AER STAFF INDUSTRY EQUITY BETA ANALYSIS

This paper was developed by the AER staff as part of their analysis of new evidence

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Executive Summary

This study is conducted to estimate the industry/sector beta for various Australian industries. Two key scenarios are examined in this study. *First,* relevant market indices for all 11 sectors are used, to be named as *Industry-level Analysis*. These Australian industries include: (1) Industrials (2) Consumer Discretionary; (3) Consumer Staples; (4) Financials; (5) Materials; (6) Health Care; (7) Energy; (8) Utilities; (9) Telecommunication; (10) Information Technology; and (11) Real estate. This analysis covers the period of 10 years, from the 1st January 2008 to the 31st December 2017, using weekly data. Standard econometric techniques OLS and LAD are used in this analysis.

Second, stock prices for listed firms identified by Bloomberg as *Energy* (193 Australian listed firms) or *Utilities* (23 Australian listed firms) are used, to be named as *Firm-level Analysis.* These two industries are selected because of their similarity to businesses which are currently regulated by the Australian Energy Regulator (AER). It is noted that some regulated firms regulated by the AER are included in the *Utilities* sector. This scenario utilises available data for the period from 2008 to March 2018. Both weekly and monthly data are used.. The OLS and LAD techniques are used in this scenario.

Key findings from the above two scenarios can be summarised as follows.

- *First,* while *Energy* sector has the second highest risk, *Utilities* sector is the third lowest risk in comparison with other Australian sectors.

- *Second,* the estimated beta, on average for the 10-year period, is within a range of approximately 1.2 - 1.3 for *Energy* sector. The estimates of beta using the OLS and the LAD techniques produce similar findings.

- *Third,* the estimated beta of the *Utilities* sector varies within the range of 0.4 and 0.7 (for OLS) and 0.5 and 0.7 (for the LAD).The mean estimate for the sector is 0.56 (using OLS) and 0.60 (using LAD). The medians are 0.58 (for OLS) and 0.62 (for LAD). The 95 percent confidence interval varies within the range of 0.42 – 0.71 (OLS, Weekly data) and 0.41 – 0.78 (LAD, Weekly data).

- *Fourth,* it is impractical to determine a point estimate of beta for regulatory purposes from the sample including all listed firms classified by Bloomberg as *Energy* or *Utilities* because estimated betas from these samples (23 firms for *Utilities* or 193 firms for *Energy*) vary within a very wide range.

Further analyses are conducted to examine the robustness of the above findings. Five scenarios are considered in this analysis:

(i)   An unrestricted sample of 23 Australian listed firms in *Utilities*;

(ii)   a restricted sample of 17 firms, removing all firms which are not listed as *Utilities* by the Australian Stock Exchange;

(iii)   a restricted sample of 20 firms, removing all firms with the current market capitalisation, as at December 2017, of less than 10 million AUD;

(iv)   a restricted sample of 14 firms, removing all firms with constraints as discussed in Scenario 2 and Scenario 3; and

(v)   a restricted sample of 9 firms, including only large listed Australian firms in *Utilities* with the market capitalisation of AUD 100 million or more as at December 2017.

Across these 5 different scenarios for the research period from 2008 to 2018, the average of estimated beta falls within the range of 0.49 and 0.76. When the median of all estimates is used, the estimated beta lies within the range of 0.45 and 0.71.

In summary, findings from this empirical study indicate that using sector/industry indices, estimated equity beta for *Utilities* is within a range of 0.55 – 0.60. In addition, this study provides evidence that it is impractical to derive the industry/sector beta from all estimates of all listed firms classified in a particular industry.

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1. Introduction

This study is conducted to consider a possibility that the equity beta can be estimated for the entire industries/sectors, rather than for a sample of selected firms as the AER and other economic regulators have been doing for the last 15 years or so. It has been suggested that doing so will avoid problems which are embedded in the current AER's approach of estimating beta: (i) the de-levered/re-levered process using a benchmark gearing of 60 per cent and the assumed debt beta of zero; [1,2] and (ii) a benchmark sample currently including a small number of Australian listed firms.[3]

Two scenarios are examined in this study.

- *First,* relevant market indices for all 11 sectors as classified by Bloomberg are used, to be labelled as *Industry-level analysis*. These Australian industries include: (1) Industrials (2) Consumer Discretionary; (3) Consumer Staples; (4) Financials; (5) Materials; (6) Health Care; (7) Energy; (8) Utilities; (9) Telecommunication; (10) Information Technology; and (11) Real estate. This analysis covers the period of 10 years, 1 January 2008 to 31 December 2017, using weekly data. The standard econometric techniques OLS and LAD are used in this analysis.

- *Second,* stock prices for listed firms identified by Bloomberg as *Energy* (193 Australian listed firms) or *Utilities* (23 Australian listed firms) are used, to be named as *Firm-level analysis*. These two industries are selected because of their similarity to businesses which are currently regulated by the Australian Energy Regulator (AER). It is noted that some regulated firms regulated by the AER are included in the *Utilities* sector. The study covers the period from 2008 until 2018. Both weekly and monthly data are used for consistency with the AER's Beta Analysis in June 2017. The OLS and LAD regressions are used in this scenario.

This study is then extended by conducting further analyses to consider the robustness of findings from the above analysis by examining various scenarios of how the benchmark sample can be developed.

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[1]   Partington, G. and Satchell, S. (2016), Report to the AER: Discussion of comparator firms for estimating beta, June 2016.

[2]   In a report prepared for the Australian Energy Regulator (September 2017), Partington and Satchell considered that the assumption of a zero beta for debt is clearly not correct given the riskiness of the BBB debt rating that the AER assumes in calculating the regulated rate of return. In addition, they considered that the use of the AER's re-levering (with the assumed debt beta of zero) results in an upward biased estimate of the equity beta. This potential bias is a reason why they caution against the re-levering process.

[3]   For example, a report prepared for APA Group by Frontier Economics (December 2016) examined other Australian infrastructure firms to derive estimated equity beta for Australian energy network businesses currently regulated by the AER. Some of the companies included in this Frontier Economics' extended sample include Auckland International Airport Limited; Aurizon Holdings Limited; Sydney Airport and many others.

The structure of this study is as follows. Following this Introduction, Section 2 presents the framework of estimating beta using the market prices. Empirical results are presented in Section 3. Section 4 presents a summary of the robustness analyses. Concluding remarks are discussed in Section 5.

2. The AER's analysis of equity beta in 2017

2.1. The framework of estimating beta using market prices of individual stocks and industries

The equity beta is a key input parameter in the Sharpe–Lintner Capital Asset Pricing Model (CAPM). Equity beta measures the sensitivity of an asset or business's returns to movements in the overall market returns (systematic or market risk).[4] The CAPM predicts that the expected return to the asset *i* is estimated by:

$$r_{i,t} = \alpha_i + \beta_i r_{mt} + \varepsilon_{i,t} \quad (1)$$

in which, the residual is $\varepsilon_{i,t} = r_{i,t} - \alpha_i - \beta_i r_{mt}$

The continuously compounded raw return to asset *i* can be calculated as:

$$r_{i,t} = \ln(P_{it}/P_{it-1})$$

The price of asset i has been adjusted for the payment of dividends. As such, this price represents a measure of total return to the investor. In addition, a return to the market, where A is the ASX300 accumulation index, can be defined as below:

$$r_{Mt} = \ln(A_{it}/A_{it-1})$$

In 2009, Associate Professor Henry from the University of Melbourne, Australia established his work in estimating equity beta for the Australian Utilities regulation as an advice to the Australian Competition and Consumer Commission (Henry, 2009). Five years later, Henry and Street (2014) updated the estimates. In these two studies, the Ordinary Least Squares (OLS) and Least Absolute Deviations (LAD) approaches are utilized.[5] The AER recently updated Henry (2014) study with the focus on structural break in the estimates of equity beta.

2.2. Ordinary Least Squares

The OLS method estimates the α_i and β_i in the equation (1) by minimizing the sum of squared residuals:

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[4]   McKenzie and Partington, *Risk, asset pricing models and WACC*, June 2013, p. 21; Brealey, Myers, Partington, Robinson, *Principles of Corporate Finance*, McGraw-Hill Australia: First Australian Edition, 2000, p. 187.

[5]   Vo et al. (2014) re-examined the estimates of beta in the Australian regulatory context. In their study, a data set was updated in comparison with Henry's study in 2009. In addition, another key contribution from Vo et al. (2014) study was that two new approaches were added in their study: (i) the Maximum Likelihood robust theory (MM) and (ii) the Theil Sen methodology. For each of these new approaches, the authors argued that among the robust regression estimators currently available, the MM regression had the highest breakdown point (50 percent) and high statistical efficiency (95 percent) while the Theil Sen estimator was proposed by Fabozzi (2013) in response to the OLS estimator being acutely sensitive to outliers. Further details, see Vo, D. et. al. (2014*) Equity Beta for the Australian Utilities is well below 1.0*, a paper presented at the Australasian Econometric Society Conference, Hobart, 2014.

$$\sum_{t=1}^{T} \varepsilon_{i,t}^2 = \sum_{t=1}^{T} (r_{i,t} - \hat{r}_{i,t})^2 = \sum_{t=1}^{T} (r_{i,t} - \hat{\alpha}_i - \hat{\beta} r_{m,t})^2$$

The β coefficient from OLS indicates the average relationship between the regressor and the outcome variable based on the conditional mean function.

2.3. Least Absolute Deviations

In the LAD approach, the absolute value of residuals is minimized to achieve the estimates from equation (1) as follows:

$$\sum_{t=1}^{T} |\varepsilon_{i,t}| = \sum_{t=1}^{T} |r_{i,t} - \hat{r}_{i,t}| = \sum_{t=1}^{T} |r_{i,t} - \hat{\alpha}_i - \hat{\beta} r_{m,t}|$$

Since the sum of the absolute value of residuals is minimized rather than minimizing the sum of squares, the estimators obtained from the LAD method may alleviate the effect of outliers.

3.   Empirical results

In this study, various analyses have been conducted. *First,* estimates of equity beta for all Australian industries using their relevant market indices, *an Industry-level analysis.* The purpose of this analysis is to consider the relative extent of risk of the *Utilities* sector, a sector of interest, in comparison with all other sectors of the Australian economy. *Second, a Firm-level analysis,* estimates of equity beta for all constituents of the *Utilities* and *Energy* sectors, the two most comparable industries which have been regulated by the AER. *Third,* in this study, a robustness analysis including various scenarios is examined to consider the change in estimated beta when a benchmark sample changes.

3.1.   *An Industry-level Analysis:* Estimated beta of Australian Industries

In this analysis, all 11 sectors of the Australian economy are considered. These sectors include: (1) Industrials (2) Consumer Discretionary; (3) Consumer Staples; (4) Financials; (5) Materials; (6) Health Care; (7) Energy; (8) Utilities; (9) Telecommunication; (10) Information Technology; and (11) Real estate. Standard OLS and LAD techniques are utilised for weekly data for the period from 1 January 2008 to 31 December 2017. Findings from this analysis can be summarised as below.

- At the overall market level of systematic risk, which is proxied by beta, *Materials* and *Energy* sectors are estimated as the most risky sectors in comparison with other Australian sectors. Other industries such as *Industrials; Information Technology;* and *Consumer Discretionary* are estimated to be approximately at the market level

of risk (with an estimated beta close to 1.0). In addition, *Telecommunication; Utilities;* and *Healthcare* sectors are estimated to be the least risky (safest) sectors in comparison with the Australian market level of risk.

- Estimated beta, on average for the 10-year period, is approximately 0.4 (for *Telecommunication)* and 1.3 for *Materials* and *Energy*. The estimates of beta using the OLS and the LAD techniques produce similar findings.

- The *Utilities* sector is estimated to be relatively safe among 11 Australian sectors. In term of risk, the *Utilities* sector is estimated to be the third lowest risk (OLS) and the second lowest risk (LAD), in comparison with other industries of the Australian economy.

- The estimated beta of the Australian *Utilities* varies within the range of 0.4 and 0.7 (for OLS) and 0.5 and 0.7 (for the LAD) with the mean estimate for the sector is 0.56 (using OLS) and 0.60 (using LAD). The medians are 0.58 (for OLS) and 0.62 (for LAD).

- The *Energy* sector, on the other hand, is estimated to be relatively risky in the Australian context. This sector is estimated to be the second highest risk among all 11 Australian industries using both OLS and LAD techniques.

- The estimated beta of the Australian *Energy* varies within the range of 1.0 and 1.7 (for both OLS and LAD) with the mean estimate for the sector is 1.26 (using OLS) and 1.22 (using LAD). The medians are 1.12 (for LAD) and 1.19 (for OLS).

Detailed estimates and the relative rankings of the estimated beta for all 11 Australian industries are presented in Table 1 and Figure 1 and Figure 2 below.

For illustration purpose, expected returns for these sectors are estimated using the assumed estimate of a risk-free rate of 2.5 per cent and the assumed market return of 8 per cent. The relationship between risk (beta) and return for Australian sectors are presented in Figure 3 and Figure 4.

From this risk-return framework, *Utilities* sector is estimated to be a relatively low risk (safe) sector whereas *Energy* is estimated to be one of the most risky sectors in Australia. These findings imply that *Energy* sector and, as the consequence, its constituents should not be considered as comparable firms to businesses which are currently regulated by the AER. These findings also imply that *Energy* should not be considered as comparable to *Utilities* sector in the Australian context.

Table 1   Australian Industry Beta, Weekly Data, 2008 – 2017, OLS Estimates versus LAD Estimates

Weekly data - OLS	Industrials	Consumer Discretionary	Consumer Staples	Financials	Materials	Health Care	Energy	Utilities	Telecom	Information Technology	Real Estate
2008	0.90	0.76	0.73	0.93	1.31	0.65	1.51	0.68	0.50	0.69	1.16
2009	1.16	0.94	0.40	1.22	1.28	0.20	0.98	0.54	0.19	0.76	1.37
2010	0.97	0.74	0.65	1.11	1.25	0.53	1.17	0.56	0.38	0.93	0.61
2011	0.88	0.83	0.58	1.17	1.28	0.64	1.21	0.59	0.35	0.66	0.65
2012	1.18	0.85	0.57	0.91	1.61	0.57	1.45	0.13	0.25	0.88	0.41
2013	1.06	0.94	0.79	1.14	1.25	0.73	1.12	0.52	0.63	0.93	0.49
2014	0.98	1.07	0.96	1.04	1.25	0.75	1.17	0.66	0.85	1.34	0.73
2015	0.63	0.86	0.86	1.19	1.37	0.64	1.69	0.92	0.66	0.71	0.76
2016	0.69	0.75	0.89	1.39	1.34	0.64	1.14	0.40	0.45	1.01	0.42
2017	0.79	0.99	1.05	1.32	0.81	0.73	1.21	0.63	0.11	1.22	1.02
Average	**0.92**	**0.87**	**0.75**	**1.14**	**1.27**	**0.61**	**1.26**	**0.56**	**0.44**	**0.91**	**0.76**

Weekly data - LAD	Industrials	Consumer Discretionary	Consumer Staples	Financials	Materials	Health Care	Energy	Utilities	Telecom	Information Technology	Real Estate
2008	1.00	0.71	0.79	0.95	1.02	0.78	1.50	0.74	0.66	0.90	1.28
2009	1.09	0.97	0.53	1.21	1.33	0.37	1.04	0.60	0.33	0.61	1.24
2010	0.93	0.70	0.54	1.09	1.21	0.61	1.21	0.53	0.24	0.93	0.61
2011	0.85	0.84	0.64	1.14	1.29	0.80	1.15	0.63	0.28	0.60	0.69
2012	1.13	0.95	0.47	0.91	1.58	0.50	1.52	-0.01	0.22	0.87	0.50
2013	1.11	0.90	0.86	1.08	1.36	0.81	1.08	0.61	0.65	0.70	0.73
2014	0.99	1.19	0.94	0.98	1.26	0.71	0.97	0.64	0.79	1.20	0.77
2015	0.63	0.87	0.79	1.21	1.12	0.66	1.67	1.02	0.67	0.52	0.76
2016	0.75	0.86	0.85	1.47	1.34	0.52	1.10	0.49	0.62	0.84	0.52
2017	0.72	0.94	1.09	1.42	0.49	0.85	1.02	0.73	0.28	1.31	0.87
Average	**0.92**	**0.89**	**0.75**	**1.15**	**1.20**	**0.66**	**1.22**	**0.60**	**0.47**	**0.85**	**0.80**

Source: AER's analysis

Figure 1   Australian Industry Beta, Weekly Data, OLS, 2008 - 2017
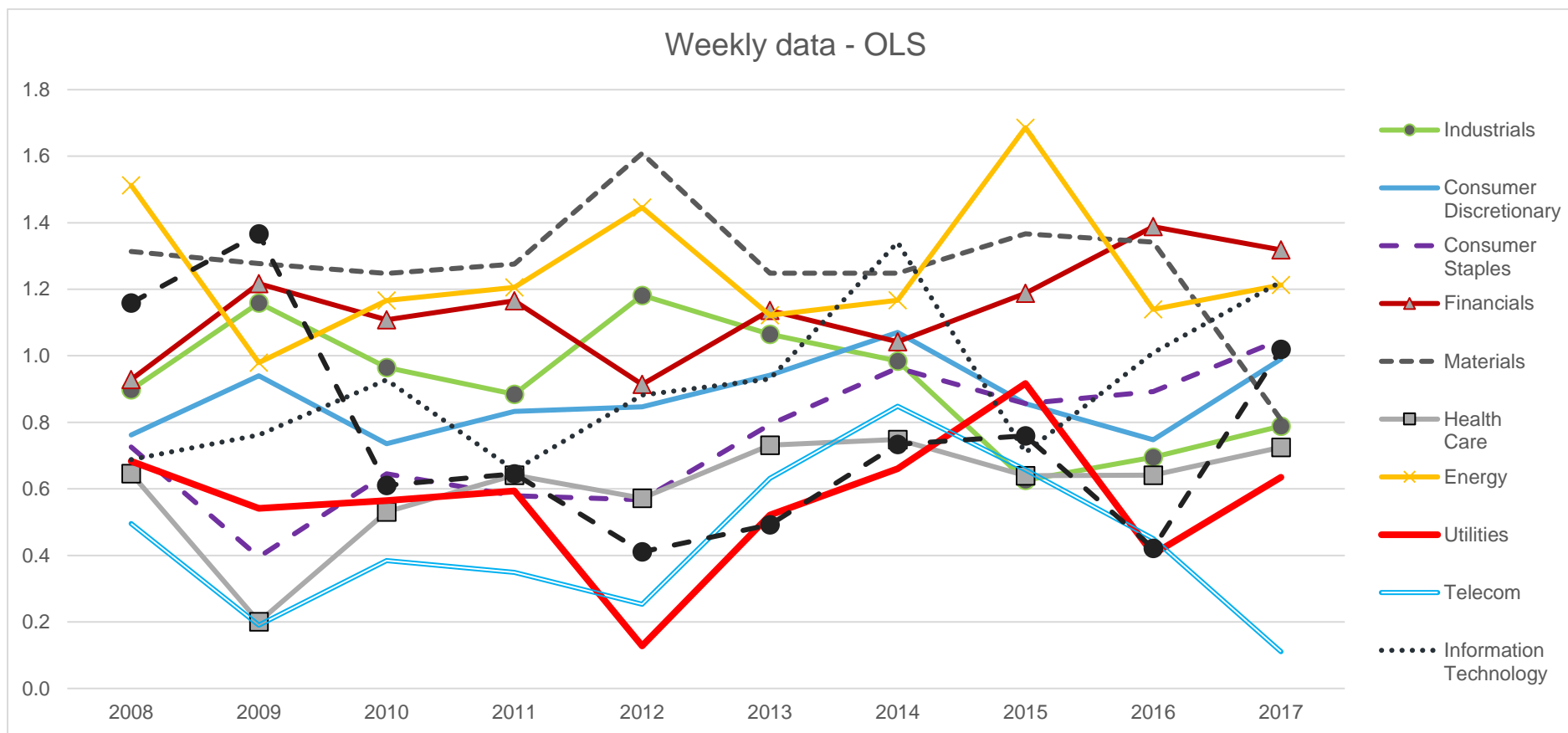
Source: AER's analysis

Figure 2   Australian Industry Beta, Weekly Data, LAD, 2008 - 2017
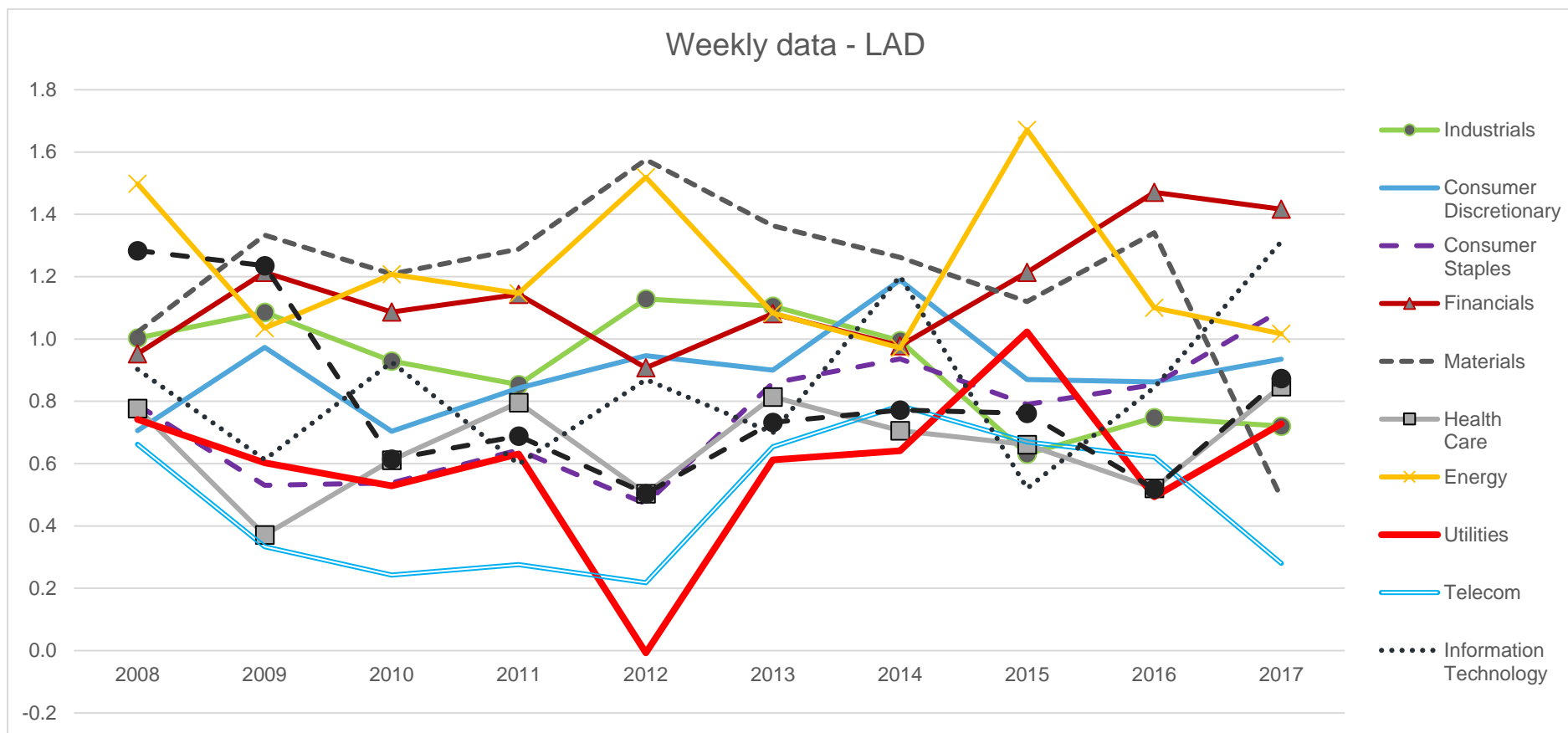
Source: AER's analysis

Figure 3   Beta and Expected Return of Australian Industries, 2008-2017, Assumed Risk-free rate of 2.5 Percent & Market return of 8 Percent, Weekly Data, OLS

Beta & Expected Return for the Australian Industries
OLS Estimates, 2008 - 2017
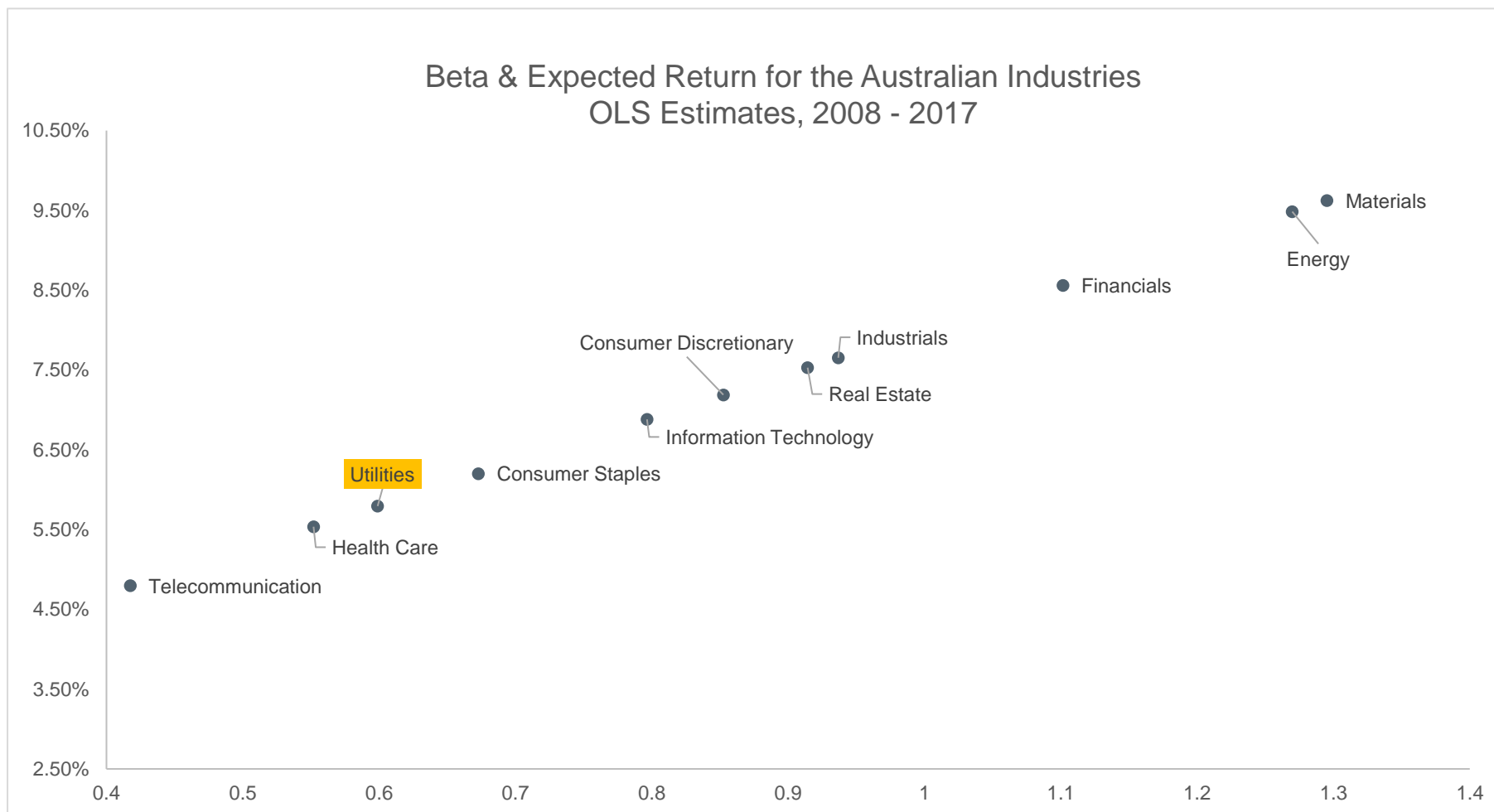
Source: AER's analysis

Figure 4   Beta and Expected Return of Australian Industries, 2008-2017, Assumed Risk-free rate of 2.5 Percent & Market return of 8 Percent, Weekly Data, LAD

Beta & Expected Return of the Australian Industries
LAD Estimates, 2008 - 2017
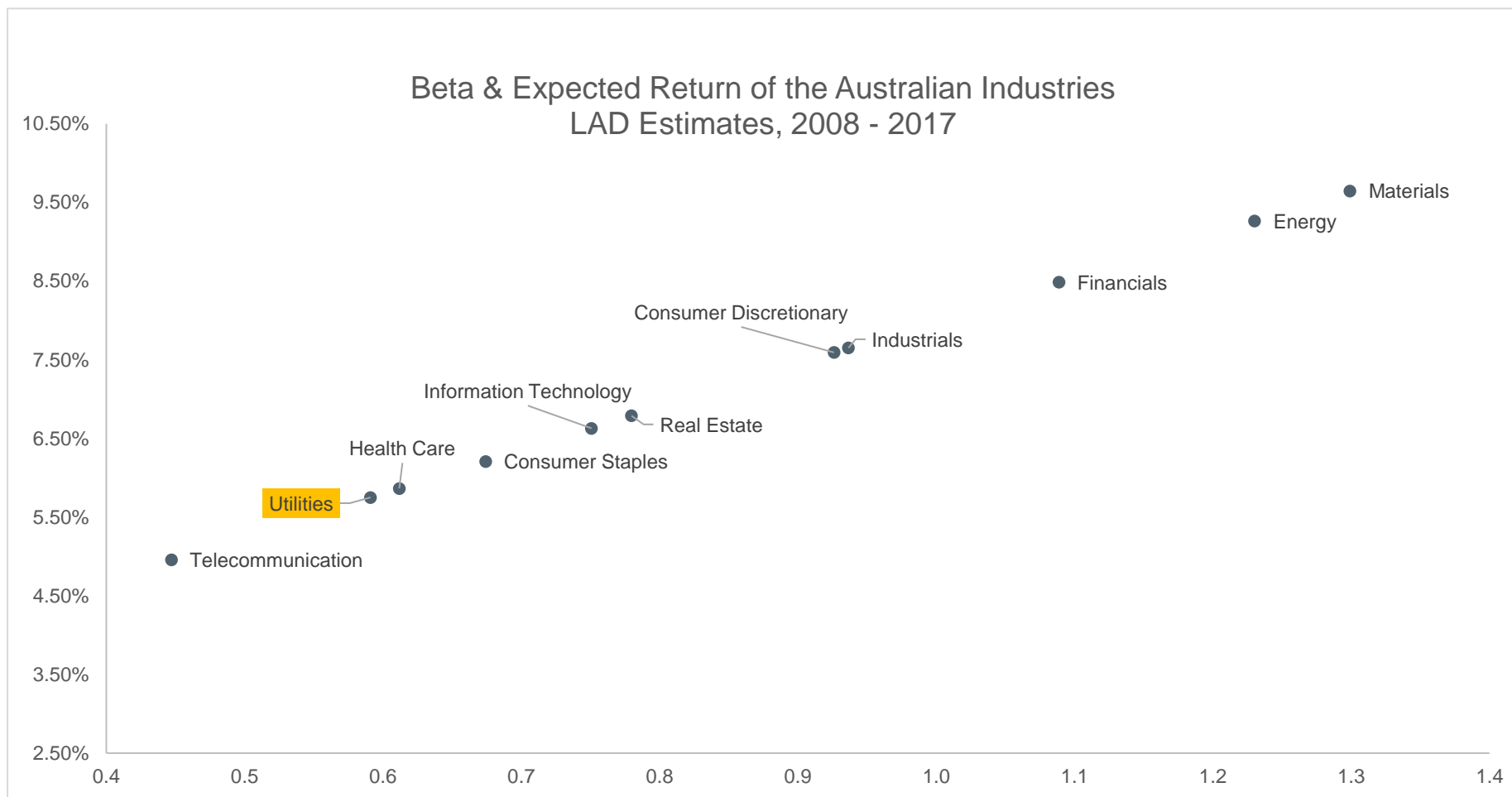
Source: AER's analysis

3.2. *A Firm-level Analysis*

In this analysis, estimates of beta for all listed firms in the Australian *Utilities* sector and *Energy* sector from Bloomberg's sector classification are conducted. Traditional econometric techniques OLS and LAD are utilised. 23 Australian listed firms are classified as *Utilities* firms by Bloomberg. 193 Australian listed firms are considered as *Energy*. For the research period from 2008 to 2018, there are 525 observations on a weekly basis for each firm with full available data in the sample. When monthly data is considered, then there are 119 observations for each firm with full available data in the sample for the research period. Table 2 below presents a summary of estimates of beta for 193 firms in *Energy* and 23 firms in *Utilities* using OLS and LAD for both weekly and monthly data. Detailed beta estimates for each firm can be found in the Appendix 1.

Table 2   A Summary of Estimated Betas for Firms in Bloomberg's *Utilities* and *Energy*

	Utilities				Energy			
	Weekly Data		Monthly Data		Weekly Data		Monthly Data	
	OLS	LAD	OLS	LAD	OLS	LAD	OLS	LAD
Min	-0.36	0.00	0.06	0.25	-1.67	-0.55	-2.54	-1.57
Average	0.76	0.49	1.45	1.22	0.89	0.45	1.32	1.02
Median	0.71	0.45	1.16	0.93	0.95	0.14	1.34	0.97
Max	1.69	1.75	5.17	3.79	2.90	2.21	3.18	7.52
Lower	0.25	0.19	0.42	0.11	0.14	0.01	-0.06	-0.28
Upper	1.27	0.79	2.49	2.32	1.64	0.88	2.70	2.31
95% Confidence Interval	0.25 - 1.27	0.19 - 0.79	0.42 - 2.49	0.11 - 2.32	0.14 - 1.64	0.01 - 0.88	-0.06 - 2.7	-0.28 - 2.31

Source: AER's analysis

Key findings from this analysis can be summarised as below.

- For the entire period of 2008 – 2018, estimated betas using weekly data for 23 Australian *Utilities* firms vary within the wide range of -0.36 and 1.69 (OLS) and 0 and 1.75 (LAD). The range is much wider when the monthly data is used, being 0.06 and 5.17 (OLS) and 0.25 and 3.79 (LAD). When the 95 per cent confidence interval is considered, the range is now at 0.25 – 1.27 (OLS); and 0.19 – 0.79 (LAD) using weekly data. For monthly data, the 95 per cent confidence interval ranges are 0.42 – 2.49 (OLS) and 0.11 – 2.32 (LAD).

- For Australian *Energy* firm, estimated betas using weekly data for 193 firms vary within the wide range of -1.67 and 2.90 (OLS) and -0.55 and 2.21 (LAD). The range is much wider when the monthly data is used, being -2.54 and 3.18 (OLS) and -1.57 and 7.52 (LAD). When the 95 per cent confidence interval is considered, the range is now at 0.14 – 1.64 (OLS); and 0.01 – 0.88 (LAD) using weekly data. For monthly data, the 95 per cent confidence interval ranges are -0.06 – 2.7 (OLS) and -0.28 – 2.31 (LAD).

- When the median of the estimated betas is considered, the range of equity beta falls within the range of 0.45 – 0.71 (weekly data) and 0.93 - 1.16 (monthly data) for Australian *Utilities.* For *Energy,* the ranges of equity beta are 0.14 – 0.95 (weekly data) and 0.97 - 1.34 (monthly data)

Findings from Table 2 indicate that estimated betas across techniques (OLS and LAD) substantially fluctuated. As such, it is argued that it is impractical to use a very wide range of the estimated betas, as presented above, for all listed firms included in the industry/sector to draw a sensible point estimate of beta for the AER's regulatory purpose.

4. Robustness Analyses

In this section, further analyses are conducted to examine the robustness of the above findings. The study is extended by developing some scenarios of how the benchmark sample can be developed. It is noted that, for example, 6 listed firms from Bloomberg's Utilities are not classified in the same sectors by the ASX. Appendices 2 & 3 are included for details.

In this robustness analysis, the following scenarios, together with the original scenario of 23 firms classified by Bloomberg, are considered.

Scenario 1:   A Bloomberg's sample of 23 Australian listed firms in *Utilities*

Scenario 2:   A restricted sample of 17 firms, removing all firms which are not listed as *Utilities* by the ASX

Scenario 3:   A restricted sample of 20 firms, removing all firms with the current market capitalisation, as at December 2017, of less than 10 million AUD

Scenario 4:   A restricted sample of 14 firms, removing all firms with constraints as discussed in Scenario 2 and Scenario 3

Scenario 5:   A restricted sample of 9 firms, including only large listed Australian firms in *Utilities* (with the market capitalisation as at December 2017 of AUD 100 million or more)

Betas and their ranges for the above 5 scenarios are summarised in Table 3 below.

Table 3   A summary of estimated betas – robustness analysis

Scenario 1: Full sample	Weekly Data			Monthly Data	
	OLS	LAD		OLS	LAD
Max	1.69	1.75		5.17	3.79
Average	0.76	0.49		1.45	1.22
Median	0.71	0.45		1.16	0.93
Min	-0.36	0.00		0.06	0.25
Lower	0.25	0.19		0.42	0.11
Upper	1.27	0.79		2.49	2.32
95% Confidence Interval	0.25 - 1.27	0.19 - 0.79		0.42 - 2.49	0.11 - 2.32
Scenario 2: Utilities only					
Max	1.69	1.75		5.17	3.79
Average	0.75	0.49		1.54	1.19
Median	0.71	0.45		1.16	0.93
Min	-0.36	0.00		0.14	0.25
Lower	0.23	0.20		0.50	0.04
Upper	1.27	0.78		2.58	2.35
95% Confidence Interval	0.23 - 1.27	0.2 - 0.78		0.5 - 2.58	0.04 - 2.35
Scenario 3: Market Cap over 10 million AUD					
Max	1.69	1.75		5.17	3.79
Average	0.77	0.54		1.51	1.24
Median	0.71	0.57		1.09	0.94
Min	-0.36	0.00		0.06	0.25
Lower	0.27	0.24		0.48	0.14
Upper	1.26	0.85		2.53	2.34
95% Confidence Interval	0.27 - 1.26	0.24 - 0.85		0.48 - 2.53	0.14 - 2.34
Scenario 4: Utilities and Market Cap over 10 million AUD					
Max	1.69	1.75		5.17	3.79
Average	0.75	0.57		1.63	1.22
Median	0.70	0.57		1.09	0.94
Min	-0.36	0.00		0.29	0.25
Lower	0.25	0.27		0.59	0.06
Upper	1.26	0.87		2.66	2.38
95% Confidence Interval	0.25 - 1.26	0.27 - 0.87		0.59 - 2.66	0.06 - 2.38
Scenario 5: Market Cap over 100 mil. AUD					
Max	1.62	1.75		1.68	1.11
Average	0.75	0.75		0.77	0.66
Median	0.63	0.62		0.76	0.70
Min	0.32	0.25		0.29	0.25
Lower	0.56	0.58		0.35	0.17
Upper	0.94	0.93		1.20	1.15
95% Confidence Interval	0.56 - 0.94	0.58 - 0.93		0.35 - 1.2	0.17 - 1.15

Source: The AER's analysis

Across 5 difference scenarios for the research period from 2008 to 2018, the average of estimated beta falls within the range of 0.49 and 0.76. When the median of all estimates is used, the estimated beta lies within the range of 0.45 and 0.71.

5.   Conclusions

This study examined various scenario of estimating beta including (i) an *Industry-level analysis* (for industry beta using the sectors' indices); (ii) a *Firm-level analysis* (for individual beta using the firms' stock prices for all listed firms classified as *Utilities* or *Energy*); and (iii) robustness analysis. Key findings for each of these scenarios are summarised in turn below.

5.1.   An Industry-level Analysis

Equity beta is estimated for all Australian sectors/industries, as classified by Bloomberg, using weekly data for the relevant indices for each and every sector/industry. This analysis is named an *Industry-level analysis.* 11 Australian industries include: (1) Industrials (2) Consumer Discretionary; (3) Consumer Staples; (4) Financials; (5) Materials; (6) Health Care; (7) Energy; (8) Utilities; (9) Telecommunication; (10) Information Technology; and (11) Real estate. The study covers the period of 10 years from 1 January 2008 to 31 December 2017. Standard econometric techniques OLS and LAD are used in this analysis. Findings from this *Industry-level analysis* are as follows.

- While *Energy* sector is estimated as relatively high (the second highest risk), *Utilities* sector is estimated as relatively low (the third lowest risk) in comparison with other Australian sectors.

- The lowest estimated beta, on average for the 10-year period, is approximately 1.3 for *Energy* sector. The estimates of beta using the OLS and the LAD techniques produce similar findings.

- The estimated beta of the Australian *Utilities* varies within the range of 0.4 and 0.7 (for OLS) and 0.5 and 0.7 (for the LAD) with the mean estimate for the sector is 0.56 (using OLS) and 0.60 (using LAD). The medians are 0.58 (for OLS) and 0.62 (for LAD).

5.2.   A Firm-level Analysis

At a *Firm-level analysis,* the study is then extended by estimating equity beta for individual firms in the *Utilities* sector and its most comparable sector, the *Energy* sector. From Bloomberg's classification, 23 Australian listed firms are included in the *Utilities* sector

whereas 193 firms are included in the *Energy* sector. For the period from 2008 to 2018, the conventional econometric techniques OLS and LAD are utilised.

Key findings from this analysis can be summarised as below.

- For the entire period of 2008 – 2018, estimated betas using weekly data for 23 Australian *Utilities* firms vary within the wide range of -0.36 and 1.69 (OLS) and 0 and 1.75 (LAD). The range is much wider when the monthly data is used, being 0.06 and 5.17 (OLS) and 0.25 and 3.79 (LAD).

- For Australian *Energy* firm, estimated betas using weekly data for 193 firms vary within the wide range of -1.67 and 2.90 (OLS) and -0.55 and 2.21 (LAD). The range is much wider when the monthly data is used, being -2.54 and 3.18 (OLS) and -1.57 and 7.52 (LAD).

On the ground of the above analyses, it is concluded that estimating beta for the entire sector using all individual firms classified by Bloomberg as *Energy* or Utilities is impractical. It is because the estimated ranges of equity beta from these two samples (23 firms for *Utilities* and 193 firms for *Energy)* are critically wide, even in the case the 95 per cent confidence interval is considered, to draw any sensible and confident range/point of estimated beta.

5.3. Robustness Analysis

It is generally accepted that estimated betas and their reasonable ranges are heavily influenced by the selection of comparable firms included in the benchmark sample. As such, robustness analysis is conducted in this study in order to provide additional evidence in relation to the benchmark sample and the point and range of estimated betas. It is noted that these robustness analyses are only conducted for *Utilities* sector and its constituents as classified by Bloomberg. Five scenarios are examined in this study.

Across 5 difference scenarios for the research period from 2008 to 2018, the average of estimated beta falls within the range of 0.49 and 0.76. When the median of all estimates is used, the estimated beta lies within the range of 0.45 and 0.71.

5.4. Overall Conclusions

In summary, on the ground of various analyses presented in this empirical study, key findings to the estimate of beta for the AER's regulatory purposes can be summarised as below:

- *First,* Australian *Utilities* industry is estimated as a relatively safe sector among all 11 sectors of the Australian economy.

- *Second,* at the industry level, the point estimate of the Australian *Utilities* beta varies within a tight range of 0.55 and 0.60.

- *Third,* Australian *Energy* industry should not be considered comparable to the Australian Utilities.

- *Fourth,* determining a point estimated beta, for the AER's regulatory purposes, from a very wide range, which is obtained when all listed firms classified in the entire *Utilities* sector are considered, is impractical.

Appendix 1:

This Appendix 1 presents detailed beta estimates of beta for 23 Australian firms which are classified in *Utilities* and 193 Australian firms in *Energy* during the period from 2008 to 2018.

A.1.1 Estimates of Individual Beta for 23 Australian firms in the Utilities sector, 2008 - 2018

In this analysis, estimates of beta for all listed firms in the Australian *Utilities* sector from Bloomberg's sector classification are conducted. Traditional econometric techniques OLS and LAD are utilised. 23 Australian listed firms are classified as Utilities firms by Bloomberg. For the research period from 2008 to 2018, there are 525 observations on a weekly basis for each firm with full available data in the sample. When monthly data is considered, then there are 119 observations for each firm with full available data in the sample for the considered period.

Table 4   Estimates of Beta for Australian Listed Firms in _Utilities_, Weekly Data

No.	Utilities	Obs.	OLS				LAD			
			Beta	**S.e**	**Lower**	**Upper**	**Beta**	**S.e**	**Lower**	**Upper**
1	AGL	525	0.52	0.05	0.43	0.62	0.56	0.05	0.47	0.65
2	ORG	525	1.04	0.07	0.91	1.18	0.99	0.07	0.86	1.12
3	APA	525	0.63	0.05	0.52	0.73	0.66	0.05	0.55	0.76
4	AST	525	0.41	0.05	0.31	0.52	0.58	0.05	0.47	0.68
5	SKI	525	0.44	0.06	0.32	0.55	0.45	0.06	0.34	0.57
6	IFN	525	1.05	0.12	0.82	1.28	0.92	0.11	0.70	1.13
7	EWC	525	1.62	0.16	1.30	1.93	1.75	0.16	1.43	2.07
8	EPW	379	0.69	0.16	0.39	1.00	0.62	0.14	0.34	0.89
9	PEA	475	0.32	0.15	0.02	0.62	0.25	0.10	0.05	0.45
10	GNX	140	1.69	0.44	0.83	2.54	1.16	0.34	0.49	1.83
11	LPE	289	-0.36	0.56	-1.47	0.75	0.00	0.40	-0.78	0.78
12	HRL	514	0.32	0.23	-0.13	0.77	0.00	0.12	-0.24	0.24
13	KPO	415	0.86	0.24	0.39	1.34	0.00	0.17	-0.32	0.32
14	VPR	426	0.71	0.42	-0.11	1.53	0.00	0.18	-0.36	0.36
15	BKT	509	0.71	0.36	0.02	1.41	0.00	0.11	-0.21	0.21
16	AFR	511	0.99	0.25	0.50	1.48	0.85	0.17	0.52	1.19
17	VIV	495	0.61	0.22	0.18	1.03	0.36	0.19	-0.01	0.72
18	BCT	325	1.14	0.36	0.43	1.85	0.70	0.33	0.06	1.35
19	RNE	525	1.06	0.17	0.74	1.39	0.98	0.14	0.70	1.25
20	HPR	469	0.76	0.20	0.36	1.16	0.39	0.14	0.11	0.68
21	WRG	274	0.89	0.97	-1.01	2.78	0.00	0.18	-0.36	0.36
22	ENB	360	0.72	0.43	-0.12	1.55	0.00	0.13	-0.26	0.26
23	PTR	470	0.69	0.29	0.12	1.26	0.00	0.12	-0.23	0.23

Source: _AER's analysis_

Table 5   Estimates of Beta for Australian Listed Firms in *Utilities*, Monthly Data, 2008 - 2018

No.	Utilities	Obs.	Monthly Data								
			OLS					LAD			
			Beta	S.e	Lower	Upper		Beta	S.e	Lower	Upper
1	AGL	119	0.50	0.11	0.28	0.71		0.33	0.13	0.07	0.60
2	ORG	119	0.79	0.18	0.44	1.14		0.73	0.16	0.42	1.04
3	APA	119	0.76	0.11	0.54	0.99		0.70	0.13	0.45	0.95
4	AST	119	0.40	0.10	0.20	0.60		0.55	0.10	0.35	0.74
5	SKI	119	0.29	0.11	0.07	0.50		0.25	0.16	-0.05	0.56
6	IFN	119	1.03	0.30	0.44	1.61		1.11	0.35	0.42	1.80
7	EWC	119	1.68	0.43	0.84	2.52		0.95	0.66	-0.34	2.23
8	EPW	85	0.71	0.38	-0.03	1.45		0.71	0.33	0.07	1.36
9	PEA	119	0.81	0.25	0.33	1.30		0.58	0.23	0.13	1.03
10	GNX	30	5.17	1.45	2.33	8.00		3.79	2.06	-0.25	7.82
11	LPE	72	2.03	1.04	-0.01	4.08		1.62	1.19	-0.71	3.95
12	HRL	117	0.51	0.44	-0.35	1.37		0.25	0.42	-0.57	1.07
13	KPO	97	1.35	0.57	0.22	2.47		1.70	0.53	0.67	2.73
14	VPR	105	2.64	0.85	0.98	4.30		1.91	0.78	0.38	3.45
15	BKT	116	1.56	0.69	0.21	2.91		1.66	0.44	0.79	2.53
16	AFR	119	2.66	0.53	1.62	3.70		2.36	0.54	1.30	3.43
17	VIV	119	0.06	0.49	-0.90	1.02		0.69	0.43	-0.16	1.53
18	BCT	79	1.72	0.78	0.19	3.25		2.06	0.95	0.21	3.92
19	RNE	119	1.16	0.36	0.46	1.85		0.93	0.35	0.24	1.62
20	HPR	117	1.71	0.38	0.95	2.46		1.71	0.46	0.80	2.62
21	WRG	85	4.28	1.34	1.66	6.91		1.91	1.30	-0.64	4.45
22	ENB	117	1.49	0.66	0.19	2.78		0.68	0.70	-0.69	2.04
23	PTR	110	0.14	0.57	-0.99	1.26		0.83	0.57	-0.28	1.95

Source: AER's analysis

A.1.2   Estimates of Individual Beta for 193 Australian firms in the Energy sector

In this analysis, estimates of beta for all listed firms in the Australian *Energy* sector from Bloomberg's sector classification are conducted. Traditional econometric techniques OLS and LAD are utilised. 193 Australian listed firms are considered as *Energy.* For the research period from 2008 to 2018, there are 525 observations on a weekly basis for each firm with full available data in the sample. When monthly data is considered, then there are 119 observations for each firm with full available data in the sample for the considered period.

Table 6   Estimates of Beta for Australian Listed Firms in *Energy*, Weekly Data, 2008 – 2018

No.	Energy	Obs.	Weekly Data							
			OLS				LAD			
			Beta	S.e	Lower	Upper	Beta	S.e	Lower	Upper
1	WPL	525	1.24	0.05	1.13	1.34	1.14	0.05	1.04	1.24
2	OSH	525	1.31	0.07	1.17	1.45	1.14	0.06	1.03	1.25
3	STO	525	1.46	0.09	1.29	1.63	1.32	0.06	1.20	1.44
4	CTX	525	1.18	0.07	1.04	1.32	1.12	0.06	1.00	1.23
5	YAL	292	0.26	0.39	-0.51	1.03	0.00	0.26	-0.50	0.50
6	SOL	525	0.60	0.05	0.51	0.69	0.49	0.04	0.42	0.57
7	WHC	525	1.66	0.12	1.42	1.90	1.61	0.12	1.37	1.85
8	BPT	525	1.31	0.10	1.11	1.51	1.26	0.10	1.07	1.45
9	NHC	525	0.88	0.08	0.71	1.04	0.78	0.08	0.62	0.94
10	SXY	525	1.30	0.14	1.02	1.58	1.13	0.14	0.86	1.41
11	COE	525	0.93	0.12	0.70	1.16	0.88	0.12	0.64	1.12
12	NCZ	252	-0.50	0.46	-1.41	0.40	0.00	0.38	-0.74	0.74
13	FAR	523	1.49	0.20	1.09	1.88	1.18	0.16	0.87	1.50
14	KAR	520	1.74	0.15	1.45	2.04	1.49	0.13	1.24	1.74
15	AWE	525	1.56	0.11	1.34	1.78	1.43	0.10	1.23	1.63
16	LNG	525	1.87	0.18	1.51	2.22	1.75	0.17	1.42	2.09
17	BUL	525	1.22	0.17	0.88	1.57	1.13	0.19	0.77	1.50
18	ATS	83	0.63	0.54	-0.43	1.68	0.00	0.53	-1.04	1.04
19	EDE	501	1.08	0.28	0.53	1.63	0.92	0.18	0.56	1.28
20	NVX	115	0.22	0.60	-0.96	1.40	0.00	0.57	-1.12	1.12
21	COI	525	0.82	0.21	0.41	1.23	0.00	0.15	-0.29	0.29
22	AJL	489	1.07	0.19	0.70	1.44	0.51	0.18	0.17	0.86
23	BRU	497	1.21	0.16	0.89	1.53	0.91	0.16	0.59	1.22
24	WND	29	-0.50	0.57	-1.61	0.61	-0.39	0.64	-1.65	0.87
25	CZA									
26	SMR	425	1.28	0.25	0.79	1.76	1.07	0.20	0.67	1.47
27	CVN	525	1.51	0.15	1.21	1.80	1.54	0.16	1.23	1.84
28	BYE	420	0.84	0.20	0.45	1.23	0.38	0.10	0.20	0.57

29	CCE	508	0.58	0.14	0.30	0.86	0.57	0.13	0.32	0.83
30	EMR	512	0.90	0.20	0.51	1.29	0.29	0.13	0.03	0.55
31	TIG	315	0.04	0.35	-0.64	0.73	0.00	0.20	-0.40	0.40
32	HZN	525	1.38	0.12	1.13	1.62	1.18	0.11	0.96	1.40
33	88E	450	0.61	0.35	-0.08	1.30	0.00	0.22	-0.42	0.42
34	EME	525	1.20	0.23	0.76	1.65	0.85	0.16	0.53	1.16
35	NGY	392	0.34	0.31	-0.25	0.94	0.00	0.14	-0.28	0.28
36	PDZ	519	1.66	0.24	1.19	2.14	1.63	0.22	1.21	2.05
37	KRL	434	0.39	0.36	-0.32	1.10	0.00	0.16	-0.31	0.31
38	SEA	525	1.57	0.20	1.18	1.96	1.40	0.17	1.06	1.73
39	ELK	506	0.89	0.22	0.47	1.32	0.46	0.18	0.12	0.81
40	GEV	519	0.72	0.26	0.22	1.22	0.62	0.20	0.23	1.00
41	STX	525	1.12	0.14	0.84	1.40	0.93	0.14	0.66	1.21
42	RFX	378	0.88	0.34	0.21	1.55	0.79	0.33	0.14	1.44
43	GSL	520	0.96	0.16	0.65	1.27	0.85	0.13	0.59	1.12
44	CTP	525	1.41	0.20	1.02	1.80	1.43	0.16	1.11	1.75
45	ZEN	44	0.08	0.58	-1.06	1.21	0.14	0.75	-1.34	1.61
46	TER	395	1.16	0.33	0.52	1.80	0.91	0.28	0.37	1.45
47	TOU	234	0.69	0.47	-0.24	1.62	0.00	0.35	-0.68	0.68
48	OEL	523	1.04	0.14	0.76	1.32	0.76	0.12	0.53	1.00
49	NMS	428	1.34	0.17	1.01	1.67	1.04	0.12	0.81	1.27
50	SND	507	0.73	0.12	0.50	0.95	0.21	0.08	0.06	0.37
51	LKO	525	0.58	0.42	-0.23	1.40	0.00	0.00	0.00	0.00
52	MCE	434	0.65	0.18	0.30	1.00	0.61	0.17	0.28	0.94
53	BOE	446	0.76	0.30	0.18	1.35	0.49	0.23	0.03	0.94
54	LCK	132	0.26	0.61	-0.93	1.45	0.54	0.55	-0.54	1.61
55	GAS	22	2.90	1.06	0.84	4.97	2.21	1.40	-0.53	4.95
56	ATU	282	1.56	0.38	0.82	2.30	1.09	0.36	0.39	1.78
57	SGC	416	0.73	0.33	0.08	1.37	0.00	0.26	-0.51	0.51
58	CUE	525	0.91	0.12	0.67	1.15	0.88	0.11	0.67	1.08
59	AJQ	305	1.17	0.39	0.41	1.93	1.24	0.34	0.58	1.91
60	MRV	510	1.40	0.32	0.77	2.03	0.38	0.13	0.13	0.64
61	DRG	427	1.14	0.33	0.50	1.79	0.00	0.24	-0.47	0.47
62	TAP	525	1.29	0.12	1.06	1.53	1.03	0.11	0.82	1.24
63	PSA	525	1.16	0.15	0.86	1.46	0.95	0.14	0.67	1.22
64	OXX	332	1.10	0.35	0.41	1.80	0.48	0.24	0.02	0.95
65	TEG	455	1.01	0.46	0.12	1.90	0.00	0.10	-0.19	0.19
66	GLL	519	1.01	0.20	0.61	1.40	0.68	0.14	0.40	0.96
67	PRL	511	0.93	0.23	0.47	1.38	0.70	0.20	0.31	1.08
68	CE1	493	0.82	0.30	0.23	1.41	0.23	0.22	-0.20	0.67
69	KPL	312	0.18	0.29	-0.39	0.75	0.00	0.17	-0.33	0.33
70	KLH	281	-0.10	0.58	-1.23	1.03	0.00	0.00	0.00	0.00

71	COB	58	1.91	1.67	-1.36	5.18	1.65	1.83	-1.93	5.24
72	JAL	454	1.36	0.29	0.79	1.92	0.94	0.18	0.58	1.30
73	RES	525	1.63	0.21	1.22	2.05	1.33	0.18	0.97	1.69
74	GPP	333	0.56	0.40	-0.23	1.34	0.00	0.22	-0.43	0.43
75	WEL	153	-0.48	0.53	-1.52	0.57	0.00	0.33	-0.65	0.65
76	PVE	422	0.76	0.23	0.31	1.21	0.08	0.12	-0.16	0.32
77	ATR	358	0.44	0.14	0.17	0.71	0.18	0.10	-0.01	0.38
78	ODY	411	0.98	0.29	0.41	1.55	0.00	0.13	-0.26	0.26
79	PPP	491	0.71	0.12	0.47	0.95	0.58	0.10	0.38	0.77
80	PCL	523	1.18	0.27	0.66	1.70	1.06	0.18	0.72	1.41
81	LER	331	1.03	0.29	0.46	1.59	0.00	0.24	-0.47	0.47
82	RLE	220	0.66	0.43	-0.18	1.49	0.00	0.49	-0.96	0.96
83	MEL	525	1.33	0.21	0.92	1.74	0.88	0.17	0.55	1.21
84	TDO	484	1.40	0.23	0.95	1.84	1.08	0.17	0.74	1.42
85	VMX	364	0.05	0.28	-0.49	0.59	0.00	0.23	-0.45	0.45
86	FZR	430	0.65	0.20	0.26	1.04	0.00	0.14	-0.27	0.27
87	INK	511	0.82	0.25	0.33	1.31	0.00	0.14	-0.28	0.28
88	PVD	305	0.64	0.38	-0.10	1.38	0.57	0.32	-0.07	1.21
89	UTR	227	0.39	0.41	-0.42	1.19	0.00	0.41	-0.80	0.80
90	JPR	488	1.16	0.19	0.79	1.54	0.00	0.05	-0.09	0.09
91	NWE	523	1.21	0.27	0.68	1.73	0.26	0.10	0.07	0.46
92	EXR	497	0.97	0.32	0.33	1.61	0.00	0.14	-0.27	0.27
93	EEG	519	0.95	0.21	0.54	1.36	0.00	0.14	-0.27	0.27
94	AEB	363	0.05	0.32	-0.59	0.68	-0.32	0.19	-0.70	0.06
95	ICN	525	1.52	0.16	1.21	1.83	1.21	0.14	0.93	1.49
96	ADX	525	1.22	0.27	0.69	1.76	0.46	0.14	0.20	0.73
97	MNE									
98	EYM									
99	WOF	422	0.78	0.31	0.17	1.39	0.00	0.18	-0.36	0.36
100	WEC	519	1.11	0.20	0.71	1.50	0.98	0.17	0.65	1.30
101	MAY	523	1.07	0.24	0.59	1.54	1.48	0.16	1.16	1.79
102	AOK	516	1.01	0.18	0.65	1.37	0.92	0.19	0.55	1.30
103	CNX	486	1.22	0.23	0.77	1.68	1.01	0.21	0.61	1.41
104	SSN	521	1.14	0.29	0.57	1.71	0.49	0.15	0.20	0.78
105	REZ	177	0.94	0.45	0.06	1.83	0.00	0.15	-0.30	0.30
106	WBE	512	0.47	0.26	-0.03	0.98	0.00	0.09	-0.18	0.18
107	CGE	44	-1.67	2.76	-7.09	3.74	0.00	2.58	-5.06	5.06
108	RMP	408	1.47	0.30	0.88	2.06	0.98	0.19	0.60	1.36
109	BRK	491	0.89	0.24	0.42	1.35	0.61	0.14	0.34	0.89
110	AHQ	156	0.91	1.00	-1.06	2.87	0.00	0.64	-1.25	1.25
111	EOR	427	0.61	0.33	-0.03	1.25	0.00	0.00	0.00	0.00
112	KEY	505	0.77	0.28	0.22	1.33	0.00	0.15	-0.29	0.29

113	BAS	493	0.90	0.33	0.25	1.56	0.00	0.00	0.00	0.00
114	AOW	193	-0.17	0.48	-1.12	0.78	-0.55	0.32	-1.18	0.08
115	CEL	498	1.03	0.28	0.47	1.58	0.54	0.26	0.03	1.06
116	ETE	521	0.96	0.20	0.57	1.35	0.85	0.17	0.53	1.18
117	SRK	503	1.36	0.17	1.02	1.70	0.78	0.13	0.53	1.03
118	LIO	309	0.14	0.26	-0.37	0.64	0.00	0.06	-0.12	0.12
119	GBP	458	0.40	0.20	0.00	0.80	0.00	0.07	-0.14	0.14
120	BUY	523	1.16	0.21	0.76	1.57	0.00	0.12	-0.24	0.24
121	TMK	323	1.67	0.55	0.60	2.75	0.00	0.00	0.00	0.00
122	SER	521	1.22	0.26	0.72	1.72	0.60	0.20	0.20	0.99
123	UIL	146	0.02	0.52	-1.00	1.04	0.00	0.48	-0.95	0.95
124	NCR	411	0.87	0.47	-0.06	1.79	0.00	0.14	-0.27	0.27
125	ABL	426	0.91	0.33	0.27	1.56	0.24	0.19	-0.12	0.61
126	TNP	411	0.60	0.48	-0.34	1.55	0.00	0.11	-0.21	0.21
127	PAK	381	0.57	0.29	0.00	1.13	0.00	0.18	-0.36	0.36
128	OEX	525	1.30	0.24	0.83	1.77	0.92	0.17	0.58	1.26
129	KKO	243	1.04	0.49	0.07	2.01	0.44	0.33	-0.20	1.09
130	AJC	453	0.98	0.33	0.32	1.63	0.00	0.13	-0.25	0.25
131	NAE	386	0.95	0.39	0.20	1.71	0.00	0.17	-0.34	0.34
132	MSM	208	2.01	0.81	0.43	3.59	1.81	0.50	0.83	2.79
133	EER	354	1.21	0.32	0.59	1.82	1.04	0.22	0.60	1.48
134	AIR	299	0.29	0.30	-0.29	0.87	0.00	0.06	-0.12	0.12
135	GGE	488	0.47	0.38	-0.27	1.20	0.00	0.00	0.00	0.00
136	AVD	375	0.96	0.40	0.17	1.75	0.00	0.20	-0.39	0.39
137	PGS	483	1.52	0.30	0.92	2.12	0.99	0.22	0.55	1.42
138	IHS	249	0.27	0.41	-0.54	1.08	0.00	0.24	-0.48	0.48
139	RAW	319	0.80	0.29	0.22	1.38	0.32	0.22	-0.10	0.75
140	CBD	85	1.45	2.83	-4.10	7.00	0.81	1.04	-1.22	2.85
141	PGY	246	1.06	0.90	-0.71	2.83	0.00	0.00	0.00	0.00
142	DAF	224	0.30	0.64	-0.96	1.56	0.00	0.26	-0.51	0.51
143	NSE	508	1.01	0.28	0.47	1.55	0.00	0.14	-0.28	0.28
144	GRV	286	1.28	0.36	0.58	1.99	0.00	0.14	-0.28	0.28
145	GGX	458	1.18	0.33	0.54	1.82	0.00	0.13	-0.25	0.25
146	SPB	290	0.60	0.47	-0.32	1.52	0.00	0.25	-0.48	0.48
147	TEX	438	1.39	0.37	0.67	2.11	1.14	0.22	0.71	1.56
148	ROG	426	0.91	0.53	-0.13	1.96	0.00	0.00	0.00	0.00
149	BKP	423	1.21	0.54	0.16	2.26	0.00	0.00	0.00	0.00
150	IOG									
151	KTE	451	0.60	0.33	-0.05	1.25	0.00	0.14	-0.27	0.27
152	SUR	502	0.45	0.28	-0.09	0.99	0.00	0.10	-0.20	0.20
153	IPB	195	1.33	0.82	-0.28	2.94	0.00	0.30	-0.58	0.58
154	CCJ	193	1.28	0.57	0.16	2.40	0.00	0.25	-0.49	0.49

155	CRM	70	0.44	0.35	-0.24	1.12	0.00	0.18	-0.35	0.35
156	SRO	525	0.13	0.18	-0.23	0.49	0.00	0.00	0.00	0.00
157	JKA	361	0.95	0.39	0.18	1.71	0.00	0.16	-0.31	0.31
158	OTI	65	0.08	0.84	-1.57	1.73	0.00	0.35	-0.68	0.68
159	OBL									
160	ENX	139	-0.39	0.62	-1.60	0.82	0.00	0.00	0.00	0.00
161	PEC	77	-0.13	1.26	-2.61	2.35	0.00	0.68	-1.34	1.34
162	TPD	181	0.55	0.62	-0.66	1.77	0.00	0.24	-0.48	0.48
163	BPH	478	1.37	0.40	0.58	2.16	0.00	0.16	-0.32	0.32
164	SYS	348	0.74	0.47	-0.17	1.66	0.00	0.13	-0.25	0.25
165	PZC	430	1.30	0.36	0.60	2.00	0.73	0.21	0.32	1.14
166	PKO	324	0.93	0.65	-0.35	2.21	0.00	0.20	-0.40	0.40
167	BSP	119	2.15	1.64	-1.06	5.36	0.00	0.10	-0.20	0.20
168	AOG	266	0.22	0.65	-1.06	1.50	0.00	0.00	0.00	0.00
169	MPO	484	1.09	0.13	0.83	1.35	0.84	0.12	0.60	1.07
170	IND	434	1.03	0.38	0.28	1.77	0.00	0.06	-0.11	0.11
171	AZZ	386	1.10	0.28	0.55	1.66	1.11	0.16	0.79	1.43
172	CTR									
173	EVM	418	-0.12	0.26	-0.63	0.40	0.00	0.22	-0.43	0.43
174	ODN	267	0.48	0.53	-0.57	1.52	0.00	0.14	-0.27	0.27
175	DUC	246	0.80	1.24	-1.63	3.23	0.00	0.78	-1.53	1.53
176	MBT	357	0.89	0.63	-0.34	2.12	0.00	0.16	-0.32	0.32
177	CFU	365	0.99	0.25	0.50	1.49	1.02	0.15	0.73	1.30
178	BCL	417	1.12	0.30	0.54	1.70	0.92	0.16	0.61	1.24
179	EGO	495	0.93	0.22	0.50	1.36	0.44	0.14	0.18	0.71
180	LGO	357	0.48	0.39	-0.28	1.25	0.00	0.00	0.00	0.00
181	IGE	368	0.77	0.47	-0.15	1.68	0.00	0.00	0.00	0.00
182	LWP	477	1.24	0.35	0.54	1.93	0.14	0.13	-0.11	0.40
183	ESM	173	-0.45	0.79	-2.00	1.11	0.00	0.38	-0.74	0.74
184	GOE	357	0.95	0.29	0.39	1.51	0.62	0.20	0.22	1.02
185	AQJ									
186	KIK	399	1.62	0.37	0.88	2.35	0.00	0.12	-0.23	0.23
187	OGY	412	0.79	0.38	0.05	1.54	0.00	0.00	0.00	0.00
188	EWE	303	1.24	0.35	0.56	1.92	0.00	0.37	-0.73	0.73
189	HOG	394	0.48	0.34	-0.20	1.15	0.00	0.16	-0.31	0.31
190	SWE									
191	LNC	117	1.40	0.61	0.21	2.59	1.24	0.46	0.35	2.14
192	ESC									
193	CRA									

Source: *AER's analysis*

Table 7   Estimates of Beta for Australian Listed Firms in *Energy*, Monthly Data, 2008 - 2018

| No. | Energy | Obs. | Monthly Data | | | | | | | |
| | | | OLS | | | | LAD | | | |
			Beta	S.e	Lower	Upper	Beta	S.e	Lower	Upper
1	WPL	119	1.18	0.11	0.97	1.40	1.13	0.12	0.91	1.36
2	OSH	119	0.83	0.14	0.55	1.10	1.01	0.15	0.70	1.31
3	STO	119	1.25	0.21	0.84	1.67	0.95	0.23	0.50	1.39
4	CTX	119	0.95	0.18	0.61	1.30	0.92	0.19	0.55	1.29
5	YAL	67	-0.29	0.91	-2.08	1.50	0.22	0.86	-1.47	1.91
6	SOL	119	0.72	0.12	0.49	0.96	0.49	0.15	0.20	0.78
7	WHC	119	1.68	0.34	1.02	2.35	1.64	0.36	0.94	2.35
8	BPT	119	1.25	0.27	0.72	1.79	1.35	0.33	0.71	1.99
9	NHC	119	1.11	0.18	0.76	1.45	1.16	0.19	0.78	1.54
10	SXY	119	1.74	0.37	1.00	2.47	1.35	0.34	0.68	2.02
11	COE	119	1.21	0.27	0.67	1.75	1.22	0.31	0.60	1.83
12	NCZ	62	0.81	1.12	-1.38	3.01	0.96	1.10	-1.21	3.12
13	FAR	119	1.68	0.54	0.62	2.75	1.76	0.36	1.05	2.46
14	KAR	117	1.95	0.38	1.20	2.70	2.19	0.37	1.47	2.92
15	AWE	119	1.26	0.25	0.78	1.74	1.13	0.25	0.65	1.61
16	LNG	119	1.87	0.55	0.80	2.94	1.25	0.58	0.12	2.38
17	BUL	119	1.77	0.45	0.89	2.66	1.71	0.40	0.91	2.50
18	ATS	18	-0.80	1.95	-4.63	3.03	-1.57	1.89	-5.27	2.13
19	EDE	114	1.45	0.63	0.21	2.69	1.10	0.49	0.13	2.06
20	NVX	25	2.77	2.02	-1.19	6.72	1.47	2.60	-3.63	6.57
21	COI	119	1.39	0.50	0.41	2.37	1.45	0.46	0.56	2.35
22	AJL	112	1.04	0.45	0.15	1.93	0.87	0.43	0.02	1.72
23	BRU	112	0.28	0.45	-0.59	1.15	0.15	0.55	-0.93	1.22
24	WND									
25	CZA									
26	SMR	97	1.95	0.56	0.84	3.05	2.13	0.66	0.84	3.43
27	CVN	119	1.66	0.39	0.90	2.43	1.99	0.35	1.30	2.68
28	BYE	115	1.04	0.36	0.33	1.75	0.78	0.35	0.10	1.46
29	CCE	119	0.69	0.37	-0.04	1.42	0.70	0.33	0.05	1.36
30	EMR	117	1.70	0.39	0.94	2.46	1.41	0.34	0.74	2.08
31	TIG	75	0.51	0.58	-0.61	1.64	0.84	0.56	-0.26	1.95
32	HZN	119	1.84	0.31	1.23	2.46	1.61	0.37	0.90	2.33
33	88E	114	0.42	0.86	-1.26	2.10	0.80	0.67	-0.52	2.12
34	EME	119	1.59	0.62	0.37	2.80	1.78	0.40	1.00	2.56
35	NGY	110	1.71	0.59	0.55	2.88	0.58	0.59	-0.59	1.74
36	PDZ	119	2.28	0.49	1.32	3.24	2.11	0.55	1.03	3.19
37	KRL	107	1.84	0.67	0.53	3.15	1.31	0.64	0.05	2.58

38	SEA	119	2.55	0.49	1.60	3.50	2.39	0.51	1.39	3.39
39	ELK	119	0.73	0.45	-0.15	1.61	0.97	0.32	0.35	1.59
40	GEV	119	1.34	0.56	0.25	2.44	1.13	0.58	-0.01	2.27
41	STX	119	1.46	0.34	0.80	2.12	1.13	0.43	0.28	1.98
42	RFX	85	0.67	0.78	-0.87	2.21	0.43	0.70	-0.94	1.80
43	GSL	119	0.76	0.43	-0.09	1.61	0.46	0.33	-0.19	1.10
44	CTP	119	2.29	0.51	1.29	3.29	1.99	0.59	0.83	3.15
45	ZEN									
46	TER	90	0.78	0.77	-0.74	2.30	1.39	0.76	-0.11	2.89
47	TOU	57	1.23	0.87	-0.48	2.95	1.52	1.33	-1.09	4.13
48	OEL	119	1.15	0.34	0.49	1.81	0.80	0.32	0.16	1.43
49	NMS	115	2.11	0.34	1.45	2.77	1.97	0.40	1.20	2.75
50	SND	119	0.78	0.23	0.33	1.23	0.75	0.21	0.34	1.15
51	LKO	119	1.12	0.61	-0.08	2.32	0.00	0.58	-1.13	1.13
52	MCE	98	1.45	0.49	0.49	2.40	1.21	0.52	0.18	2.23
53	BOE	113	1.48	0.69	0.13	2.83	1.10	0.61	-0.09	2.29
54	LCK	28	1.41	1.69	-1.90	4.72	1.02	2.66	-4.19	6.23
55	GAS									
56	ATU	66	2.00	0.89	0.25	3.75	1.32	1.13	-0.90	3.53
57	SGC	117	0.92	0.56	-0.17	2.01	0.87	0.52	-0.16	1.90
58	CUE	119	1.15	0.26	0.63	1.66	1.21	0.35	0.52	1.89
59	AJQ	69	2.15	0.79	0.59	3.71	2.89	0.78	1.36	4.41
60	MRV	117	1.84	0.62	0.63	3.05	0.73	0.57	-0.40	1.85
61	DRG	117	1.84	0.67	0.53	3.16	1.58	0.74	0.12	3.04
62	TAP	119	1.65	0.29	1.08	2.22	1.53	0.37	0.80	2.27
63	PSA	119	1.40	0.34	0.73	2.07	1.31	0.37	0.58	2.04
64	OXX	98	2.05	0.55	0.97	3.13	1.47	0.60	0.30	2.65
65	TEG	111	1.79	0.77	0.29	3.29	1.60	0.71	0.19	3.00
66	GLL	119	1.32	0.39	0.56	2.08	0.44	0.35	-0.23	1.12
67	PRL	119	1.67	0.50	0.69	2.64	1.72	0.52	0.71	2.73
68	CE1	119	1.17	0.60	0.00	2.35	0.46	0.71	-0.92	1.84
69	KPL	73	0.60	0.59	-0.54	1.75	0.26	0.47	-0.66	1.18
70	KLH	100	0.56	0.75	-0.90	2.03	0.00	0.67	-1.31	1.31
71	COB									
72	JAL	116	1.00	0.63	-0.23	2.23	1.17	0.59	0.02	2.32
73	RES	119	2.04	0.59	0.87	3.20	2.26	0.56	1.17	3.35
74	GPP	108	0.83	0.82	-0.77	2.44	0.00	0.75	-1.47	1.47
75	WEL	41	0.82	1.19	-1.52	3.16	0.39	1.13	-1.83	2.61
76	PVE	117	0.99	0.62	-0.23	2.22	0.23	0.37	-0.49	0.95
77	ATR	117	0.57	0.26	0.05	1.09	0.44	0.25	-0.05	0.92
78	ODY	119	1.62	0.55	0.53	2.71	1.85	0.48	0.91	2.80
79	PPP	115	0.82	0.28	0.26	1.37	1.07	0.22	0.63	1.51

80	PCL	119	1.38	0.49	0.42	2.35	0.83	0.53	-0.20	1.86
81	LER	111	1.01	0.50	0.04	1.98	0.82	0.57	-0.29	1.94
82	RLE	49	1.16	1.03	-0.85	3.18	2.19	1.26	-0.27	4.65
83	MEL	119	1.18	0.48	0.25	2.12	0.89	0.37	0.17	1.61
84	TDO	119	1.94	0.49	0.99	2.90	1.76	0.59	0.60	2.92
85	VMX	101	1.22	0.52	0.21	2.23	0.51	0.46	-0.40	1.41
86	FZR	112	0.96	0.36	0.26	1.66	0.00	0.33	-0.65	0.65
87	INK	119	1.89	0.62	0.67	3.11	1.18	0.71	-0.21	2.56
88	PVD	71	1.91	0.90	0.15	3.66	0.31	0.79	-1.23	1.85
89	UTR	64	2.54	1.06	0.47	4.61	2.37	1.11	0.19	4.55
90	JPR	117	1.89	0.45	1.00	2.78	0.00	0.25	-0.49	0.49
91	NWE	119	2.02	0.56	0.94	3.11	1.61	0.54	0.55	2.66
92	EXR	119	1.50	0.59	0.34	2.65	1.25	0.59	0.10	2.40
93	EEG	119	1.18	0.44	0.31	2.05	1.45	0.36	0.75	2.15
94	AEB	84	-0.25	0.56	-1.35	0.85	0.12	0.55	-0.95	1.19
95	ICN	119	1.60	0.42	0.78	2.43	1.64	0.40	0.86	2.42
96	ADX	119	1.84	0.62	0.61	3.06	1.05	0.57	-0.07	2.17
97	MNE									
98	EYM									
99	WOF	112	1.19	0.57	0.07	2.32	1.68	0.56	0.58	2.77
100	WEC	119	1.94	0.48	1.01	2.88	1.95	0.49	0.98	2.92
101	MAY	119	2.47	0.62	1.25	3.70	1.93	0.50	0.94	2.91
102	AOK	119	1.00	0.40	0.21	1.79	1.04	0.51	0.05	2.03
103	CNX	111	0.97	0.56	-0.14	2.07	0.80	0.51	-0.19	1.79
104	SSN	119	1.52	0.55	0.44	2.60	1.06	0.56	-0.04	2.16
105	REZ	78	0.57	0.58	-0.56	1.70	0.00	0.55	-1.08	1.08
106	WBE	117	0.52	0.55	-0.56	1.61	0.48	0.66	-0.83	1.78
107	CGE	24	3.18	3.94	-4.55	10.91	7.52	4.99	-2.27	17.31
108	RMP	112	1.81	0.72	0.41	3.21	0.33	0.53	-0.72	1.37
109	BRK	111	1.63	0.58	0.48	2.77	1.15	0.50	0.17	2.13
110	AHQ	61	1.14	1.29	-1.39	3.68	0.30	1.57	-2.78	3.38
111	EOR	119	1.17	0.59	0.02	2.32	1.22	0.55	0.14	2.31
112	KEY	119	1.68	0.55	0.59	2.77	1.85	0.64	0.60	3.10
113	BAS	119	1.58	0.51	0.58	2.57	0.83	0.49	-0.12	1.79
114	AOW	43	-0.20	0.99	-2.15	1.75	0.00	1.27	-2.49	2.49
115	CEL	119	2.18	0.62	0.97	3.40	1.63	0.60	0.45	2.80
116	ETE	119	1.81	0.38	1.06	2.56	1.95	0.43	1.11	2.80
117	SRK	119	2.36	0.40	1.57	3.14	1.53	0.44	0.67	2.39
118	LIO	112	0.19	0.47	-0.73	1.11	0.53	0.42	-0.30	1.36
119	GBP	117	0.61	0.38	-0.13	1.35	0.61	0.32	-0.01	1.23
120	BUY	119	1.43	0.44	0.57	2.30	0.66	0.30	0.07	1.25
121	TMK	106	1.61	0.78	0.09	3.14	0.00	0.63	-1.23	1.23

122	SER	119	2.09	0.50	1.10	3.08	2.21	0.56	1.10	3.31
123	UIL	38	1.06	0.82	-0.55	2.68	0.76	1.06	-1.31	2.84
124	NCR	95	1.88	0.99	-0.06	3.81	1.12	0.66	-0.17	2.41
125	ABL	113	2.93	0.66	1.64	4.22	2.90	0.62	1.68	4.11
126	TNP	117	0.94	0.66	-0.35	2.23	0.81	0.59	-0.34	1.96
127	PAK	104	0.86	0.66	-0.43	2.14	0.95	0.46	0.05	1.85
128	OEX	119	1.28	0.55	0.19	2.36	0.85	0.55	-0.23	1.93
129	KKO	67	3.15	1.04	1.11	5.19	3.06	0.71	1.66	4.45
130	AJC	117	1.04	0.63	-0.19	2.27	1.34	0.64	0.08	2.60
131	NAE	113	1.44	0.67	0.13	2.74	1.21	0.65	-0.07	2.48
132	MSM	46	0.00	1.57	-3.07	3.07	-0.35	1.74	-3.77	3.07
133	EER	113	1.69	0.67	0.38	3.00	2.00	0.62	0.80	3.21
134	AIR	95	1.08	0.61	-0.11	2.27	0.00	0.46	-0.90	0.90
135	GGE	117	2.05	0.57	0.93	3.16	1.37	0.70	0.00	2.74
136	AVD	112	1.72	0.90	-0.05	3.49	1.92	0.67	0.62	3.23
137	PGS	119	1.62	0.63	0.39	2.85	1.45	0.65	0.18	2.72
138	IHS	72	1.38	0.77	-0.13	2.88	0.66	0.86	-1.03	2.35
139	RAW	111	1.17	0.62	-0.04	2.39	0.20	0.66	-1.11	1.50
140	CBD	34	-2.54	3.94	-10.27	5.19	0.64	4.23	-7.65	8.93
141	PGY	56	2.12	1.84	-1.47	5.72	0.00	0.51	-1.00	1.00
142	DAF	76	1.39	1.00	-0.57	3.36	0.00	1.22	-2.39	2.39
143	NSE	119	1.00	0.61	-0.20	2.21	0.46	0.58	-0.67	1.59
144	GRV	113	2.19	0.66	0.89	3.49	1.93	0.76	0.44	3.41
145	GGX	119	0.93	0.58	-0.21	2.07	0.45	0.46	-0.45	1.36
146	SPB	101	2.11	0.72	0.70	3.52	1.04	0.63	-0.19	2.27
147	TEX	117	2.32	0.68	0.98	3.65	2.09	0.52	1.08	3.10
148	ROG	113	1.62	0.75	0.14	3.09	0.00	0.35	-0.68	0.68
149	BKP	104	1.50	0.73	0.08	2.92	0.00	0.17	-0.33	0.33
150	IOG									
151	KTE	119	2.68	0.58	1.55	3.81	1.53	0.58	0.39	2.68
152	SUR	119	0.92	0.54	-0.14	1.98	1.15	0.55	0.07	2.22
153	IPB	57	3.09	1.57	0.02	6.16	1.68	0.78	0.15	3.21
154	CCJ	67	0.88	0.92	-0.92	2.68	1.33	0.82	-0.27	2.93
155	CRM	64	0.13	0.71	-1.25	1.52	0.00	0.22	-0.44	0.44
156	SRO	119	0.67	0.41	-0.14	1.48	0.00	0.12	-0.24	0.24
157	JKA	82	1.77	0.78	0.24	3.30	1.15	0.96	-0.73	3.03
158	OTI	55	0.66	1.00	-1.30	2.62	0.00	0.68	-1.33	1.33
159	OBL									
160	ENX	51	-0.93	0.90	-2.69	0.83	0.00	0.86	-1.68	1.68
161	PEC	53	-0.54	1.20	-2.88	1.81	0.00	1.03	-2.03	2.03
162	TPD	55	1.78	0.99	-0.17	3.72	0.55	1.17	-1.75	2.84
163	BPH	119	1.00	0.71	-0.38	2.39	0.87	0.70	-0.51	2.24

164	SYS	117	1.62	0.74	0.16	3.08	0.00	0.46	-0.91	0.91
165	PZC	111	1.83	0.64	0.57	3.09	2.09	0.79	0.55	3.64
166	PKO	97	1.03	1.10	-1.12	3.17	0.00	0.69	-1.35	1.35
167	BSP	55	0.80	1.65	-2.44	4.04	0.00	0.90	-1.77	1.77
168	AOG	117	0.99	1.03	-1.04	3.02	0.00	0.63	-1.24	1.24
169	MPO	110	0.80	0.32	0.17	1.43	0.73	0.37	0.00	1.46
170	IND	101	0.92	0.73	-0.51	2.35	0.00	0.70	-1.37	1.37
171	AZZ	90	1.09	0.75	-0.37	2.56	0.96	0.44	0.10	1.81
172	CTR									
173	EVM	98	0.33	0.57	-0.79	1.45	1.01	0.48	0.08	1.94
174	ODN	94	0.54	0.87	-1.17	2.24	0.00	0.70	-1.37	1.37
175	DUC	66	-0.42	2.19	-4.71	3.88	-0.97	1.69	-4.29	2.35
176	MBT	101	2.40	1.03	0.38	4.42	0.70	0.54	-0.37	1.76
177	CFU	83	1.34	0.60	0.16	2.52	1.39	0.41	0.58	2.19
178	BCL	96	1.67	0.59	0.51	2.83	0.67	0.46	-0.24	1.57
179	EGO	113	1.03	0.48	0.10	1.97	0.86	0.45	-0.02	1.74
180	LGO	104	1.09	0.56	-0.01	2.20	0.00	0.40	-0.79	0.79
181	IGE	89	0.95	0.85	-0.71	2.62	0.53	0.43	-0.30	1.37
182	LWP	113	0.78	0.67	-0.55	2.10	0.78	0.64	-0.47	2.03
183	ESM	77	2.15	1.24	-0.28	4.58	1.79	0.80	0.22	3.35
184	GOE	87	1.09	0.55	0.02	2.17	0.72	0.70	-0.66	2.10
185	AQJ									
186	KIK	98	2.78	0.93	0.95	4.61	0.45	0.72	-0.96	1.85
187	OGY	96	2.04	0.58	0.89	3.18	0.89	0.58	-0.24	2.03
188	EWE	82	1.95	0.69	0.60	3.30	1.15	0.56	0.05	2.25
189	HOG	103	1.48	0.66	0.19	2.76	0.59	0.69	-0.75	1.94
190	SWE									
191	LNC	26	-0.22	1.71	-3.57	3.12	0.42	1.61	-2.74	3.59
192	ESC									
193	CRA									

Source: *AER's analysis*

Appendix 2:

Detailed Information of Bloomberg's Listed Firms in *Energy*

No.	Bloomberg's ticker	Full name	Current market capitalisation (AUD million) as at Dec 2017	Industry	Main business activities
1	WPL	WOODSIDE PETROLEUM LTD	25139	Energy	Management and operation of hydrocarbon exploration, development, production, transportation and marketing; implementation and operation of the North-West Shelf Gas Project; exploration and development of gas, oil and condensate reserves
2	OSH	OIL SEARCH LTD	11199	Energy	Exploration, development and production of oil and gas resources, with 98% of the Company assets in Papua New Guinea.
3	STO	SANTOS LTD	9061	Energy	Gas and petroleum exploration and the production, treatment and marketing of natural gas, crude oil, condensate, naphtha and liquid petroleum gas; transportation by pipeline of crude oil.
4	CTX	CALTEX AUSTRALIA LTD	8841	Energy	Purchase, refining, distribution, and marketing of petroleum products and the operation of convenience stores.
5	YAL	YANCOAL AUSTRALIA LTD	4836	Energy	Coal production.
6	SOL	WASHINGTON H SOUL PATTINSON & COMPANY LTD	3945	Energy	Investment, coal mining, pharmaceutical, telecommunications, building materials.
7	WHC	WHITEHAVEN COAL LTD	3745	Energy	Coal mining and exploration

8	BPT	BEACH ENERGY LTD	2241	Energy	Oil and gas exploration, development and production, and investment in the resource industry.
9	NHC	NEW HOPE CORPORATION LTD	1600	Energy	An Australian controlled diversified energy company with interests and operations spanning coal mining, exploration, port operation, conventional oil, agriculture, innovative technologies and investment.
10	SXY	SENEX ENERGY LTD	507	Energy	Petroleum production, exploration and development.
11	COE	COOPER ENERGY LTD	479	Energy	
12	NCZ	NEW CENTURY RESOURCES LTD	448	Materials	Mineral exploration and development.
13	FAR	FAR LTD	371	Energy	Exploration for oil and gas
14	KAR	KAROON GAS AUSTRALIA LTD	297	Energy	Oil and gas exploration
15	AWE	AWE LTD	275	Energy	Oil and gas exploration and appraisal
16	LNG	LIQUEFIED NATURAL GAS LTD	221	Energy	To develop and operate liquefied natural gas plants, using as its feedstock stranded gas, being discovered natural gas reserves for which to date no identifiable markets have been established or flare/vented gas, being gas that is vented into the atmosphere
17	BUL	BLUE ENERGY LTD	160	Energy	CBM Exploration and Development
18	ATS	AUSTRALIS OIL & GAS LTD	167	Energy	Oil and gas exploration
19	EDE	EDEN INNOVATIONS LTD	196	Energy	Alternate energy exploration
20	NVX	NOVONIX LTD	168	Materials	Exploration and mining
21	COI	COMET RIDGE LTD	173	Energy	Oil and gas exploration in Australia

22	AJL	AJ LUCAS GROUP LTD	155	Capital Goods	Specialist infrastructure and mining services. Largest supplier of drilling services to Australia's coal and coal seam gas industries. One of Australia's largest builders of long distance gas pipelines. Construction, civil and property services; developer of unconventional hydrocarbon properties.
23	BRU	BURU ENERGY LTD	110	Energy	Petroleum exploration.
24	WND	WINDLAB LTD	111	Utilities	Wind energy development.
25	CZA		118		
26	SMR	STANMORE COAL LTD	126	Energy	Metallurgical and thermal coal producer.
27	CVN	CARNARVON PETROLEUM LTD	103	Energy	Oil and gas exploration and production.
28	BYE	BYRON ENERGY LTD	89	Energy	Oil and gas exploration and development in the shallow waters of Gulf of Mexico, USA.
29	CCE	CARNEGIE CLEAN ENERGY LTD	102	Utilities	Wave Energy Solar Energy Battery Microgrid Technology Development
30	EMR	EMERALD RESOURCES NL	97	Materials	Oil and gas exploration
31	TIG	TIGERS REALM COAL LTD	124	Materials	Coal exploration in Russia.
32	HZN	HORIZON OIL LTD	87	Energy	Petroleum exploration, development and production.
33	88E	88 ENERGY LTD	79	Energy	Oil and Gas Exploration.
34	EME	ENERGY METALS LTD	88	Energy	Uranium exploration
35	NGY	NUENERGY GAS LTD	90	Energy	Various gas exploration activities.
36	PDZ	PRAIRIE MINING LTD	90	Energy	Exploration for coal, at the Lublin Coal Project in Poland
37	KRL	KANGAROO RESOURCES LTD	69	Materials	Mineral Exploration
38	SEA	SUNDANCE ENERGY AUSTRALIA LTD	65	Energy	Oil and Gas Exploration.

39	ELK	ELK PETROLEUM LTD	64	Energy	Oil and Gas Exploration.
40	GEV	GLOBAL ENERGY VENTURES LTD	61	Energy	The Company's business is the development of compressed natural gas projects.
41	STX	STRIKE ENERGY LTD	71	Energy	Oil and Gas Exploration.
42	RFX	REDFLOW LTD	49	Capital Goods	Energy storage technology.
43	GSL	GREATCELL SOLAR LTD	68	Semiconductors & Semiconductor Equipment	Commercialisation of Perovskite Solar Cell (PSC) technology
44	CTP	CENTRAL PETROLEUM LTD	59	Energy	Oil and Gas exploration and production.
45	ZEN	ZENITH ENERGY LTD	65	Utilities	Independent power production.
46	TER	TERRACOM LTD	75	Energy	Coal Mining
47	TOU	TLOU ENERGY LTD	60	Energy	Identification and development of unconventional gas opportunities in southern Africa.
48	OEL	OTTO ENERGY LTD	47	Energy	Oil and Gas Exploration.
49	NMS	NEPTUNE MARINE SERVICES LTD	55	Energy	Engineered services and solutions for the offshore oil and gas industry
50	SND	SAUNDERS INTERNATIONAL LTD	56	Capital Goods	The Company specialises in the design, construction and maintenance of steel bulk liquid storage tanks and services a variety of blue chip clients ranging from multinational oil, gas and mining companies to water authorities.
51	LKO	LAKES OIL NL	52	Energy	Oil and gas exploration and investment.
52	MCE	MATRIX COMPOSITES & ENGINEERING LTD	46	Energy	The manufacture and supply of specialised engineered products and services to the global oil and gas exploration and production sector using syntactic foam and thermoplastic technologies.

53	BOE	BOSS RESOURCES LTD	48	Materials	Boss Resources LTD is an exploration company primarily focused on the Honeymoon Uranium Project, South Australia. The Company is also a JV partner with Teranga Gold Corporation over gold assets in Burkina Faso.
54	LCK	LEIGH CREEK ENERGY LTD	52	Energy	Energy and Minerals Explorer and Developer
55	GAS	STATE GAS LTD	43	Energy	Conventional gas exploration
56	ATU	ATRUM COAL LTD	44	Materials	High Grade and Ultra High Grade Anthracite Developer and Near Term Producer
57	SGC	SACGASCO LTD	43	Energy	Oil and gas exploration, in Australia and US
58	CUE	CUE ENERGY RESOURCES LTD	40	Energy	Oil and Gas exploration and production.
59	AJQ	ARMOUR ENERGY LTD	30	Energy	Discovery and development of gas and associated liquids resources in a hydrocarbon province in northern Australia.
60	MRV	MORETON RESOURCES LTD	38	Energy	Carbon Materials, Base Metals and Energy
61	DRG	DRAIG RESOURCES LTD	34	Materials	Gold Exploration at Bellevue Gold Project, Western Australia
62	TAP	TAP OIL LTD	27	Energy	Oil and gas production and exploration.
63	PSA	PETSEC ENERGY LTD	26	Energy	Oil and gas exploration, development and production; Investment in mineral exploration, development and production; General investment.
64	OXX	OCTANEX LTD	27	Energy	Oil and Gas Exploration.
65	TEG	TRIANGLE ENERGY (GLOBAL) LTD	33	Energy	Petroleum Exploration and Production
66	GLL	GALILEE ENERGY LTD	25	Energy	Exploration and development of hydrocarbons
67	PRL	PETREL ENERGY LTD	34	Energy	Petrel Energy is an international oil and gas EandP company focused on large conventional and unconventional projects. Its primary projects are in Uruguay and Spain

68	CE1	CALIMA ENERGY LTD	26	Energy	Oil and Gas Exploration.
69	KPL	KINA PETROLEUM LTD	25	Energy	Oil and Gas Exploration.
70	KLH	KALIA LTD	27	Energy	Exploration of precious and energy metals
71	COB	COBALT BLUE HOLDINGS LTD	18	Materials	Cobalt exploration and development
72	JAL	JAMESON RESOURCES LTD	26	Materials	Exploration for coal in Canada
73	RES	RESOURCE GENERATION LTD	28	Energy	Exploration and development of energy related resources
74	GPP	GREENPOWER ENERGY LTD	22	Energy	Clean Energy Exploration and Production
75	WEL	WINCHESTER ENERGY LTD	31	Energy	Oil and Gas Exploration and Development.
76	PVE	PO VALLEY ENERGY LTD	21	Energy	Gas development and exploration.
77	ATR	ASTRON CORPORATION LTD	24	Materials	Development of mineral sands mining projects, trading and development of allied downstream technologies
78	ODY	ODYSSEY ENERGY LTD	23	Energy	Oil and gas exploration and production in the USA
79	PPP		22		
80	PCL	PANCONTINENTAL OIL & GAS NL	26	Energy	Petroleum Exploration.
81	LER	LEAF RESOURCES LTD	21	Materials	Research, development and commercialisation of process technologies and products for the green chemical and materials industrial markets
82	RLE	REAL ENERGY CORPORATION LTD	23	Energy	Oil and Gas Exploration.
83	MEL	METGASCO LTD	20	Energy	Oil and gas exploration, appraisal, development and investment in and development of associated energy infrastructure
84	TDO	3D OIL LTD	16	Energy	Oil and Gas Exploration.

85	VMX	VALMEC LTD	17	Energy	Provider of project engineered equipment, construction and commissioning solutions to the energy and resources sectors.
86	FZR	FITZROY RIVER CORPORATION LTD	17	Energy	Oil and gas investment holding company
87	INK	INDAGO ENERGY LTD	15	Energy	Oil and Gas Exploration.
88	PVD	PURA VIDA ENERGY NL	15	Energy	Oil exploration.
89	UTR	ULTRACHARGE LTD	18	Capital Goods	Exploration of lithium, tantalum, tin, graphite and rare earth metals.
90	JPR	JUPITER ENERGY LTD	15	Energy	Oil and Gas Exploration in Australia and Kazakhstan.
91	NWE	NORWEST ENERGY NL	15	Energy	Exploration for petroleum resources
92	EXR	ELIXIR PETROLEUM LTD	15	Energy	Oil and gas exploration, development and production
93	EEG	EMPIRE ENERGY GROUP LTD	9	Energy	Oil and gas exploration and production company operating in the Appalachian Basin and Mid Continental regions of the USA.
94	AEB	ALGAE.TEC LTD	16	Energy	Renewable energy in the form of commercialisation of the McConchie-Stroud algae production and processing system.
95	ICN	ICON ENERGY LTD	16	Energy	Oil and Gas Exploration.
96	ADX	ADX ENERGY LTD	14	Energy	Oil and Gas Exploration.
97	MNE		4		
98	EYM		6		
99	WOF	WOLF PETROLEUM LTD	13	Energy	Exploration for oil.
100	WEC	WHITE ENERGY COMPANY LTD	11	Energy	Commercialisation of coal technologies.
101	MAY	MELBANA ENERGY LTD	13	Energy	Exploration for oil and gas.

102	AOK	AUSTEX OIL LTD	8	Energy	The Company's chief activity is oil and gas production and development in the USA.
103	CNX	CARBON ENERGY LTD	13	Energy	To produce clean energy and chemicals feedstock from Underground Coal Gasification (UCG) syngas
104	SSN	SAMSON OIL & GAS LTD	7	Energy	Oil and gas exploration and development
105	REZ	RESOURCES & ENERGY GROUP LTD	11	Materials	Resource and energy exploration.
106	WBE	WHITEBARK ENERGY LTD	11	Energy	Oil and Gas Exploration and Production
107	CGEM		10		
108	RMP	RED EMPEROR RESOURCES NL	9	Energy	Mining/Oil Exploration Company
109	BRK	BROOKSIDE ENERGY LTD	9	Energy	Oil and Gas Exploration.
110	AHQ	ALLEGIANCE COAL LTD	9	Materials	Coal exploration and development.
111	EOR	ENHANCED OIL & GAS RECOVERY LTD	9	Energy	In transitional change of business direction with new focus on energy related activities.
112	KEY	KEY PETROLEUM LTD	9	Energy	
113	BAS	BASS OIL LTD	10	Energy	Oil and gas explorer
114	AOW	AMERICAN PATRIOT OIL & GAS LTD	6	Energy	Oil and natural gas exploration and development.
115	CEL	CHALLENGER ENERGY LTD	7	Energy	Exploration for oil and gas
116	ETE	ENTEK ENERGY LTD	7	Energy	Oil and Gas Exploration.
117	SRK	STRIKE RESOURCES LTD	6	Materials	Exploration
118	LIO	LION ENERGY LTD	6	Energy	Exploration, development and production of oil and gas.
119	GBP	GLOBAL PETROLEUM LTD	6	Energy	Oil and Gas explorer with interests in offshore Italy and Namibia.

120	BUY	BOUNTY OIL & GAS NL details	6	Energy	Exploration for and production of oil and gas.
121	TMK	TAMASKA OIL AND GAS LTD	4	Energy	Oil and Gas Exploration.
122	SER	STRATEGIC ENERGY RESOURCES LTD	7	Materials	Mineral and Oil and Gas Exploration
123	UIL	UIL ENERGY LTD	6	Energy	
124	NCR	NUCOAL RESOURCES LTD	5	Materials	Exploration for coal.
125	ABL	ABILENE OIL AND GAS LTD	5	Energy	Resource exploration and investment in Australia and resource exploration in USA with a focus on oil and gas.
126	TNP	TRIPLE ENERGY LTD	4	Energy	Oil and Gas Exploration.
127	PAK	PACIFIC AMERICAN COAL LTD	6	Materials	Metallurgical coal exploration and production throughout North America.
128	OEX	OILEX LTD	5	Energy	Oil exploration
129	KKO	KINETIKO ENERGY LTD	5	Energy	Coal bed methane exploration.
130	AJC	ACACIA COAL LTD	5	Energy	Acacia Coal LTD (ASX:AJC) is involved in coal exploration and development. The Company identifies, acquires and exploits opportunities in coal resources that could be brought into production to provide coking and thermal coal suitable for the export
131	NAE	NEW AGE EXPLORATION LTD	4	Energy	The Company is firmly focused on developing mineral resource projects with a view to identifying economically attractive deposits of sufficient grade and size to provide sustainable returns to shareholders.
132	MSMN		4		
133	EER	EAST ENERGY RESOURCES LTD	4	Energy	Coal exploration

134	AIR	ASTIVITA LTD	4	Capital Goods	The Company's primary business activity is to import, warehouse and distribute bathroom, kitchen and solar products for sale to a range of retailers, plumbing merchants, hardware suppliers, and solar power dealers.
135	GGE	GRAND GULF ENERGY LTD	3	Energy	
136	AVD	ANTILLES OIL AND GAS NL	2	Energy	Oil and gas exploration, development and production.
137	PGS	PLANET GAS LTD	3	Energy	Exploration and development of various coal bed methane projects.
138	IHS	INTERPOSE HOLDINGS LTD	4	Energy	Oil and Gas Exploration.
139	RAW	RAWSON OIL AND GAS LTD	3	Energy	Oil and Gas Exploration.
140	CBDE		3		
141	PGY	PILOT ENERGY LTD	3	Energy	Oil and Gas Exploration.
142	DAF	DISCOVERY AFRICA LTD	3	Materials	Gold exploration in Western Australia.
143	NSE	NEW STANDARD ENERGY LTD	1	Energy	Exploration for Oil and Gas
144	GRV	GREENVALE ENERGY LTD	3	Energy	Mineral exploration in Queensland with a focus on Oil Shale
145	GGX	GAS2GRID LTD	3	Energy	
146	SPB	SOUTH PACIFIC RESOURCES LTD	5	Energy	Oil and Gas Exploration.
147	TEX	TARGET ENERGY LTD	4	Energy	Oil exploration
148	ROG	RED SKY ENERGY LTD	3	Energy	The Company is an Australian-based energy company established to acquire, explore, assess and exploit oil and gas deposits and solar opportunities
149	BKP	BARAKA ENERGY & RESOURCES LTD	2	Energy	Conventional and Unconventional Oil and Gas exploration in the Southern Georgina Basin, Northern Territory.

150	IOG	INCREMENTAL OIL AND GAS LTD	3	Energy	Oil production in Wyoming, Colorado and California, USA.
151	KTE	K2 ENERGY LTD.	3	Utilities	Oil and Gas Exploration.
152	SUR	SUN RESOURCES NL	3	Energy	Oil and gas exploration and production
153	IPB	IPB PETROLEUM LTD	2	Energy	Oil and gas exploration.
154	CCJ	COUNTY INTERNATIONAL LTD	2	Energy	Exploration and development of thermal coal resources and projects in the USA.
155	CRM	CARBON MINERALS LTD	2	Energy	Natural resources exploration in Australia
156	SRO	SHAREROOT LTD	2	Software & Services	Ownership and operation of a user-generated content marketing platform.
157	JKA	JACKA RESOURCES LTD	2	Energy	Oil and gas exploration.
158	OTI	ORIENTAL TECHNOLOGIES INVESTMENT LTD	2	Capital Goods	Importing, marketing and sale of lead acid batteries.
159	OBL		2		
160	ENX	ENEGEX LTD	2	Energy	Oil and Gas Exploration.
161	PEC	PERPETUAL RESOURCES LTD	2	Energy	Development of coal mines through exploration interests in Indonesia.
162	TPD	TALON PETROLEUM LTD	1	Energy	Exploration and development of petroleum resources in the United States of America.
163	BPH	BPH ENERGY LTD	1	Pharmaceuticals, Biotechnology & Life Sciences	Development of biomedical research and technologies within Australian Universities and Hospital Institutes. The company provides early stage funding, project management and commercialisation strategies for a direct collaboration, a spin out company or
164	SYS	SYNGAS LTD	1	Energy	Oil and Gas Exploration.
165	PZC	PAN ASIA CORPORATION LTD	1	Energy	Coal exploration.
166	PKO	PEAKO LTD	1	Energy	Oil and gas and uranium exploration and production

167	BSP	BLACK STAR PETROLEUM LTD	1	Energy	Exploration for oil.
168	AOGC		0		
169	MPO	MOLOPO ENERGY LTD	35	Energy	Oil and Gas Exploration, Development
170	IND	INDUS ENERGY NL	3	Energy	Oil and gas exploration.
171	AZZ	ANTARES ENERGY LTD	120	Energy	International hydrocarbon exploration and production.
172	CTR	CITATION RESOURCES LTD	15	Energy	Oil and gas exploration.
173	EVM	ENVIROMISSION LTD	56	Utilities	EnviroMission is the global developer of Solar Tower renewable energy power station intellectual property.
174	ODN	ODIN ENERGY LTD	6	Energy	Exploration for oil and gas
175	DUCP		1		
176	MBT	MISSION NEWENERGY LTD	1	Energy	Renewable Energy Producer
177	CFU	CERAMIC FUEL CELLS LTD	12	Capital Goods	Fuel cell technology.
178	BCL	BARALABA COAL COMPANY LTD	41	Energy	Coal mining, development and exploration.
179	EGO	EMPIRE OIL & GAS NL	12	Energy	Oil and gas production and exploration in Western Australia.
180	LGO	LONGREACH OIL LTD	10	Energy	Oil and gas, gold and other mineral exploration and investment of funds.
181	IGE	INTEGRATED GREEN ENERGY SOLUTIONS LTD	8	Materials	Mineral exploration and investment in mining properties.
182	LWP	LWP TECHNOLOGIES LTD	6	Energy	LWP Technologies is an oil and gas technology company with its core business being the development of a unique technology for the manufacture of ceramic proppants for use in the Hydraulic Fracturing market.
183	ESM	ESPERANCE MINERALS LTD	3	Materials	Mineral exploration

184	GOE	GO ENERGY GROUP LTD	27	Capital Goods	Sustainable water and power solutions
185	AQJ	AUS ASIA MINERALS LTD	1	Energy	Minerals exploration
186	KIK	KAIRIKI ENERGY LTD	2	Energy	Petroleum exploration, gold mining, exploration and investment
187	OGY	ORCA ENERGY LTD	6	Energy	Exploration for advanced oil and gas opportunities
188	EWE	EAST WEST ENERGY LTD	4	Energy	Oil and Gas Exploration and Production
189	HOG	HAWKLEY OIL AND GAS LTD	1	Energy	Oil and gas exploration.
190	SWE	SWALA ENERGY LTD	6	Energy	Exploration for oil and gas in sub-Saharan Africa.
191	LNC		16		
192	ESCL				
193	CRA	CONSOLIDATED AFRICA LTD	6		

Appendix 3:

Detailed Information of Bloomberg's Listed Firms in Utilities

No.	Bloomberg's ticker	Full name	Current market capitalisation (AUD million) as at Dec 2017	Industry	Main business activities
1	AGL	AGL ENERGY LTD.	16533	Utilities	The Company operates Australia's largest retail energy and dual fuel customer base and consists of a substantial portfolio of wholesale energy contracts and assets to support its retail customer base.
2	ORG	ORIGIN ENERGY LTD	13799	Energy	Operating energy businesses
3	APA	APA GROUP	9505	Utilities	APA Group is Australia's largest natural gas infrastructure business
4	AST	AUSNET SERVICES LTD	6390	Utilities	Electricity transmission and distribution and gas distribution.
5	SKI	SPARK INFRASTRUCTURE GROUP	4323	Utilities	Investing in a diversified portfolio of quality regulated utility infrastructure assets
6	IFN	INFIGEN ENERGY	687	Utilities	Infigen Energy is an active participant in the Australian energy market. It is a developer, owner and operator of renewable energy generation assets delivering energy solutions to Australian businesses and large retailers.
7	EWC	ENERGY WORLD CORP LTD	503	Utilities	Production and sale of power, oil and natural gas; development of independent power projects; the manufacture and sale of liquefied natural gas (LNG); the development of energy related projects including marketing LNG.

8	EPW	ERM POWER LTD	334	Utilities	The Company sells electricity to large and small business customers in Australia and the United States. The Company also has ownership interests in and operates two low emission gas-fired power stations in Australia.
9	PEA	PACIFIC ENERGY LTD	225	Utilities	Investment in power generation, infrastructure and mineral projects, either in operation or development.
10	GNX	GENEX POWER LTD	79	Utilities	Genex Power LTD (GNX) is a power generation and energy storage company based in Australia. Its current focus is the development of the Kidston Renewable Energy Hub in Northern Queensland. Stage 1 is 50MW of solar PV and stage 2 is an integrated 250MW
11	LPE	LOCALITY PLANNING ENERGY HOL	60	Utilities	Retail energy supply.
12	HRL	HRL HOLDINGS LTD	28	Commercial & Professional Services	Environmental services, hazardous material, waste management and ongoing compliance solutions utilising technological platforms.
13	KPO	KALINA POWER LTD	23	Utilities	Kalina Cycle Power Solutions for Energy Efficiency and Geothermal Projects
14	VPR	VOLT POWER GROUP LTD	25	Utilities	Power generation technology developer and asset owner.
15	BKT	BLACK ROCK MINING LTD	25	Materials	Exploration company focussed on Australian assets, geothermal and hydrocarbon projects.
16	AFR	AFRICAN ENERGY RESOURCES-CDI	21	Energy	Power Generation in sub-saharan Africa
17	VIV	VIVID TECHNOLOGY LTD	18	Capital Goods	Vivid Technology is a diversified Australian-based company with interests in technology focused solutions in the industrial energy efficiency and CO2-to-fuel conversion markets.
18	BCT	BLUECHIIP LTD	12	Technology Hardware & Equipment	Wireless tracking technology.

19	RNE	RENU ENERGY LTD	13	Utilities	Supplier of clean energy products and services, delivering independent power solutions through the development of, build, own, operate and maintain solar PV and bioenergy, projects in Australia.
20	HPR	HIGH PEAK ROYALTIES LTD	6	Utilities	Acquisition of royalty interests, exploration permits and various oil and gas assets.
21	WRG	WATER RESOURCES GROUP LTD	4	Utilities	Water Resources Group (WRG) seeks to develop technologies associated with the low cost treatment of water. Its core technology under consideration involves the front end treatment of water prior to its entry into the Reverse Osmosis plant, with associated
22	ENB	ENEABBA GAS LTD	4	Utilities	Energy and resource exploration
23	PTR	PETRATHERM LTD	1	Utilities	Exploration for sources of geothermal energy.