9	0.64	0.30	-0.08	0.11	0.03	1.15	1.19	1.11	0.98	1.03	0.95
2710 Aero.	27	6.5	0.57	0.37	0.03	0.03	0.05	1.02	1.24	1.02	0.84	1.05	0.86
2720 Gen. Ind.	21	16.9	0.50	0.43	0.13	-0.06	0.13	1.05	1.06	1.04	0.85	0.87	0.85
2730 Elec.	58	2.0	0.54	0.18	-0.17	0.00	-0.12	1.33	1.22	1.25	1.20	1.11	1.13
2750 Ind. eng.	51	2.9	0.65	0.33	-0.04	0.05	0.03	1.14	1.24	1.12	0.97	1.07	0.96
2770 Ind. tran.	24	5.5	0.53	0.28	0.05	-0.01	-0.02	0.97	1.32	0.97	0.83	1.15	0.84
2790 Support sv.	79	3.1	0.48	0.24	-0.04	-0.09	-0.09	1.10	1.11	1.07	0.98	1.00	0.95
3350 Auto.	10	7.5	0.58	0.48	0.14	0.05	0.03	1.25	1.07	1.22	1.02	0.90	1.00
3530 Bev.	10	20.2	0.45	0.34	0.21	-0.14	0.00	0.41	1.09	0.75	0.31	0.95	0.65
3570 Food	34	4.8	0.50	0.35	0.00	-0.07	0.00	0.71	1.19	0.75	0.62	1.03	0.65
3720 H'hold.	37	4.7	0.61	0.46	0.00	0.02	0.09	1.20	1.12	1.15	0.96	0.92	0.93
3740 Leisure gds.	16	1.9	0.50	0.13	-0.10	-0.06	-0.20	1.28	1.24	1.25	1.19	1.16	1.17
3760 Pers. gds	30	3.7	0.52	0.22	-0.07	-0.05	-0.09	1.27	1.17	1.21	1.13	1.05	1.08
3780 Tobacco	7	30.6	0.54	0.51	0.15	-0.01	0.07	0.67	1.37	0.67	0.55	1.12	0.55
4530 Health care	91	3.8	0.49	0.20	-0.05	-0.08	-0.12	0.92	1.20	0.92	0.84	1.10	0.84
4570 Pharm.	40	15.7	0.33	0.11	0.05	-0.29	-0.22	1.02	1.24	1.01	0.96	1.17	0.95
5330 Food & drug	18	6.9	0.50	0.30	0.10	-0.09	0.00	0.78	1.09	0.81	0.68	0.95	0.70
5370 Gen. ret.	103	5.8	0.47	0.23	0.02	-0.11	-0.15	1.22	1.24	1.15	1.10	1.13	1.04
5550 Media	34	10.7	0.44	0.28	0.15	-0.13	-0.05	1.24	1.32	1.18	1.08	1.17	1.03
5750 Tr. & leis.	50	3.6	0.48	0.40	-0.04	-0.09	0.06	1.23	1.19	1.14	1.01	1.00	0.95
6530 Fix. comm.	10	19.3	0.44	0.73	0.08	-0.13	0.26	0.94	1.37	0.97	0.70	1.00	0.71
6570 Mob. comm.	7	5.3	0.63	0.57	0.04	0.12	0.20	1.07	1.26	1.03	0.81	0.97	0.79
7530 Elec.	36	6.1	0.81	1.12	0.18	0.32	0.42	0.56	0.94	0.58	0.38	0.60	0.39
7570 Gas, wat. ut.	52	2.5	0.69	0.78	-0.11	0.16	0.32	0.48	0.83	0.54	0.37	0.60	0.40
8350 Banks	87	6.5	0.73	1.06	-0.07	0.24	0.35	0.80	1.08	0.83	0.53	0.72	0.56
8530 Nonlife ins.	37	8.3	0.81	0.21	0.11	0.27	-0.07	0.86	1.34	0.87	0.77	1.20	0.78
8570 Life ins.	15	8.5	0.93	0.34	0.14	0.31	0.01	1.35	1.21	1.20	1.10	1.05	1.02
8630 Real est.	5	2.0	0.62	0.42	-0.06	0.06	0.18	1.80	1.07	1.47	1.42	0.87	1.17
8670 REIT	72	2.2	0.63	0.74	-0.02	0.12	0.30	0.87	1.01	0.88	0.63	0.74	0.64
8770 Fin. sv.	54	8.5	0.57	0.67	0.10	0.00	0.04	1.33	1.17	1.21	1.06	0.97	0.97
8980 Equity inv.	2	1.2	1.00	0.29	-0.14	0.46	0.01	1.47	1.02	1.29	1.23	0.89	1.11
9530 Soft. & comp.	79	9.4	0.37	0.07	-0.02	-0.23	-0.31	1.41	1.30	1.30	1.36	1.25	1.25
9570 Tech. hard	112	7.3	0.49	0.10	0.00	-0.09	-0.24	1.61	1.28	1.49	1.52	1.22	1.40
Mean	1508	6.2	0.56	0.38	0.00	0.00	0.00	1.11	1.17	1.07	0.95	1.01	0.92
Median		1.5	0.55	0.23	0.00	0.00	0.00	1.07	1.19	1.07	0.91	1.05	0.95

5. Conclusion

The detailed rationale behind our conclusion is presented in the executive summary. In short, an appropriate equity beta estimate for a regulated water network in Australia is 0.9 and reasonable range of 0.8 to 1.0 is consistent with most of the analysis. These are re-geared beta estimates assuming leverage of 60%.

Our conclusion is based upon two specific sub-samples – nine Australian-listed energy networks and 17 US- and UK-listed water businesses – but they are informed by information from much larger samples of 2400 Australian-listed firms and 1508 US- and UK-listed firms. They are also based upon three estimation techniques, two of which account for firm characteristics aside from industry, namely market capitalisation, book-to-market ratio and debt-to-equity ratio.

Neither sample of data is perfect for the task at hand, nor is any one estimation technique, so the issue becomes how much weight to place on each sample and technique. With respect to techniques, we repeat that if, within the sample, firm characteristics had no role to play in estimating systematic risk, then the coefficients on these variables would be zero. So it seems that if the returns information itself was considered reliable for the purposes of beta estimation, at least some reasonable weight should be placed upon this relevant information. With respect to samples, there is an obvious limitation associated with each sample in terms of product and market. Again, the issue is simply how much weight should be placed on each sample.

There is a well-documented imprecision associated with OLS regression and the real potential for the samples of listed firms to be unreliable proxies for the risks faced by a representative regulated water network in Australia. Given these limitations, consideration needs to be given to the basic premise that a highly geared utility is subject to the same systematic risk of the market. In other words, it could still be the case that an equity beta of one is appropriate. A reasonable range of 0.8 to 1.0 is therefore appropriate and consistent with the confidence intervals comprising most of the analysis.

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