EQUITY BETA FOR THE AUSTRALIAN UTILITIES IS WELL BELOW 1.0

Duc Vo*

Stefan Mero

Beauden Gellard

Economic Regulation Authority

469 Wellington Street, Perth, WA 6000, Australia

Phone: (08) 6557 7900

Fax: (08) 6557 7999

March 2014

* We are greatly indebted to Greg Watkinson, Rajat Sarawat and Bruce Layman for the support and constructive comments they have provided during the writing of this paper. The views expressed herein in this paper are those of the authors and do not necessarily represent those of the Secretariat or the Economic Regulation Authority. All remaining errors are ours.

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Abstract

Australian regulated utilities have argued for an extended period of time that their equity beta should be equal to 1.0 in the regulatory decisions. Australian regulators such as the Economic Regulation Authority and the Australian Energy Regulator agreed that the business risk of the Australian regulated utilities is below the market level and that their financial risk is above the market level. However, both regulators concluded that there is no evidence to confirm that the equity beta for these businesses should be equal to that of the market which is 1.0 due to these two effects. As such, empirical study in which an equity beta is estimated is required.

In response to this, we have conducted the empirical study to estimate the equity beta for Australian regulated businesses. We have employed different econometric techniques, from the conventional OLS to LAD; MM and Theil-Sen estimates to derive an appropriate estimate for equity beta on a sample of Australian electricity and gas businesses for an extended period of time. In addition, bootstrapping is also used to test the robustness of the estimates.

Based on our estimates, we conclude that equity beta for Australian regulated businesses is well below 1.0. We also concluded that their argument for the equity beta of 1.0 is not on a reasonable and strong ground. Our estimates indicate that, on average, equity beta for Australian regulated businesses fall within a close range of 0.5 and 0.7.

JEL Classification Numbers: *G11; G18*

Keywords: *Equity beta; Regulated businesses; robust regression; bootstrapping; Australia.*

March 2014

Introduction

Under the capital asset pricing model (**CAPM**) model, the total risk of an asset is divided into systematic and non-systematic risk. Systematic risk is a function of broad macroeconomic factors (such as economic growth rates) that affect all assets and cannot be eliminated by diversification of the investor's asset portfolio.

The key insight of the CAPM is that the contribution of an asset to the systematic risk of a portfolio of assets is the correct measure of the asset's risk (known as beta risk) and the only systematic determinant of the asset's return, over and above the return on a risk free asset.

In contrast, non-systematic risk relates to the attributes of a particular asset. The CAPM assumes this risk can be managed by portfolio diversification. Therefore, the investor in an asset does not require compensation for this risk.

Formally, there are three main components of the Sharpe Lintner CAPM for measuring the return on an asset: (i) the market risk premium (MRP), which is the return on the market portfolio in excess of the risk free rate of return, (ii) the beta risk β, which correlates the return on the specific asset, in excess of the risk free rate of return, to the rise and fall of the return on the market portfolio and iii) the risk free rate of return. The most common formulation of the CAPM directly estimates the required return on the equity share of an asset as a linear function of the risk free rate and a component to reflect the risk premium that investors would require over the risk free rate:

$$R_e = R_f + \beta_e \left(R_m - R_f \right) \tag{1}$$

where

R_e is the required rate of return on equity;

R_f is the risk-free rate;

β_e is the equity beta that describes how a particular portfolio i will follow the market which is defined as;

$\beta_e = \operatorname{cov}\left(r_i, r_M\right) / \operatorname{var}\left(r_M\right)$; and

$\left(R_m - R_f\right)$ is the market risk premium, MRP.

In the CAPM, the equity beta value is a scaling factor applied to the market risk premium, to reflect the relative risk for the return to equity of the firm in question. Two types of risks are generally considered to determine a value of equity beta for a particular firm: (i) the type of business, and associated capital assets, that the firm operates; and (ii) the amount of financial leverage (gearing) employed by the firm.

The need for empirical evidence

Australian regulated businesses and their consultants generally agree that the business activities of regulated businesses have less systematic risk than average. However, they also have argued that these regulated businesses have much higher financial leverage, and therefore higher financial risk, than the average firm (given average gearing of 60 per cent for regulated businesses versus gearing of 30 per cent for the average firm). They consider that the two effects operate in different directions and that there is no compelling a priori reason to suggest which of these effects should dominate the other. As such, they have proposed that the appropriate a priori expectation is that the equity beta for these regulated businesses is no different from that of the average firm, which is 1.0.

We note that higher levels of financial leverage are possible for network businesses because of their stable cash flows. We also note that there is some evidence to suggest that higher leverage provides a signal for investors as to the stability of cash flows and the overall viability of the network businesses.[1]

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[1] Klein L.S., O'Brien T.J. and Peters S.R. 2002, Debt vs. Equity and Asymmetric Information: A review, *The Financial Review* 37, pp. 317-350.

Overall, we consider that the lower cash flow risk of regulated businesses results in a lower equity beta compared with the market, even with the observed higher gearing levels.

The Brattle group argued that as empirical beta estimates rely on historical data, there may be a delay in incorporating changes in systematic risk and therefore equity beta estimates are inherently backward-looking and hence imprecise.[2] CEG also argued that the lack of statistical precision makes the empirical estimates of equity beta inappropriate. CEG argued that using empirical estimates implies that investors form their forward-looking expectations of beta based on regression analysis.[3]

We agree that the return on equity derived from the Sharpe-Lintner CAPM is a forward looking estimate. We do not agree that the appropriate a priori expectation of the equity beta for transmission and distribution businesses is at the market level of one. There is no a priori expectation of an appropriate value of equity beta for regulated gas businesses in Australia. As a consequence, estimates of equity beta using historical data are required in order to inform an appropriate range for the equity beta of the benchmark efficient firm. Therefore, we believe that any estimate of equity beta must be informed by empirical evidence.

The Economic Regulation Authority (**ERA**) and the Australian Energy Regulator (**AER**) adopted this approach. For example, the AER adopted this approach in its weighted average cost of capital (**WACC**) 2009 Review and the ERA in their various decisions.[4] Professor Myers agrees with this point, suggesting that the required equity beta can be estimated using historical data.[5] Professor Myers also outlined the imprecision in estimating equity beta, suggesting that the true beta estimate could lie anywhere within a given confidence interval, not just the midpoint.[6] Australian regulators including the ERA and the AER have consistently acknowledged a high level of imprecision for any empirical estimates of equity beta. We consider that issues of imprecision are best addressed via the use of multiple models and statistical techniques to inform a possible range for any equity beta estimate. Therefore the primary evidence used to inform the value for the equity beta of a regulated entity should be based on quantitative evidence.

Current approaches to estimating equity beta in the Australian utility regulation

In its 2009 WACC review for electricity transmission and distribution network service providers, the AER, with the assistance of Associate Professor Henry of the University of Melbourne, established a sample of Australian businesses, comprising gas-only network businesses, one electricity-only network business, network businesses active in both electricity and gas, and general utility businesses.[7] Given the limitations of available Australian data, the AER considered that gas network businesses could be considered as reasonable but not perfect comparators to electricity network businesses, given that both industries involve the transportation of energy.[8]

Based on empirical work by Henry, the AER concluded that a reasonable range of the equity beta for a gas or electricity distribution networks was between 0.4 and 0.7. Its final decision was to adopt a conservative approach to the estimation the equity beta that was commensurate with prevailing market conditions and the risks involved in providing reference services. The AER also considered the need

2 The Brattle Group, *Estimating the Cost of Equity for Regulated Companies*, A report prepared for Australian Pipeline Industry Association, 17 Feb 2013.

3 Competition Economists Group, *Regression estimates of equity beta*, September 2013.

4 Australian Energy Regulator 2009-10, Final decision: WACC review, May 2009.

5 Myers S.C. *Estimating the Cost of Equity: Introduction and Overview*, A report prepared for Australian Pipeline Industry Association, 17 Feb 2013.

6 Ibid.

7 Henry, O (2009) "Estimation Beta", Advice Submitted to the Australian Competition and Consumer Commission.

8 The sample consisted of: AGL (2002 to 2005); Alinta (2002 and 2007); Alinta Network Holdings Pty Ltd (2003 to 2006); Country Energy (2002 to 2006); Diversified Utility and Energy Trusts (2003 to 2008); ElectraNet Pty Ltd (2002 to 2008); Energy Australia (2002 to 2006); Envestra Ltd (2002 to 2008); Ergon Energy Corporation (2002 to 2008); ETSA Utilities (2002 to 2008); GasNet Australia (Operations) Pty Ltd (2002 to 2007); Integral Energy (2002 to 2006); SP AusNet Group (2006 to 2008), and SPI PowerNet Pty Ltd (2002 to 2005).

for regulatory certainty. On this basis, the AER considered that a value of 0.8 provided the best estimate of the equity beta for gas and electricity transmission and distribution networks.[9]

We had conducted our own analysis with regard to the estimates of equity beta. In 2012, we used the same approach that was adopted by Henry but used an updated data set (which included data up to October 2011). This analysis formed the basis for the ERA's decision on equity beta in the Western Power final decision.[10]

All data for our application of Henry's study was sourced from Bloomberg. Data was collected on both a monthly and weekly sampling frequency. Henry advised that sampling the data at a weekly frequency is a reasonable compromise of the trade-off between the noisy nature of daily data and too few monthly observations to produce reliable estimates of beta. Consistent with Henry's approach, we adopted both ordinary least squares (**OLS**) and Least Absolute Deviations (**LAD**) methods in this analysis.

Our original empirical study was conducted in two stages.

first, using a shorter dataset from 2002 to 2008 to be consistent with the period used in Henry's 2008 study; and

second, using an updated dataset from 2002 to 2011.

The main objective of the first stage of our empirical analysis were: (i) to make a "like for like" comparison with Henry's results across this period, and (ii) to omit the effect of events associated with the Global Financial Crisis which occurred post September 2008. The estimated betas from our 2012 analysis are not statistically different from Henry's 2009 estimates.

When the updated data set was used, we noted that the weekly sample had 15 of the 18 estimates of equity beta that were not statistically different from Henry's estimates. The differences of the remaining 3 equity beta estimates between Henry 2009's study and our 2012's study using the extended dataset include: (i) the beta estimate for Envestra (ENV) when both OLS and LAD methods were used; and (ii) the beta estimate for SKI using the LAD method at the five per cent level of confidence.

Our analysis, using the extended dataset to October 2011, can be summarised as below:

- the estimates of the equity beta using monthly data range from 0.0675 to 0.9688, with a mean of 0.4569 and median of 0.4253; and
- the estimates of the equity beta using weekly data range from 0.2168 to 1.3378, with a mean of 0.5204 and median of 0.4261.

Given the results from both Henry's 2009 study and our analysis, the ERA, in the access arrangement for Western Power in 2012, decided an appropriate range for equity beta was between 0.5 and 0.8. The ERA was of the view that the point estimate of the equity beta of 0.65, being the average of the lower and upper bounds of the range adopted in 2009, was reasonable for the draft and final decisions on Western Power's Access Arrangement in 2012 for the following reasons:

- the estimated equity beta of 0.65 falls in the range of the estimates that came from the empirical studies by Henry in 2009, which produced the range of 0.4 and 0.7; and by We in 2011, which produced the range of 0.5 and 0.8; and
- the midpoints are taken to reduce the undesired effects of outliers, such that their effect is averaged out.

Table 1 contains a summary of the adopted equity beta from recent Australian regulatory decisions. Australian economic regulators have adopted values of equity beta for regulated businesses within the range of 0.55 and 0.80.

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9 See for example: Australian Energy Regulator 2009-10, Final decision: WACC review, May 2009; or Powerlink Transmission determination, 2012-13 to 2016-17 (Draft Decision, 29 November 2011, p. 33).

10 Economic Regulation Authority (Western Australia) 2012, *Final decision on proposed revisions to the access arrangement for Western Power*, www.erawa.com.au.

Table 1 Estimates of Equity Beta adopted by Australian Regulators

Regulator	Year	Equity beta
ACCC[11]	2011	0.7
AER[12]	2012	0.8
ERA[13][14]	2012	0.65/0.8
IPART[15]	2012	0.6-0.8
QCA[16]	2012	0.55
ESCOSA[17]	2012	0.8

Source: Compiled by the authors

In 2013, we extended the above analysis for the purpose of estimating equity beta for Australian regulated businesses in the ERA's Draft Guidelines.[18] This analysis extended the above analysis by using an updated data set (containing data to April 2013) in addition to introducing new econometric techniques. The 2013 analysis is described in detail below.

Estimating equity beta: Empirical studies in 2013

We have utilised the same companies used by Henry in his advice to the AER in 2009 to form the basis of its analysis. Table 2 below presents the sample of companies and data period used by Henry.[19]

11 Australian Competition and Consumer Commission, *Inquiry to make final access determinations for declared fixed line services — Final report*, July 2011, p. 49.

12 Australian Energy Regulator, *Access Arrangement Information for the ACT, Queanbeyan and Palerang gas distribution network*, 1 July 2010 – 30 June 2015 p. 12.

13 Economic Regulation Authority (Western Australia), *Final decision on proposed revisions to the access arrangement for Western Power*, 2012.

14 Economic Regulation Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline*, 31 October 2011, p. 158.

15 Independent Pricing and Regulatory Tribunal, *Review of prices for Sydney Water Corporation's water, sewerage, stormwater drainage and other services, From 1 July 2012 to 30 June 2016*, p. 197.

16 Queensland Competition Authority, *Final report, Sunwater irrigation price review 2012–17, Volume 1, May 2012*, p. 498.

17 Essential services commission of South Australia, *Advice on a regulatory rate of return for SA Water—Final advice*, February 2012, p. 49.

18 Economic Regulation Authority, Explanatory Statement for the Draft Rate of Return Guidelines, 6 August 2013.

19 Henry, O (2009) "Estimation Beta", Advice Submitted to the Australian Competition and Consumer Commission.

Table 2 Sample of companies and data period from the 2013 analysis

Name	Bloomberg's ticker	From	To
Envestra	ENV	14/12/2001	19/04/2013
APA Group	APA	14/12/2001	19/04/2013
GasNet Australian Group	GAS	21/12/2001	17/11/2006
Alinta Limited	AAN	14/12/2001	17/08/2007
Jemena	AGL	14/12/2001	13/10/2006
DUET Group	DUE	20/08/2004	19/04/2013
Hastings Diversified Utilities Funds	HDF	17/12/2004	23/11/2012
SP Ausnet	SPN	23/12/2005	19/04/2013
Spark Infrastructure Group	SKI	16/12/2005	19/04/2013
All ordinary Index	20AS30	4/01/2002	19/04/2013

Source: Bloomberg

GasNet Australian Group, Alinta Limited, and Jemena are excluded from the sample because, unlike the other companies, the three excluded companies do not have recent data as they have ceased trading. As a result, the sample used by us contains only 6 companies.

Price data used was the last price for all stocks provided by the Australian Stock Exchange (**ASX**) using the Bloomberg Terminal. Dividend data used in the study was gross dividends including cash distributions, but omitting unusual items such as stock distributions and rights offerings. The dividend was then added to the closing price on the Friday after the ex-dividend dates as this is the first day the price would reflect the payout of the dividend in the data. For the All Ordinaries index, which represents a return for the entire Australian stock market, the gross last dividend per share was used which includes the net dividend and any tax credit where applicable. No adjustments were made to historical volume in Bloomberg. It is noted that net debt information for the six firms in the sample is the sum of short and long-term borrowings less cash and near cash items, marketable securities and collaterals. In addition, market capitalisation for the six firms was measured as the current monetary value of all outstanding shares stated in the pricing currency. Some adjustments were made to be consistent with Bloomberg's reporting of data.

Returns in CAPM regressions are usually based on continuously compounded returns which is presented in equation (16) below. Both the AER[21] and Henry found no evidence that β estimates obtained from discretely compounded data, as presented in equation (17), are manifestly different from those obtained from continuously compounded data. As a consequence, we have used continuously compounded returns as described in equation (16) for estimating equity beta.

$$r_{i,t}^{c} = \ln\left[(p_{i,t-1} + d_{i,t}) / p_{i,t-1} \right] \tag{2}$$

$$r_{i,t}^{d} = \frac{p_{i,t} - p_{i,t-1} + d_{i,t}}{p_{i,t-1}} \tag{3}$$

[20] Australian Energy Regulator (2008), "Explanatory Statement: Electricity transmission and distribution network service providers Review of the weighted average cost of capital (WACC) parameters, www.aer.gov.au, p. 200.

where

$r_{i,t}^{c}$ is the continuously compounded return for asset i in day t; taking into account dividend d;

$r_{i,t}^{d}$ is the discretely compounded return for asset i in day t; taking into account dividend d;

p_{it} is the price of asset i in day t; and

d_{it} is the dividend payout to asset i on day t.

Henry outlined in his advice to the AER that beta is estimated by applying regression analysis to the following equation:[22]

$$r_{i,t} = \alpha_i + \beta_i r_{m,t} + \varepsilon_{i,t} \quad (4)$$

where

β_i is the equity beta for asset i;

r_{it} is the observed raw returns to asset i in year t;

r_{mt} is the observed market returns in year t;

α_i is a constant specific to asset i; and

ε_{it} are the residuals.

Based on this advice, we have adopted equation 4 as the basis for empirically estimating equity beta.

In his study, Henry outlined the possibility of the existence of heteroscedasticity in the estimate of beta. This means that the residuals may be related to the observation, $\text{Var}[\varepsilon_{i,t}] = \sigma_i^2$. Henry suggested using the Least Absolute Deviations (**LAD**) estimator, to reduce the influence of outliers on the resulting beta estimate. We have employed the Ordinary Least Squares (**OLS**) and LAD methods, in addition to: (i) the maximum likelihood robust methodology (**MM**), and (ii) the Theil-Sen methodology.

The MM estimator has previously been utilised in studies which have been used in regulatory decisions with respect to gamma.[23] We have also adopted this MM method in its recent empirical study on the estimate of the market value of franking credits. The MM regression is a form of robust regression that has a high breakdown point (50 per cent) and high statistical efficiency (95 per cent). The MM regression has the highest breakdown point and statistical efficiency of robust regression estimators currently available, and for this reason, it is adopted in our study on equity beta in 2013.

Fabozzi (2013)[24] suggests the use of the Theil-Sen estimator for estimating the appropriate value for the equity beta. Fabozzi proposes this estimator in response to the OLS estimator being acutely sensitive to outliers. Fabozzi proposes that outliers in financial data are far more common than is usually assumed, and that it is surprising that the Theil-Sen estimator is not more widely used and appreciated. This was one of the main reasons behind our adoption of the method in its 2013 study.

[22] Henry, O (2009) "Estimation Beta", Advice Submitted to the Australian Competition and Consumer Commission, www.accc.gov.au, p 2.

[23] SFG 2011, *Dividend drop-off estimate of theta*, A report to the Australian Competition Tribunal and the Australian Energy Regulator, Final Report, 21 March 2011.

[24] Fabozzi, F.J(2013) Encyclopaedia of Financial Models, Wiley Publications, p. 442.

All regression results, associated standard errors and test statistics, were computed using R 2.13.2 open source software. All equity betas in the following analysis are de-levered using the relevant company's average gearing ratio over the period and re-levered using the 60 per cent assumption.

The estimates of equity beta for each company in the sample are presented in the following manner for comparison:

- *First*, estimated equity betas for those companies that are included in the sample of both our 2012 and 2013 studies. Only the OLS and the LAD methods are considered for consistency with the estimates obtained from our 2012 study (see Table 3).
- *Second*, estimated equity betas, using the updated data set to April 2013, using all four methods, namely the OLS; the LAD; the MM; and the Theil-Sen methods (see Table 4). The data set used below is from January 2002 to April 2013.

Table 3 Estimated Equity Betas in the studies in 2012 and 2013 using OLS and LAD

Company	APA	DUE	ENV	HDF	SKI	SPN
			The analysis in 2012			
OLS	0.6041	0.2971	0.3681	1.1873	0.5178	0.2677
LAD	0.5990	0.2438	0.3465	0.8907	0.3889	0.2452
N	540	400	540	383	330	330
			The analysis in 2013			
OLS	0.6138	0.2255	0.3714	1.2025	0.5427	0.1248
LAD	0.5556	0.2391	0.3548	0.9725	0.4390	0.2601
N	589	453	589	415	383	383

Source: Authors' estimates

The results show that the estimates of the equity beta have remained relatively stable over time.

For individual firm's betas, we consider that the sample period of 5 years with weekly intervals is appropriate as it reduces the possibility of structural breaks in the data set, whilst having enough data points to estimate beta with statistical accuracy. Table 4 estimates each firm beta across the different regression methodologies, with a data set from April 2008 to April 2013.

Table 4 Estimates of equity beta for individual firms in 2013 using all four methods

	APA	DUE	ENV	HDF	SKI	SPN	Average
Gearing	0.5418	0.742	0.6884	0.3936	0.4436	0.6107	**0.5700**
OLS	0.5930	0.1746	0.4425	1.1970	0.5432	0.0490	**0.4999**
LAD	0.5549	0.2331	0.4434	1.1054	0.3668	0.2563	**0.4933**
Robust MM	0.6334	0.2507	0.4497	1.0015	0.4801	0.3043	**0.5199**
Thiel Sen	0.5643	0.2656	0.4456	1.0054	0.3915	0.2221	**0.4824**
Average	**0.5864**	**0.2310**	**0.4453**	**1.0773**	**0.4454**	**0.2079**	**0.4989**

Source: Authors' estimates

The results in Table 4 show that, on average, the MM robust regression produces higher estimates of equity beta than the OLS method. The Theil-Sen method produces the lowest estimates of equity beta. On average, both OLS and LAD methods produce the estimates of equity beta which fall between the two newly proposed methods: the MM and Theil-Sen methods. It is noted, however, that for individual companies, the two newly adopted methods in this 2013 analysis can produce estimates of equity beta that can be higher or lower than estimates derived using the two methods adopted in our analysis in 2012.[25]

As such, there is no biased tendency to over- or under-estimate equity beta when the two new methods are adopted. In comparison with the estimate equity betas from the OLS method, equity betas estimated from the LAD, MM and Theil-Sen methods appear to be more consistent.

In 2009, Henry's study contained six portfolios. The 2013 analysis contains only five portfolios because Bloomberg data for both SPN and SKI became available in the same week. As such, the sixth portfolio, which reflected the later 'drop in' date for SKI as in Henry's study, is not needed. Two scenarios are considered in this study which is consistent with the approach adopted in Henry's 2009 study: (i) equally-weighted portfolios; and (ii) value-weighted portfolios. As a result, the total of ten portfolios is created in this 2013 study. Of these 10 portfolios, five portfolios are equally-weighted, and the other five portfolios are value-weighted.

The key purpose of a portfolio analysis is to allow a single portfolio to be created and, as such, a single corresponding equity beta for that portfolio can be estimated as an equity beta of the industry. It is noted that companies may enter and leave the industry at various points of time. As a result, portfolios are required to be recreated when there is a new composition of the industry (i.e. where there is a firm which leaves the industry and/or a firm that enters into the industry).

The structure of the portfolios and their starting dates are listed in Table 5 below.[26]

Table 5 Portfolios in the 2013 study

Portfolio	Start Date	Firms in Portfolio					
P0	4/01/2002	ENV	APA				
P1	5/09/2003	ENV	APA				
P2	20/08/2004	ENV	APA	DUE			
P3	17/12/2004	ENV	APA	DUE	HDF		
P4	23/12/2005	ENV	APA	DUE	HDF[27]	SPN	SKI

Source: Authors' analysis

The five equally-weighted portfolios consisting of n companies have all observations of returns weighted by $1/n$ to form a single set of portfolio return observations for each equally-weighted portfolio.

25 The high resulting estimate for HDF is a result of their low average gearing resulting in a large levering factor to represent 60 per cent gearing which is then applied to the raw beta estimate.

26 It is noted that time-varying portfolios, where non-constant portfolio weights are used, were not constructed due to the substantial measurement error that results from this approach. This concern has been raised in Henry's 2009 study.

27 It is noted that data for HDF only covers the period from 23 December 2005 to 23 November 2012. All other companies in the portfolio have data available until 19 April 2013.

Table 6 Equally- Weighted Portfolio Beta Estimates

	P0	P1	P2	P3	P4	Average
Gearing	0.6187	0.6310	0.6752	0.6046	0.5854	**0.6230**
OLS Beta	0.4892	0.4938	0.3870	0.5497	0.4915	**0.4823**
LAD Beta	0.5335	0.5431	0.4123	0.5804	0.5903	**0.5319**
MM Beta	0.4863	0.4980	0.4104	0.5794	0.5644	**0.5077**
Theil-Sen Beta	0.4351	0.4592	0.3976	0.5461	0.5254	**0.4727**
Average	**0.4860**	**0.4985**	**0.4018**	**0.5639**	**0.5429**	**0.4986**
Observations	589	503	453	415	362	

Source: Authors' estimates

The results in Table 6 suggests that, on average, the LAD and MM methods produce higher beta estimates across the portfolios than the OLS and Theil-Sen methods. This is broadly consistent with the estimated equity betas for individual firms as presented in Table 4 above. Portfolio 3 starting in December 2004 produces the highest estimate on average across all four methods while Portfolio 2 produces the lowest estimates. The most up to date portfolio (*Portfolio 4*) produces the second highest estimate of around 0.54.

In order to calculate value-weighted portfolios, the average market capitalisation was calculated for each firm, which remained listed until 2013, over the period from when they first appeared. For each firm in the portfolio, its weight is determined by the ratio between the average of a single firm and the sum of the averages of all firms in each portfolio in terms of market capitalisation. The averages were taken over a sample period for all firms in each portfolio. The weights were then applied to their relevant firms in the portfolio.

Table 7 Value- Weighted Portfolio Beta Estimates

	P0	P1	P2	P3	P4	Average
Gearing	0.5929	0.6093	0.6638	0.6319	0.6002	**0.6196**
OLS Beta	0.5277	0.5274	0.3987	0.4733	0.3989	**0.4652**
LAD Beta	0.5555	0.5515	0.4362	0.5119	0.5072	**0.5125**
MM Beta	0.5279	0.5321	0.4321	0.5100	0.4936	**0.4991**
Theil-Sen Beta	0.4729	0.4880	0.4143	0.4944	0.4541	**0.4648**
Average	**0.5210**	**0.5248**	**0.4203**	**0.4974**	**0.4635**	**0.4854**
Observations	589	503	453	415	362	

Source: Authors' estimates

For the value-weighted portfolios, on average, the beta estimates from the LAD and MM methods are higher than those estimated from the OLS and the Theil-Sen methods. As presented in Table 7, *Portfolio 1* produces the highest estimates while *Portfolio 2* produces the lowest beta estimates. The latest portfolio (*Portfolio 4*) produces an average estimate of approximately 0.46 which is lower than the average estimate under the equally-weighted portfolio approach. However, the average of estimated equity beta across all portfolios under the value-weighted approach is 0.4854, which is lower than the average of 0.4986 under the equally-weighted portfolio approach.

It is argued that estimates of equity beta using historical data lack robustness and the estimates approaches do not take into account a significant issue known as thin trading. As such, we have conducted its tests of robustness in response to these two concerns.

The following section presents tests of statistical significance for various scenarios: (i) estimated beta for individual firms; (ii) estimated beta for the equally-weighted portfolios; and (ii) estimated beta for the value-weighted portfolios. Each of these three scenarios is discussed in turn below.

Table 8 presents the t-statistics of beta estimates for individual firms. It is noted that the t-statistics over 1.96 indicate that the beta estimate is statistically different from zero at the 5 per cent level of significance. The values for DUET (DUE) and SP Austnet (**SPN**) are the only two values that are not statistically significantly different from zero under the OLS method. However, we note that, for other methods including the LAD, Robust MM and Thiel-Sen estimates, all beta estimates are all statistically significant at the 5 per cent level of significance.

The Theil-Sen estimates are all significant at the 5 per cent level. Although a standard error cannot be calculated using this method, the fact that the lower band of the 95 per cent confidence interval does not contain zero indicates that the estimates are significant at the 5 per cent level of significance.

Table 8 Statistical significance of estimates of betas for individual firms

	APA	DUE	ENV	HDF	SKI	SPN
OLS						
t-statistic	7.0746	1.8116	6.0787	3.8758	2.9859	0.3038
Beta Upper bound	0.7572	0.3635	0.5851	1.8023	0.8998	0.3648
Beta Lower bound	0.4287	-0.0143	0.2998	0.5917	0.1866	-0.2669
LAD						
t-statistic	8.4091	5.5719	22.1069	19.5201	4.6622	3.7430
Beta Upper bound	0.6842	0.3151	0.4827	1.2164	0.5210	0.3905
Beta Lower bound	0.4256	0.1511	0.4041	0.9944	0.2126	0.1221
Robust MM						
t-statistic	8.9345	6.1857	8.2328	8.3040	5.0602	4.3751
Beta Upper bound	0.7723	0.3301	0.5567	1.2379	0.6661	0.4407
Beta Lower bound	0.4944	0.1712	0.3426	0.7651	0.2942	0.1680
Theil-Sen						
Upper Bound	0.7193	0.3727	0.5758	1.2942	0.6341	0.3920
Lower Bound	0.3988	0.1640	0.3174	0.7174	0.1559	0.0477
N	261	261	261	240	261	261
R-Square (OLS)	0.1619	0.0125	0.1249	0.0594	0.0333	0.0004

Source: Authors' estimates

In his study in 2009, Henry noted that a concern from SFG was that there is evidence of bias in regressions with the R^2 values which are less than ten percent in the samples of 48 observations.[28] However, given our preference is to use weekly data, the number of observations in the sample is far greater than 48 observations, as presented in Table 8 above, this concern is not an issue in this study.

Tests of statistical significance of estimated beta for all four methods adopted in the equally-weighted portfolios are conducted. The outcomes from the tests are presented in Table 9 below.

28 Henry, O. 2009, "Estimation Beta", *Advice Submitted to the Australian Competition and Consumer Commission*, 48.

Table 9 Statistical significance of the equally-weighted portfolio equity beta estimates

	P0	P1	P2	P3	P4
The OLS method:					
Standard Error	0.0427	0.0434	0.0425	0.0594	0.0617
t-statistic	11.47	11.37	9.10	9.26	7.97
Upper Bound	0.5728	0.5790	0.4703	0.6662	0.6124
Lower Bound	0.4056	0.4087	0.3036	0.4333	0.3707
The LAD method:					
Standard Error	0.0323	0.0338	0.0364	0.0413	0.0437
t-statistic	16.51	16.06	11.33	14.07	13.51
Upper Bound	0.5968	0.6094	0.4836	0.6613	0.6759
Lower Bound	0.4702	0.4769	0.3410	0.4996	0.5047
The MM method:					
Standard Error	0.0334	0.0335	0.0287	0.0357	0.0395
t-statistic	14.56	14.88	14.30	16.25	14.30
Upper Bound	0.5517	0.5636	0.4666	0.6493	0.6417
Lower Bound	0.4208	0.4324	0.3541	0.5095	0.4870
The Theil-Sen method:					
Upper Bound	0.5168	0.5389	0.4676	0.6362	0.6219
Lower Bound	0.3511	0.3739	0.3267	0.4591	0.4219

Source: Authors' estimates

The equally-weighted portfolio OLS beta estimates were all statistically significant at the 5 per cent level of significance. The most current and diversified portfolio (*Portfolio 4*) has the highest standard error, while the least diversified portfolio (*Portfolio 0*) has the lowest standard error. This difference most likely reflects the much larger sample size in *Portfolio 4* over which the variance can be scaled down.

It is noted that the LAD equally-weighted estimates draw inference from the strong assumption that they are t-distributed. All estimates are statistically significant at the 5 per cent level. The standard errors under this method are lower than those of the OLS estimates and tend to increase with the increase in sample size.

The equally-weighted portfolio MM robust estimates also draw inference from the strong assumption that they are t-distributed. All estimates are statistically significant at the 5 per cent level. The standard errors in this method are lower than those estimated from the OLS method and generally lower than those of the LAD estimates as well. The standard errors in this method appear to be less sensitive to the reduction in sample size than in the estimates from the OLS and LAD methods.

We note that, given that none of the lower confidence intervals contain zero, the Theil-Sen estimates are all statistically significant at the 5 per cent level. Tests of statistical significance of estimated beta for all four methods adopted in the value-weighted portfolios are now conducted. The outcomes from the tests are presented in Table 10 below.

Table 10 Statistical significance of the value-weighted portfolio equity beta estimates

	P0	**P1**	**P2**	**P3**	**P4**
The OLS method:					
Standard Error	0.0469	0.0476	0.0453	0.0513	0.0605
t-statistic	11.25	11.07	8.80	9.23	6.60
Upper Bound	0.6197	0.6208	0.4875	0.5738	0.5175
Lower Bound	0.4357	0.4341	0.3100	0.3728	0.2804
The LAD method:					
Standard Error	0.0421	0.0429	0.0330	0.0337	0.0342
t-statistic	13.21	12.84	13.21	15.20	14.85
Upper Bound	0.6379	0.6357	0.5010	0.5779	0.5742
Lower Bound	0.4731	0.4674	0.3715	0.4459	0.4403
The MM method:					
Standard Error	0.0365	0.0360	0.0302	0.0332	0.0396
t-statistic	14.45	14.80	14.33	15.35	12.48
Upper Bound	0.5995	0.6026	0.4912	0.5751	0.5712
Lower Bound	0.4563	0.4616	0.3730	0.4449	0.4161
The Theil-Sen method:					
Upper Bound	0.5518	0.5706	0.4841	0.5923	0.5996
Lower Bound	0.3749	0.3959	0.3382	0.4274	0.4068

Source: Authors' estimates

All estimates using all four different methods are statistically significant at a 5 per cent level of significance. In addition, the Theil-Sen estimates are all statistically significant at 5 per cent given that none of the lower confidence intervals contain the value of zero.

Another concern in relation to regression analysis for estimating equity beta is that some securities do not trade regularly. As such, this may bias the OLS beta estimates toward zero. In his study, Henry had tested the evidence of thin trading by using Dimson's betas and test statistics.[29] This test is now adopted in this new study in 2013.

The following regression is used in order to get the estimates of lagged, coincident and leading betas.[30]

29 Dimson, E. And P. Marsh (1983) "The stability of UK risk measures and the problem in thin trading", *Journal of Finance*, 38 (3) pp. 753 - 784.

30 Other variations of this regression omit the leading term, such as Morningstar's 'sum beta'. This specification, however, is more robust as it accounts for lags that run both from the market to the individual stock and from the individual stock to the market.

$$r_{i,t} = \alpha_i + \beta_{i-1} r_{m,t-1} + \beta_{i-1} r_{m,t} + \beta_{i-1} r_{m,t+1} + \varepsilon_{i,t} \quad (5)$$

where

$r_{i,t}$ is the return on asset i at time t;

α_i is a constant;

$\beta_{i-1} r_{m,t-1}$ is the beta on the market return at time $t-1$;

$\beta_{i+1} r_{m,t+1}$ is the beta on the market return at time $t+1$; and

$\varepsilon_{i,t}$ is the regression error term.

The all three estimated betas are then summed to produce a Dimson's beta estimate.[31]

$$\hat{\beta}_i^D = \hat{\beta}_{i-1} + \hat{\beta}_i + \hat{\beta}_{i+1} \quad (6)$$

The null hypothesis $\beta_i^{OLS} = \beta_i^D$ is tested using the test statistics outlined in (7) below. The rejection of the null hypothesis is to present an evidence of thin trading.

$$t = \frac{\hat{\beta}_i - \hat{\beta}_i^D}{SE(\hat{\beta}_i)} \quad (7)$$

At a five per cent level of significance, absolute values for the t-test with values greater than 1.96 indicates evidence of thin trading.

The findings from this test are presented in Table 11 below. There is no evidence of thin trading in the sample. This conclusion is similar with Henry's view in his 2009 study.

[31] Dimson, E. And P. Marsh (1983) "The stability of UK risk measures and the problem in thin trading", *Journal of Finance,* 38 (3) pp. 753 - 784.

Table 11 Dimson's thin trading tests

	ENV	APA	DUE	HDF	SKI	SPN
Lagged Beta	0.0990	-0.0467	0.2365	0.1631	0.0974	0.1305
Standard Error	0.1000	0.0801	0.1501	0.2104	0.1332	0.1659
Beta	0.5680	0.5176	0.2707	0.7896	0.3905	0.0503
Standard Error	0.0934	0.0732	0.1494	0.2037	0.1308	0.1656
Lead Beta	0.0073	-0.1047	-0.1593	-0.1645	-0.1597	-0.0996
Standard Error	0.1002	0.0799	0.1506	0.2100	0.1331	0.1661
Dimson's Beta	**0.6744**	**0.3662**	**0.3479**	**0.7882**	**0.3281**	**0.0813**
t-test	**-1.1381**	**2.0697**	**-0.5168**	**0.0068**	**0.4769**	**-0.1869**

Source: Authors' estimates

The choice of the sampling period and interval for equity beta estimation

CEG criticised our analysis for the use of the time period from 4/01/2002 to 19/04/2013. CEG argued that adopting this sampling period implies that investors only consider this sampling period appropriate to form their view on a forward-looking beta. We note that this time period was advised by Henry to avoid the effects of the 'dot com bubble' in his advice to the AER in 2008.[32] When the analysis is updated for regulatory decisions in the future, the sample period will be updated accordingly.

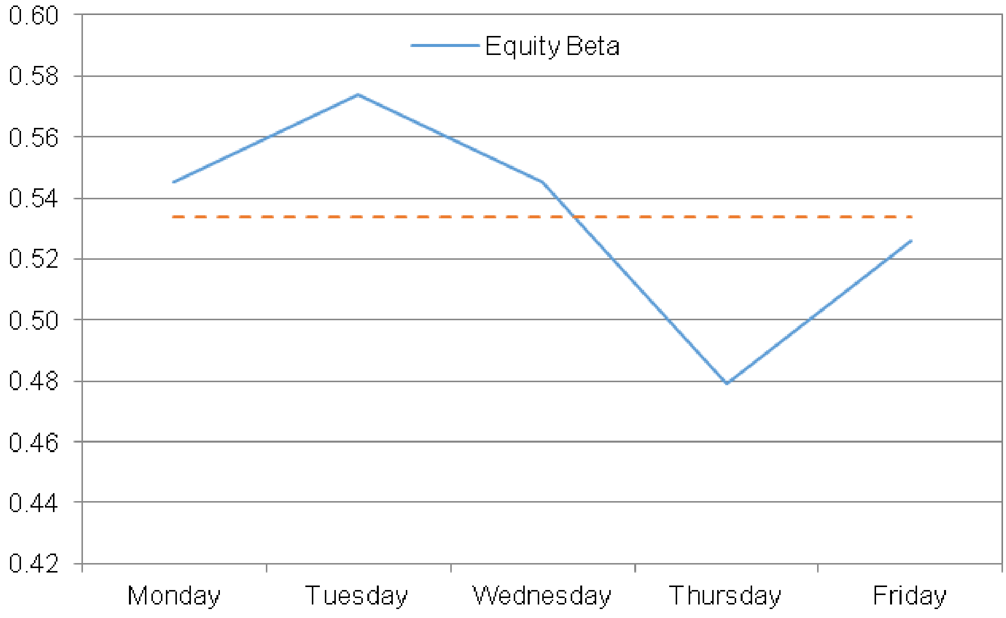
CEG also argued evidence demonstrating that the estimate of equity beta is dependent on the sampling interval chosen to calculate returns. For example, altering the day of the week that returns are calculate from, or if the sampling interval is changed to a daily or monthly interval results in a wide range of equity beta estimates.

To investigate the sensitivity that sampling intervals have on equity beta estimation, we has replicated the methodology outlined in the draft determination but altered the day of the week from which the returns have been calculated from. This resulted in 5 data sets, each conditional on the day of the week returns are calculated from. The data set was for the same period of April 2008 to April 2013. Each firm's equity beta was calculated across the four different regression estimators. An average equity beta was calculated across the individual firms and regression procedures for each data set. This produces an average equity beta estimate conditional on the day of the week returns are calculated from. The results are demonstrated graphically below in Figure 1**Error! Reference source not found.**. A significant day-of-the week effect appears to be evident with higher covariance of returns on Tuesday and lower covariance of returns on Thursday.[33]

[32] Competition Economists Group, *Regression estimates of equity beta*, September 2013.

[33] It is noted that beta is a measure of covariance between the returns on the market and the stock in question; not returns in isolation. Therefore the day-of- the week effect in returns such as those documented in Kohers. G, Kohers. N, Pandey. V and Kohers, T (2004) '*The Disappearing Day-of-the-week Effect in The World's Largest Equity Markets*' Applied Economics Letters, Vol. 11, pp. 167-171 are different to the effect that is under consideration here.

Figure 1 **Authority's estimate of equity beta average using different week days**



Source: Authors' analysis

The use of closing data is a commonly used convention in the finance literature. This is also the convention adopted by Henry in his advice to the AER.[34] An average of the various day of the week betas are not significantly different from the Friday based beta estimate (0.5261 versus the average of 0.5340, a difference of 0.0078). As a consequence, it is appropriate to utilise Friday based returns for the purposes of equity beta estimation. We will also utilise confidence intervals in order to estimate acceptable ranges for equity beta and not rely on point estimates for equity beta, diminishing the relevance of the choice of weekday.

We are of the view that weekly data is preferred to monthly data. It is noted that estimates of equity beta using monthly data create a smaller sample which is likely to result in a reduced statistical efficiency of the estimates. In addition, estimates using monthly data are also vulnerable to the "day-of-the-week effect". This means that if prices are dependent on the day-of-the-week, then this effect is required to be controlled to ensure that returns are observed on the same weekday (Monday, Tuesday, Wednesday, Thursday, Friday). This effect cannot be controlled when the monthly data is used because a calendar month can end on any day of the week.

In his advice to the AER in 2008, Henry discussed the issue of daily versus monthly estimates.[35] He then concluded that weekly data is an appropriate trade-off between noisy daily data and lack of degrees of freedom (due to smaller samples) using monthly data. In addition, the average of the estimates based on daily data that CEG has presented appears to be comparable to the average of the estimates based on weekly data closing Friday.[36] We therefore conclude that weekly intervals are appropriate for equity beta estimation.

Bootstrap Analysis

In order to ascertain the statistical accuracy of each regression estimator, we have estimated the sampling distribution for each equity beta estimate using the Bootstrap approach. The empirically observed or 'bootstrapped' distributions allow us to more robustly check the statistical accuracy of each robust estimator with respect to the OLS estimator. This also allows more accurate confidence intervals to be calculated between the different estimators, allowing for direct comparisons between each estimation procedure. This is in contrast to the conventional assumption which assumes a t-distribution for the equity beta coefficients.

[34] Henry, O (2008), *Econometric advice and beta estimation*, Advice to the AER, November 2008.

[35] Ibid.

[36] Competition Economists Group, *Regression estimates of equity beta*, September 2013, Figure 3.

Bootstrapping is the statistical procedure by which the sampling distribution of a relevant statistic is estimated by re-sampling the available data.[37] In addition to being able to ascertain the statistical accuracy of estimators, bootstrapping allows theoretical quantities of the sampling distribution to be calculated, such as the median, percentiles and standard error. Bootstrapping is advantageous over traditional statistical analysis in that no parametric assumptions are made regarding the sampling distribution of a statistic.[38] In particular, no assumption regarding the normality of errors is required. This allows us to calculate confidence intervals more robustly, given that the assumptions underpinning traditional regression analysis are violated.

We have used the data from its 2013 analysis for each firm, using a weekly sampling interval ending on Friday for the period of 5 years from 19 April 2008 to 19 April 2013. Exactly 10,000 bootstrap replications were calculated in order to estimate each sampling distribution.

We note that there is no significant bias present within any of the regression estimators as estimated by the bootstrap approach. With respect to the bootstrapped standard error, as presented in Table 12, the OLS estimator has the highest standard error across all estimated firms, with the exception of the LAD estimator for SKI. This means that the OLS estimation procedure exhibits a higher level of imprecision of its estimates relative to the other estimators. This is not a surprising result given the violation of the OLS assumptions, and its tendency to breakdown even due to slight violations of the Gauss-Markov assumptions, as previously discussed.

Confidence intervals calculated using this bootstrap approach are more accurate than the traditional approach, which assume a parametric form regarding the regression coefficients. Confidence intervals calculated using the bootstrap approach are directly comparable across regression estimators, whereas they are not under the traditional approach. As a consequence, it is appropriate to use confidence intervals derived from the bootstrap approach to inform our judgement in relation to the appropriate range for equity beta. The 95 per cent confidence interval using the bootstrapping procedure falls within the range of 0.3 and 0.72 when an average of the end points for each firm are taken.

[37] Fox J (2002), *An R and S-PLUS Companion to Applied Regression,* Appendix p 1, Sage Publishing.

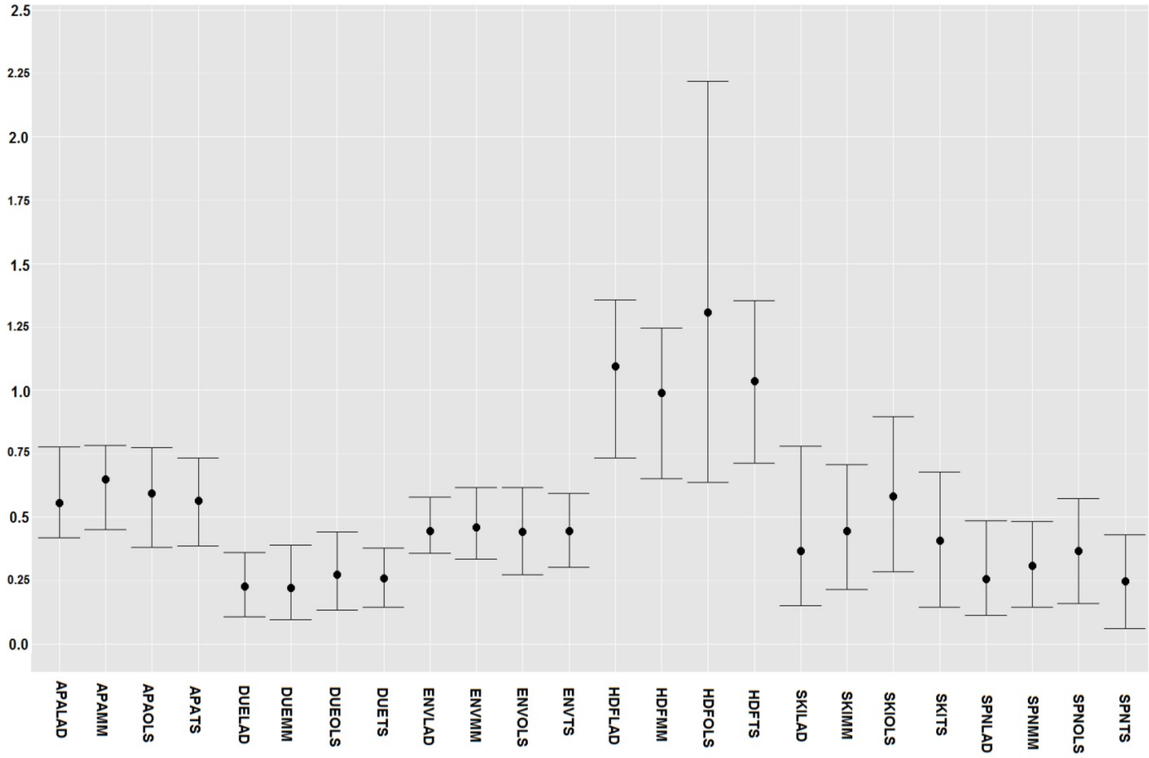
[38] Mooney C.Z, Duval R.D, *Bootstrapping: A Nonparametric Approach to Statistical Inference Issues 94-95,* Sage Publishing, p. 4.

Table 12 Summary of Statistics of Bootstrap Results, B=10,000, n=260

	APA	DUE	ENV	HDF	SKI	SPN
OLS Estimate	**0.5930**	**0.2711**	**0.4425**	**1.308**	**0.5799**	**0.3654**
Mean	0.5891	0.2741	0.4440	1.312	0.5801	0.3638
$bias_B$	-0.0039	0.003	0.0015	0.004	0.0002	-0.0016
Median	0.5938	0.2687	0.4436	1.269	0.5760	0.3620
95% Confidence Interval	[0.380-0.773]	[0.133-0.441]	[0.273-0.616]	[0.636-2.218]	[0.2830-0.8964]	[0.1598-0.5730]
Bootstrapped Standard Error	0.1004	0.0791	0.0862	0.4045	0.1559	0.1042
LAD Estimate	**0.5549**	**0.2262**	**0.4434**	**1.092**	**0.3663**	**0.2562**
Mean	0.5870	0.2224	0.4529	1.0670	0.4039	0.2691
$bias_B$	0.0321	-0.0038	0.0095	-0.025	0.0376	0.0129
Median	0.5771	0.2272	0.4418	1.0900	0.3673	0.2557
95% Confidence Interval	[0.417-0.776]	[0.107-0.360]	[0.358-0.579]	[0.731-1.357]	[0.151-0.779]	[0.113-0.485]
Bootstrapped Standard Error	0.0967	0.0681	0.0611	0.1543	0.1626	0.0997
MM Estimate	**0.6467**	**0.2188**	**0.4589**	**0.9881**	**0.4449**	**0.3087**
Mean	0.6365	0.2266	0.4623	0.9787	0.4484	0.3100
$bias_B$	-0.0102	0.0078	0.0034	-0.0094	0.0035	0.0013
Median	0.6436	0.2207	0.4583	0.9920	0.4424	0.3067
95% Confidence Interval	[0.451-0.782]	[0.0955-0.390]	[0.3322-0.6147]	[0.6510-1.248]	[0.2144-0.7054]	[0.1437-0.4826]
Bootstrapped Standard Error	0.0846	0.0771	0.0698	0.1495	0.1222	0.0854
TS Estimate	**0.5643**	**0.2580**	**0.4456**	**1.036**	**0.4069**	**0.2470**
Mean	0.5617	0.2581	0.4464	1.035	0.4086	0.2469
$bias_B$	-0.0026	0.0001	0.0008	-0.001	0.0017	-0.0001
Median	0.5641	0.2574	0.4458	1.037	0.4070	0.2466
95% Confidence Interval	[0.3858-0.7317]	[0.1452-0.3774]	[0.3023-0.5935]	[0.7107-1.354]	[0.1456-0.6758]	[0.0610-0.4293]
Bootstrapped Standard Error	0.0886	0.0590	0.0733	0.1614	0.1337	0.0936

Source: Authors' analysis

Figure 2 **95 per cent Confidence Intervals and Estimated Coefficient for Equity Beta by Firm and Regression Technique using Bootstrap**



Source: Authors' analysis

Recursive Beta Estimates

There is evidence indicating that equity beta estimates are not constant through time for individual firms or portfolios. In his advice to the AER, Henry produced recursive estimates of portfolio betas and concluded that there is no strong evidence of instability in the estimates of β_i. We has conducted its own analysis of how the equity beta estimate changes through time with respect to firm betas.

We have produced rolling beta estimates for each firm using a weekly sampling interval ending on Friday. This involves recursively estimating the beta estimates by varying the dates included in the calculation. Each estimate of beta is calculated by taking the start date, and the date corresponding to 5 years in the future and using the returns in this interval as the sample. The next equity beta is calculated by incrementing the start and end dates by one month. Beta estimates for each firm are calculated from the point in time where 5 years of data is first available for each firm. The results are presented graphically below:

Figure 3 ENV Rolling Betas, 3/01/2007-19/04/2013

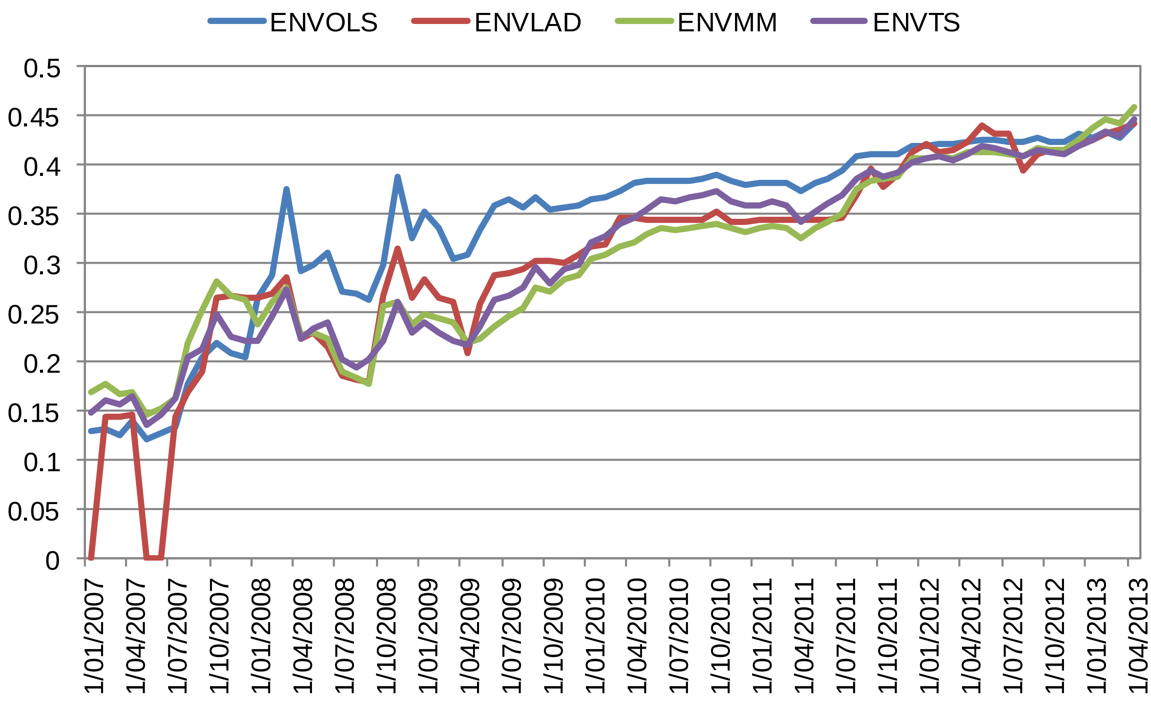


Figure 4 APA Rolling Betas, 3/01/2007-19/04/2013

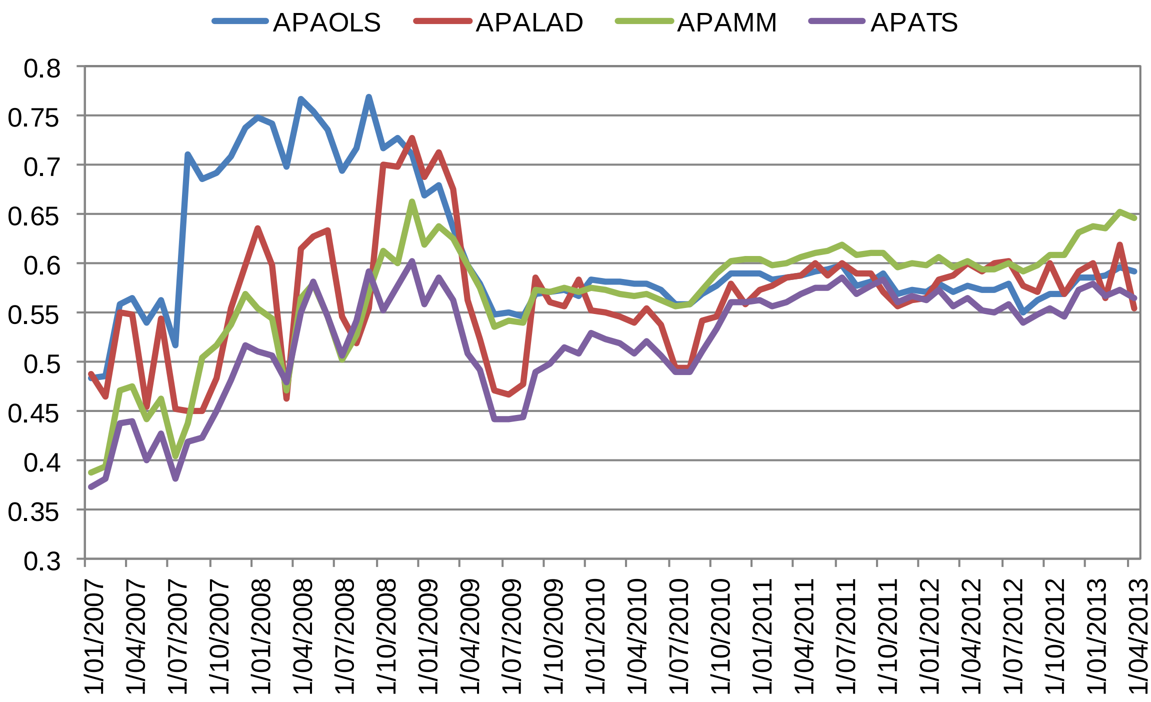


Figure 5 DUE Rolling Betas, 13/08/2009-19/04/2013

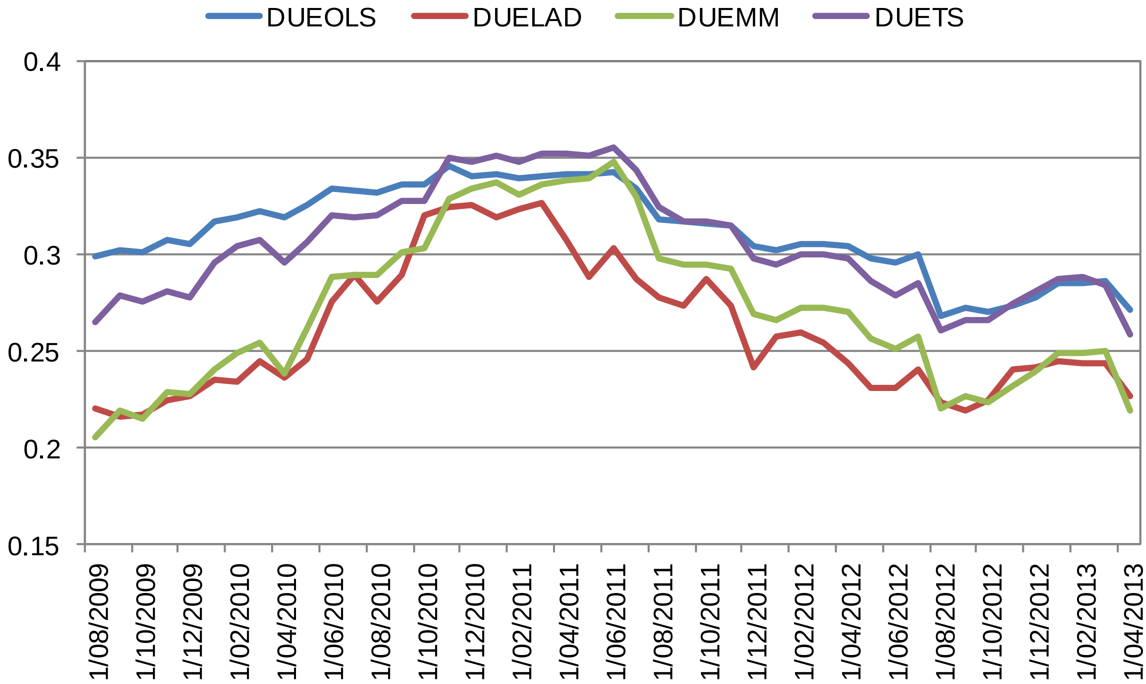


Figure 6 HDF Rolling Betas, 13/12/2009-19/04/2013

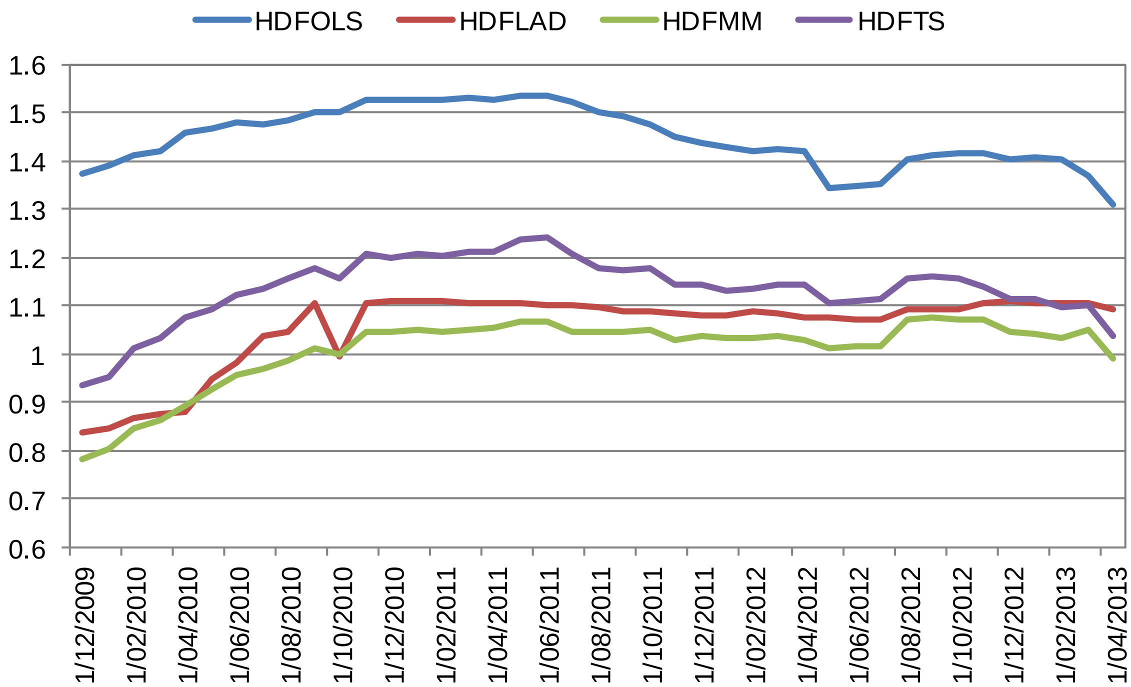


Figure 7 SKI Rolling Betas, 16/12/2010-19/04/2013

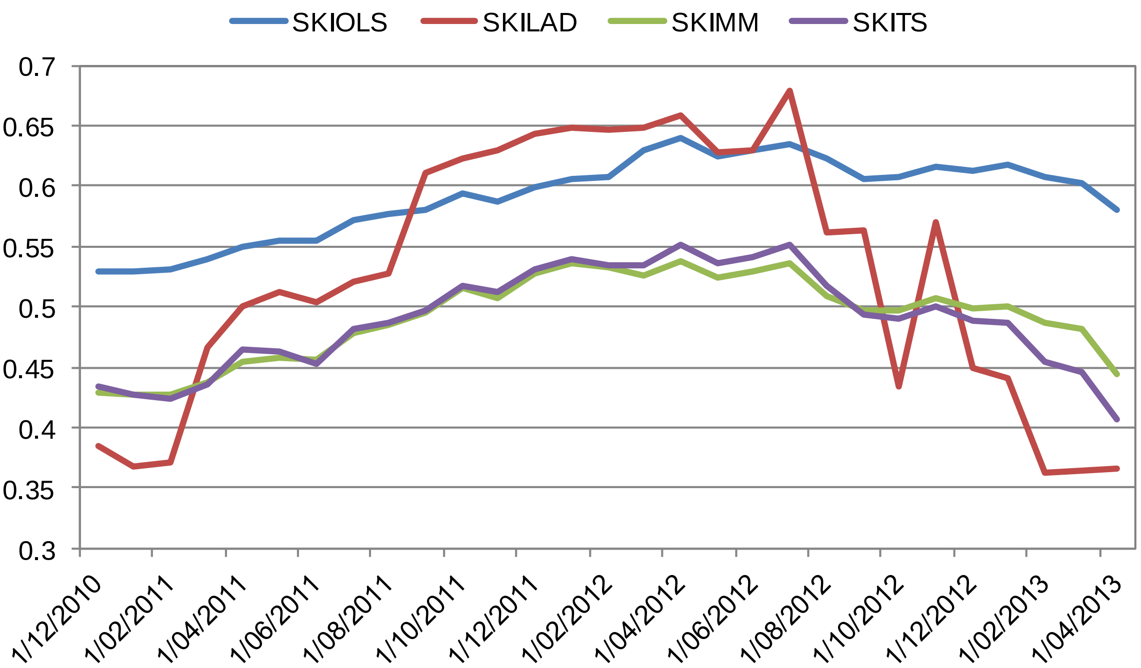
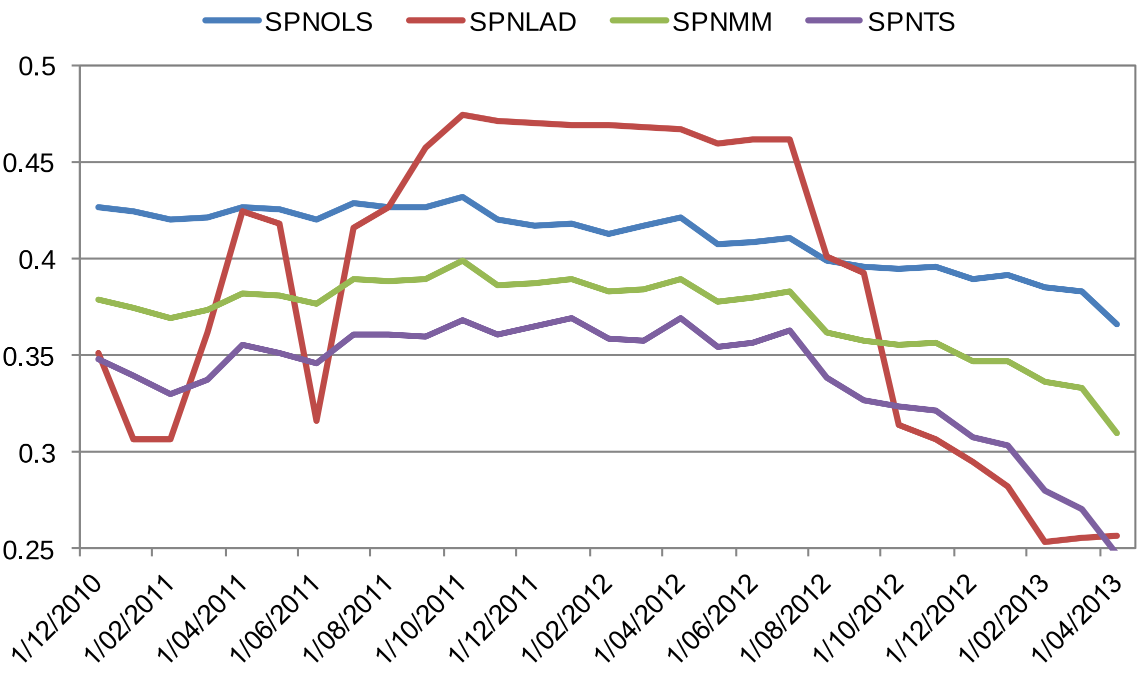


Figure 8 SPN Rolling Betas, 14/12/2010-19/04/2013



Conclusion

This study was conducted in response to an argument raised by Australian regulated businesses that their equity beta should be equal to 1.0. Australian regulators such as the ERA and the AER have agreed that the business risk of Australian regulated businesses is below the market level; however, the financial risk is above the market level. However, both regulators concluded that there is no evidence to confirm that the equity beta for these businesses should be equal to that of the market which is 1.0. As such, empirical study in which an equity beta is estimated is required.

In response to this, we have conducted the empirical study to estimate the equity beta for Australian regulated businesses. We have employed different econometric techniques, from the conventional OLS to LAD; MM and Theil-Sen estimates to derive an appropriate estimate for equity beta. In addition, bootstrapping is also used to test the robustness of the estimates.

Based on our estimates, we conclude that equity beta for Australian regulated businesses is well below 1.0. We also concluded that their argument for the equity beta of 1.0 is not on a reasonable and strong ground. Our estimates indicate that, on average, equity beta for Australian regulated businesses fall within a close range of 0.5 and 0.7.