Review of Regulatory Capital Structure and Asset / Equity Beta for Aurizon Network

Report to the Queensland Competition Authority

9 December 2013

Table of Contents

1. Executive Summary

1.1 Summary of findings

In response to the Scope of Works provided to us by the Queensland Competition Authority, our key findings are as follows:

- Aurizon Network's proposal includes a first principles analysis of its systematic risk that concludes that Aurizon Network exhibits risk characteristics that are similar to those of US Class 1 railroads. We disagree with the findings of this analysis. We undertake a first principles analysis, and conclude that Aurizon Network's systematic risk would be expected to be materially lower than US Class 1 railroads and rather to share many of the systematic risk characteristics of regulated energy and water businesses. We observe that this conclusion is similar to previous findings on this matter by ourselves as well as the Authority.

- Aurizon Network proposed a benchmark gearing level of 55 per cent debt to assets, and we agree with this position. While this figure is slightly below the standard benchmark gearing level of 60 per cent that is applied to regulated energy networks in Australia, the 55 per cent benchmark gearing level is appropriate for Aurizon Network in view of the greater cash flow instability than regulated energy networks that it experiences at times (for example, where a severe weather event affects mine production and increases maintenance costs).

- SFG Consulting, as adviser to Aurizon Network, has estimated Aurizon's asset beta as a weighted average of the beta for regulated energy networks and two transport sectors (Australian industrial transport and US railroads), and has estimated asset betas using conventional methods and also by applying a novel econometric technique. We disagree with the use of the transport sectors as comparable entities given that our first principles analysis suggests that Aurizon Network's systematic risk is much lower than these sectors. SFG's novel method also produces a much higher asset beta estimate for regulated energy networks, which we do not think provides a reliable estimate of the asset beta for that sector (the SFG method has the effect of deriving an estimate of the asset beta for regulated energy networks with reference to an industry classification that is dominated by firms that would be expected to have substantially different systematic risk).[1] We observe that SFG does not conduct a first principles analysis of the systematic risk of Aurizon Network.

- We conclude, based on a sample of 107 firms drawn from a number of regulated and non-regulated industries, that a benchmark asset beta in the range of 0.35 to 0.49 is appropriate to apply to Aurizon Network, with:

  – The bottom of this range (0.35) being defined by independent expert Grant Samuel's assessment of the asset beta of the Dalrymple Bay Coal Terminal (DBCT), which is a

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1 We agree with a key technical issue with beta estimation that SFG did raise. Specifically, SFG observed that materially different beta estimates may be obtained depending upon the date within the month that is used for measuring monthly returns, which can result in aberrant beta estimates. We reached similar findings to SFG on this technical point, and have sought to address this concern by producing beta estimates that reflect an average across the betas that would be estimated by using each day in the month as the end date.

regulated asset in the same coal chain as, and in our view similar systematic risk characteristics to, Aurizon Network;

 – The middle of this range (0.42) being the estimated asset beta of a large international group of regulated energy and water businesses; and

 – The top of this range (0.49) being the estimated asset beta for toll roads, which share some similar risk characteristics to Aurizon Network but, in our view, are subject to significantly more volume (revenue) risk.

- Within this range, our recommended point estimate of the asset beta of Aurizon Network is 0.42, which corresponds to an equity beta of 0.73 for a gearing level of 55 per cent. Our recommended point estimate of 0.42 reflects our view, informed by empirical analysis, that Aurizon Network exhibits many of the systematic risk characteristics of regulated energy and water networks.

1.2 Context and scope of works

The Queensland Competition Authority (QCA or the Authority) has engaged Incenta Economic Consulting (Incenta) to undertake a review of the proposed asset beta, capital structure and equity beta for the regulatory cost of capital of Aurizon Network.

Aurizon Network (formerly QR Network) Pty Ltd, is a subsidiary of Aurizon (formerly QR National) Limited, a vertically integrated rail company which was sold by the Queensland Government in November 2011. The current Aurizon Network access undertaking expires on 30 June 2013 (extended to 30 June 2014), and on 30 April 2013, Aurizon Network submitted a voluntary draft access undertaking (i.e. the 2013 DAU (UT4)) to the Authority for approval. The Aurizon Network's proposed indicative post-tax, nominal vanilla WACC range of 7.27%-8.18% was based on a number of individual parameter ranges, with the ranges of the parameters relevant to the current report being:

- A debt to value of 55 per cent;

- An asset beta range of 0.50 to 0.60; and

- An equity beta range of 0.90 to 1.0.

The Authority has engaged Incenta to provide advice to the Authority on three main issues:

1. An assessment of Aurizon Network's proposal;

2. An appropriate benchmark capital structure; and

3. A recommendation about an appropriate equity beta for Aurizon Network.

In undertaking these tasks, Incenta engaged the services of Associate Professor Joe Hirschberg, a specialist in econometrics within the Department of Economics at the University of Melbourne.

1.3 Assessment of Aurizon Network's proposal

Aurizon Network's first principles analysis

As background to the discussion is this section, it is our view that estimation of the asset beta of Aurizon Network is made difficult by the fact that there are no close stock market comparators for a regulated, below-rail export coal infrastructure provider. It is therefore not possible to select a sample of close market-listed comparators, average their observed asset betas over an appropriate period, and thereby derive an estimate of the asset beta of Aurizon Network. Rather, judgement is required to determine which listed firms or sectors (for which betas are available) are likely to have the closest level of systematic risk to Aurizon Network.

Our key point of disagreement with Aurizon Network's first principles analysis is that it underestimates the effect of regulation in reducing asset beta through the buffering of cash flows, when examined within the context of the sound economics of the Aurizon Network business. Aurizon Network concluded that based on its first principles analysis, US Class 1 railroads should be used as comparators for it, since Aurizon Network concluded that that sectors are similar on a number of systematic risk dimensions. However, we consider that once it is recognised that Aurizon Network's revenues are regulated and reviewed at periodic intervals in line with cost, which is a feature that it has in common with regulated energy and water networks and is not a feature of US Class 1 railroads, most of the points that have been raised by Aurizon Network's first principles analysis are made irrelevant.

- *Nature of regulation* – Aurizon Network proposed that Aurizon Network may be subject to greater regulatory risk than the US Class 1 railroads.

  However, empirical evidence suggests that regulation tends to reduce systematic risk by buffering cash flows (this is known as the 'Peltzman buffering hypothesis'). Regulated firms are also generally exposed to less market risk. This is because their product/service is valuable and they typically face little competition, these characteristics in turn typically being the rationale for applying formal cost-based regulation.

  Aurizon Network also did not explore the impact of regulation on other beta-determining characteristics that may influence Aurizon Network, such as operating leverage, or growth options. Our view is that regulation suppresses the impact of these factors relative to their potential impact on non-regulated businesses. For example, if a regulated firm has high operating leverage, it would also need to have high earnings volatility for that operating leverage to have a strong impact on beta.

- *The mix of demand/traffic* – Aurizon Network noted that North American Class 1 railroads have a more diversified mix of traffic than Aurizon Network, which will provide an element of revenue buffering, and should therefore be seen as valid comparators for Aurizon Network.

  In view of the manner in which Aurizon Network contracts and is regulated, the volatility in its revenue is expected to be much lower than the volatility of its demand (particularly in net present value terms). Even putting aside our views about the buffering nature of regulation, the nature of the traffic carried by Aurizon Network is different to the US and Canadian railroads, and experience shows that in a significant downturn (e.g. the global financial crisis of 2008-09) almost all components of the Class 1 railroads' traffic mix fell in unison. The exception was the Canadian Class 1 railroads' grain traffic, which is determined by weather patterns (rather than economic cycles), and is subject to explicit regulation. By contrast, we show that Aurizon Network's coal traffic has not been related to Australian (or Queensland) economic and stock market cycles.

- *Pricing flexibility* – Aurizon Network stated that the North American Class 1 railroads have far greater pricing flexibility than Aurizon Network, which implies that other things being equal, it could have greater systematic risk than North American Class 1 railroads.

  Aurizon Network has a stable revenue base (especially in NPV terms) due to its take-or-pay contracts and its revenue-cap framework even without pricing flexibility. Whilst we agree that it is generally true that North American Class 1 railroads have greater pricing flexibility than Aurizon Network, this is not relevant in Aurizon Network's circumstances.

- *Duration of contracts* – Aurizon Network assumed that the contract terms of US Class 1 railroads, are 'not known.'

  As discussed above, the key point is that Aurizon Network is regulated in combination with a captive customer base, which are features that distinguish it from Class 1 railroads. Notwithstanding this fact, our discussions with North American investment analysts covering US and Canadian Class 1 railroad stocks indicated that the contract term is typically 1 to 3 years, with up to 5 years in the case of coal. This contrasts with the 10 to 15 year take-or-pay contracts of Aurizon Network, which are staggered and much longer than the typical economic cycle.

- *Market power* – Aurizon Network noted that it clearly has significantly more market power than US Class 1 railroads, but considered that the impact that this might have on asset beta is unclear.

  We consider that Aurizon Network's market power, in the context where its prices are regulated in line with cost, suggests a greater stability of demand (at the regulated price), and lower stranded asset risk, which suggest lower beta risk.[2]

- *Growth options* – Aurizon Network submitted that due to its large expansions in capacity relative to its existing asset base, it has more risky growth options than US Class 1 railroads, which have not been expanding their capital base as quickly.

  The cost-based regulatory regime gives Aurizon Network a high degree of assurance of receiving a commercial return on new investment. When undertaking an expansion Aurizon Network interacts with its customers and other stakeholders (including the QCA) prior to commitment, and the scope of its new capex is approved by the Authority ahead of commitment of funds. Expansions by the US Class 1 railways are not protected by long

[2] An unregulated firm with market power would be expected to raise prices close to the point where substitutes become viable and demand is price elastic, and so generates a sensitivity of cash flow to economic cycles, that is not unlike firms in workably competitive markets. It is for this reason that market power is typically found in empirical studies to have an ambiguous effect on beta.

term take-or-pay contracting and face much greater competition and stranded asset risk. It is therefore of little consequence that during the last decade (and particularly since the global financial crisis) the growth of US Class 1 railroads has been significantly lower than that of Aurizon Network. On this factor the US Class 1 railroads should have higher systematic risk.

- *Operating leverage* – Aurizon Network's submission noted that Aurizon Network has a similar high degree of operating leverage as US Class 1 railways.

  As noted above, we consider that for regulated businesses operating leverage should have a relatively minor impact on asset beta (since it interacts with earnings volatility, which is dampened by regulation). In any event, Aurizon Network provided no evidence to support its view that Aurizon Network has a similar high degree of operating leverage as US Class 1 railways. By contrast, even putting aside our views about the buffering effect of regulation, we show that US Class 1 railroads have relatively higher operating leverage than Aurizon Network based on three different measures.

Our first principles analysis

We consider the key features of Aurizon Network that are important in the determination of its asset beta to be:

- *A regulatory framework that aligns revenue with cost at periodic intervals and that minimises revenue risk during a regulatory period* – Aurizon Network has a regulated asset base (RAB) and is provided with a rate of return on these assets that is updated at periodic reviews in line with current market evidence, thereby limiting its exposure to cost risk and interest rate risk.

- *Underlying economics that imply confidence of recovery of regulated revenues* – The strong underlying economics of Aurizon Network means that there is a high degree of confidence that the revenues promised by the regulatory regime would be received, and that investors will not factor in market-based stranded asset risk – this reduction in stranded asset risk is also reduced by the regulatory regime measures noted below:

  – <u>Surety of long term demand for the service</u> – Queensland's export coal industry possesses many advantages, including relatively low cost open-cut mining, relatively short railway routes to the ports, and ports that are well situated relative to the growing demand for coal in developing Asian economies. Consistent with this, we observe that there is a forecast for overall growth of Queensland coal exports, which indicates a continuing domination of world trade over the next 30 years.

  – <u>A high percentage of traffic under long term take-or-pay contracts</u> – Aurizon Network has fewer customers, and a less diverse mix of customers than the typical regulated energy or water business. However, approximately 70 per cent of Aurizon Network's contracted capacity is based on take-or-pay contracts mostly with terms of 10 to 15 years at signing.

We also consider that asset stranding risk is reduced by Aurizon Network's regulatory framework, which imposes a rolling 20 year asset life for depreciation on new capex, and has resulted in most of the original value of assets at Aurizon Network's privatisation having already been depreciated (i.e. capital has been returned to investors). Furthermore, spur lines to specific mines are paid for by the mines themselves (i.e. they bear the stranding risk).

Overall, our first principles analysis suggests that Aurizon Network's systematic risk is likely to be similar to regulated energy and water businesses, with the key similarity being regulation and review at periodic intervals in line with cost. For example, the resilience of Aurizon Network's cash flows at the time of the Global Financial Crisis (2008-09), and the stable cash flows of regulated energy and water businesses contrasts with the GFC's uniformly negative impact on the cash flows of US Class 1 railroads.

We further observe that when Grant Samuel (the leading Australian firm of independent experts in relation to merger and acquisition transactions) faced a similar issue in not finding close comparators for the Dalrymple Bay Coal Terminal (DBCT), it did not rely on beta evidence for unregulated general cargo ports, but on the fact that DBCT is regulated, and applied an asset beta that was lower than the values it applied to regulated energy networks. We therefore take comfort that our approach is not dissimilar to that applied in similar circumstances by financial market practitioners more widely.

SFG's econometric analysis

SFG submitted that an asset beta of 0.55 is an appropriate estimate for Aurizon Network (assuming a Conine de-levering/re-levering method and a debt beta of 0.12), which translates to an equity beta of 1.0 at a gearing level of 55 per cent.[3] Unlike Aurizon Network's submission, SFG did not provide a first principles analysis of Aurizon Network relative to its chosen comparator groups, and included only a very brief discussion of the relative characteristics of Aurizon Network and the comparator industries. SFG stated that:[4]

> QR Network [i.e. Aurizon Network] shares a characteristic of the energy network businesses, in that it is a single operator of a network business subject to a similar regulatory regime. But revenue for these comparator firms is driven by an entirely different customer segment. It also shares a characteristic of the transportation firms, namely a *broadly* similar customer base and product, but is not exposed to the risks associated with the unregulated segments of the listed businesses. The substantially different capital structures of these industry sectors suggests that their underlying risks are, in fact, different. What is unclear is just how similar the systematic risk of QR Network is to either sector.

However, having identified the key question for analysis, given that there are no listed close comparators for Aurizon Network, and having noted that Aurizon Network is 'not exposed to the risks associated with the unregulated segments of the listed businesses,' SFG did not investigate these issues at all. Instead of examining the fundamental beta-determining characteristics of Aurizon Network, and comparing these to various reference firms and industries, SFG simply calculated a beta estimate based on applying different weights to its chosen comparator industries: Australian listed energy networks; Australian listed transport businesses; and US Class 1 railroads.[5]

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3 SFG (31 August, 2012), *Systematic risk of QR Network*, p.5.
4 SFG (31 August, 2012), p.3.
5 That is, SFG calculated weighted averages of beta estimates by applying weights of 50 per cent or 100 per cent to the results obtained with different methodologies (i.e. the conventional approach vs SFG's alternative methodologies) and alternative industry comparator groups (i.e. Australian regulated energy vs Australian Industrial Transportation and US railroads).

Turning to SFG's empirical work, it derived beta estimates for its chosen comparator industries using a conventional estimation technique (i.e. ordinary least squares regression), and also applied two new approaches (with these new approaches closely related) to derive these estimates. SFG then applied weights to all of the different estimates to derive its proposed asset beta. We summarise first SFG's method, and then provide our observations.

SFG's conventional (OLS) regression approach

SFG applied Ordinary Least Squares (OLS) regression using monthly data, but submitted that the definition of a 'month' as the last day of a calendar month is arbitrary. SFG found that if different start dates are applied (i.e. different definitions of a 'month'), widely varying beta estimates can be obtained. Hence, SFG repeated the OLS regression analysis 20 times using 20 different starting days, and took the average of these 20 beta estimates as its overall beta estimate.

SFG's alternative estimation techniques – pooled and fitted regressions

SFG also undertook a substantial empirical exercise that involved estimating an equation for predicting the beta for a particular firm according to four characteristics of that firm, being the industry within which it resided, size (measured as the market capitalisation at that point), the book/market ratio, and gearing. Two methods were applied to derive such an equation, which were labelled as the 'pooled' approach and 'fitted' approach;[6] however, they delivered similar results. SFG then inserted the average characteristics of its target comparable industries (i.e., Australian energy networks, Australian Industrial Transportation and US Railroads) to derive an alternative beta estimate for these industries.[7]

The results that SFG obtained are summarised in Table 1.1 below.

Table 1.1: Summary of beta estimates (SFG)

	Equity beta			Asset beta			Re-levered to 60%		
	Conv[a)]	Pooled	Fitted	Conv	Pooled	Fitted	Conv	Pooled	Fitted
Aust. energy networks	0.54	0.87	0.82	0.35	0.52	0.49	0.59	0.93	0.88
Aust. Industrial Transportation	0.82	0.78	0.80	0.67	0.65	0.66	1.25	1.21	1.23
US Railroads	0.99	0.96	0.99	0.78	0.75	0.78	1.47	1.42	1.48

Source: Adapted from SFG (31 August, 2012), p. 4. Notes; a) Denotes the 'conventional' ordinary least squares methodology.

6 The "pooled" approach involved estimating the relevant equation directly, i.e., by regressing the excess returns for a large sample of stocks against the relevant explanatory variables. For the fitted approach, beta estimates for the sample of stocks were first derived and then these estimates (converted into percentiles in order to reduce the statistical noise) were used as the explanatory variable in a second stage, that is, where the relationship between the beta estimates and the four firm characteristics was estimated. The relevant equations were also estimated for different days of the month, following the approach used for the conventional estimates.

7 The sample for the pooled and fitted approaches spanned all Australian firms (which amounted to 2,400 in all) and spanned the period since 1976, with 138 months (11.5 years) of observations available for each firm, on average. A sample of 192 US Transport Industry firms was employed by SFG, but the period of analysis is not clear.

SFG's use of its beta estimates

Based on its analysis of the three industry groups examined, and the alternative estimation methodologies applied (i.e. conventional vs the alternative methodologies), SFG concluded that an asset beta of 0.55 is justified as follows:

- If 100 per cent weight were to be accorded to the Australian listed energy networks using the conventional technique, the asset beta estimate is 0.35 and the re-levered beta estimate is 0.59;
- If 100 per cent weight were to be placed on the conventional technique, with 50 per cent weight placed on Australian listed energy network companies and the remaining 50 per cent with equal weight to Australian industrial transportation firms and US listed railroads, an asset beta of 0.54 is obtained, with an equity beta estimate of 0.98; and
- If 50 per cent weight is given to the conventional technique, with 50 per cent weight to Australian listed energy network companies, and the remaining 50 per cent with equal weight to Australian industrial transportation firms and US listed railroads, an asset beta of 0.57 is obtained, with an equity beta estimate of 1.05.

That is, SFG considered it to be unreasonable to place 100 per cent weight on the beta estimates for 9 Australian energy networks, and that if significant weight is placed on the other two industries (i.e. Australian Industrial Transportation and US listed railroads), a weighted average asset beta range of 0.54 to 0.57 is obtained, which SFG rounds to an average asset beta estimate of 0.55 (which implies an equity beta of 1).

Our observations on SFG's beta estimation methodology

First, for the reasons that we have already summarised above, we do not think that either Australian Industrial Transportation broadly defined, or US Railroads, should be used as a comparator for Aurizon Network. We therefore disagree that any weight should be applied to these industries. Rather, we consider that their relevance can be discounted with first-principles analysis and associated empirical work which SFG has not undertaken. We further note that our views on this matter are consistent with the Authority's views in previous reviews.[8]

Turning to the asset beta for regulated energy networks, there is a substantial difference between the asset beta depending upon whether a conventional method is applied (0.34) and the alternative methods (0.52 or 0.49). However, this difference arises because under the alternative method, the Australian regulated energy networks are assigned an industry classification that was dominated by firms that were not comparable to regulated energy networks or to Aurizon Network.[9] We do not consider that SFG's alternative method therefore results in a valid estimate of the asset beta for a regulated energy network.

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8 QCA (July, 2005), *QR's 2005 Draft Access Undertaking*; QCA (June, 2010), *Draft Decision, QR National's 2010 DAU – Tariffs and Schedule F.*

9 We obtained the current composition of the industry classifications from FTSE in London and discuss it further in the text. We observe here that the industry to which regulated energy networks were assigned contains a disparate collection of firms that includes a firm that owns unregulated gas-fired generators in Indonesia.

Indeed, we observe that the alternative method that SFG employed produced asset betas that were materially similar to what would be obtained by simply taking an average of the firms that were contained in the relevant industry classification. This is because, of the four firm characteristics that SFG used to predict the beta, the effect of the industry classification dominated, and the remaining factors had little effect on the predicted beta. As the Australian Industrial Transportation and US Railroad firms were given an industry classification that contained very similar firms, the conventional and alternative methods delivered very similar results. However, as the Australian regulated energy networks were assigned an industry classification that included very different firms, the alternative method produced a very different asset beta, but only because the estimate was based upon an industry classification that was dominated by non-comparable firms.[10]

Having said that, we agree with two methodological comments in SFG's report.

First, one of SFG's criticisms of the previous estimation of the asset beta for Aurizon Network is that the asset beta estimate for a regulated energy network – which had been used as a key comparable for Aurizon Network – had been estimated on the basis of a fairly small sample of Australian-only firms. We have accepted this point and have responded to it by estimating the asset beta for a regulated energy network on the basis of a wider sample of firms (i.e., one that includes overseas firms). Widening the sample in this manner results in a higher asset beta estimate for regulated energy networks than what SFG obtained for Australian firms alone (0.42 compared to 0.35).

Secondly, we agree with SFG's proposal that there is merit to estimating beta by reference to more than one definition of 'a month'. SFG submitted that selecting the last day of the month is arbitrary, and that a more accurate estimate is obtained by averaging betas estimated from 20 different starting days in the month, and we note that the 'turn of the month effect' is recognised as a 'puzzle' in the literature. Our view is that a more accurate way of dealing with the 'turn of the month effect' is to randomise the choice of the number of days in the months during the estimation period based on the frequency distribution of actual trading days observed over time in calendar 'months'. However, we note that undertaking a simulation that generates 4,995 beta estimations using these 'simulated months', we obtained estimates that on average (i.e. for all firms in our original sample) were relatively close to estimates obtained using SFG's much simpler 20 day month assumption.

1.4 Assessment of Aurizon Network's benchmark capital structure

Sample selection

We use the same sample of firms to assess the appropriate capital structure for Aurizon Network as we do for the beta, and so discuss the process that we adopt for both purposes in this section.

The last time the Authority assessed the beta of Aurizon Network (then QR-Network), its adviser reviewed the betas of firms in Australian energy transmission and distribution, the Australian and New Zealand transport industries, US and Canadian railroads, and US and Australian coal miners, with a final sample of 34 (non-energy network) firms.[11] In selecting our sample, we began with the

[10] We also raise in the body of the report a number of technical questions with SFG's alternative methods; however, these are secondary to the matters summarised in this section.

[11] Allen Consulting Group (June 2009), *Queensland below rail network – Update of cost of capital parameters*, Final report to the Queensland Competition Authority, p.2.

proposition that the main characteristics of Aurizon Network are that it operates a regulated below-rail infrastructure network to facilitate the export of coal. Hence the key characteristics are:

- Regulated
- Infrastructure
- Rail
- Network
- Coal (exports)

In Table 1.2 we set out a number of industry sectors that share some of the characteristics that are relevant to the key characteristics of Aurizon Network. With respect to regulation, only the energy and water networks are regulated in a manner that is comparable to Aurizon Network (i.e. cost regulation and regular reviews, which buffers the earnings of the firm). Regulation of the other firms/industries is either absent (coal), light-handed, or non-constraining.

As noted above, SFG criticised the Authority for its reliance on a small number of Australian regulated energy networks in its last decision on Aurizon Network.[12] We have therefore widened the sample of regulated network businesses considerably, to include a large number of regulated energy and water network businesses in Australia, North America, New Zealand and the UK. The majority of the regulated energy businesses are the same firms employed by SFG in its recent analysis of beta for this sector.[13] Our original sample also included coal mining firms and four specific transport industries (railroads, ports, airports and tollroads).[14] We did not include Aurizon Limited in the sample, as it does not fit neatly into any of these industries, is comprised of substantial regulated and unregulated activities, and has only been listed since 2011 (which provides too few monthly return observations).[15]

Our original sample of 155 firms was reduced to a sample of 107 firms through a screening process that excluded firms with inappropriate operations (i.e. not in line with the industry description), had less than 50 per cent of their revenue regulated (in the case of energy and water), and/or had a market capitalisation less than $400 million. In summary, compared with the 34 company sample that was used in the Authority's last assessment of Aurizon Network's beta, our 107 company sample is larger, is comprised of larger firms (which are more comparable to Aurizon Network), and includes firms arranged in more specifically defined transport industries.

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12 SFG (31 August, 2012), p.12.

13 SFG (24 June, 2013), *Regression-based estimates of risk parameters for the benchmark firm*, p.10

14 Only three ports passed the screening process, and these were not considered to be enough to derive a reliable industry average beta and other firm characteristics.

15 Again, for Aurizon Limited we do provide estimates of beta and other firm characteristics for comparative purposes.

Table 1.2: Aurizon Network's key characteristics vs reference industries/firms

Industry	Regulated	Infrastructure	Railroad	Network	Coal mining
Transport:					
Railroad (Class 1)	×	√	√	√	×
Airport	×a)	√	×	×	×
Tollroad	√b)	√	×	×	×
Non-transport:					
Coal mining	×	×	×	×	√
Regulated Energy	√	√	×	√	×
Regulated Water	√	√	×	√	×

Source: Incenta. Notes: a) While airports are subject to varying degrees of light-handed regulation, they often have substantial unregulated operations. B) While tollroad prices are fixed, they are generally not subject to a periodic review whereby revenues are realigned with cost, creating an exposure to fluctuations in demand.

The key qualitative risk factors that we have identified as applicable to these industries, and on our assessment, to Aurizon Network, are set out in Table 1.3, which reflects the discussion and evidence that we provide in our first principles analysis that was summarised above. The key point in the table is that on the major risk factors, Aurizon Network is expected to be most similar to regulated energy and water businesses.

Table 1.3: Aurizon Network vs reference industries – qualitative risk factors

	Regulation	Contracting	Revenue risk	Opex risk	Stranding risk
Coal	None	Volume contracts	Volatile coal price	Cost structure dependent	Cost structure dependent
Rail (Class 1)	Not constraining	1-3 year contracts	Sensitive to economy	High	Potentially on some spurs
Airport	Monitoring	n.a.	Sensitive to economy	Medium	Low
Tollroad	Price (without periodic review)	n.a.	Less sensitive	Medium	Potential by-pass
Energy	Regulated (price/revenue cap/ cos)	n.a.	Less sensitive	Medium	Low
Water	Regulated (price/revenue cap/ cos)	n.a.	Unrelated to economy	Medium	Low
Aurizon Network	Regulated (u/o revenue cap)	10-15 year TOP contracts	Unrelated to economy	Low	Low

Source: Bloomberg and Incenta. Note: Asset beta is median 10 year simulated month asset beta with debt beta of 0.12.

Taking account of the qualitative and quantitative analysis, although they are not the ideal reference points (i.e. comparators), and as concluded by the Authority in its previous regulatory reviews of Aurizon Network's predecessor, Queensland Rail's below-rail (coal) Network, we consider that regulated energy and water businesses do provide the most relevant benchmark against which Aurizon Network's systematic risk should be judged.

Benchmark capital structure

Aurizon Network's submission proposed the continued application of the benchmark gearing level of 55 per cent that has previously been adopted by the Authority. We note that this level is slightly less than the 60 per cent gearing level that is widely applied in the regulation of energy and water networks in Australia. One of the key determinants of capital structure, is the potential for default due to earnings fluctuations, and in particular through a sudden downward shock to earnings. In Table 1.4 we have arranged the observed median gearing levels of the six reference industries, as well as the observed median earnings volatility (coefficient of variation in EBIT over the trailing 5 years), and change in earnings (change in EBIT between 2008 and 2009) during the global financial crisis.

Apart from the airport industry, it is apparent that those industries with less down-market EBIT sensitivity have higher gearing levels. Aurizon Network has experienced some EBIT volatility in recent years. From 2008 to 2009 Aurizon Network's EBIT increased strongly, as it was in the middle of a strong capex phase. However, even if Aurizon Network's EBIT were to dip unexpectedly, as it did in 2011 due to the disruption of the Queensland floods, market investors (and banks in particular) know that most users are committed to take-or-pay contracts, and that the revenue-cap will restore earnings within two years.[16] Hence, despite the possibility of some EBIT volatility, Aurizon Network is in a strong position to take on more debt than the average firm, and would potentially be able to support more than 55 per cent debt. On the other hand, Aurizon Network is potentially subject to more earnings volatility than Australian energy networks (which have a benchmark gearing level of 60 per cent), and on this basis the application of a slightly lower benchmark gearing level of 55 per cent may be more appropriate.

Table 1.4: Capital structures by industry, 2009 to 2012

Industry	Median Net gearing	Median Gross gearing	Median CoV EBIT	Average Delta EBIT 2008-09	Standard Error of Delta EBIT	Median Delta EBIT 2008-09
Tollroad	53%	59%	0.176	41.7%	47.9%	3.2%
Airport	47%	50%	0.179	-24.6%	17.0%	-14.4%
Energy	46%	46%	0.136	4.9%	3.6%	4.4%
Water	39%	40%	0.100	5.1%	3.8%	5.2%
Railroad	22%	23%	0.184	-28.5%	7.8%	-22.7%
Coal mining	19%	24%	0.414	64.5%	54.0%	42.5%

Source: Bloomberg data, and Incenta's analysis. Note: CoV refers to the Coefficient of Variation, which is the Standard Deviation of EBIT divided by the average EBIT over the period. Delta EBIT is the percentage change in EBIT between 2008 and 2009.

When Aurizon was privatised in 2011, it did not have a commercial capital structure. On May 13, 2013, however, the firm announced that it would be implementing a new long-term capital structure, with $3 billion of new committed debt facilities placed at the Aurizon Network level, which are 'supported by the below rail regulated infrastructure assets.' With $2.2 billion to be drawn initially, and a current RAB value of approximately $4.8 billion, Aurizon has noted that the 'Network's gearing

16 See Standard & Poor's (15 May, 2013), *Ratings Direct: Aurizon Network Pty Ltd*, p.5, which dismisses any short term variability in earnings during a regulatory period owing to the revenue-cap mechanism.

levels will be broadly consistent with the regulator's assumption of 55% Debt/RAB.'[17] At the same time, Aurizon Network has obtained credit ratings from Moody's (Baa1 stable) and Standard & Poor's (BBB+ stable), which accord with the current regulatory assumption. On balance, we consider that a 55 per cent benchmark gearing level is appropriate for Aurizon Network.

1.5 Estimate of Aurizon Network's beta

Our approach has been to first estimate the benchmark betas for the identified reference industries, and apply our first principles analysis of Aurizon Network relative to the reference industries in order to select an appropriate beta.

Industry beta analysis

The average (and median) betas for the final sample of firms identified in our industry groupings are displayed in Table 1.5.[18] Our beta estimates apply the standard approach of applying the ordinary least squares regression method,[19] but are based on an intensive use of daily share price data in order to provide an estimate that reflects the average of the betas that would be estimated from using each day of the month as the end date for measuring monthly returns (although we used "simulated months" that were based upon the observed distribution of days in each month, which we refer in this text as using simulated months (SIM)). We also report the beta estimates that are derived from using returns measured only to the end of each month for comparison purposes, and observe that the use of simulated months appears to have reduced some of the random variability in beta estimates that apply a single definition of a month.[20]

Whether applying 10 year estimates, or more recent estimates based on 60 months of data, the regulated energy and water companies in our sample were in a range of 0.40 to 0.42 for a debt beta assumption of 0.12. These estimates were approximately 5 points (0.05) higher than the conventional estimates for these industries. The asset beta estimates for regulated energy and water (approximately 0.40 to 0.42) were between 8 to 10 points (0.08 to 0.10) and 50 points (0.50) lower than for the three unregulated transport industries (i.e. tollroads, airports and US/Canadian Class 1 railroads). The highest asset beta (approximately 1.20 to 1.35) was observed for the coal mining industry. Hence, our results suggest that the regulated network infrastructure industries (energy and water) have materially lower systematic risk than the unregulated transport industries, the latter of which in turn have material differences amongst them.

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17 Aurizon (May, 2013), *Further Information on Aurizon Network*, p.8.

18 Note that the total number of firms in these industry groupings is 107. The single firm we have not included here (but have included in the regression analysis) is Asciano, since it is not a Class 1 Railroad, and also has port as well as rail operations.

19 That is, we regress the dependent variable (individual stock returns in excess of the risk free rate), against the independent variable (the market's returns in excess of the risk free rate).

20 The 97.5 per cent confidence interval around the beta estimate for the total sample has reduced from ±0.188 using one definition of the end of the month, to ±0.155 using the SIM beta estimation approach.

Table 1.5: Asset beta estimates by industry and firm (median values) to June 2013

Asset beta estimate	No. of firms	Conventional asset beta		SIM asset beta	
Observations (maximum months)		117	117	117	117
		Mean	**Median**	Mean	**Median**
Coal	10	1.20	**1.29**	1.26	**1.35**
Rail	7	0.89	**0.99**	0.93	**0.89**
Airport	6	0.70	**0.67**	0.65	**0.63**
Tollroad	7	0.47	**0.49**	0.49	**0.49**
Energy	70	0.36	**0.34**	0.41	**0.42**
Water	7	0.34	**0.35**	0.41	**0.40**

Source: Data obtained from Bloomberg, Incenta analysis

Evidence from independent experts

We also searched for evidence from financial practitioners regarding beta estimates for similar firms, and the approach adopted when there are no close comparators for the firm being assessed. As noted above, independent expert Grant Samuel did not consider general commercial ports to be appropriate comparators for the regulated DBCT coal export port. Instead, based on its regulatory framework, DBCT was estimated to have a geared (at 60 per cent to 70 per cent) equity beta in the range of 0.70 to 0.80, which translates to an equivalent asset beta estimate of 0.35 if the Conine formula is applied with a debt beta assumption of 0.12.[21] This was less than the approximately 0.42 asset beta (using the same assumptions) that Grant Samuel applied to value Prime Infrastructure's stake in Powerco, a New Zealand regulated gas and electricity distribution business.[22]

Estimated beta range for Aurizon Network

In summary, we consider that an asset beta range of 0.35 to 0.49 is appropriate for Aurizon Network, based on the Conine formula and a debt beta of 0.12. Our estimated asset beta range is based on the following observations:

- *Tollroads* – The 0.49 asset beta estimate for tollroads defines the upper bound of the range. The tolls for tollroads are typically prescribed but not subject to period review (often set as the outcome of an initial tendering process), and as such are more subject to cyclical economic activity than Aurizon Network, and are subject to greater asset stranding risk.

- *Regulated energy or water network businesses* – Our preferred asset beta estimate of 0.42 for Aurizon Network reflects the fact that it shares many of the systematic risk characteristics of regulated energy and water networks.

- *Grant Samuel's beta estimate for DBCT* – As noted above, in 2010 Grant Samuel's independent expert report on the assets of Prime Infrastructure applied an asset beta of 0.35 to DBCT (when

21 While Grant Samuel used Asciano as the only identified comparator for DBCT, it decided to apply an asset beta to DBCT that was significantly less than the asset beta of Asciano; i.e. it did not use Asciano's beta as a guide to what beta should be applied to DBCT.

22 Grant Samuel (24 September, 2010), *Proposal from Brookfield Infrastructure Partners L.P.*, Independent Expert report addressed to the board of directors of Prime Infrastructure Holdings Limited.

adjusted for a debt beta of 0.12), a coal export port that is in the same Queensland coal supply chain and regulated in a similar manner as Aurizon Network.

Our best estimate of Aurizon Network's asset beta, 0.42, translates into an equity beta of 0.73 for the assumed benchmark gearing level of 55 per cent (and using a debt beta assumption of 0.12 and the Conine de-levering/re-levering formula). This is equivalent to a 60 per cent geared equity beta of 0.80, which is the value currently applied to regulated energy transmission and distribution businesses by the AER.[23]

Impact of form of regulation

The Authority also asked us to investigate the question of whether the form of regulation is likely to affect the asset beta of a regulated firm. We observe that the reference to form of regulation relates to two attributes of regulatory regimes, namely the question of the degree to which a firm is able to be rewarded or penalised depending upon its ability to control cost (often referred to as the degree of incentive power in the regime) as well as the question of the form of price control that applies to the firm and the consequent degree of volume-related revenue risk that is borne between periodic reviews (with the bookends being price caps and revenue caps).

The hypothesis that the form of regulation can be expected to have a significant effect on asset beta can be derived from a formulation of asset beta that de-composes beta into a revenue beta and a variable cost beta.[24] Other things being equal, under this hypothesis it would be expected that a change in the revenue beta due to the operation of an alternative form of regulation would result in a significant change in asset beta.

The alternative hypothesis is that the revenue and cost beta are only components of the firm's total beta. The work of Campbell and Shiller (1988), Campbell and Mei (1993), and Campbell and Voulteenaho (2004) characterised beta as being composed of a cash flow component and a discount rate component, with the latter being more important, and particularly for regulated utilities.[25] Hence, the alternative hypothesis would propose that the form of regulation would not be expected to have a significant impact on asset beta, since it would be expected to act mainly on the cash flow beta, and this is a relatively small determinant of the overall beta of a regulated utility.

An early analysis of different regulatory frameworks undertaken by Alexander, Mayer and Weeds (1996) found that regimes with high-powered incentives (UK price-cap regulation) showed higher betas than low-powered (US cost of service) regimes.[26] While Grout and Zalewska (2006) found that

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23 We note that in a recent discussion paper, the AER has flagged a preference for a potential future application of a 60 per cent geared equity beta of 0.70 for energy transmission and distribution (see AER, (October, 2013), *Better Regulation – Equity beta issues paper*). However, this value is yet to be applied.

24 Brealey, R., S. Myers, G. Partington and D. Robinson, (2000), *Principles of Corporate Finance*, McGraw-Hill.

25 Campbell, J.W., R. Shiller (1988), 'The Dividend-Price ratio and Expectations of Future Dividends and Discount Factors', *Review of Financial Studies*, 1, pp. 195-228; Campbell, J.W., and Mei (1993), 'Where do betas come from? Asset pricing dynamics and the sources of systematic risk', *Review of Financial Studies*, 1, No. 2, pp. 195-228; and Campbell, J.W. and T. Vuolteenaho, (December, 2004), 'Bad beta, Good beta', *The American Economic Review*, Vol. 94, No. 5, pp. 1249-1275.

26 Alexander, I., C. Mayer and H. Weeds, (December, 1996), *Regulatory structure and risk: An international comparison*, The World Bank Policy Research Working Paper No 1698.

discussions about moving from an incentive regulation to a profit sharing regulatory framework in the UK was associated with a fall in beta, there are issues in the interpretation of these results.[27] A much more extensive recent international study by Gaggero (2012) could not find any consistent differences in beta for different forms of regulation (including price cap vs revenue cap),[28] and a recent review by Rothballer (2012) suggests that an effect will only become apparent when regulation is free of political interference.[29]

In order to test the hypothesis that form of regulation has a significant impact on asset beta, we classified each of the 70 firms in our regulated energy sample into the following regulatory forms: price-cap, revenue-cap, cost of service, decoupled cost of service, and incentive-based cost of service. De-coupling is a form of revenue-cap regulation that has been introduced in the US, with the term 'de-couple' referring to the fact that the volume of energy transported/sold is made independent of the revenue that is earned, which has the same effect as applying a revenue cap.[30]

Table 1.6 below shows that we could not find a discernable difference between the 60 month asset betas of the alternative regulatory forms in North America – all three regulatory forms had an average/median asset beta in the range of 0.40 to 0.43. Outside of North America there were relatively fewer firms (9), but even so there was relatively little difference between price cap and revenue cap firms (i.e. the 3 revenue cap firms had a slightly higher average asset beta, and a slightly lower median beta than the price-cap firms).

Table 1.6: Form of regulation and asset beta (2012)

	All firms	Price-cap	Revenue-cap	Decoupled	Cost of service	Incentive
Countries		Australia, NZ and UK			US and Canada	
No. of firms	70	6	3	23	37	21
Average beta	0.40	0.31	0.32	0.40	0.43	0.41
Median beta	0.41	0.31	0.27	0.40	0.42	0.43

Source: Bloomberg and Incenta. Note: Total number of firms does not add across, as there were some decoupled firms that are also described as operating under an incentive framework.

The fact that alternative regulatory forms do not appear to influence systematic risk could be considered to provide support for the hypothesis of Campbell and Mei (1993). Their results imply that the asset beta of price-regulated businesses would not be expected to be materially affected by the extent of volatility in cash flow, for example, as may be associated with the choice between a price cap and revenue cap, but is more affected by the extent of excess return risk that is borne (i.e. the

27 Grout, P.A. and A. Zalewska (2006), 'The impact of regulation on market risk', *Journal of Financial Economics*, Vol. 80 (1), pp.149-184.

28 Gaggero, A. (2010), 'Regulation and Risk: A Cross-Country Survey of Regulated Companies,' *Bulletin of Economic Research*, pp.1-13.

29 Rothballer, Christoph (2012), *Infrastructure Investment Characteristics: Risk, Regulation, and Inflation Hedging*, Doctoral Thesis, Technical University of Munich.

30 While it has been submitted by some US regulators that the regulated ROE should be reduced in the case where there is 'de-coupling' owing to an asserted reduction in risk, very few regulators have done this, and a study by the Brattle Group has found no evidence that decoupling is associated with a lower estimated cost of equity: See, The Brattle Group, (March, 2011), *The Impact of Decoupling on the Cost of Capital – An Empirical Investigation*, Discussion Paper.

tendency for movements in the risk premium element of the discount rate applied by investors to be inversely related to market cycles, and thereby generate a pro-cyclical movement in asset values). [31]

Conclusion on Aurizon Network's asset and equity beta

Based on our review of the evidence, we conclude that, assuming the application of the Conine formula, and a debt beta of 0.12, an asset beta rage of 0.35 to 0.49 is appropriate for Aurizon Network. With a benchmark gearing assumption of 55 per cent, this translates to an equity beta range of 0.59 to 0.87. Within this range, the mid-point asset beta of 0.42 (equity beta of 0.73 with 55 per cent gearing) is our preferred point value estimate, as this corresponds with the asset beta estimate observed for a large international sample of regulated energy and water network businesses.

[31] We note that Chen and Zhao (2009) have questioned the relative size of the cash flow beta, which has been estimated as the residual after direct estimation of the discount rate beta (which itself is imprecise), however, their results are also consistent with the view that temporal variation in the equity risk premium is an important determinant of aggregate returns. See Chen, L. and X. Zhao, (2009), 'Return Decomposition', *The Review of Financial Studies*, Volume 22, No. 12, p.5245.

2. Terms of Reference and outline of report

2.1 Background

Aurizon Network (formerly QR Network) Pty Ltd, is a subsidiary of Aurizon (formerly QR National) Limited, a vertically integrated rail company which was sold by the Queensland Government in November 2011. The current Aurizon Network access undertaking expires on 30 June 2013 (extended to 30 June 2014), and on 30 April 2013, Aurizon Network submitted a voluntary draft access undertaking (i.e. the 2013 DAU (UT4)) to the Authority for approval. Aurizon Network's proposed indicative post -tax, nominal vanilla WACC range of 7.27% - 8.18%was based on a number of individual parameter ranges, with the ranges of the parameters relevant to the current report being:

- A debt to value of 55 per cent;
- An asset beta range of 0.50 to 0.60; and
- An equity beta range of 0.90 to 1.0.

2.2 Terms of reference

The Authority has engaged Incenta to provide advice to the Authority in relation to the following matters.

Task A.1: Assessment of Aurizon Network's Proposal

Aurizon Network has proposed an asset beta range of 0.5-0.6. Estimates from this range represent an increase from the estimate of 0.45 that the Authority approved for the asset beta in UT3. Aurizon Network justifies its proposed range of estimates, inter alia, on the basis of:

- A 'first principles' review of the Aurizon Network's systematic risk profile, where 'first principles' involves consideration of factors that can affect systematic risk and are therefore used to identify relevant comparators. As set out by Lally (2004), these include: nature of the product or service, nature of the customer, pricing structure, duration of contracts, market power, nature of regulation, growth options, and operating leverage;
- Reference to a sample of firms, including Australian-listed industrial transportation firms (including Aurizon Holdings Limited), US Class 1 railroads and Australian-listed energy network businesses; and
- Applying different empirical estimation techniques to the sample of firms identified.

For Task A.1, the Authority has requested Incenta to assess the qualitative and empirical material presented by Aurizon Network and SFG Consulting (SFG), and assess the extent to which this material supports arguments for an asset beta range of 0.5–0.6, ensuring that this assessment addresses Aurizon Network's and SFG's:

- 'First principles' analysis of the underlying business characteristics of Aurizon Network that affects its systematic risk, including: nature of the product or service, nature of the customer, pricing structure, duration of contracts, market power, growth options, and operating leverage;

- Consideration of the impact of the form of regulation (e.g. revenue cap) and related ancillary mechanisms (e.g. cost pass-throughs, etc.) on Aurizon Network's systematic risk (see further, detailed discussion under Task A.2);

- Choice of comparators;

- Empirical methodology, including:

  – selection of multiple 'starting points' for the regression analysis;

  – selection of the regression period;

  – the approach to accounting for firm characteristics;

  – pooling method;

  – choice of estimation techniques (OLS estimation by firm, pooled regression using firm characteristics, cross-sectional regression to determine 'fitted' beta estimates); and

  – adjustments for differences between observed, systematic volatility (i.e. observed beta estimates) and Aurizon Network's true, underlying systematic volatility due to the impact of the regulatory arrangements (e.g. a revenue-cap);

  – approach to addressing estimation error (i.e., using a broader sample and different estimation techniques to account for estimation error); and

  – interpretation and application of the empirical results, including any adjustments for the regulatory arrangements' implications for Aurizon Network's true, underlying systematic volatility.

Task A.2: Estimate of Aurizon Network's Asset Beta for UT4

As a separate task, the Authority has requested Incenta to undertake its own estimate of Aurizon Network's asset beta based on a comprehensive first principles analysis, and empirical estimation of Aurizon Network's systematic risk. In undertaking this analysis, the Authority requested us to give detailed consideration to:

- factors that potentially impact Aurizon Network's systematic risk profile, including the nature of the product or service, the nature of the customer, pricing structure, duration of contracts, market power, growth options, and operating leverage;

- the form of regulation and any ancillary mechanisms, including:
  - revenue cap;
  - unders-and-overs account;
  - cost pass-through provisions; and
  - other regulatory arrangements that potentially affect risk.

In terms of the unders-and-overs account, the Authority noted that the regulatory economics literature highlights that regulatory mechanisms, including related ancillary mechanisms, can affect the allocation of risk among the regulated firm, its customers, and tax payers in general. Therefore, to the extent that the regulatory arrangements affect Aurizon Network's systematic risks, it is important that the beta estimate reflects these effects.

The Authority considers this last point to be particularly important, as regulatory arrangements might have changed the allocation of risk among these parties since the first access undertaking. Therefore, the Authority has requested us to undertake a detailed consideration and analysis of the allocation of risks among Aurizon Network, its customers, and tax payers (the latter, if applicable) and the implications for the asset beta estimate for Aurizon Network. The Authority has requested that this analysis attempt to quantify, to the extent possible, such effects, including estimating Aurizon Network's revenue beta, cost betas, and volume beta, and apply the results to inform Incenta's assessment of Aurizon Network's systematic risk, and recommended asset beta estimate.

We have also been asked to address the treatment of statistical estimation error, including:

- Identifying possible options to address it in the present context; and
- Making a recommendation regarding how to address it.

Task B: Capital Structure

Aurizon Network has proposed a benchmark capital structure of 55 per cent debt and 45 per cent equity for regulatory cost of capital purposes. The proposed level of 55 per cent debt is consistent with the benchmark capital structure proposed by QR Network, and approved by the Authority, in the previous undertaking. As a result, Aurizon Network has not sought to change its estimate for this parameter in its proposed cost of capital.

For this component of the review, therefore, the Authority has requested us to undertake an assessment of an appropriate benchmark capital structure for Aurizon Network. In arriving at a benchmark estimate, this task should necessarily involve:

- Considering Aurizon Network's total risk (i.e. both systematic and non-systematic) and assessing that risk in comparison to the risks of other, relevant businesses in Australia and in other jurisdictions (as appropriate); and

- Taking into account the extent to which the regulatory arrangements, including the treatment of the regulatory asset base (RAB), affect Aurizon Network's total risk.

Task C: Equity Beta

On the basis of the recommended estimates for the benchmark asset beta and capital structure, and any other factors considered relevant, the Authority has requested us to recommend an appropriate value for the benchmark equity beta to apply to Aurizon Network for UT4.

In undertaking these tasks, Incenta engaged the services of Associate Professor Joe Hirschberg, a specialist in econometrics within the Department of Economics at the University of Melbourne.

2.3 Outline of Report

The remainder of this report is structured as follows:

- In Chapter 3 we undertake a first principles analysis of Aurizon Network's asset beta, and then comment on Aurizon's first principles analysis of Aurizon Network's asset beta, which proposes that on this basis US and Canadian Class 1 railroads should be considered close comparators for the purpose of estimating Aurizon Network's asset beta.

- In Chapter 4 we summarise SFG's econometric analysis, which underpins its beta estimates for a number of industries, and make a number of comments about its approach, including its non-conventional econometric methodologies (i.e. 'fitted' and 'pooled' estimates) and choice of comparators.

- In Chapter 5 we assess the benchmark gearing level, and estimate Aurizon Network's asset beta and equity beta. We estimate asset betas for the selected industries, and examine the proposition that alternative forms of regulation within a given industry will result in materially different levels of systematic risk.

3. First Principles Analysis of Aurizon Network's beta

3.1 Introduction

3.1.1 The need to undertake a "first principles" analysis

The Aurizon Network business provides the below-rail service for the carriage of coal from mine sites to ports for the export of that commodity to various other countries. The price that Aurizon Network is able to charge for that service is regulated in line with the cost of provision through the application of what has become known as the "building block" approach (the characteristics of the regulatory regime applicable to Aurizon Network is described further below).

Neither we nor Aurizon Network have discovered other share market listed entities that are materially the same as Aurizon Network. If a sufficient number of such entities existed, the betas for those comparable entities could simply be estimated and applied to Aurizon Network, with the task being confined to the proper measurement of the betas for those comparable entities. Rather, in view of the absence of other share market listed entities that are materially the same as Aurizon Network, it is necessary to base the estimated asset beta for the Aurizon Network business upon the estimates of betas for firms in other sectors.

This process first requires other sectors that are considered to have a similar level of systematic risk to the Aurizon Network business, or that otherwise may be informative, to be identified. This process of *a priori* reasoning is typically referred to as a "first principles" analysis, and is the topic of this chapter.

3.1.2 Aurizon Network's "first principles" analysis

Aurizon Network compared the systematic risk of its business against three other sectors, namely US Class 1 railroads, the Australian industrial transportation sector and US Class 1 railroads. Aurizon Network concluded that its systematic risk is likely to be most similar to that of the US Class 1 railroads, less similar to the industrial transportation sector and least similar to Australian electricity network providers, which Aurizon Network stated "provide a fundamentally different service".[32] Aurizon Network reached this conclusion by comparing seven different factors that were said to predict systematic risk between itself, and US Class 1 railroads as a potential comparator sector. These factors were (in order of discussion):

- nature of the product or service / nature of the customer
- pricing structure
- duration of contracts
- market power

32 Aurizon (30 April, 2013), *2013 Draft Access Undertaking, Volume 3, Maximum Allowable Revenue and Reference Tariff*, p.141.

- nature of regulation
- growth options, and
- operating leverage.

3.1.3 Overview of our "first principles" analysis

We reach a different conclusion to Aurizon Network. Our view is that the regulated energy network businesses (and regulated water businesses) provide the closest comparators to the systematic risk of the Aurizon Network business, and that a subset of the industrial transportation sector (tollroads) is informative, in that it is likely to set an upper limit to the asset beta of Aurizon Network.[33] Our principal criticism of the Aurizon Network analysis is that it underemphasises the importance of the regulatory regime, in combination with the underlying economics of the Aurizon Network business, for predicting the systematic risk of the Aurizon Network business. That is, our view is that the most important characteristics of the Aurizon Network business are that:

- its prices are regulated and reviewed at periodic intervals in line with cost, and
- the underlying economics of the Aurizon Network business is such that there should be substantial confidence that the revenue anticipated under the regulatory regime will be recoverable by Aurizon Network, which is also supported by the presence of long term take-or-pay contracts.

The presence of cost based regulation limits the extent to which the market value of Aurizon Network would, in principle, vary with the economy as a whole (the test of systematic risk), since:

- variations in volumes transported do not translate into changes in revenue (at least in NPV terms) in the short term because of the application of a revenue cap to Aurizon Network, and at price reviews the new prices are determined such that forecast actual sales will lead to costs being recovered[34]
- differences between forecast and actual expenditure during a regulatory period are subject to a range of pass-through clauses and, outside of this, are corrected for on a forward-looking basis after each periodic price review

33 We also think that the Dalrymple Bay Coal Terminal asset beta would be very similar to that of the Aurizon Network business. However, the asset beta of the Dalrymple Bay Coal Terminal cannot be estimated directly, and we draw attention instead to secondary evidence of this beta.

34 One of the matters that we were asked to address in this report was whether differences in the form of regulation would be expected to lead to a difference in systematic risk. We looked at two differences in the form of regulation, namely (i) the extent of incentive power in the regime, and (ii) whether a price cap or revenue cap was applied. We found that for the former matter the evidence is mixed. Regarding the form of price control, there have been fewer studies on this matter; however, in relation to regulated energy businesses, the existing studies suggest that the form of price control does not affect systematic risk, and this is supported by our findings. This matter is addressed in Chapter 5.

- the rate of return that is provided on regulated assets is updated at periodic price reviews in line with current market evidence, thus limiting exposure to interest rate risk, and

- the underlying economics of the Aurizon Network business, in combination with certain characteristics of the regulatory regime and presence of take or pay contracts is such that investors would not be expected to factor in a material prospect of assets being "stranded" in the future (that is, a situation where the regulated revenues may not be recoverable because of insufficient demand for the service at the regulated price).

These characteristics – which we consider to be very important for the systematic risk of the Aurizon Network business – are most like those of the heavily regulated utility firms, for which regulated energy and water businesses provide the closest examples. These characteristics are also very different from those of the US Class 1 railroads, which face substantial competition from one each other and from other transport modes, typically do not achieve their allowed regulatory rate of return and whose revenues vary with the volumes transported (and with these volumes in turn varying substantially and moving in line with the business cycle).

Moreover, our view is that the presence of regulation also affects materially the importance of a number of the factors that Aurizon Network considered in its first principles analysis, namely:

- *Variability of volumes transported* – which would typically be important (at least if this variation was in line with variations in the overall market); however, the presence of a revenue cap for Aurizon Network means that any such variation does not translate into variation in revenue (at least in NPV terms)[35]

- *Operating leverage* – we agree that a higher operating leverage would suggest a higher asset beta; however, the fact that Aurizon Network is subject to cost based regulation with a revenue cap would suggest a breaking of the link between operating leverage and the asset beta

- *Presence of growth options* – would, all else constant, typically suggest a higher asset beta; however, this is less likely where the expansion projects are also regulated in line with cost, and

- *Market power* – has an unambiguous effect on beta risk for unregulated firms; however, for a firm whose prices are regulated in line with cost, this adds to the confidence that the revenues the regulator determines are achievable (and that investors would not factor in a material prospect that regulated revenues would not be recovered).

35 This comment raises the question of whether Aurizon Network's asset beta is likely to be higher if it was subject to a price cap rather than a revenue cap. We do not think this would be the case. Our analysis suggests that the variation in Aurizon Network's volumes does not bear a strong relationship to either the Australian economy / share market or to the world economy / share market, with the variation due mainly to factors that would be classified as idiosyncratic (diversifiable). In addition, the presence of contracts with users that have a high take or pay component would reduce the extent that a change in volume translates into a change in revenue.

3.1.4 Structure of the remainder of this chapter

As our principal criticism of Aurizon Network's first principles analysis is that it omitted to consider a factor that we consider to have substantial importance (namely the presence of cost based regulation), it is important first to set out our views on this matter. This comprises a discussion of:

- The form of regulation applicable to the Aurizon Network business, and
- The underlying economics of the Aurizon Network business, including the position of its customers (the mines) on the world coal export supply curve and the market power of the Aurizon Network business as against other possible transporters of coal along the routes where its assets exist.

We then provide comments on the factors that Aurizon Network identified as predictors of systematic risk. For many of these, we conclude that the form of regulation makes them irrelevant. However, we also observe for some factors that, even if the effect of regulation was put to one side, the relevant factor would suggest that Aurizon Network had a lower level of systematic risk that the US Class 1 railroads.[36]

Selection of reference industries

As part of this discussion, given the lack of close listed company comparators for Aurizon Network, we consider a wider group of potential reference industries, and examine their systematic risk characteristics relative to Aurizon Network. The industries chosen for this analysis were based on the following broad characteristics that have some relationship with Aurizon Network:

- regulated (energy networks, water)
- infrastructure (energy, water, tollroad, airport, US Class 1 railroads)
- railroad (US Class 1 railroads)
- network (energy networks, water, US Class 1 railroads), and
- coal mining (coal mining).

Within our first principles analysis we assess which of these potential comparator industries bears the closest resemblance to Aurizon Network in relation to systematic risk, and conclude that the regulated energy and water sectors are the closest comparators for this purpose.

Comparison with financial market practitioners

We note that in 2010 the market leading Australian independent expert firm of Grant Samuel was faced with a similar task when it estimated the beta of the regulated Dalrymple Bay Coal Terminal

36 For example, we find that the volumes transported by Aurizon Network appear to be less volatile and less related to the market than that of the US Class 1 railroads. We also find that the operating leverage of the Aurizon Network business (using three different measures) appears to be much lower than that of the US Class 1 railroads.

(DBCT) owned by Prime Infrastructure Holdings (Prime).[37] That is, Grant Samuel could not find close comparators for DBCT, and made only passing reference to the Asciano Group (equity beta of 1.33),[38] but this did not influence its choice of a much lower beta for DBCT. Despite DBCT being a port, Grant Samuel did not refer to the ports comparator group that it used to assess the beta of Prime's Euroports business (including Hamberger Hafen, Forth Ports and Eurokai KGnA), as these were not deemed to be appropriate comparators for DBCT (a regulated coal port terminal).[39] Aurizon Network is part of the same coal supply chain as DBCT, and the two assets are regulated in a similar manner (i.e. building block approach with revenue-caps administered by the QCA).

Rather than rely on the much higher beta observed for general cargo ports, which are not regulated in the same way and whose traffic and revenues are more sensitive to the economic cycle, Grant Samuel relied on the fact that DBCT is regulated, and that this implies a lower beta. It concluded that DBCT's asset beta was 0.35 (if a Conine transformation and a debt beta of 0.12 is assumed), noting that:[40]

> While this appears low, none of the other listed ports are regulated and in Grant Samuel's view, the regulated nature of the asset (and the certainty of its cash flows) warrants a lower beta.

Grant Samuel's assessment of the asset beta of DBCT provides direct evidence from an expert advisor (in the context of a transaction) recognising that other assets that are within the same sector (in that case, ports) can have materially different systematic risk, and that the presence of price regulation is a key factor in explaining systematic risk. This is consistent with the analysis and conclusions that we present in this report.

3.2 The nature of regulation

The presence of economic regulation is expected to have a dampening influence on the variability of a company's earnings, and therefore its asset beta. In the academic literature, Binder and Norton[41] tested Peltzman's hypothesis[42] that regulatory buffering of the firm's profits will decrease the firm's asset beta, noting that:[43]

> However, in response to a shock today, the firm's profits may not be buffered until some future period because of frictions in the regulatory process, i.e., 'regulatory lag.' Regulatory lag should not pose a problem for tests with security price data, because if the regulator makes the change in security holder wealth smaller, in an efficient capital market investors will rationally use the information about the future action of the regulator in adjusting the security price today.

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37 Grant Samuel (24 September, 2010), *Proposal from Brookfield Infrastructure Partners L.P.*, Independent Expert report addressed to the board of directors of Prime Infrastructure Holdings Limited.

38 Presumably, Asciano was referenced as it has cargo port operations, but Grant Samuel did not infer that its high equity beta was appropriate to apply to DBCT.

39 Since Grant Samuel emphasised the regulated nature of DBCT, this characteristic set it apart from the other ports, which deal with general cargoes.

40 Grant Samuel (24 September, 2010), Appendix 1, p.10.

41 See John J. Binder and Seth W. Norton (1999), 'Regulation, Profit Variability and Beta', *Journal of Regulatory Economics*, Vol. 15, pp. 249-265.

42 Sam Peltzman, (1976), 'Toward a More General Theory of Regulation,' *Journal of Law and Economics*, Vol. 19, pp.211-240.

43 See John J. Binder and Seth W. Norton (1999), p. 250.

When testing the Peltzman regulatory buffering hypothesis in the US electricity industry, Binder and Norton found that a higher the degree of 'regulatory stringency' was associated with statistically significantly lower asset betas.

3.2.1 Key features of Aurizon Network's regulatory framework

We observe that Aurizon Network's prices are regulated under a conventional application of the "building block" approach (that is, where prices are reviewed at periodic intervals so as to provide an expectation that efficient costs will be recovered), and with a revenue cap form of price control applying to prices between such periodic cost based reviews.[44] Specific features of that regulatory framework address various revenue and cost risks, which are summarised in Table 3.1.

Table 3.1: Key features of Aurizon Network's regulatory framework

Regulatory framework applying in UT4	Difference from UT3
Regulatory framework	
Application of a cost based regulatory regime with periodic price reviews (the "building block" approach)	
Prices are reviewed at periodic intervals such that revenues are realigned with cost, with the effect on profit of any difference between forecast and actual outcomes for expenditure or demand being corrected on a forward-looking basis.	
The value of the capital assets from one review to the next is updated by adding in new capital expenditure at cost, indexing for CPI inflation and deducting depreciation. Provision for the Authority to deem capital expenditure as imprudent and disallow its recovery exists (this is noted below).	
At each periodic price review, the forecast revenue requirement (i.e., the assessed annual cost) is based upon a contemporaneous estimate of the cost of capital associated with the activity in question.	
Revenue risk during a regulatory control period:	
In the event that the take-or-pay mechanism does not recover a revenue shortfall, it will be recovered two years later through an adjusted tariff (with an NPV adjustment to make the firm whole). Since the NPV of revenue will be preserved, the stock market price should not react to changes in revenue. Hence, a reduction in shipments (and temporarily, revenue) associated with a fall in the general market would not result in a decline in share price.	
Since UT3 an annual process has been introduced to reset volume forecasts in order to reduce the size of the revenue cap overs-and-unders, and hence the extent of revenue subject to timing differences.	Introduced since UT3

44 We observe that Aurizon has recently informed its investors that Aurizon Network "operates under a stable and well established regulatory regime": Aurizon, (May, 2013), *Further Information on Aurizon Network*, p. 10.

Opex risk:	
Variation in operating cost compared to forecast during a regulatory period is borne by Aurizon Network, subject to the following measures to reduce the cost/benefit:	
• A mechanism has been introduced to adjust the cost of electricity and transmission/distribution costs where these vary by more than 2.5 per cent.	Introduced since UT3
• Certain costs are now being escalated based on Maintenance Costs Index (MCI), which provides a better alignment with Aurizon Network's actual costs, and there is an annual adjustment process, which corrects for differences between forecast and actual NCA and forecast and actual CPI.	Introduced since UT3
• If maintenance costs prudently and efficiently incurred by Aurizon Network exceed the allowance by more than 2.5 per cent, this was a review event that could result in a variation to tariffs, however the definition of review event has been expanding over the years to include any material change in circumstances.	Introduced since UT3
• A pass through for Force Majeure costs of over $1 million has been introduced, and was used in relation to the 2011 floods.	Introduced since UT3
Capex risk:	
The scope of new capex is approved by customers prior to commencement of works, which eliminates stranding risk from this source; however, capex could still be declared to be imprudent by the QCA.	
Stranding risk:	
• A rolling 20 year asset life has been introduced for new capital expenditure, which substantially reduces the risk of asset stranding.	Introduced since UT3
• The risk of asset stranding has also been further reduced by an increase in the percentage of fees in the event of relinquishment from 40 per cent of two years of access charges under UT1, to 50 per cent of the NPV of the take-or-pay contract over the remaining life of the access agreement.	Introduced since UT3

Source: QRC's Submission to the QCA[45]*, Aurizon Network's Undertaking*[46]*, and Incenta's analysis*

As noted above, regulation has been found to be associated with lower asset betas. The regulatory framework that Aurizon Network operates under can be expected to result in a significantly lower asset beta than a Class 1 railroad. How much impact different regulatory arrangements have on beta is still an open question, and is considered in detail in Chapter 5 below.

45 Queensland Resources Council (March, 2013), *Submission to the QCA, Risk and the Form of Regulation*, pp.6-7.

46 QCA (2010) *QR's 2010 Access Undertaking, Schedule A.*

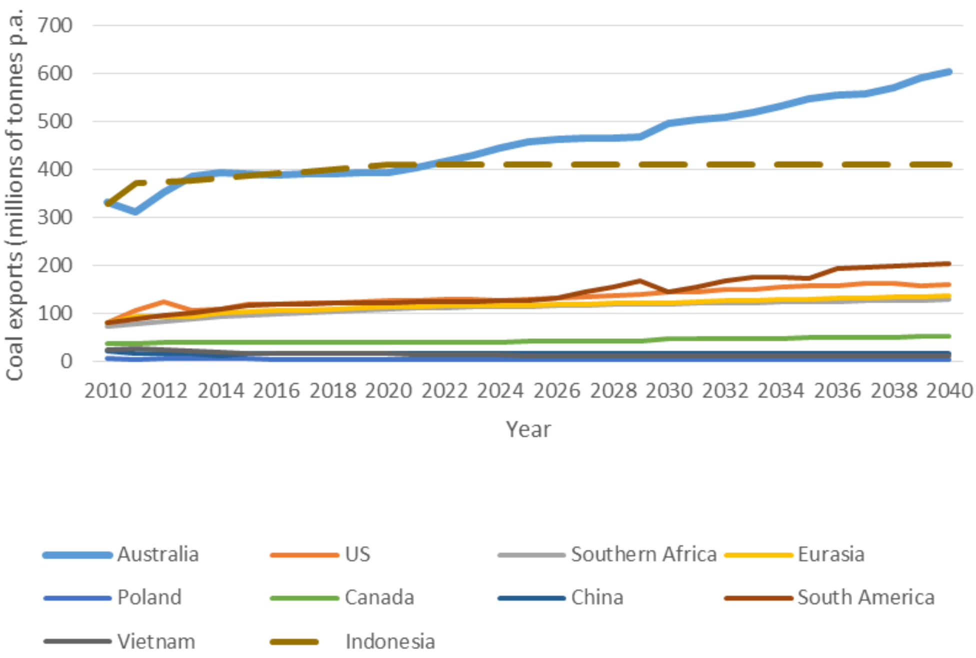
3.3 The underlying economics of Aurizon Network's business

3.3.1 Surety of long term demand for the service

As noted by Aurizon Network, the coal mines that are served by Aurizon Network are well situated in relation to the major source of growth in demand for coal, which is Asia. The mines are open-cut and relatively close to ports compared with competitors in North and South America.

The US Energy Information Administration (EIA) undertakes independent research in the energy sector and generates annual forecasts of coal exports/imports to 2040. Figure 3.1 shows the EIA's forecast that Australia's coal exports will increase at a compound annual growth rate of 1.2 per cent, matching Asia's growth of 1.2 per cent in imports over the period to 2040, and supply approximately 600 million tonnes per annum by that date. The only coal exporting region expected to grow faster is South America, but from a much lower base, with Indonesia having topped out its export potential at its current 400 million tonnes per annum.

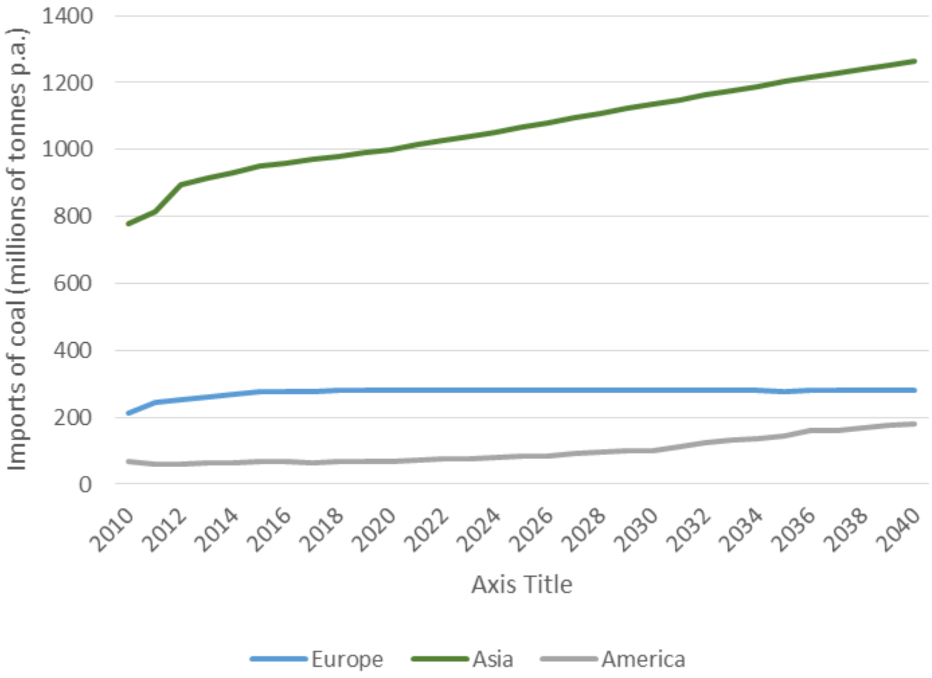
Figure 3.1: World coal exports growth - Historical and forecast to 2040



Source: EIA (2013) Annual Energy Outlook 2013, Data Tables, Table 72.

In the period to 2040, the EIA's analysis shows that Asia will drive growth in world coal exports, with some further growth coming from America. As shown in Figure 3.2, the EIA is predicting that the growth in Asian coal imports will be sourced mainly by Australia, which is an indicator of the capacity of the Australian coal industry, and also its strong relative competitiveness in the world seaborne export coal market.

Figure 3.2: World coal imports growth - Historical and forecast to 2040



3.3.2 A high percentage of traffic under long term take-or-pay contracts

Take-or-pay contracts reduce the risk that Aurizon Network's revenues will fall short of expectations. A take-or-pay contract protects Aurizon Network in the event of technical factors or demand conditions affecting a user's shipments of coal. Within the period of the contract this protection will apply up to the point that the user defaults. Even in the event of default, a re-organised business would need to resume operations applying the same take-or-pay contracts.[47] The proportion of take-or-pay contracts has risen considerably over the last decade, and the percentage of the contract to be paid in the event of relinquishment has increased to 50 per cent.

- Take-or-pay contracts cover approximately 70 per cent of Aurizon Network's contracted capacity.
- On average, contracts are concluded for terms of 10 to 15 years at signing.

Table 3.2: Aurizon Network – Take-or-pay contracts as a percentage of revenue

	2011/12	2010/11	2009/10	2008/09
Revenue ($,000)	742,370	687,618	667,704	512,015
Take-or-Pay Revenue ($,000)	534,790	473,173	463,556	368,101
Percentage Take-or-Pay	72.0%	68.8%	69.4%	72.1%

Source: QCA's website

47 During UT1, only approximately 30 per cent of Aurizon Coal's AT3 and AT4 (i.e. QR-Coal's) contracted capacity was under take-or-pay contracts. Under UT2 and UT3 100 per cent of contracts on AT2, AT3 and AT4 revenues were take-or-pay.

Thus, on the basis of the length of Aurizon Network's contracts, we would expect it to have a lower asset beta than the average for the market, other things being equal.[48] However, Aurizon Network's asset beta is likely to be dominated by the nature of its regulatory arrangements, as discussed above.

3.4 Aurizon Network's first principles analysis

As indicated above, we have also examined Aurizon Network's first principles analysis as a matter of completeness. For each of the systematic risk factors analysed by Aurizon Network we have also provided our own commentary on Aurizon Network's evidence and analysis. Aurizon Network's first principles analysis did address some of the factors that we have examined above. Importantly, it did not examine the fundamental question of the Queensland coal industry's position on the international export coal supply curve, and it gave scant attention to the influence of regulation.

3.4.1 Aurizon Network considers its heavy-handed regulation could increase beta risk

Aurizon Network submitted that:[49]

> In theory, the US Class 1 railroads are exposed to more systematic volume risk than Aurizon Network because they are only subject to light-handed regulation. The assumption here is that regulation reduces rather than increases risk: heavy-handed regulation could increase risk because it significantly reduces the firm's commercial flexibility, including its ability to raise its prices in response to changes in market circumstances.

The implication was that Aurizon Network may be subject to greater risk through heavy-handed regulation constraining its ability to respond to changing economic circumstances through the commercial flexibility to raise prices.

Incenta's comments

Pricing flexibility is likely to result in a lower beta than if prices were constrained by regulation, but there is no cost-based regulation with periodic review.[50] However, Aurizon Network does not require pricing flexibility as it is subject to cost-based regulation with regular reviews, and is thereby protected from changes in operating and financing costs. The regulation of US Class 1 railroads by the US Surface Transportation Board (STB) does not provide revenue or rate of return protection. The STB determines a composite cost of capital for the freight rail industry each year and uses this to evaluate the adequacy of individual railroad revenues each year, and for disputes about rail charges.[51] However, the rate of return earned by the US Class1 railroads rarely achieves the benchmark rate of return.[52] Hence, regulation by the STB rarely imposes a constraint on the commercial freedom of the

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48 With gearing in the Australian market at 30 per cent, applying the Conine formula and a debt beta of 0.12 implies an average market asset beta of 0.77. With a market gearing level of 35 per cent the asset beta falls to 0.72.

49 Aurizon (30 April, 2013), *2013 Draft Access Undertaking, Volume 3, Maximum Allowable Revenue and Reference Tariff*, p.142.

50 This was the case when US airlines were deregulated. See Allen, S.A., L.F. Cunningham, W.R. Wood (1990), 'Airline industry deregulation and changes in systematic risk, *Transportation*, Vol.17, pp.49-66.

51 See Surface Transportation Board (November, 2012), p.29. The STB's published list of dispute hearings shows that these are generally constrained to coal and chemicals.

52 In 2007 and 2008 Norfolk Southern exceeded the benchmark, but this resulted in no action by the STB, and no rate disputes from its customers. In 2010 Union Pacific exceeded the benchmark, and while in

US Class 1 railroads, and neither does it provide any buffering of returns (in contrast to the regulation of US energy utilities, and of Aurizon Network). Hence, while the US Class 1 railroads have the flexibility to change prices to match costs, they are also fully exposed to the vagaries of competition and changes in market demand.

3.4.2 Aurizon Network considers its demand risk to be higher than that of the more diversified traffic of US Class 1 railroads

Of the three industry sectors included in SFG Consulting's (SFG's) beta analysis (considered separately in Chapter 4 below), Aurizon Network considers that its operations are closest to the US Class 1 railroads, less similar to general industrial firms, and least similar to electricity network providers, which 'provide a fundamentally different service.'[53] Aurizon Network notes that in 2011 between 6.3 per cent and 31.6 per cent of the traffic of the US Class 1 railroads was coal haulage, and that the latter businesses are larger and more diversified in their carriage of commodities, and that the diversified nature of the US and Canadian Class 1 traffic 'may be able to protect its returns in the event of a contraction in domestic activity given its diversified revenue base.'[54] By contrast, the Aurizon Network business is a single commodity business, and 'given the importance of the export coal industry to the Queensland economy this provides an important link between that industry and domestic activity.'[55]

Incenta's comments

In view of the fact that Aurizon Network is subject to a revenue-cap, variations in demand should not translate into variations in economic returns. However, if Aurizon Network were not subject to a revenue-cap then analysis of how demand is related to co-movements with the market as a whole would be a more important indicator of systematic risk. However, our evidence suggests that in any event, Aurizon Network's demand does not co-vary with movements in the Australian economy or market.

The majority of coal transported by US and Canadian railroads is domestic coal that has greater sensitivity to the domestic economic cycle. This sensitivity to an economic downturn can be seen in Table 3.3 below, where the Global Financial Crisis was associated with 20 to 22 per cent declines in coal traffic in the US and Canada, in line with significant reductions in other commodities. Most sensitive to the downturn were automobile shipments in 2009, which declined by 36.4 per cent in the US, and 31.2 per cent in Canada. However, there was only a 1.6 per cent reduction in agricultural traffic in Canada during this period, as the majority of Canada's agricultural traffic is grain (a food staple), which is regulated by the Canadian Transportation Agency.

2011 a case was brought to the STB regarding coal haulage rates, these were not found to be unreasonable.

53 Aurizon, (30 April, 2013), p.141.
54 Aurizon, (30 April, 2013), p.141.
55 Aurizon, (30 April, 2013), p.141.

Table 3.3: US and Canadian Class 1 rail movements by commodity group, 2003-2012

	2004	2005	2006	2007	2008	2009	2010	2011	2012
US rail movements (yoy % change)									
US GDP (yoy)	**3.8%**	**3.4%**	**2.7%**	**1.8%**	**-0.3%**	**-2.8%**	**2.5%**	**1.8%**	**2.8%**
Intermodal	12.3%	11.6%	9.3%	0.3%	5.7%	-20.3%	21.8%	14.1%	9.0%
Automotive	0.6%	6.8%	3.9%	0.6%	-9.6%	-36.4%	44.8%	19.5%	19.8%
Coal	7.1%	14.8%	13.1%	5.2%	26.4%	-20.3%	17.1%	18.7%	-11.3%
Agriculture	5.7%	23.5%	20.7%	9.6%	22.3%	-13.8%	12.8%	6.9%	-2.0%
Canada rail movements (yoy % change)									
Canada GDP (yoy)	**3.1%**	**3.2%**	**2.6%**	**2.0%**	**1.2%**	**-2.7%**	**3.4%**	**2.5%**	**1.7%**
Intermodal	13.4%	21.2%	16.4%	8.1%	11.3%	-20.6%	27.2%	10.2%	7.6%
Automotive	3.6%	9.1%	4.3%	10.0%	-2.9%	-31.2%	45.9%	10.8%	15.9%
Coal	24.2%	39.6%	-3.1%	5.7%	14.2%	-21.9%	32.6%	12.1%	10.7%
Agriculture	17.0%	16.1%	23.2%	10.4%	5.4%	-1.6%	13.6%	7.0%	4.2%

Source: Bloomberg

The fact that demand / traffic of Queensland export coal was not negatively impacted by the Global Financial Crisis, while US and Canadian Class 1 railroads were significantly impacted, indicates that the latter are not appropriate comparators for Aurizon Network's asset beta.

3.4.3 Aurizon Network submits that the contracting arrangements of US Class 1 railroads are unknown

Aurizon Network submitted that its contracts are typically only for 10 years, relinquishment fees are only 50 per cent, and that US Class 1 railroads also enter long term contracts, but the specific conditions are unknown.

Incenta's comments

We contacted a number of investment bank analysts in North America who continuously research Class 1 railroads, and asked them about the typical contracting behaviour in the industry. They informed us that typical contracts are for 1 to 3 years, with up to 5 years in the case of coal traffic. Hence, there is no evidence that Aurizon Network is similar to the US Class 1 railroads on the basis of its contracts, which are in fact written for much longer periods than the typical US Class 1 railroad contract.

3.4.4 Aurizon Network considers it has less pricing flexibility than US Class 1 railroads

Aurizon Network submits that since US Class 1 railroads are only subject to light-handed regulation, they have more pricing flexibility relative to Aurizon Network, but their pricing arrangements are not known, (and are liable to vary by commodity carried). No conclusions are drawn by Aurizon Network about the influence of US Class 1 railroad pricing structures, and their impact on beta relative to Aurizon Network.

Incenta's comments

Given our views about the dominating effect of regulation on the asset beta of Aurizon Network, we consider that this is point is not relevant. However, even putting this aside, our discussions with analysts at North American investment banks confirmed that US Class 1 railroads negotiate directly with customers, whilst being subject to regulatory oversight of their rates. However, the STB only assesses rate challenges from customers based on 'constrained market pricing' (CMP) principles, which recognise that 'to earn adequate revenues, railroads need pricing flexibility, including charging higher rates on 'captive traffic' (traffic with no alternative means of transportation).' The CMP guidelines also limit a railroad's pricing flexibility through the STB's application of the 'stand-alone cost' test(SAC):[56]

> Under this constraint, a railroad may not charge a shipper more than it would cost to build and operate a hypothetical new, optimally efficient railroad ('a stand-alone railroad') tailored to serve a selected traffic group that includes the complainant's traffic.

The only North American railroad traffic that appears to be subject to explicit revenue cap regulation is the Canadian grain traffic, which is regulated by the CTA.[57]

3.4.5 Aurizon Network believes that the beta impact of monopoly power is indeterminate

Aurizon Network submitted that both Aurizon Network and US Class 1 railroads have market power, but that the directional effect on beta is indeterminate.

Incenta's comments

US Class 1 railroads experience significant competition from road haulage for many of their commodities on shorter routes, and from parallel rail lines operated by their US Class 1 railroad competitors. The extent of Aurizon Network's monopoly is far greater, since there is no prospect of competition from road haulage for coal. As we noted above, when monopoly power is married with regulation of revenues, it is expected that the directional effect is a lower asset beta.

3.4.6 Aurizon Network submits that it has a similarly high operating leverage to US Class 1 railroads

Aurizon Network submitted that it has high operating leverage, which has previously been acknowledged by the Authority in its 2005 Draft Decision on Queensland Rail (QR). It submitted that between 2002 and 2011 the average change in operating income for US Class 1 railroads exceeds

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56 Surface Transportation Board (November, 2012), *FY2011 Annual Report*, p.31.

57 See Canadian Transportation Agency, (December 11, 2011), *Decision No. 425-R-2011, Review of the methodology used by the Canadian Transportation Agency to determine the cost of capital for federally-regulated railway companies*, pp.3-4: 'The Agency calculates cost of capital rates for three main purposes: (1) the transportation of western grain; (2) interswitching; and (3) other specified regulatory purposes… The Agency's prescribed mandate with respect to the cost of capital is narrow when compared to the full spectrum of regulators and their applications of the cost of capital. For the most part, the Agency is regulating, for not more than a year in advance, small, well developed subsets of the operations of two mature companies, which have well established capital bases in a stable industry.'

unity, which indicates high operating leverage. The implication was that Aurizon Network and the US Class 1 railroads have a similarly high degree of operating leverage.

Incenta's comments

Given our views about the dominating effect of regulation on the asset beta of Aurizon Network, we consider that this is point is not likely to be relevant. However, even putting this aside, our analysis shows that Aurizon Network's inferences about relative levels of operating leverage are not correct.

Aurizon Network's submission did not provide a page number reference relating to the QCA's 2005 Draft Decision. Our reading of the decision shows only that the QCA considered Queensland Rail (QR) to have operating leverage that is high relative to DBCT, similar to that of regulated electricity businesses, and significantly lower than that of coal companies:[58]

> In any event, ACG concurred with Dr Bowman that QR faces relatively high operating leverage, the magnitude of which is comparable to other regulated businesses in Australia (e.g. the Queensland electricity distributors)… Further, while QR has high operating leverage, evidence presented to the Authority suggests that coal mining companies have higher operating leverages on average, which implies greater sensitivity of their revenues to economic downturns.

The relevant question in the comparison being made by Aurizon Network is whether it has similar operating leverage to the US Class 1 railroads, since it considers these businesses to be 'close comparators' for Aurizon Network. No comparable operating leverage evidence was provided for Aurizon Network. However, based on the alternative measures of operating leverage, Table 3.4 shows that on all three measures of operating leverage that we have calculated, Aurizon Network has a lower level of operating leverage than US Class 1 railroads considered individually, or as a whole.[59]

Table 3.4: Measures of Operating Leverage – US Class1 railroads vs. Aurizon Network

Median values (2009-2012)	Inverse of EBIT Margin	γ_1 from regression of Ln(Sales) vs Ln(EBIT)	Opex / Assets
Kansas City Southern	3.72	2.26	26.7%
Union Pacific Corp	3.42	1.61	32.6%
CSX Corp	3.46	1.54	29.9%
Canadian Pacific Railway	4.73	1.62	31.0%
Norfolk Southern	3.53	1.52	28.2%
Genesee & Wyoming Inc	4.87	1.47	30.6%
Canadian National Railway	2.74	1.40	22.4%
Aurizon Network	**2.58**	**1.01**	**8.4%**

Source: QCA and Bloomberg data, and Incenta analysis. Note: US Class 1 railroads ratio of opex/assets is measured relative to total non-current assets, and for Aurizon Network is measured relative to the RAB.

This analysis demonstrates that the operating leverage of US Class 1 railroads is materially higher than for Aurizon Network. However, even if the operating leverages had been the same, it is not likely that this would have a material impact on Aurizon Network. This is because the buffering of

58 QCA, (December, 2005), *Decision – QR's 2005 Draft Access Undertaking*, p.20 and p.30.
59 The methodologies applied to measure operating leverage are described in Appendix D.

cash flows resulting from its regulated revenue-cap would have largely neutralised any impact of operating leverage on systematic risk.

3.4.7 Aurizon Network believes it has higher growth option risk than US Class 1 railroads

Aurizon Network submitted that its growth options are more sensitive to changes in economic conditions compared with US Class 1 railroads:[60]

> Given the scale of the expansions contemplated in the Central Queensland coal region relative to Aurizon Network's existing asset base, Aurizon Network's growth options could be more sensitive to changes in economic conditions compared with the Class1 railroads.

Incenta's comments

Aurizon Network's submission ignores the fact that compared with US Class 1 railroads, the returns from Aurizon Network's growth options are constrained by regulation, as are its risks (by regulation and contracting). Hence, the same growth options will have much less influence on Aurizon Network's beta.

3.5 Our conclusions on the appropriate reference industries for Aurizon Network

Having discussed the beta-determining factors with respect to Aurizon Network and a number of reference industries, the key question is: 'which industry/industries provide the best reflection of Aurizon Network's systematic risk profile?' In Table 3.5 we describe Aurizon Network's risk characteristics relative to the reference industries in qualitative terms.

Table 3.5: Aurizon Network vs Reference Industries – qualitative risk factors

	Regulation	Contracting	Revenue risk	Opex risk	Stranding risk
Coal	None	Volume contracts	Volatile coal price	Cost structure dependent	Cost structure dependent
Rail (Class 1)	Not constraining	1-3 year contracts	Sensitive to economy	High	Due to competition
Airport	Monitoring	n.a.	Sensitive to economy	Medium	Low
Tollroad	Price regulated without periodic review	n.a.	Less sensitive	Medium	Potential by-pass
Energy	Regulated	n.a.	Less sensitive	Medium	Low
Water	Regulated	n.a.	Unrelated to economy	Medium	Low
Aurizon Network	Regulated	10-15 year TOP contracts	Unrelated to economy	Low	Low

Source: Incenta analysis

60 Aurizon, (30 April, 2013), p.142.

We find that Aurizon Network's systematic risk characteristics are most closely related to the regulated energy and water businesses:

- *Regulation:* As it is subject to full economic regulation, Aurizon Network is similar to regulated energy and water businesses. By comparison, the prices tollroads are allowed to charge are normally fixed, often as part of an initial tendering process. As periodic cost based reviews are rare, tollroad operators bear the impact of variations in cost, demand or discount rates on their economic returns over an extended period of time. Similarly, airports are typically only price monitored (with a threat of regulation), and the regulation of US Class 1 railroads does not constrain the earned rates of return (the outcome of negotiations and market forces). Cost based regulation with periodic reviews buffers the regulated firm's cash flows, resulting in a lower asset beta.

- *Contracting:* In the coal mining industry, contracts with purchasers of coal are set for varying periods, but the price is set with reference to a premium or discount to a global coal price index. This exposes the coal mining firms to movements in the coal price, and contrasts with the situation of Aurizon Network, which benefits from the stability provided by 10-15 year take-or-pay contracts, which are based on regulated revenues. Not one of the other reference industries has similar contract coverage, which, other things being equal, should result in a lower asset beta.

- *Revenue risk:* Aurizon Network's revenue risk is buffered by its regulatory framework (and, in any event, would appear to be unrelated to the state of the economy). On this characteristic, Aurizon Network is closest to regulated energy network and water businesses, and most unlike Class 1 rail, and airports, whose revenues are highly sensitive to the economic cycle. While Aurizon Network's infrastructure transports coal to the ports, the nature of its contracting and regulatory arrangements buffers it from the influence of volatile coal prices (which impact heavily on the coal mining companies).

- *Opex risk:* Aurizon Network has relatively low opex risk, as this component is a relative low proportion of total asset value, revenues are updated in line with a new forecast of costs at periodic reviews and there are elements in the components that can be passed through between price reviews if costs exceed expectations. On the other hand, Class 1 railroads and coal mines have relatively high opex risk (i.e. opex is a relatively large percentage of the value of total assets).

- *Stranding risk:* Coal mines will be subject to stranding risk depending on their position on the international cost curve and the price of coal. Queensland's coal mines have a strong position on the international cost curve, and the IEA forecasts that most of the future growth in Asian coal demand will be sourced from Queensland. Hence, there is a relatively low risk of stranding over the life of Aurizon Network's current assets. Airports generally have relatively low stranding risk owing to the continued development of their hinterland, and the difficulty of replicating the infrastructure. Regulated energy and water businesses are also generally subject to low stranding risk. Tollroads are subject to stranding as commuter patterns change and alternative roads / bridges or tunnels are constructed, and due to their competitive environment. US Class 1 railroads are also subject to potential stranding of assets due to competition from other railroads, and from shifting economic relationships (such as the shift from coal to gas consumption in the US).[61]

[61] On current US railroad problems in coal shipments, which could result in impairment of assets, see JP Morgan, (19 April, 2012), *Waiting for the Coal Cloud to Clear – CSX Outlook Remains Mixed – Tweaking the EPS Estimates*, North American Equity Research.

4. SFG's econometric analysis of Aurizon Network's equity beta

4.1 Introduction

SFG Consulting (SFG) was engaged by Aurizon Network to undertake an analysis of the systematic risk of the Aurizon Network.[62] SFG undertook an econometric analysis, which focused on comparing the Australian energy transmission and distribution businesses with firms in the Australian industrial transport industry, the US transport industry, and US Class 1 railroads. In this chapter we set out the methodology applied by SFG, as well as its findings and conclusions, and then provide our own commentary on its methodology and conclusions.

4.2 Summary of SFG's analysis

4.2.1 SFG's conclusions

SFG submitted that an asset beta a 0.55 is appropriate to apply to Aurizon Network (assuming a Conine de-levering/re-levering method and a debt beta of 0.12), which translates to an equity beta of 1.0 at a gearing level of 55 per cent.[63] Unlike Aurizon Network's submission, SFG did not provide a first principles analysis of Aurizon Network relative to its chosen comparator groups, and only a very brief discussion of the relative characteristics of Aurizon Network and the comparator industries. We reproduce this discussion in full below:[64]

> QR Network [i.e. Aurizon Network] shares a characteristic of the energy network businesses, in that it is a single operator of a network business subject to a similar regulatory regime. But revenue for these comparator firms is driven by an entirely different customer segment. It also shares a characteristic of the transportation firms, namely a *broadly* similar customer base and product, but is not exposed to the risks associated with the unregulated segments of the listed businesses. The substantially different capital structures of these industry sectors suggests that their underlying risks are, in fact, different. What is unclear is just how similar the systematic risk of QR Network is to either sector.

However, having identified the key question for analysis, namely that there are no listed close comparators for Aurizon Network, SFG did not investigate this critical issue further. Instead of analysing the fundamental beta-determining characteristics of Aurizon Network, and comparing these to various reference firms and industries, SFG simply calculated a weighted average beta estimate based on applying different weights to the chosen industries.

SFG concluded that:

- If 100 per cent weight were to be accorded to the Australian listed energy networks using the Ordinary Least Squares (OLS) technique, the asset beta estimate is **0.35** and the re-levered beta estimate is 0.59;
- If 100 per cent weight were to be placed on the OLS technique, with 50 per cent weight placed on Australian listed energy network companies and the remaining 50 per cent with equal weight to

62 SFG (31 August, 2012), *Systematic risk of QR Network.*
63 SFG (31 August, 2012), p.5.
64 SFG (31 August, 2012), p.3.

Australian industrial transportation firms and US listed railroads, an asset beta of **0.54** is obtained, with an equity beta estimate of 0.98; and

- If 50 per cent weight is given to the OLS technique, with 50 per cent weight to Australian listed energy network companies, and the remaining 50 per cent with equal weight to Australian industrial transportation firms and US listed railroads, an asset beta of **0.57** is obtained, with an equity beta estimate of 1.05.[65]

SFG concluded against applying a 100 per cent weight to Australian listed energy networks using the conventional approach, and having obtained asset beta estimates of between 0.54 and 0.57 using the alternative weighting approaches (i.e. giving significant weight to the Australian industrial transportation firms and US listed railroads, and the alternative beta estimation techniques), it considered that an asset beta of 0.55 is appropriate for Aurizon Network.

SFG also commented that previously the Authority's decisions about Aurizon Network's beta have:[66]

> … relied upon analysis of a small sample of listed energy network businesses. Hence, there is a high probability that the OLS beta estimates are not representative of the systematic risk we would expect to be incorporated into the required returns to equity holders for the firms analysed. Furthermore, even if the risks of those firms could be analysed with precision, there is a high probability that the firms analysed are not representative of the risk of QR Network.

4.2.2 SFG's asset beta estimates – method employed

Conventional regression estimates

SFG applied Ordinary Least Squares regression using monthly data, but submitted that the definition of a 'month' as the last day of a calendar month is arbitrary, and instead repeated the analysis 20 times using 20 different starting days. It took the average of these values as its beta estimate. Using this approach, SFG estimated an asset beta of 0.35 for Australian energy networks, compared with estimates of 0.67 and 0.78 for Australian Industrial Transportation and US Railroads respectively.

SFG's alternative regression techniques – pooled and fitted regressions estimates

SFG's 'pooled' regression analysis

As an alternative to conventional OLS regression, SFG proposed a 'pooled' regression methodology. This alternative methodology is similar to the conventional estimation of beta, where the coefficient on the market excess return variable (i.e. the 'slope coefficient', or 'beta') is estimated from a regression against the excess returns on the stock using monthly data. However, in SFG's analysis each pooled regression 'observation' is a monthly excess return that has an associated combination of firm characteristics for that month attached to it (i.e. 'size', measured as the market capitalisation at

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65 That is, while 50 per cent of the overall weighted average beta estimate is derived from the application of OLS regression to Australian energy networks (i.e. weighted 25 per cent overall) and 50 per cent to Australian Industrial Transportation and US railroads (i.e. each weighted 12.5 per cent overall), the other 50 per cent of the overall weighting is obtained from beta estimates using the fitted and pooled methodologies (with the same splits for Australian energy networks, Australian industrial transportation and US railroads).

66 SFG (31 August, 2012), p.12.

that point, the book/market ratio, gearing, and industry membership). This resulted in a regression with 323,061 observations for 2,400 firms listed over the period since 1976.[67]

The coefficient on the industry dummy variable (i.e. denoting the industry a firm is classified in) is the beta of a firm in that industry with median values for the other firm characteristics. Adding or subtracting the net difference from the industry beta determined by the other estimated 'firm characteristic' coefficients (i.e. the coefficients multiplied by the observed values for those characteristics for the stock) a 'pooled' estimate of the beta for that stock is made. The beta estimates for all the stocks in the industry group are then averaged to yield the average 'pooled' equity beta.

SFG's 'fitted' regression analysis

SFG's 'fitted' regression analysis methodology is similar to its 'pooled' methodology, except that the dependent variable is the OLS beta estimate, and the independent variables are the same four mentioned above.[68] The same effect is seen as in the pooled estimates, where for Australian Industrial Transportation and US railroads beta estimate are likely to be similar to what would have been obtained from a simple averaging of the beta estimates for all firms in the industries. However, for Australian Energy networks the result is raised to a level that is close to the average beta that would be obtained from the three component industries.

Up- and down-market scenarios

SFG also provided separate estimates of betas depending upon whether the market return was positive or negative. However, these results were not a major feature of the SFG analysis, and so this aspect is not considered in greater detail in this report.

4.2.3 SFG's asset beta estimates - results

The results shown in Table 4.1 below are adapted from SFG's Table 1.[69]

- For the US Railroads and Australian Industrial Transportation industries, the conventional, 'pooled' and 'fitted' asset beta estimates are quite similar (i.e. approximately 0.66 and 0.78 respectively); and
- For Australian energy networks the conventionally estimated beta is 0.35, but the pooled and 'fitted' estimates are both approximately 0.50.

Table 4.1: Summary of beta estimates (SFG)

	Equity beta			Asset beta			Re-levered to 60%		
	Conv[a)]	Pooled	Fitted	Conv	Pooled	Fitted	Conv	Pooled	Fitted
Aust. energy networks	0.54	0.87	0.82	0.35	0.52	0.49	0.59	0.93	0.88
Aust. Industrial Transportation	0.82	0.78	0.80	0.67	0.65	0.66	1.25	1.21	1.23
US railroads	0.99	0.96	0.99	0.78	0.75	0.78	1.47	1.42	1.48

67 On average, approximately 134 monthly observations for each of the 2,400 firms.
68 Percentiles, rather than actual values are used to reduce statistical noise in the variables.
69 SFG (31 August, 2012), p.4.

Source: Adapted from SFG (31 August, 2012), p. 4. Note: a) 'Conv' refers to the conventional ordinary least squares methodology.

4.3 Our comments on SFG's estimation methodology

4.3.1 Overview

We disagree with SFG's conclusion that an appropriate estimate of the asset beta for the Aurizon Network business is 0.55. We have two principal areas of disagreement with SFG, which are as follows:

- First, we do not consider it appropriate to place weight on asset beta estimates for the Australian Industrial Transportation or US Class 1 railroad sectors, and disagree with SFG's comment that it was inappropriate for the Authority last time to place weight on energy network businesses when determining an asset beta for the Aurizon Network business. This is because our first principles analysis presented in Chapter 3 suggests that the US Class 1 railroads and the wider transport sector are likely to have materially different systematic risk to the the Aurizon Network business, whereas heavily regulated utility firms (like regulated energy network firms) are likely to have the closest level of systematic risk.

- Secondly, we do not consider that SFG's estimates of the asset beta for regulated energy network businesses using the 'pooled' and 'fitted' methods are valid. Rather, our analysis of SFG's method and results suggests that this result was due to the energy network businesses being classified as belonging to an industry that was dominated by firms that were not regulated energy networks and that undertook activities that were not comparable to those of an energy network business. This would be expected to result in an upward biased estimate of the asset beta for a regulated energy network.

We also identify a number of more technical concerns with the pooled and fitted methods that are not essential to our conclusions but that we set out for completeness, including that:

- We do not consider that the pooled and fitted estimates add material value compared to a simpler analysis that estimates the asset beta for an industry by taking an average or median of the asset betas of the target industry. In particular, we note that:
  - Of the explanatory variables for explaining betas that were tested, the effect of the "industry" variable dominated, and the remaining variables explained little of the variation in betas
  - Some of the variables that were tested were statistically insignificant or marginally significant, notwithstanding the very large sample size employed, and
  - The gearing variable consistently had a sign that was inconsistent with theory and other empirical evidence,[70] and

70 The SFG analysis showed that an increase in gearing was associated with a lower equity beta. This relationship would never be expected for an individual firm. Our expectation is that this relationship

- We would question the relevance of including data for firms back to 1976 in view of the likelihood that material differences in factors relevant to asset betas have occurred since that time (although we do consider there to be merit in looking back for a period of 10 years). This issue is discussed further in section 4.3.4.

However, we also agree with two key methodological points of SFG's and have incorporated these into our analysis, in particular:

- We agree that a better estimate of the asset beta for a regulated energy network would be obtained by broadening the sample of comparable entities from the very limited sample of Australian listed firms. We have done this by extending the sample to include regulated energy networks in other Western developed economies (principally the US and UK) and also extending the sample to include regulated water businesses.

- We also agree with SFG that the observation that materially different beta estimates may arise depending upon the end date that is chosen within a month for measuring returns means that there is the potential for biased and/or unnecessary volatility in beta estimates and that this should be addressed in the estimation method. We have responded to this by estimating asset betas that are an average of the betas that would be estimated for the range of end dates within a month (we employ a more sophisticated method than SFG, but ultimately obtain very similar results to SFG's method).

The first of our areas of disagreement with SFG (that of the appropriate comparators to the Aurizon Network business) is addressed in detail in Chapter 3 above, and so this matter is not addressed further here. As noted above, SFG has not provided its own analysis of the systematic risk of the Aurizon Network business compared to the various candidate comparator industries.

The remainder of this chapter examines in turn:

- Our second principal area of disagreement with SFG (its estimate of the asset beta for regulated energy networks)

- The more technical (but second order) concerns that we have with the SFG analysis, and

- The two comments of SFG of a methodological nature with which we agree (i.e., broadening the sample for energy networks and addressing the "end of month" issue).

4.3.2 Inappropriate estimate of the asset beta for energy networks

SFG's estimated beta of the 9 energy networks increased by a large margin depending on whether a conventional OLS approach was applied to these 9 firms individually, or SFG's alternative methodologies were applied using the broader sample of firms classified in three ICB energy industries (i.e. 0.35 and 0.50 respectively). Hence, the composition of the firms in the comparator industry is important, and if that composition is not reflective of the characteristics of the energy

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was found because SFG undertook a cross section analysis, and the relationship was found because the high equity beta was associated with unobserved factors that were generally associated with a lower debt carrying capacity (for example, firms for which real options constitute a material portion of their market value).

network group (i.e. the industry definition has been drawn too broadly), there is scope for material estimation error. As noted in the following section, industry effects dominate in determining the beta that is 'fitted' to a given firm using SFG's methodology. Similarly, SFG's 'pooled' estimate methodology raises the 'pooled' network estimate up closer to the average level for the industry.

SFG did not list the full composition of firms included in the three industries that the network firms are allocated to, which are ICB industries 7530 Electricity, 570 Oil equipment, services & distribution, and 7570 Gas, water and multi-utilities. However, we obtained the current composition of Australian listed firms in the three ICB energy industry groupings listed above from London's FTSE Client Services.[71] In addition to the 5 currently listed energy networks (Spark, SP AusNet, APA, Envestra and DUET), this group includes the following inappropriate members:

- *Boart Longyear Limited* – which manufactures oil drilling equipment and provides contract drilling services;
- *Energy World Limited* – which operates gas-fired power plants in Indonesia and the Northern Territory;
- *Imdex Limited* – which provides drilling fluids and leading down hole instrumentation to the mining, oil and gas, water well, and civil engineering industries worldwide;
- *Infigen Energy Limited* – which operates wind farms that generate electricity from windmills in Australia and the United States;
- *Miclyn Express Offshore Limited* - which provides offshore support vessels to the offshore oil and gas industry, and operates a shipyard in Batam in Indonesia; and
- *Worley Parson Limited* - which provides professional services to the energy, resource and complex process industries.

These members of the three industry groups are likely to have significantly greater systematic risk than regulated energy networks. Hence the application of SFG's alternative methodologies to infer an asset beta for energy networks based on much more broadly defined (i.e. mis-specified) industries is likely to over-state the asset beta of energy networks.

4.3.3 Industry factors dominate SFG's results

In SFG's 'fitted' regression methodology the dependent variable became the OLS estimate of beta converted into a percentile in order to reduce statistical noise. The three variables representing firm characteristics (apart from industry) on their own had an adjusted R-squared value of 0.072 (i.e. explained 7.2 per cent of the variance in betas). When the industry dummy variables were included the explanatory power increased significantly (adjusted R-squared of approximately 80 per cent).

Due to the dominance of industry effects, there is little or nothing to be gained from the extra complexity introduced by the application of SFG's 'fitted' and 'pooled' methodologies, even if firms

71 That is, ICB industries: '7570 Gas, water & multi-utilities'; '7530 Electricity'; and, '570 Oil equipment, services & distribution').

were classified into appropriate ‘comparable’ industry groups. That is, essentially the same result would be obtained by simply calculating the average (or median) of the appropriately defined comparator industry group.

4.3.4 Period of analysis

SFG relied on data for firms listed on the Australian stock market since 1976. This raises the question of how relevant much of these data are, given that over such a long period of time there may be significant changes in market relationships, operating characteristics of firms, regulatory arrangements, and the composition of the Australian stock market itself. As one example, during the period between 1976 and 1998 AGL Limited moved from a light-handed regulatory regime to full economic regulation. The potential irrelevance of historical data from many decades ago is the reason that most commercial providers of beta estimates use data for 4 or 5 years.[72] However, we consider there is merit in providing beta estimates over a period of say, 10 years, particularly if there have been significant recent disruptions to the market.[73]

4.3.5 Insignificant relationships

In statistical terms, given that SFG’s ‘pooled’ analysis had 323,061 observations, it might be expected that almost any variable would be found to be statistically significant (i.e. the estimated coefficient would have a 95 per cent or 99 per cent probability of not being due to chance).[74] Surprisingly, the market capitalisation and book-to-market ratio variables in this regression were not found to be statistically significant. Apart from industry, gearing is the only variable that was found to be statistically significant, but it is of the ‘wrong sign’ (i.e. it picks up the fact that higher gearing is a characteristic of firms that have lower beta risk).

4.3.6 Points of agreement with SFG

Having expressed disagreement with SFG on major components of its methodology, we do agree with two specific methodological comments in SFG’s report.

- SFG criticised the Authority’s previous estimates of the asset beta for Aurizon Network for being based on the asset beta estimate for regulated energy networks, where this had been estimated on the basis of a fairly small sample of Australian-only firms. While the Authority’s previous decisions referred to other reference points as well as energy networks, we have accepted this point and have responded by estimating the asset beta for a regulated energy network on the basis of a much larger sample of regulated energy firms (i.e., one that includes overseas firms).[75]

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[72] Brailsford, T.J., R.W. Faff and B. Oliver, (1997), *Volume 1, Research Design Issues in the Estimation of Beta*, McGraw Hill Series in Advanced Finance, p.16.

[73] Soon after the dot-com boom and bust, this case was made by Stephen Gray, Jason Hall, Jerry Bowman, Tim Brailsford, Robert Faff and Bob Officer, (May, 2005), *The performance of alternative techniques for estimating equity betas of Australian firms*, Report prepared for the Energy Networks Association.

[74] Statistical significance is achieved with larger samples because the larger the number of observations the lower the required cut-off for statistical significance (e.g. the ‘t-statistic’ required for a 95 per cent confidence level will fall).

[75] For example, the 2006 decision made reference to the Port of Tauranga (prior to its move into container traffic) and Westshore Terminal, the Canadian coal port terminal (prior to its adoption of a loading rate

- We also agree with SFG's proposal that there is merit to estimating beta by reference to more than one definition of 'a month'. SFG submitted that estimating returns based on the last day of the month is arbitrary, and that beta will be more accurately estimated by averaging betas estimated from 20 different starting days in the month. The 'turn of the month effect' is recognised as a 'puzzle' in the literature. However, our view is that a more appropriate way of dealing with the 'turn of the month effect' is to randomise the choice of the number of days in the months during the estimation period based on the frequency distribution of actual trading days observed over time in calendar 'months'. This methodology is considered more fully in the following chapter.

formula tied to the US dollar coal price). In 2010 the Authority referenced US railroads, coal and Australian and New Zealand transport industry comparators, but rejected these as appropriate comparators. See, QCA (December, 2009), *Draft Decision, QR Network 2009 Draft Access Undertaking*, pp. 17-18.

5. Estimation of Aurizon Network's benchmark capital structure and asset beta

5.1 Introduction

This chapter sets out:

- how we have derived the reference sample of firms to assist in the derivation of an asset beta for the Aurizon Network business and a benchmark capital structure, applying the conclusions that were reached in Chapter 3
- our derivation of a benchmark capital structure
- the methodological choices that we have made to estimate asset betas
- the resulting asset beta estimates, and
- our analysis of how the form of regulation affects asset betas.

5.2 Sample description

5.2.1 Selection of reference industries

The key role of the sample of firms that we establish in this section is to aid in the estimation of an asset beta for Aurizon Network. However, we have also used the same sample to assist in the derivation of a benchmark capital structure for the Aurizon Network business, although we note that the drivers of the asset beta (covariance between the economic returns to an asset and the market as a whole) differ to the drivers of the benchmark capital structure (which include, amongst other things, the total variance of cash flow).

The main characteristics of Aurizon Network are that it operates a regulated below-rail infrastructure network to facilitate the export of coal. As set out in Chapter 3, these characteristics are:

- Regulated
- Infrastructure
- Rail
- Network
- Coal (exports)

In Table 5.1 we set out a number of industry sectors that share some of these characteristics. Only the energy and water networks are regulated in a manner that is comparable to Aurizon Network (i.e. cost based regulation with periodic price reviews. Regulation of the other firms/industries is either absent (coal), light-handed (airports), non-constraining (US Class 1 railroads) or have "regulated" prices that are not subject to periodic review to reflect changes in revenue, cost and interest rates (tollroads).

Table 5.1: Aurizon Network's key characteristics vs reference industries/firms

Industry	Regulated	Infrastructure	Railroad	Network	Coal mining
Transport:					
Railroad (Class 1)	×	√	√	√	×
Airport	×a)	√	×	×	×
Tollroad	√b)	√	×	×	×
Non-transport:					
Coal mining	×	×	×	×	√
Regulated Energy	√	√	×	√	×
Regulated Water	√	√	×	√	×

Source: Incenta. Notes: a) While airports are subject to varying degrees of light-handed regulation, they often have substantial unregulated operations. B) While tollroad prices are fixed, they are generally not subject to comprehensive review, creating an exposure to fluctuations in demand.

5.2.2 Selection of reference firms

In selecting reference firms from the identified industry sectors, we employed the Bloomberg service, and restricted our search to firms with their main operations located in the developed English speaking countries, as well as western Europe. This was done in order to obtain a reasonably large sample of firms with relatively low sovereign risk, which operate within market, regulatory and institutional frameworks that are not too dissimilar from Australia's. With respect to regulated energy networks, we also considered the sample of 78 regulated energy businesses that was identified by Competition Economists Group (CEG), and was referenced by SFG in a recent report.[76]

An initial sample of 155 firms was derived in this way. We then scrutinised the Bloomberg description of operations for each of these firms, and reviewed its breakdown of revenues for different operations. Firms that were not considered to have operations that are reflective of the industry descriptor were eliminated,[77] as were firms with less than 5 years of history as a listed firm, or had a market capitalisation of less than AUD$400 million. A market capitalisation cut-off of $400 million would place those firms among the top 250 Australian firms, which significantly reduces concerns about illiquid trading, and increases confidence in the accuracy of the beta estimates. In the case of regulated firms, we eliminated those where revenue from regulated activities constituted less than 50 per cent of total revenue. This resulted in a final sample of 107 firms, as follows:[78]

- 15 listed firms in rail sector reduced to a final sample of 7 firms;
- 8 listed firms in the airports sector reduced to a final sample of 6 firms;

76 That is, SFG (24 June, 2013), *Regression-based estimates of risk parameters for the benchmark firm*, which references CEG (June, 2013), *Information on equity beta from US companies*. We included CEG's sample of energy firms where more than 50 per cent of revenues were regulated.

77 For example: we eliminated a number of European railroads, as their operations were not similar to the US Class 1 railroads (e.g. they operate tourist railways, or have large bus operations); and one coal company was eliminated because it engages in coal exploration, and is not a coal miner.

78 This number does not include Aurizon Limited, which we have also examined, since it was mentioned by SFG and incorporates Aurizon Network's operations.

- 10 listed firms in the ports sector reduced to a sample of 3 firms, which was considered not to be representative of the industry (and hence was excluded);
- 8 listed firms in the tollroads sector reduced to a final sample of 7 firms;
- 15 listed firms in the coal mining sector reduced to a final sample of 10 firms;
- 86 listed firms in the energy network sector reduced to a final sample of 70 firms; and
- 13 listed firms in the water network sector reduced to a final sample of 7 firms.

The original sample, and final sample of firms are listed in Appendix A.

5.3 Benchmark capital structure

5.3.1 Factors influencing capital structure

The 'capital structure' of a firm relates to the proportions of debt and equity that are employed in financing its operations and investments. The 'benchmark capital structure' is the combination of debt and equity financing that maximises the enterprise value of the firm (i.e. the sum of the market values of debt and equity), and is therefore the natural gearing level for firms with similar characteristics.

Under the Modigliani and Miller (M&M) hypothesis, in an ideal world in which debt and equity are taxed equally, there are no bankruptcy costs, and no informational asymmetries, the capital structure does not influence the value of the firm. However, the M&M paper has been more influential in focussing attention to the factors that are important in determining optimum capital structures. Since the 'classical' taxation framework taxes debt at a lower rate than equity, this implies that enterprise value will increase with more gearing (i.e. a higher proportion of debt), with the theoretical maximum increment in enterprise value (absent the costs discussed below) being:

$$\Delta V = t_c \Delta D$$

Where, Δ refers to 'change', V is enterprise value, t_c is the company tax rate, and D is the quantum of debt.

In Australia, if dividend imputation credits can be fully utilised and valued, then double taxation of equity would be removed – and there would be no tax-related benefit from debt finance. Empirical evidence suggests that this is not the case, but the level of utilisation and valuation of these credits has been controversial in regulatory contexts. Other complications include:

- *Bankruptcy costs* - Higher debt levels increase the chance of bankruptcy, and raise the probability that bankruptcy costs will be incurred, which is an additional violation of the M&M assumptions. It implies that any advantage that may be derived from the tax shield benefit of debt, will be offset to some degree as the proportion of debt increases.
- *Financial flexibility* - Managers will favour debt levels that are lower than the theoretical optimum that would maximise enterprise value in a steady state in order to maintain financial flexibility. That is, managers may prefer to retain debt raising capacity so that the firm can potentially raise new debt to finance an unforseen investment opportunity.

- *Free cash flow* – On the other hand, firms that are not optimally geared will have greater free cash flows available to finance new projects, and if the market considers managers will apply a lower than desirable level of scrutiny to new investments, shareholder value will decline.

- *Market signalling* – When a firm takes on more debt, this could be seen as a positive signal to shareholders that shareholder value will be maximised (since it conveys the confidence of management that a new stream of fixed payments can be met, while maintaining the dividend per share paid).

The benchmark optimal capital structure will be determined by a number of factors, including the level of business risk in an industry, taxation and incentive effects, and the expected losses in the event of default. Other things being equal, if a firm experiences more volatile operating cash flows, it would be expected to carry less debt.

5.3.2 Aurizon Network's current and prospective gearing level

When Aurizon was privatised in 2011, it did not have a commercial capital structure. On May 13, 2013, however, the firm announced that it would be implementing a new long-term capital structure, with $3 billion of new committed debt facilities placed at the Aurizon Network level, which are 'supported by the below rail regulated infrastructure assets.' With $2.2 billion to be drawn initially, and a current RAB value of approximately $4.8 billion, Aurizon has noted that the 'Network's gearing levels will be broadly consistent with the regulator's assumption of 55% Debt/RAB.'[79] At the same time, Aurizon Network has obtained credit ratings from Moody's (Baa1 stable) and Standard & Poor's (BBB+ stable), which accord with the current regulatory assumption.

On 13 May, 2013 Aurizon made an announcement to the market that it was intending to implement a new long term capital structure, with new stand-alone debt facilities at both the Aurizon level and at the level of its subsidiary, Aurizon Network. A facility of $3 billion was being placed at the Aurizon Network level, with an initial drawdown of $2.2 billion, which would result in Aurizon Network's 'gearing levels [being] broadly consistent with the regulator's assumption of 55% Debt/RAB.'[80]

J.P. Morgan's research has estimated that if Aurizon Network maintains a gearing ratio of 55 per cent to RAB, given expansions in the next two years, it should support a total debt of $3.45 billion by the end of FY2015.[81] Hence, both Aurizon, and investment analysts in the market, consider that a gearing level of 55 per cent is achievable by Aurizon Network on a stand-alone basis. This view appears also to be supported by Standard & Poor's, which has assigned a stand-alone BBB+ credit rating to Aurizon Network based on its new debt facility and what is considered to be a 'strong' business risk profile and 'intermediate' financial risk profile.[82]

5.3.3 Evidence from capital structures of reference firms

While the benchmark capital structure may be observed from the behaviour of similar (comparator) firms, on the assumption that average behaviour is reflects the value maximising capital structure, this

79 Aurizon (May, 2013), *Further Information on Aurizon Network*, p.8.

80 Aurizon (28 May, 2013), *Aurizon Progresses its Debt Refinancing*, Announcement to ASX – Further information on Aurizon Network, p. 8.

81 J.P. Morgan (13 May, 2013), *Aurizon Holdings Limited – Scenarios around a possible separation*, Australian Equity Research, p.2.

82 Standard and Poor's (15 May, 2003), pp.4-7.

need not be the case, particularly if there has been recent market instability. The net gearing measure is net debt to net debt plus market equity (where net debt is defined as the book value of total debt less cash).

Firms with less volatile cash flows, and low vulnerability to catastrophic falls in cash flows, have the option to increase gearing while maintaining an investment grade credit rating. In Table 5.2 below we show the median gross and net capital structures of the identified reference industries. The net gearing of regulated Australian, New Zealand and UK energy networks has been close to 60 per cent, while other regulated businesses (North American energy and US and UK water businesses have gearing levels of 39 per cent to 43 per cent). It is also noticeable that the industry with the largest median fall in EBIT during the global financial crisis is railroads, which also has the second lowest median net gearing level (22 per cent). The relatively high net gearing observed for the sample firms in the airport industry (47 per cent) is above expectations given its relative volatility and vulnerability to an economic downturn (as represented by the 2008-09 EBIT decline in the course of the global financial crisis).

While Aurizon Network has experienced some declines in EBIT over the past decade, these declines have been unrelated to economic cycles. In 2008-09 Aurizon Network's EBIT increased by 45.9 per cent, but in 2010-11 it decreased by 13.6 per cent, primarily due to the floods occurring in that year.[83] However, under Aurizon Network's revenue-cap regulation framework, any shortfall in revenue during 2011 was recovered in two years' time.

Table 5.2: Capital structures by industry, 2009 to 2012

Industry	Median Net gearing	Median Gross gearing	Median CoV EBIT	Average Delta EBIT 2008-09	Standard Error of Delta EBIT	Median Delta EBIT 2008-09
Tollroad	53%	59%	0.176	41.7%	47.9%	3.2%
Airport	47%	50%	0.179	-24.7%	17.0%	-14.4%
Energy	46%	46%	0.136	6.3%	4.4%	4.4%
Water	39%	40%	0.100	5.1%	3.8%	5.2%
Railroad	22%	23%	0.184	-21.1%	3.9%	-18.0%
Coal mining	19%	24%	0.414	64.5%	53.4%	42.5%

Source: Bloomberg

Aurizon Network's ability to support a significantly higher debt component in its capital structure compared with US Class 1 railroads, whilst maintaining a BBB+ credit rating, is another indicator that its asset beta is more likely to be closer to those observed for regulated energy and water companies than to the asset beta observed for US Class 1 railroads.

5.3.4 Recommended benchmark capital structure

The operation of the regulatory framework and the strength of Aurizon Network's cash flows suggest that it is capable of supporting a capital structure in the range observed for regulated businesses, and can support a gearing level of 55 per cent. Aurizon Network has also signalled its intention of

83 We note that much of this fall in EBIT was due to an increase in operating costs during 2011.

matching its gearing level to the benchmark level of 55 per cent of RAB. Therefore, we find no compelling reason to shift away from the previous assumption of a benchmark gearing level of 55 per cent for Aurizon Network.

5.4 Beta estimation methodologies

5.4.1 Methodological choices

Specification of the CAPM

Our beta estimates were derived by applying ordinary least squares regression to monthly excess returns for individual stocks against and the relevant market return:

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

Where,

$r_{i,t}$, $r_{m,t}$ and $r_{j,t}$ denote the return on stock *i*, the return on the relevant market and the risk free rate respectively in period *t*, and

$\varepsilon_{i,t}$ is an error term for stock *i* during period *t*.

Discrete vs continuous returns

In beta analysis returns are most commonly estimated using continuously compounded returns, calculated as the natural logarithm of one plus the discrete return. The advantages of continuous returns is that they can be aggregated over different periods of time, are more likely to be normally distributed, and less likely to be influenced by outliers.[84] Hence, returns were defined as:

$$r_{i,t} = ln\left(\frac{(P_t + D_t)}{P_{t-1}}\right)$$

Where,

$r_{i,t}$ is the return on stock *i* for period *t*, P_t is the price of the asset in period *t*, and D_t is the dividend per share paid in period *t*.

Market index

The market index should be calculated consistently with the calculation of returns for the firms. Broad market accumulation indexes were assembled for the following markets:

- Australia: S&P/ASX Accumulation 200 Index;
- New Zealand: New Zealand Exchange Ltd NZX All Total Return Index

84 See Brailsford, T.J., R.W. Faff and B. Oliver (1997).

- United Kingdom: FTSE 100 Net Dividend Total Return Index
- Canada: S&P/TSX Composite Total Return Index
- United States: S&P 500 Total Return Index
- Spain: IBEX 35 Net Return Index
- Portugal: PSI20 Index
- Italy: FTSE MIB Net Total Return Index
- France: CAC40 Total Return Index
- Germany: Deutsche Borse AG German Stock Index DAX
- Austria: ATX Total Return Index
- Switzerland: Swiss Total Return Index

Return period

While stock and market returns are measured on daily, weekly or monthly periods, it is most commonly monthly returns that are estimated in regulatory applications. The use of daily or weekly data can sometimes cause bias in the case of less frequently traded stocks if there is lack of trading in the shorter interval. However, we assembled daily data so that alternative definitions of months could be calculated (as discussed further below).

Market liquidity

Low market liquidity can bias results as prices may not change within the return window, implying a zero return that is not reflective of the change in the market value of the stock that would have been recorded if a transaction had occurred. Liquidity issues are a lesser concern when monthly data are used, but we vary the definition of a month with the use of daily data. However, as noted above, we have constrained the sample to include firms with market capitalisations in excess of $400 million, which implies a reasonable level of market liquidity.

Return window

Ten years of price, market returns and dividend data was assembled so that longer (120 month) estimates of beta could be made; however the widely applied benchmark of 60 monthly observations was also applied.

Re-leveraging formula

The equity beta that is appropriate for the benchmark level of gearing is the primary concern for regulators applying the CAPM. It is well established that the equity beta will change as the level of gearing changes, and empirical estimates of equity betas relate to (and are influenced by) the actual gearing of the firm for which the beta is estimated. Thus, a means of adjusting the betas to a common level of gearing is required.

In this report, we follow the Authority's previous approach of focussing on the asset beta, which is the theoretical beta for the equity holders of a firm if that firm has no gearing. Once the asset beta is selected, we convert this to the equity beta that is consistent with the benchmark gearing level (that is, 55 per cent debt to assets). We have applied the Authority's standard formula for this purpose, which is known as the Conine formula, and we have also applied the Authority's standard assumption of a debt beta of 0.12[85]

The Conine formula is as follows:

$$\beta_e = \beta_a + (\beta_a - \beta_d)(1 - T)\left(\frac{D}{E}\right)$$

And the re-levering formula is given as:

$$\beta_a = \frac{\beta_e + \beta_d(1 - T)\left(\frac{D}{E}\right)}{\left(1 + (1 - T)\left(\frac{D}{E}\right)\right)}$$

Where,

β_e, β_a and β_d are respectively the equity, asset and debt betas, D and E are the values of net (book) debt and market equity, and T is the imputation adjusted tax rate. That is, $T = t(1 - \gamma)$, where t is the corporate tax rate and γ is gamma, the value of distributed franking credits. The Authority applies a gamma value of 0.50 and, as noted above, a debt beta assumption of 0.12. We note there is evidence to support the 0.12 debt beta assumption applied by the Authority. Based on an analysis of Australian investment grade corporate bond indices, a recent PwC (NZ) study found a debt beta in the range of 0.061 for AAA bonds, to 0.106 for BBB rated bonds.[86]

Mean reversion of beta

Blume (1975) documented the tendency for mean reversion among OLS beta estimates, speculating that this could be the result of a process by which the portfolio of assets over time approaches the systematic risk of the market as a whole (i.e. a beta of 1.0).[87] Australian regulators have tended not to accept the Blume adjustment, on the grounds that by definition the benchmark firm cannot adjust its assets so that its systematic risk matches the market portfolio.

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85 We observe that the Authority's standard approach differs to the current practice of most other Australian regulators in that the latter use the Harris and Pringle formula and assume a zero debt beta. This means that care is required when comparing the asset beta that the Authority may use with asset betas that may be quoted by other regulators.

86 PwC New Zealand (5 April, 2012), *Transpower New Zealand Limited – Leverage and the Cost of Capital*, p. 24.

87 M.E. Blume, (1975), 'Betas and their regression tendencies,' *Journal of Finance*, Vol. 30, pp.785-795.

Robust regression

SFG did not raise the question of outliers, which has been raised previously by Gray and Officer (2005).[88] At that time the asset betas of regulated businesses were being depressed following the dot-com bust (2000-01), and the exclusion of those downward outlier observations raised the beta estimate closer toward the long run average.

Later estimation of energy network betas in 2007 and 2008 (i.e. post the dot-com boom and bust) showed that application of the Least Absolute Deviation (LAD) and Re-weighted Least Squares (RWLS) robust regression methodologies reduced the average estimated beta by 2 or 3 points relative to OLS estimates. A more recent report by SFG concluded that LAD beta estimates are systematically downward biased.[89] While we also estimated LAD betas, and found them to be 2-3 points below the OLS estimates, we have not relied on these results.

5.4.2 Dealing with the "point in the month" effect

As discussed in Chapter 4, SFG emphasised the needed to undertake multiple estimates of monthly returns in order to ensure that the choice of the day of the month does not bias the resulting beta estimate:[90]

> We reiterate the importance of performing the analysis 20 times and reporting mean values. For the Industrial Transportation sector, across the 20 sets of analysis the minimum beta estimate was 0.76 and the maximum beta estimate was 0.93. For the Gas, water & multi-utilities sector, the minimum beta estimate was 0.62 and the maximum estimate was 0.90. These differences result purely from the selection of the day at which the four-weekly returns are computed, and there is no reason to believe that one start point will be more reliable than another start point.

We consider this to be a reasonable criticism of beta estimates that are based on only one (random) definition of a monthly interval. We agree with SFG that there is a degree of arbitrariness in the standard approach of using the last day of the month to measure the returns of the stock and the market index. There is nothing in finance theory that specifies that any reference day in a calendar month is superior to any other day, and that not taking account of this potential variability could bias the estimate of beta for a given stock, and affect the comparability of beta estimates between different stocks. A market 'puzzle' termed the 'turn of the month' effect has been documented by researchers since it was first noted by Lakonishok and Smidt (1988).[91]

While we agree with SFG that it is appropriate to apply an adjustment, our approach, which is outlined in more detail in Appendix B, is to identify the distribution of market trading days and use this to generate a random a series of different length 's-months' for a given beta estimation period. Thus, for a 60 month estimate of beta we have taken 61 months of daily returns data up to the date in question (e.g. 31 December, 2012), and randomly generated 4,995 simulations (different

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88 Gray, S. and R.R. Officer (17 April, 2005), *The Equity Beta of an Electricity Distribution Business*, Report prepared for ETSA Utlilties.

89 SFG (26 June, 2013), *Comparison of OLS and LAD regression techniques for estimating beta*.

90 SFG (31, August, 2012), p. 14.

91 Joseph Lakonishok and Seymour Smidt, (Winter, 1988), 'Are Seasonal Anomalies Real? A Ninety Year Perspective,' *Review of Financial Studies*, No. 1, pp. 403-425; and John J. McConnell and Wei Xu, (April-May, 2008), 'Equity Returns at the Turn of the Month', *Financial Analyst Journal*, Vol. 64, No. 2, pp. 49-64.

combinations of pseudo-months) of different lengths for that period, with 4,995 corresponding estimates of beta. This formed a histogram of estimates of beta for a given firm over that estimation period, and we took the mean estimate from that distribution as the simulated beta estimate (i.e. SIM β).

5.5 Beta estimates

5.5.1 Industry betas

Table 5.3 displays the median OLS asset betas of the 107 firms described above arranged into the 6 industry groups that were also discussed. For the simulated months estimates (SIM), the daily stock and market returns data spanned close to 10 years (118 months to 28 June, 2013).[92]

Table 5.3: Conine asset beta estimates by industry and firm (debt beta = 0.12) to June 2013

Asset beta estimate	No. of firms	Conventional asset beta		SIM asset beta	
Obs. (maximum months)		117	117	117	117
		Mean	**Median**	Mean	**Median**
Coal	10	1.20	**1.29**	1.26	**1.35**
Rail	7	0.89	**0.99**	0.93	**0.89**
Airport	6	0.70	**0.67**	0.65	**0.63**
Tollroad	7	0.47	**0.49**	0.49	**0.49**
Energy	70	0.36	**0.34**	0.41	**0.42**
Water	7	0.34	**0.35**	0.41	**0.40**

Source: Data obtained from Bloomberg, Incenta analysis

On average, the simulated month asset betas are found to be approximately 3 points (0.03) higher than the conventional OLS asset beta estimates (i.e. 0.55 vs 0.52).[93] There is a 5 point (0.05) increase in the average asset beta for the regulated energy industry (and an 8 point (0.08) increase in the median), and a 10 point reduction (0.99 to 0.89) in the median asset beta of the railroad industry (but an increase in the average asset beta from 0.89 to 0.93). The two industries subject to cost based regulation with periodic price reviews (regulated energy, water) have lower median asset betas than the unregulated, non-reviewable regulated or lightly regulated transport industries (rail, airport and tollroad).

Table 5.4 shows the annual movements in 60 month simulated month (SIM) betas from 2008 to 2012 by industry group. This table shows that the SIM asset beta of the relatively large group of regulated energy firms was relatively stable over the entire period, with the average / median beta fluctuating between 0.40 and 0.44. The smaller regulated water group of firms fluctuated more widely, being at one point (2008) higher than energy and toll roads, and more recently well below the level of regulated energy firms. The tollroads asset beta always stayed above the energy beta, and the airport

92 For the SIM beta estimates one extra month was required in order to begin the draw of randomly generated simulated months.

93 We also found that the 97.5 per cent confidence interval around the beta estimate for the total sample reduced from ±0.188 using one definition of the end of the month, to ±0.155 using the SIM beta estimation approach.

and rail industries stayed significantly above tollroads. Through the period coal was consistently and by far the highest asset beta industry.

Table 5.4: Conine asset beta (SIM) estimates by industry and firm (debt beta = 0.12), 2008-2012

		2008	2009	2010	2011	2012	**Average**
Obs. (maximum months)		60	60	60	60	60	60
Industry (No. of firms)							
Coal (10)	Mean	1.37	1.47	1.48	1.47	1.33	1.42
	Median	**1.40**	**1.56**	**1.62**	**1.53**	**1.39**	**1.50**
Rail (7)	Mean	0.87	0.95	0.97	0.97	0.94	0.94
	Median	**0.73**	**0.91**	**0.97**	**0.96**	**0.94**	**0.90**
Airport (6)	Mean	0.77	0.77	0.72	0.67	0.64	0.71
	Median	**0.77**	**0.76**	**0.72**	**0.64**	**0.60**	**0.70**
Tollroad (7)	Mean	0.46	0.54	0.50	0.50	0.46	0.49
	Median	**0.48**	**0.55**	**0.50**	**0.50**	**0.48**	**0.50**
Energy (70)	Mean	0.44	0.43	0.42	0.42	0.40	0.42
	Median	**0.43**	**0.44**	**0.42**	**0.42**	**0.41**	**0.42**
Water (7)	Mean	0.53	0.43	0.39	0.36	0.35	0.41
	Median	**0.54**	**0.43**	**0.37**	**0.34**	**0.32**	**0.40**

Source: Bloomberg and Incenta

5.5.2 Other (indirect) market evidence

In Chapter 3 we mentioned that when assessing the asset beta of the DBCT coal terminal port, independent expert Grant Samuel did not consider general cargo ports to be appropriate comparators as they were not subjected to the same heavy regulation as DBCT.[94] In valuing Prime's business operations Grant Samuel produced a table (reproduced as Table 5.5 below) of its benchmark gearing and equity beta assumptions.

With respect to DBCT, Grant Samuel concluded that:[95]

> A beta in the range of 0.7-0.8 has also been adopted for DBCT. While this appears low, none of the other listed ports are regulated and in Grant Samuel's view, the regulated nature of the asset (and the certainty of its cash flows) warrants a lower beta.

This range of equity betas/gearing levels translates to an asset beta of approximately 0.35 (assuming a Conine formula transformation and a debt beta of 0.12). As can be observed in Table 5.5, Grant Samuel concluded that DBCT's asset beta is lower than that of a regulated energy network (Powerco), which was assessed to have an asset beta of approximately 0.42 (assuming a Conine transformation and a debt beta of 0.12). As this analysis formed part of a valuation for a market transaction, it

94 Grant Samuel (24 September, 2010), *Proposal from Brookfield Infrastructure Partners L.P.*, Independent Expert report addressed to the board of directors of Prime Infrastructure Holdings Limited.

95 Grant Samuel (24 September, 2010), Appendix 1, p.10.

provides indirect evidence of a case where a regulated asset operating in the same value chain as Aurizon Network was considered to have less systematic risk than a regulated electricity network.

Table 5.5: Grant Samuel's equity beta ranges for Prime Infrastructure assets, 2010

Asset	Equity beta range	Equity beta range
Utilities operations:		
DBCT	60% - 70%	0.70 – 0.80
Powerco	50% - 60%	0.70 – 0.80
International Energy Group	25% - 30%	0.70 – 0.80
Fee for service operations:		
NGPL	25% - 35%	0.70 – 0.80
WestNet Rail	20% - 25%	1.0 – 1.10
Euroports	10% - 15%	1.10 – 1.20
Tas Gas	50% - 60%	0.70 – 0.80

Source: Grant Samuel (24 September, 2010), pp.8 and 10.

We consider that Grant Samuel's asset beta estimate of 0.35 forms the lower bound of expectations for Aurizon Network, which (as discussed in Chapter 3) we have considered to demonstrate systematic risk characteristics that are similar to those of regulated energy networks.

5.5.3 Aurizon Network's beta estimate based on first principles and industry analysis

As concluded in Chapter 3, we consider that regulated energy and water businesses provide the most relevant benchmark against which Aurizon Network's systematic risk should be judged. With this in mind, our estimate of a reasonable range of asset betas for Aurizon Network is based on the following evidence and reasoning:

- *Below tollroads* – We consider that the 0.49 asset beta observed for tollroads defines the upper boundary of a reasonable range for Aurizon Network's asset beta. As discussed in Chapter 3, tollroads are not regulated (or subject to light-handed regulation of some component of revenue), are more subject to cyclical economic activity than Aurizon Network, and are likely to be subject to more asset stranding risk than Aurizon Network. All of these factors are indicative that the systematic risk of tollroads will be greater than the systematic risk of energy and water businesses, and of Aurizon Network.

- *Similar to regulated energy network businesses* – As discussed in Chapter 3, we consider the systematic risk characteristics of Aurizon Network to be similar to those observed for regulated energy and water businesses. Our point asset beta estimate of 0.42 for Aurizon Network reflects the fact that we have observed an estimated asset beta in the range of 0.41 to 0.42 for regulated energy businesses. The 70 firm sample of businesses used in deriving this estimate is by far the largest of any industry group considered, and we therefore have the greatest degree of confidence in this number relative to all the other industry betas we have estimated. While this estimate still has a wide confidence interval around it, we have constrained the reasonable boundaries of our estimate based on the estimate for tollroads (discussed above), and Grant Samuel's estimate of the asset beta of DBCT (discussed next).

- *Above Grant Samuel's beta estimate for DBCT* – As noted above, in 2010 Grant Samuel's independent expert report on the assets of Prime Infrastructure applied an asset beta of 0.35 to DBCT, a coal export port that is in the same Queensland coal supply chain as Aurizon Network. This is an indirect market observation that was applied in the valuation of a business in the course of a market transaction. It is therefore indicative of participants in the market applying a beta to an asset that has many characteristics similar to Aurizon Network, which is below the asset beta that was applied to a regulated energy network (Powerco).[96] Whilst our empirical findings agree with the asset beta that Grant Samuel applied to Powerco, we do not agree that there is evidence to indicate that Aurizon Network's asset beta is lower than that of a regulated energy network. Hence, we consider that Grant Samuel's opinion on the asset beta of DBCT should be seen as the lower bound of a reasonable range of asset betas for Aurizon Network.

We have developed the above asset beta range of 0.35 to 0.49 based on an assumption that regulated businesses will have a similar asset beta in the same industry, irrespective of the nature of the form of that regulation. Whilst it is plausible that different regulatory approaches (e.g. cost of service and price-cap or incentive regulation) could have different asset betas, in the following section we test this proposition using the regulated energy firms' sample, and cannot find evidence to support the hypothesis.

5.6 Influence of form of regulation on beta

5.6.1 Form of regulation

In this section we investigate the question of whether the form of regulation affects the asset beta of a regulated firm. The Authority has requested that we review this question, and as noted above, our analysis so far, being based on a range of business regulated in different ways, has implicitly assumed that within an industry asset betas do not differ materially under alternative forms of regulation. We observe that the reference to form of regulation relates to two attributes of regulatory regimes:

- The degree to which a firm is able to be rewarded or penalised depending upon its ability to control cost (often referred to as the degree of incentive power in the regime); and
- The form of price control that applies to the firm and the consequent degree of volume-related revenue risk that is borne between periodic reviews.

The choice with respect to these elements of a regulatory regime will affect the extent to which volatility in cash flow would be expected to translate into volatility in economic returns. At one end of a spectrum, if a firm's prices were continuously updated to reflect changes in cost and revenue (or updated after the fact with retrospective effect), then cash flow volatility would not cause volatility in economic returns. At the other end of the spectrum, if regulated prices were never reviewed, then

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96 That is, in the same expert report Grant Samuel applied an asset beta of 0.42 to the New Zealand energy distribution business Powerco.

changes to cash flow would translate directly into changes in economic returns. In practice, neither of these extremes exist,[97] and differences in the forms of regulation tend to be more subtle.[98]

5.6.2 Findings of previous studies

It has long been held that incentive regulation, which allows firms to out-perform regulatory targets (but also provides scope for under-performance) will result in higher asset betas. An early analysis of different regulatory frameworks undertaken by Alexander, Mayer and Weeds (1996) found that regimes with high-powered incentives (UK price-cap regulation and revenue-caps) showed higher betas than low-powered (US cost of service) regimes.[99] However, their methodology was to consider alternative regulatory frameworks in different countries for the same industry (specifically, rate of return regulation in the US and 'incentive' CPI-X regulation in the UK), which is not ideal.[100] A recent study of the regulated US energy industry found no evidence that beta was related to the type of regulation (i.e. high vs low incentive), although it did not test the beta impact of revenue caps, as is practiced by the QCA with respect to Aurizon Network.[101]

In the UK, Grout and Zalewska (2006) found that discussions about moving from an incentive based to a profit sharing regulatory framework (which according to Grout and Zalewska sits between incentive based and cost of service regulation in the systematic risk scale) was observed to be associated with a reduction in the estimated beta.[102] However, this study is difficult to interpret because the proposal in question did not eventuate, but rather was discussed, committed to and then reversed without actually going into effect. Thus, unless the profit sharing was going to be retrospective (which was not alluded to by Grout and Zalewska), the new framework would not have changed current cash flow, and so the change in the betas presented in the study could not have reflected the change in the covariance of cash flow with the market that would be caused by the measure. Rather, the change in the betas presented would have reflected the relationship between the expected effect of a move to profit sharing on future cash flows, with the current economic return on the market as a whole.

A study by the Allen Consulting Group (ACG) in 2008 found no difference in the betas of groups of US energy utilities depending on whether a form of incentive regulation had been applied.[103] This report and others were cited by New Zealand Commerce Commission, when it concluded that, 'In

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97 Having said that, as discussed above, tollroads provide an example of where an allowed price is normally set but not typically subject to a cost-based review.

98 As noted at the end of this section, commentators have even questioned whether there is a material difference in incentive power between the US-style rate of return regulation and incentive regulation as practiced in the UK. In particular, under US-style rate of return regulation rates are only ever changed prospectively, and so there is never perfect correspondence between cost and revenue. In addition, the outcome of a regulatory review is a schedule of rates that are fixed in nominal terms, which exposes firms to both volume risk and inflation risk, neither of which tend to be borne by UK firms.

99 Alexander, I., C. Mayer and H. Weeds, (December, 1996), *Regulatory structure and risk: An international comparison*, The World Bank Policy Research Working Paper No 1698.

100 Alexander, I. Mayer, C. and H. Weeds (1996), *Regulatory Structure and Risk: An International Comparison*, paper prepared for the World Bank.

101 CEG (June, 2013), Information on equity beta from US companies,

102 Grout, P. A. and A Zalewska (2006), 'The impact of regulation on market risk', *Journal of Financial Economics*, Vol. 80 (1), pp. 149-184.

103 Allen Consulting Group (17 September, 2008), *Beta for regulated electricity transmission and distribution*, Report for Energy Networks Association, Grid Australia and APIA, pp.49-50.

practice, the empirical evidence has not shown a significant difference between the systematic risks associated with different types of regulation.'[104]

A much more extensive recent international study by Gaggero (2012) could not find any consistent differences in beta for different forms of regulation (including price cap vs revenue cap),[105] and a recent international study by Rothballer (2012) suggests that incentive regulation will only increase beta relative to cost-based regulation when the regulatory framework is free of political interference, but did not test price cap vs revenue cap.[106]

During the last decade in North America there has been a shift away from the traditional cost of service regulatory approach toward incentive regulation, and also away from having schedules of prices fixed (which is akin to a price cap) towards 'decoupling' (which is akin to a revenue cap, with decoupling meaning that earnings are decoupled from the volume of energy sold). Where there has been a shift to "decoupling", a minority of state regulators have asserted that there is a reduction in systematic risk, and have applied a 10 to 50 basis points lower ROE.[107] However, the US consulting firm, The Brattle Group, examined this hypothesis with a group of 'decoupled' and 'non-decoupled' US regulated gas businesses, and found that, if anything, the decoupled group had a marginally higher cost of equity.[108]

5.6.3 Alternative hypotheses about the impact of regulation

The hypothesis that the form of regulation will have a material impact on asset beta is consistent with the view that the asset beta may be decomposed into the revenue beta and the variable cost beta, as proposed by Brealey, Myers, Partington, and Robinson:[109]

$$\beta_A = \beta_R \frac{R}{A} - \beta_{VC} \frac{VC}{A}$$

Where, β_A, β_R and β_{VC} are respectively the asset beta, revenue beta and variable cost beta. In this formulation, the application of a revenue-cap would be expected to reduce the revenue beta to a small value (and smaller than that of a firm subject to a price cap), thus reducing the asset beta possibly to a small value (with the final result depending upon the sign and magnitude of the cost beta).

The alternative hypothesis is that the simple decomposition of the asset beta into revenue and cost betas is flawed because it ignores the other – and possibly more important – factor that causes

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104 Commerce Commission (22 December, 2010), *Input Methodologies (EDBs & GPBs) – Reasons Paper*, p. 540.

105 Gaggero, A. (2010), 'Regulation and Risk: A Cross-Country Survey of Regulated Companies,' *Bulletin of Economic Research*, pp.1-13.

106 Rothballer, Christoph (2012), *Infrastructure Investment Characteristics: Risk, Regulation, and Inflation Hedging*, Doctoral Thesis, Technical University of Munich.

107 Only 22 per cent of regulators reduced the ROE as a result of decoupling, with more than half of these reductions being 10 basis points. See Morgan, P. (February, 2013), *A Decade of Decoupling for US Energy Utilities: Rate Impacts, Designs, and Observations*, Graceful Systems LLC, p. 14.

108 The Brattle Group, (March, 2011), *The Impact of Decoupling on the Cost of Capital*, An Empirical Investigation.

109 Brealey, R., S. Myers, G. Partington and D. Robinson (2000), *Principles of Corporate Finance*, McGraw-Hill.

systematic risk, namely variation in the discount rate that investors apply the a particular project. This alternative hypothesis is that volatility (covariance) in cash flow contributes very little to the asset beta of an average firm – and even less to the asset beta of utility firms – so that a change in regulation that alters the volatility of, say revenue, would not be expected to have a material effect on asset beta estimates.

This alternative hypothesis is based on the work of Campbell and Shiller (1988), Campbell and Mei (1993), [110] and Campbell and Vuolteenaho (2004).[111] Campbell and Mei (1993) de-composed beta into three components: cash flow beta, real interest rate beta, and expected excess returns beta. They found that cash flow beta was generally a small contributor to overall beta, and especially so for utilities. Their results imply that the asset beta of price-regulated businesses would not be expected to be materially affected by the extent of volatility in cash flow, for example, as may be associated with the choice between a price-cap and revenue-cap, but is more affected by the extent of excess return risk that is borne (i.e. the tendency for movements in the risk premium element of the discount rate applied by investors to be inversely related to market cycles, and thereby generate a pro-cyclical movement in asset values). In a later influential paper published in the *American Economic Review*, Campbell and Vuolteenaho (2004) collapsed the real interest rate beta and expected excess returns beta into a 'discount rate beta', and characterised total market beta as the sum of the cash flow beta, and the discount rate beta. The relative size of the cash flow beta estimates has been questioned by Chen and Zhao (2009), who found that for Treasury bonds, which should have a zero cash flow beta, the methodology applied by Campbell and Vuolteenaho derived a relatively large cash flow beta.[112]

Oxera has found that for National Grid and Scottish & Southern Electricity, the cash flow component of beta (calculated in the manner suggested by Campbell and Vuolteenaho) has been a small fraction of the total beta (10 per cent as opposed to 20 per cent for the market as a whole), which was considered to be largely determined by the discount rate beta component.[113] In the US, Cornell (1999) found that for long term Treasury bonds, over a period of 20 years to 1997, the average beta ranged from 0.30 to 0.50, even though these bonds had no cash flow risk.[114] Whilst there are measurement issues, this research is consistent with the view that a relatively small component of the total beta of regulated businesses is due to cash flow beta.

If the beta of regulated businesses is determined largely by the discount rate component, then differences in cash flow (or revenue) beta will have a relatively small influence on total asset beta. Hence, if alternative regulatory arrangements mainly affect the cash flow beta, the differences in total

110 Campbell, J.W. and J. Mei. (1993), 'Where do betas come from? Asset price dynamics and the sources of systematic risk', *Review of Financial Studies*, 1, No. 2, pp.195-228.

111 Campbell, J.W. and R. Shiller (1988), 'The Dividend-Price Ratio and Expectations of Future Dividends and Discount Factors,' Review of Financial Studies, 1, pp. 195-228; Campbell, J.W. and T. Vuolteenaho, (December, 2004), 'Bad Beta, Good Beta', *The American Economic Review*, Vol. 94, No. 5, pp. 1249-1275.

112 Chen, L. and X. Zhao, (2009), Return Decomposition, *The Review of Financial Studies*, Volume 22, No. 12, p. 5245. Chen and Zhao also noted that its findings were consistent with the view that temporal variation in the equity risk premium has an important impact on the determination of aggregate returns.

113 Oxera, (July, 2011), *The impact of longer asset lives on the cost of equity: estimating cash flow betas*, Prepared for Energy Networks Association, pp.6-7.

114 Cornell, B., (1999), 'Risk, Duration, and Capital Budgeting: New Evidence on Some Old Questions,' *Journal of Business*, vol. 72, No. 2, pp. 183-200; and Davis, K., (March, 2005), 'The Systematic Risk of Debt', *Australian Economic Papers*, pp.30-46.

asset betas between these different regulatory approaches could be relatively small. Therefore, the alternative hypothesis is that form of regulation would not have a great influence on beta.

Some observers have remarked that alternative regulatory regimes are often not as different as they at first seem. For example, Joskow considers that incentive regulation in the UK is not dissimilar to US cost-of-service regulation,[115] and it has been observed that US and UK regulatory regimes have been moving closer together over time.[116]

In summary, it has often been hypothesised that incentive regulation with a price-cap will attract the highest beta, while rate of return regulation will attract the lowest beta, with revenue-cap regulation being in between. The alternative hypothesis is that for a given industry group, different forms of regulation will not result in material differences in asset beta.

Empirical results

Table 5.5 below displays the results, which compare the simulated month (SIM) asset betas of alternative regulatory approaches for 2012. The key finding is that we could not find a discernable difference between the 60 month asset betas of the alternative regulatory forms:

- *North America* – all three regulatory forms (cost of service, 'decoupled' and 'incentive') had an average/median asset beta in the range of 0.40 to 0.43.
- *Australia, New Zealand and the UK* - There were relatively fewer firms (9), but even so there was relatively little difference between price-cap and revenue-cap firms. That is, the 3 revenue cap firms had a slightly higher average asset beta (0.32), and a slightly lower median asset beta (0.27) than the price-cap firms (which had average/median asset beta estimates of 0.31).[117] Due to the low number of observations (9 firms in all), this comparison does not provide evidence that there is a material difference between firms regulated with a price-cap and a revenue-cap.

Table 5.5: Form of regulation and asset beta – energy (2012)

	All firms	Price-cap	Revenue-cap	Decoupled	Cost of service	Incentive
Countries		Australia, NZ and UK		US and Canada		
No. of firms	70	6	3	23	37	21
Average beta	0.40	0.31	0.32	0.40	0.43	0.41
Median beta	0.41	0.31	0.27	0.40	0.42	0.43

Source: Bloomberg and Incenta. Note: Total number of firms does not add across, as there were some decoupled firms that were also listed as operating under an incentive framework.

115 Joskow, P.L. (9-10 September, 2005), *Incentive Regulation in Theory and Practice: Electricity Distribution and Transmission Networks*, A Paper Prepared for the National Bureau of

116 Pfeifenberger, J. (May 26-27, 2010), *Incentive Regulation: Introduction and Context*, Presentation at AUC PBR Workshop, Edmonton, Alberta. Economic Research Conference on Economic Regulation, p.44.

117 Ignoring the fact that betas are estimated with error, the difference between the revenue-cap and price-cap regulated businesses in Australia/New Zealand/UK is not statistically significant applying a t-test.

These results indicate that neither in North America nor in Australia, New Zealand and the United Kingdom, is there clear evidence that incentive regulation (i.e. called incentive regulation in North America, and price-cap regulation elsewhere) attracts a higher beta relative to a revenue-cap regime (as it is called outside North America) or 'decoupled' regime (which is effectively a revenue-cap regime in North America). Nor is there evidence, based on the categorisation of this sample, to suggest that incentive or revenue cap regulation are associated with different asset betas to those estimated for traditional cost of service regulation (in North America).

The unexpected aspect in these results is the finding that even the firms regulated under the lowest-powered cost of service regime in North America have been observed to have a higher average asset beta than both price-cap and revenue-cap businesses elsewhere. This finding causes us to view the much smaller sample of non-North American results with reservation, and is why we would prefer to adopt a cautious approach when inferring from these results the appropriate asset beta to apply to Aurizon Network. Instead, we prefer to rely on the widest available body of evidence, which is our entire 70 firm sample of regulated energy businesses.

5.7 Comparison with previous regulatory decisions

For completeness, in Table 5.6 we provide a summary of a number of Australian regulatory decisions dealing with railroad assets, as well as a summary of decisions of the AER in relation to regulated energy networks. These decisions can be summarised as follows:

- *Aurizon Network* - With assumed 55 per cent gearing, in 2005 the QCA adopted an equity beta of 0.90 for Aurizon Network's assets (i.e. QR Network), which was at the top of the range (of 0.60 to 0.90) recommended by its adviser. The QCA saw this as a conservative decision that was applied to ensure investment (and compatibility with its decision on DBCT). In 2010 the QCA reduced the equity beta to 0.80 on grounds that a special investment incentive was no longer required, and expressed disagreement with the ACCC's draft report on the Hunter Valley Coal Network (HVCN), which is discussed further below.

- *Hunter Valley Coal Network (HVCN)* - IPART adopted a slightly lower equity beta of 0.85 for HVCN than the QCA had adopted at the same time for QR Coal (middle of the range of 0.70 to 1.0) in 2005, and in 2009 adopted a higher value for HVCN than the QCA's decision on QR Network in 2010. However, IPART also allowed an additional uplift on the cost of capital, so these betas are not strictly comparable.[118] The ACCC succeeded IPART as the regulator of ARTC's Hunter Valley Coal Network (HVCN) assets, and in 2010 adopted an equity beta of 0.94. The ACCC applied an asset beta of 0.45, which appeared to reference the QCA's earlier decision to apply an asset beta of 0.45.[119] However, the ACCC converted this asset beta into an equity beta using a debt beta of zero, whereas the QCA's decision applied a debt beta of 0.12, so that materially different equity betas were arrived at. It is not clear that this schism was intended by the ACCC. As shown in Table 5.6, applying the ACCC's use of a debt beta of zero means that the

118 See, IPART, (August 2009), New South Wales Rail Access Undertaking – Review of the rate of return and remaining mine life from 1 July 2009, p.6. In this decision IPART lifted the midpoint real pre-tax WACC from 7.4 per cent to 8 per cent.

119 See ACCC (21 December, 2010), *Position Paper in relation to the Australian Railtrack Corporation's proposed Hunter Valley Rail Network Access Undertaking*, pp. 111-112.

asset beta of 0.45 re-levers into an equity beta of 0.99 (for 55 per cent gearing), which is materially above the equity beta of 0.80 that the QCA derived from the same asset beta.

Table 5.6: Previous Australian rail and regulated energy decisions

Regu-lator	Regulated asset	Year	Gearing %	Asset beta	Equity beta	Asset beta	Equity beta	AER Energy
			Original decision			Geared 55% with Debt beta=0.12		Geared 55%
Below rail coal:								
QCA	QR Network	2010	55	0.45	0.80	0.45	0.80	0.71
ACCC	ARTC / HVCN	2010	52.5	0.45	0.94	0.545	0.99	0.71
IPART	ARTC / HVCN	2009	50-60	0.32-0.46	0.70-1.0	0.48	0.85	0.71
IPART	ARTC / HVCN	2005	50-60	0.32-0.46	0.70-1.0	0.48	0.85	0.89
QCA	QR Network	2005	55	0.50	0.90	0.50	0.90	0.89
Other rail:								
ERA	Pilbara Infrastructure	2013	30	1.00	1.43	1.08	2.08	0.71
ERA	Brookfield Rail	2013	35	0.65	1.00	0.725	1.35	0.71
ERA	Public Transport Authority	2013	35	0.3	0.46	0.35	0.59	0.71
ERA	Pilbara Infrastructure	2009	30	1.00	1.43	1.08	2.08	0.71
ERA	Freight (later Brookfield)	2008	35	0.6	1.00	0.725	1.35	0.89

Source: ACCC,AER, ERA, IPART, QCA decisions, and Incenta analysis. Note: Asset and equity betas geared to 55 per cent with debt beta of 0.12 based on Conine formula; AER equity beta transformation uses Harris & Pringle formula.

- *Other rail assets* – The other rail assets regulated by the Economic Regulation Authority (ERA) are not relevant to Aurizon Network, as they refer to assets that have significantly different systematic risks (e.g. iron ore haulage in the case of Pilbara Infrastructure, and subsidised city commuter rail in the case of the Public Transport Authority).

- *Regulated energy* - Both the QCA and ACCC have referred to regulated energy as a benchmark that should be considered a comparator industry for Aurizon Network. The AER's decisions on equity beta for an equivalent 55 per cent level of gearing are also shown in Table 5.6. This shows that the 2005 decisions of the QCA and IPART were relatively similar to the AER's decisions on equity beta for energy at that time. However, since 2009, when the AER reduced its assessment of the asset beta of regulated energy networks, the three decisions on Aurizon Network / QR Network and HVCN have exceeded the equivalent equity beta for energy networks on an adjusted (55 per cent) gearing basis.

Appendix A: Sample selection and description

Industry and firm	Select/reject
Airport	
Aeroporto di Venezia Marco Polo	Reject
Auckland International Airport	Select
Flughafen Wien	Select
Flughafen Zuerich AG	Select
Frankfurt Airport Services	Select
Gemina SPA	Select
Societa Iniziative Autostradali e Servizi SpA	Reject
Sydney Airport	Select
Aeroporto di Venezia Marco Polo	Reject
Coal	
Alliance Holdings	Select
Alliance Resource Partners	Select
Alpha Natural Resources	Reject
Arch Coal	Select
Cloud Peak Energy Inc	Select
CONSOL Energy	Select
Guildford Coal	Reject
Hallador Energy	Reject
James River Coal	Reject
Natural Resource Partners LP	Select
New Hope Corp	Select
Peabody Energy Corp	Select
Rhino Resource Partners LP	Reject
Walter Energy	Select
Westmoreland Coal	Reject
Whitehaven Coal	Select
Energy	
AGL Resources Inc	Select
ALLETE Inc	Select
Alliant Energy	Select
Ameren Corp	Select
American Electric Power Co	Select
APA Group	Select

Atco Ltd	Select
Atmos Energy Corp	Select
Avista Corp	Select
Canadian Utilities Ltd	Select
CenterPoint Energy	Select
Centrica	Select
Chesapeake Utilities Corp	Select
Cleco Corp	Select
CMS Energy Corp	Select
CONSOL Energy	Reject
Consolidated Energy Inc	Select
Delta Natural Gas	Reject
Dominion Resources Inc	Select
DTE Energy Co	Select
DUET Group	Select
Duke Energy Corp	Select
Edison International	Select
El Paso Electric Co	Select
Emera Inc	Select
Empire District Electric Co	Select
Entergy Corp	Select
Envestra	Select
Exelon Corp	Reject
FirstEnergy Corp	Select
Fortis Inc	Select
Gas Natural Inc	Reject
Great Plains Energy Inc	Select
Hawaiian Electric Industries	Reject
IDACORP Inc	Select
Integrys Energy Group	Select
ITC Holdings Corp	Select
Laclede Group	Select
Macquarie Infrastructure	Reject
MGE Energy	Select
National Fuel Gas	Select
National Grid	Select
New Jersey Resources Corp	Select

NextEra Energy	Select
NiSource Inc	Select
Northeast Utilities	Select
Northwest Natural Gas	Select
Northwestern Corp	Select
NV Energy Inc	Select
OGE Energy Corp	Select
Otter Tail Corp	Reject
Pepco Holdings Inc	Select
PG&E Corp	Select
Piedmont Natural Gas	Select
Pinnacle West Capital Corp	Select
PNM Resources Inc	Reject
Portland General Electric	Select
PPL Corp	Select
Public Service Enterprise Group	Select
Qube Holdings	Reject
Questar Corp	Reject
RGC Resources	Reject
SCANA Corp	Select
Sempra Energy	Select
South Jersey Industries Inc	Select
Southern Co	Select
Southwest Gas Corp	Select
SP AusNet	Select
Spark	Select
Spectra Energy Partners LP	Reject
SSE PLC	Reject
TC Pipelines LP	Select
TECO Energy Inc	Select
TransCanada Corp	Select
UGI Corp	Reject
UIL Holdings Corp	Select
United Utilities	Select
UNITIL Corp	Reject
UNS Energy Corp	Select
Valener Inc	Reject

Vector	Select
Vectren Corp	Select
Westar Energy Inc	Select
WGL Holdings Inc	Select
Wisconsin Energy Corp	Select
Xcel Energy Inc	Select
Port	
Bremer Lagerhaus-Gesellschaft AG	Reject
Eurokai KGaA	Select**
Hamburger Hafen und Logistik	Reject
Lyttelton Port Co	Reject
Northland Port	Reject
Piraeus Port Authority	Reject
Port of Tauranga	Select**
South Port New Zealand	Reject
Thessaloniki Port Authority	Reject
Westshore Terminals	Select**
Rail	
Asciano	Select
Aurizon	Reject
Canadian National Railway	Select
Canadian Pacific Railway	Select
CSX Corp	Select
FirstGroup Plc	Reject
Genesee & Wyoming Inc	Select
Go-Ahead Group	Reject
Jungfraubahn Holdings	Reject
Kansas City Southern	Select
Norfolk Southern	Select
Providence & Worcester Railroad Inc	Reject
Stagecoach Group	Reject
Union Pacific Corp	Select
VTG AG	Reject
Tollroad	
Abertis Infraestructuras SA	Select
ASTM SPA	Select
Atlandia SpA	Select

Brisa Auto-Estradas de Portugal SA	Select
Gruppe Eurotunnel SA	Select
Macquarie Atlas Roads	Reject
Societa Iniziative Autostradali e Servizi SpA	Select
Transurban Group	Select
Water	
Acqua America Inc	Select
American States Water	Select
American Waterworks Co	Select
Artesian Resources Corp	Reject
California Water Service Group	Select
Connecticut Water Service	Reject
Dee Valley Group	Reject
Middlesex Water Co	Reject
Pennon Group	Select
Pure Cycle Corp	Reject
Severn Trent	Select
SJW Corp	Select
York Water Co	Reject

*Note: **These selected firms were not used in the analysis owing to the small group of remaining ports and the disparate nature of their operations.*

Appendix B: Estimation of simulated-month betas

The Distribution of the Number of ASX Trading Days per Month

The table below lists the number of trading days and the percentage of months with the number of trading days for the Australian Exchange based on the list of national holidays over the years from 1976 to 2013. These days are the 1st of the year, Australia Day, ANZAC Day, Good Friday, Easter Monday, Queen's Birthday, Christmas and Boxing Day. Note that if these holidays occur over a weekend the following week day is the observance.

Of the 456 months in this period only 79 (18 per cent) had 20 days and 31 of these were in the month of February with a number of months (May, July, August, and October) with no months of 20 days. Thus SFG's use of 20 days is not related to the usual monthly returns periods. We find that 21, and 22 days are more common month lengths.

Appendix Table B.1: Number of ASX trading days 1976-2013.

Month	Number of ASX trading days 1976-2013								
	16	17	18	19	20	21	22	23	Total
Jan	0	0	0	11	12	15	0	0	38
	0	0	0	28.95	31.58	39.47	0	0	100.00
Feb	0	0	0	0	31	7	0	0	38
	0	0	0	0	81.58	18.42	0	0	100.00
March	0	0	1	2	6	4	11	14	38
	0	0	2.63	5.26	15.79	10.53	28.95	36.84	100.00
April	3	9	17	5	3	1	0	0	38
	7.89	23.68	44.74	13.16	7.89	2.63	0	0	100.00
May	0	0	0	0	0	11	11	16	38
	0	0	0	0	0	28.95	28.95	42.11	100.00
June	0	0	0	5	11	22	0	0	38
	0	0	0	13.16	28.95	57.89	0	0	100.00
July	0	0	0	0	0	11	12	15	38
	0	0	0	0	0	28.95	31.58	39.47	100.00
August	0	0	0	0	0	10	11	17	38
	0	0	0	0	0	26.32	28.95	44.74	100.00
Sept	0	0	0	0	6	10	22	0	38
	0	0	0	0	15.79	26.32	57.89	0	100.00
Oct	0	0	0	0	0	12	10	16	38
	0	0	0	0	0	31.58	26.32	42.11	100.00
Nov	0	0	0	0	5	10	23	0	38
	0	0	0	0	13.16	26.32	60.53	0	100.00
Dec	0	0	0	11	5	22	0	0	38
	0	0	0	28.95	13.16	57.89	0	0	100.00
Total	3	9	18	34	79	135	100	78	456
	0.66	1.97	3.95	7.46	17.32	29.61	21.93	17.11	100.00

A Simulated Month Experiment

In order to examine the potential influence of the monthly definitions of returns on the estimation of Beta we generated a new pseudo calendar to be superimposed on the daily data. Thus instead of a day designated February 1 it might be another day of a newly defined month. In this way we can abstract from the calendar influences that may be in play when using monthly data.

The international data used in this analysis was not limited to trading days alone. Only major holidays such as Christmas and New Year's Day were added to the weekends. Because the data are not limited to one country and each country has their own particular holidays, the asset price from the last open day was copied to the day that may be missing in a particular country. Thus the distribution of the number of days per month differed from the table shown above. In addition, the daily asset prices used were limited to observations from July 21st 2003 to July 18th 2013 a total of 118 complete months. Given this limitation we found that the number of days in the months had the following distribution.

Appendix Table B.2: Number of Trading Days in International Data.

Trading Days	%	Cum %
19	0.85	0.85
20	17.80	18.64
21	27.97	46.61
22	37.29	83.90
23	16.10	100.00

In order to generate a series of pseudo-month intervals (PMI) a random process was used to draw from the distribution implied by this table to determine the length of the month. The starting day for each PMI was drawn uniformly from 1 to 23. Thus the process proceeded in the following manner:

- 1st Draw an integer from 1 to 23 to establish the first day of the first pseudo-month where July 21st 2003 is the first day (these days exclude weekends).
- 2nd Draw from a distribution based on Table B.2 to determine which day is the last day of the PMI.
- 3rd Repeat step 2 for each successive PMI until all the daily data has been exhausted.

Each set of PMI definitions were then assigned to each day in the data series much as each day would be identified with a particular month. Thus a particular day may be any day of a PMI. In order to simulate monthly data we then used the difference between the asset price, plus any accumulated ex-dividend date during the PMI just as would be used for the usual monthly definitions. The market portfolio returns were also based on the same time periods. This entire procedure was done 5,000 times for each asset in the data set. Note that in many cases the number of daily observations for a particular asset may be shorter than the full time series. In these cases we would identify which days are included in which PMI.

Alternative 20 day month replication

We also ran the 20 day month model. In this case we estimated a model where we progressively changed the start and end of the month by one day until we had 20 new sets of PMIs.

An Analysis of the Estimates of Beta

The results for these two methods are very similar. As shown in Table 3 we find that on average the mean Conine Beta using the PMIs was .0425 *greater* than the equivalent OLS values and that the mean of the simulations was within the 95 per cent confidence interval for the OLS result around 97 per cent of the time (Note that most of the cases outside the OLS confidence interval the PMI Beta was below the confidence interval for the OLS Beta).

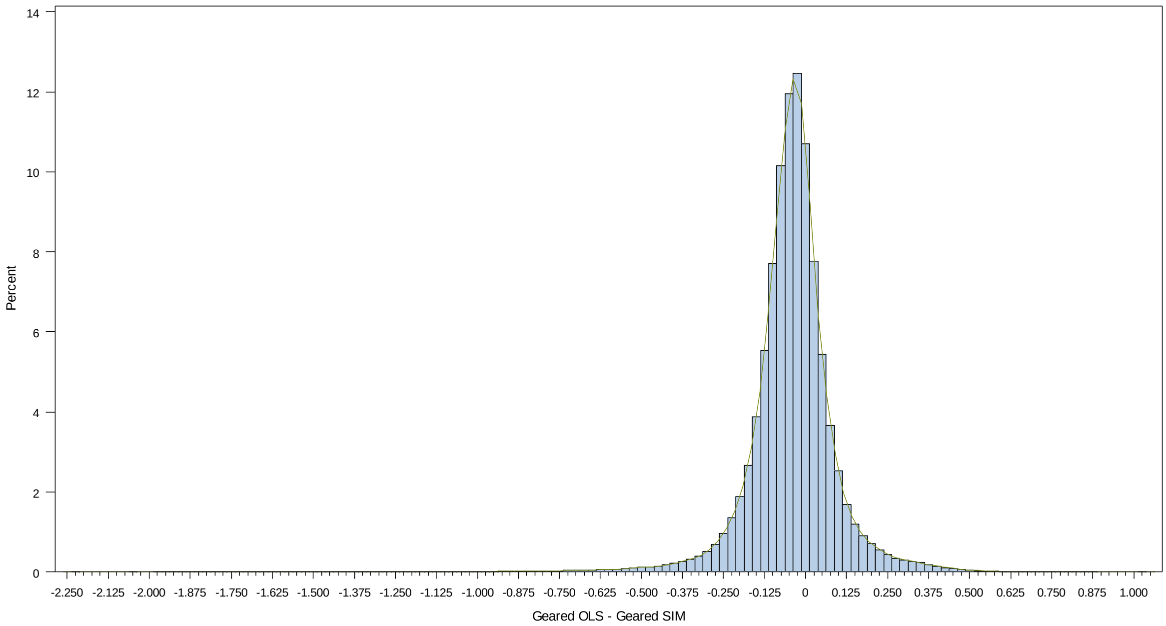
Table B.3: Summary of Simulation Results

Conine asset beta estimates	Number of simulations	
	5000	20
Average difference of OLS vs PMI beta	-0.0425	-0.0454
% of mean PMI betas within OLS 95% CI	97.45%	96.82%

These analyses were conducted for the OLS results and the equivalent results are available for the LAD Betas as well. A complete set of comparisons are provided in Tables 4 and 5 listed below including comparisons to the median of simulations and using the studentised simulation results that down weight the values of the Betas with standard errors that are greater than the OLS estimates.[120] These results are based on the individual simulations thus the difference for the % of the mean of the simulated betas as opposed to the % of all the simulated betas that fall within the OLS 95% CI as reported in Table B.3. From these tables we find that the difference between the OLS and simulated Betas are skewed to the left as a result of more of the simulated Betas being above the OLS Betas.

120 Studentised values are computed by the formula $\tilde{\beta}_s = \hat{\beta}(1-w_s)+\hat{\beta}_s w_s$ where $\hat{\beta}$ is the OLS value, $\tilde{\beta}_s$ is the simulated value using a particular definition of PMIs, $w_s = \frac{SE(\hat{\beta})}{SE(\hat{\beta}_s)}$, $SE(\hat{\beta})$ and $SE(\tilde{\beta}_s)$ are the corresponding estimated standard errors (see Efron and Tibshirani page 160-162, 1993). Note the standard errors used are all computed using the Newey-West (1994) adjusted standard errors.

Figure B.1: OLS Asset Beta minus the OLS Simulated Betas ($\hat{\beta} - \widehat{\beta_s}$) for 785,000 case/firms.



From Table B.4 we note that the highlighted rows are the difference between the OLS results and the means and medians of either the raw simulated Beta or the studentised version of Beta. From these rows we note that the difference in the means is consistently estimated at .0412 to .0446 depending on the estimated measure of central tendency used. However we do note that the limits of these differences are quite large. In all cases we have that the standard deviation of these differences that would result in the inability to reject the null hypothesis that the differences are significantly different from zero. This would also be the case if we confined our attention to the LAD results as well.

Also in this table are the differences between the computed 97.5% upper and 2.5% lower bounds of the simulations and the estimated confidence interval bounds obtained using the OLS and VAR Newey-West standard errors. These simulated bounds are based on the empirical distributions of the raw simulated Betas and the studentised Betas. Here we find that on average the differences for the lower bound are negative which implies that the OLS and VAR lower bounds are higher than the simulated bounds. For the upper bound a negative sign indicates that the OLS and LAD are higher than the simulated bounds. Here we find that three out of four of these measures indicate that the OLS and LAD upper bounds are higher than the simulated upper bound.

In addition to the location of the bounds we also checked to see how accurate the traditional $\pm 1.96 * SE(\hat{\beta})$ confidence interval is in determining where the simulated Beta might fall. In order to check for this we report the proportion of the cases in which the simulated OLS and LAD are located within the CI normally computed for either these estimators using the equivalent Newey-West standard errors. Again we find that these values range from 83.71% to 89.20% which are both lower than the theoretical 95% by from 6 to 12%.

Table B.4: The 5,000 PMI simulations compared to the OLS on the original data based on the comparisons with each simulation

Measure	Mean	Std Dev	Minimum	Maximum
OLS lower bound below Sim values	-0.1166	0.1596	-1.3680	0.2287
OLS lower bound below studentised Sim values	-0.0770	0.1720	-1.2175	0.5609
LAD lower bound below Sim values	-0.0807	0.2017	-2.1906	0.3023
LAD lower bound below studentised Sim values	-0.0520	0.2105	-2.0739	0.7147
OLS upper bound above Sim values	-0.0256	0.1325	-0.8053	0.2991
OLS upper bound above studentised Sim values	-0.0069	0.1444	-0.7989	0.4663
LAD upper bound above Sim values	-0.0026	0.1379	-0.6996	0.4851
LAD upper bound above studentised Sim values	0.0308	0.1297	-0.6904	0.3357
OLS Asset Beta - Mean of Sims	-0.0425	0.0992	-0.6424	0.2801
OLS Asset Beta - Mean of studentised Sims	-0.0412	0.1219	-0.8958	0.4053
OLS Asset Beta - Median of Sims	-0.0414	0.1000	-0.6643	0.2918
OLS Asset Beta - Median of studentised Sims	-0.0446	0.1175	-0.9127	0.3411
LAD Asset Beta - Mean of Sims	0.1571	0.5592	-0.8858	2.6721
LAD Asset Beta - Mean of studentised Sims	-0.0377	0.1325	-0.9458	0.6401
LAD Asset Beta - Median of Sims	-0.0353	0.1215	-0.9547	0.4939
LAD Asset Beta - Median of studentised Sims	-0.0359	0.1321	-1.0064	0.6181
Sim OLS inside OLS Confidence Interval	0.8920	0.1464	0.2096	1.0000

The results provided in Table B.5 are very similar, although the simulated CI's are much less accurate since they are based on far fewer data points.

Table B.5: The 20 Day PMI Simulations compared to the OLS on the original data based on the comparisons with each Simulation

Measure	Mean	Std Dev	Minimum	Maximum
OLS lower bound below Sim values	-0.1446	0.2062	-1.9502	0.2970
OLS lower bound below studentised Sim values	-0.1158	0.2218	-2.0411	0.4234
LAD lower bound below Sim values	-0.1027	0.1821	-1.8011	0.3003
LAD lower bound below studentised Sim values	-0.0654	0.1946	-1.5466	0.7621
OLS upper bound above Sim values	-0.0393	0.1470	-0.7791	0.3519
OLS upper bound above studentised Sim values	-0.0257	0.1776	-0.7729	1.3183
LAD upper bound above Sim values	-0.0188	0.1563	-0.8749	0.6249
LAD upper bound above studentised Sim values	0.0302	0.1485	-0.7166	0.5003
OLS Asset Beta - Mean of Sims	-0.0454	0.1050	-0.7497	0.2749
OLS Asset Beta - Mean of studentised Sims	-0.0462	0.1322	-1.0609	0.4361
OLS Asset Beta - Median of Sims	-0.0411	0.0998	-0.7010	0.2868
OLS Asset Beta - Median of studentised Sims	-0.0478	0.1250	-1.0164	0.4037
LAD Asset Beta - Mean of Sims	-0.0368	0.1214	-0.9634	0.4244
LAD Asset Beta - Mean of studentised Sims	-0.0410	0.1472	-1.2042	0.6010
LAD Asset Beta - Median of Sims	-0.0337	0.1320	-1.1415	0.4810

LAD Asset Beta - Median of studentised Sims	-0.0347	0.1508	-1.2662	0.6438
Sim OLS inside OLS CI	0.8831	0.1600	0.2000	1.0000
Studentized Sim OLS inside OLS CI	0.8812	0.1620	0.1500	1.0000
Sim LAD inside LAV CI	0.8755	0.1734	0.0000	1.0000
Studentized Sim LAV inside LAD CI	0.8290	0.1785	0.0000	1.0000
OLS lower bound below Sim values	-0.1446	0.2062	-1.9502	0.2970

References

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Newey, Whitney K. and Kenneth D. West (1994), 'Automatic Lag Length Selection in Covariance Matrix Estimation,' *Review of Economic Studies*, 61, 631-653.

Appendix C: Classification of energy industry sample by form of regulation

Regulated energy company	Form of regulation
DUET Group	Price cap
Duke Energy Corp	Cost of service
Consolidated Edison Inc	Incentive
Empire District Electric Co	Cost of service
El Paso Electric Co	Cost of service
Edison International	Decoupled / Incentive
Emera Inc	Cost of service
Envestra	Price cap
Entergy Corp	Cost of service
FirstEnergy Corp	Cost of service
Fortis Inc	Incentive
AGL Resources Inc	Decoupled
Great Plains Energy Inc	Cost of service
IDACORP Inc	Decoupled / Incentive
ITC Holdings Corp	Cost of service
Laclede Group	Decoupled / Incentive
Alliant Energy	Incentive
MGE Energy	Cost of service
NextEra Energy	Incentive
Northwestern Corp	Decoupled
National Fuel Gas	Cost of service
National Grid	Incentive
NiSource Inc	Cost of service
New Jersey Resources Corp	Decoupled
Northeast Utilities	Cost of service
NV Energy Inc	Decoupled / Incentive
Northwest Natural Gas	Decoupled
OGE Energy Corp	Cost of service
PG&E Corp	Decoupled / Incentive
Public Service Enterprise Group	Incentive
Pinnacle West Capital Corp	Cost of service
Piedmont Natural Gas	Decoupled
Pepco Holdings Inc	Decoupled / Incentive
Portland General Electric	Decoupled
PPL Corp	Cost of service

SCANA Corp	Cost of service
South Jersey Industries Inc	Decoupled / Incentive
Spark	Price cap
Southern Co	Cost of service
SP AusNet	Price cap
Sempra Energy	Cost of service
Southwest Gas Corp	Decoupled
TC Pipelines LP	Cost of service
TECO Energy Inc	Incentive
Integrys Energy Group	Cost of service
TransCanada Corp	Cost of service
UIL Holdings Corp	Decoupled
UNS Energy Corp	Cost of service
United Utilities	Revenue cap
Vector	Price cap
Vectren Corp	Decoupled
Wisconsin Energy Corp	Decoupled
WGL Holdings Inc	Decoupled
Westar Energy Inc	Cost of service
Xcel Energy Inc	Cost of service

Appendix D: Measurement of the degree of operating leverage

For firms in general, the degree of operating leverage (often denoted DOL) is expected to have a significant positive influence on asset beta. If a business has high fixed costs and low variable costs, the impact of variable revenue will be accentuated, as revenue rises and falls. The most commonly used formula to represent operating leverage is:

$$Degree\ of\ Operating\ Leverage = \frac{\%\Delta EBIT}{\%\Delta Q}$$

Where, ΔEBIT is the change in Operating Income Before Tax, and ΔQ is the change in the number of units sold. An empirical estimation of this relationship can be obtained through estimating the γ_1 coefficient in a regression of the form:[121]

$$Ln\ EBIT = \gamma_0 + \gamma_1\ Ln\ Sales + \mu$$

In a recent empirical analysis of operating leverage, Robert Novy-Marx concluded that:[122]

Operating leverage is, to first order approximation, the inverse of a firm's operating margins, and thus is generally closer to ten than to zero.

However, Novy-Marx also measured operating leverage as percentage of operating costs to total asset value. Our three alternative measures of DOL are:

- The sensitivity of EBIT to a change in sales - The coefficient (γ_1) on the natural logarithm of sales from a regression against the natural logarithm of EBIT (over the previous 5 years);
- The inverse of the EBIT margin over revenue;[123] and
- The percentage of operating costs to total asset value (as measured by non-current assets).

121 See, for example, Xue Zhang, (15 August, 2012), *The Role of Operating Leverage in Asset Pricing*, Master Thesis in Finance, Tilburg University.

122 Robert Novy-Marx (2011), 'Operating Leverage', *Review of Finance*, Vol.15 (1), pp.103-134.

123 We note that the correlation between EBIT and EBITDA is in the order of 0.99.