REVIEW OF WACC ISSUES

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CONTENTS

EXECUTIVE SUMMARY

This paper has examined a number of issues relating to the WACC of regulated businesses, and the principal conclusions are as follows.

Firstly, the Commission currently adds 0.10 to its estimate of the asset beta for electricity distribution businesses to obtain its estimate for gas pipeline businesses, in recognition of two points of distinction identified earlier by me that are relevant to beta: the option to expand the gas pipeline network and the higher proportion of gas being used by industrial and commercial customers rather than retail customers. The stronger of these two points is the expansion option (because the difference in the proportions of usage across the two user groups was not large). However my earlier analysis was conducted at the time these gas businesses were only subject to the threat of formal regulation rather than formal regulation per se. By contrast, they are now subject to formal regulation, this undercuts the value of expansion options in the regulated area, and therefore the argument for a higher asset beta for gas pipeline businesses is now significantly weaker. Furthermore, empirical evidence on the extent of any such beta differential is inconclusive. In view of all this, I do not favour a differential between the asset betas for the New Zealand electricity distribution and gas pipeline businesses in the present regulatory situation.

Secondly, and notwithstanding the theoretical expectation that price-capped businesses would have higher asset betas than both ROR regulated and revenue-capped businesses, there is no empirical study that provides a clear conclusion on the effect of regulation on beta. In the face of this uncertainty, and until better evidence becomes available, I consider that one should keep an open mind. Accordingly, in respect of the New Zealand DPP (price-capped) businesses, the best course of action would be to limit the comparators for them to either US ROR regulated or price capped businesses, depending upon which seems more appropriate, and I consider that the better comparators would be US price-capped businesses (including those also subject to earnings sharing in order to produce an adequate sample size), with the data used to estimate the betas being limited to the period in which the price capping prevailed. It would also be desirable to adjust for differences between the US and New Zealand for market leverage and the composition of the market indexes although related work suggests that the two effects might net out. In addition, in the absence of a sufficiently large set of suitable firms to assess the beta differential between price-capped and revenue-capped businesses, I recommend using the same asset beta for the revenue-capped as for the DPP (price-capped) businesses. This recommendation matches the view expressed in 2010 by the Commerce Commission. Nevertheless, my recommendation arises in spite of my belief that there is very likely to be a beta margin (of unknown degree) for price-capping over revenue-capping, because those businesses subject to it bear an additional source of risk (output) that would elevate beta.

Thirdly, and in relation to the Commission's 2010 estimate for the asset beta for regulated airport services, the Commission's approach commences with an estimate of 0.65 for the average asset beta of a set of comparator airports and then deducts 0.05 to account for the presumed higher beta of the unregulated activities of these airports. This approach implicitly involves estimates for the average proportion of airport value arising from that of regulated services and also the average asset beta for the unregulated services of the comparator airports. However, the Commission does not reveal its estimates for the latter two parameters. I estimate these parameters at 0.39 and 0.67 respectively, which implies deducting 0.03 from the estimated asset beta of the comparator airports in order to estimate the asset beta of the regulated services. This is similar to the Commission's estimate of 0.05. However the estimates of the two underlying parameter values are very imprecise, and the point estimate for the average weight on regulated services is also low, leading to an extremely imprecise estimate for the beta deduction.

Fourthly, in relation to Black's Simple Discounting Rule, this model could be applied to price and revenue-capping situations but there are significant limitations in doing so. Firstly, the model requires that the output of the regulated business be linearly related to the market return and no evidence has been presented on this matter. Secondly, the regulator would have to estimate the probability distribution for output without assistance from the regulated business, because the latter would have a vested interest in the result. Thirdly, a process for estimating the crucial parameter in Black's model that is referred to by Ireland Wallace would underestimate that parameter, possibly to a very significant degree. In view of these limitations, I do not favour this approach. Accordingly, there is no relief from the beta estimation problems discussed above. Information Disclosure regulation is quite different. In this case, the regulator merely estimates the WACC for comparison with the actual rate of return of the business. So, the expected cash flows of the regulated business (or expected output in a regulatory scenario) would never be estimated and therefore Black's Rule could not be applied in this case.

1. Introduction

This paper seeks to review a number of issues relating to the WACC of regulated businesses, comprising the merits of differential asset beta estimates for electricity and gas businesses, differential asset beta estimates for different regulatory regimes, a downward adjustment to the beta estimate for airports to estimate that for regulated operations, and the possible usefulness of Black's Simple Discounting Rule as a cross-check on the WACC of regulated businesses.

2. The Asset Beta

2.1 Adjustment for Gas Pipeline Businesses

The Commerce Commission (2010a, paras H8.167-179) adds 0.10 to its estimate of the asset beta for electricity distribution businesses to obtain its estimate for gas pipeline businesses. Following Lally (2008, section 5.2), this is in recognition of two points of distinction that are relevant to beta: the option to expand the gas pipeline network and the higher proportion of gas being used by industrial and commercial customers than for electricity. The stronger of these two points is the expansion option (because the difference in the proportions of usage across the two user groups was not large). However Lally's (2008) analysis was conducted at the time these gas businesses were only subject to the threat of formal regulation rather than formal regulation per se. By contrast, they are now subject to formal regulation, and this affects the argument for the differential in the asset beta. In particular, the option to expand a network affects beta to the extent that the option is valuable, and it is valuable to the extent that the expansion is expected to produce revenues in excess of costs. Furthermore, such excess revenues are more likely in the earlier scenario without formal regulation (to which Lally's analysis applied) than the current price or revenue control scenario because these controls constrain expected revenues to merely cover costs. So, the argument for a higher asset beta for gas pipeline businesses is now weaker than before. Furthermore, since the expansion option issue was the stronger of the two arguments for the asset beta differential, and that argument is now much less relevant, the argument for a beta differential relative to the electricity businesses is significantly weaker.

In respect of the point that a higher proportion of gas is being used by industrial and commercial customers than in the case of electricity, the current proportions for gas are 55% for commercial and industrial users, 4% for residential, and 41% for electricity generation

(Ministry of Business, Innovation and Employment, 2014, Figure D.16).[1] In addition, 68% of electricity generated goes to commercial and industrial users and 32% to residential users (Ministry of Business, Innovation and Employment, 2014, Figure F.6). So, the proportion of gas ultimately used by commercial/industrial users is 0.55 + 0.41(0.68) = 0.83, and the rest by residential users. By contrast, the proportion of electricity used by commercial/industrial users is 0.68. Assuming reasonably that beta is positively related to the proportion of the commodity used by commercial and industrial users, because their demand would be more sensitive to macro-economic shocks than that of residential users, the beta for the gas pipeline businesses would be higher. However the effect is likely to be small. To illustrate this point, assume that the beta of each business is entirely driven by revenues in which case the asset beta for the business is a value-weighted average of the betas for the two revenue streams (from commercial/industrial users and from residential users). Letting β_P denote the beta for residential users and K denote the beta for commercial/industrial users as a multiple of that for residential users, the Commission's asset beta estimate for the electricity distribution businesses of 0.34 can then be expressed as follows:

$$0.34 = \beta_P(0.32) + \beta_P K(0.68)$$

The asset beta for the gas businesses would then be as follows

$$\beta_G = \beta_P(0.17) + \beta_P K(0.83)$$

By positing a value for K, the first equation can be solved for β_P and then the second equation for β_G. For example, if K is 2, then $\beta_P = 0.20$ and therefore $\beta_G = 0.366$. Alternatively, if K is 3, then $\beta_P = 0.14$ and therefore $\beta_G = 0.373$. In either case, the beta for the gas businesses exceeds that for the electricity businesses by only 0.03. So, although a higher proportion of gas is used by industrial and commercial users than is the case for electricity, the proportion is not sufficiently higher to materially raise the beta for gas businesses.

Turning to empirical evidence on beta that is relevant to the current situation, there are too few listed businesses in New Zealand engaged predominantly in either gas or electricity

[1] This excludes the portion used for the production of methanol, etc, because the distance that this gas is piped is short and their contribution to revenues would be accordingly small (Lally, 2008, pp. 62-63).

distribution to be able to obtain a statically significant difference even if a difference did exist; two and zero firms respectively in 2010 (Commerce Commission, 2010a, Table H17). In respect of Australia, there are more such firms but the numbers are still not large (three of each: Commerce Commission, 2010a, Table H17) and there are differences in the regulatory regimes (price caps for gas and a mix of price and revenue caps for electricity). So, again, these are not useful. The largest set of such firms is in the US, and the Commerce Commission (2010a, Table H17) identifies 70 of them (51 electricity and 19 gas). Depending upon whether weekly or monthly data is used, the average result for electricity distributors either matches that for gas distributors or exceeds it by about 0.07 (Commerce Commission, 2010a, Table H19). On this basis, one could not reject the hypothesis that the population averages were the same. Furthermore, there is considerable variation in the regulatory regimes for the electricity distributors (ibid, Table H17) and therefore, despite the situation for the gas distributors not being reported (ibid, Table H17), the possibility of a significant difference in average regulatory regimes across the two sets of firms exists. So, even if one focused upon the empirical results using monthly data (in which the electricity firms have higher betas), and this was statistically significant, this might be due to differences in the average regulatory regime across the two sets of firms; so, one could not conclude that the asset betas were different if the two sets of firms were subject to the same regulatory regime (as is the case in New Zealand).

HoustonKemp (2016, section 2.2) argues that the rationale for the higher asset beta for gas relative to electricity businesses of 0.10 in Lally (2008, section 5.2) is equally valid today. However, HoustonKemp fail to recognise that the principal argument for the higher asset beta for the gas businesses that was presented in Lally (2008, section 5.2) is no longer applicable, as discussed above.

Colonial First State (2016, section 2) argues that the gas businesses warrant a higher asset beta than the electricity businesses because the price elasticity of demand for gas is higher than that of electricity. However, Colonial appear to be confusing the price elasticity of demand with that of the income elasticity of demand. Only the latter is relevant to beta: differences in beta are driven by differences in sensitivity to GDP shocks, and GDP shocks affect the demand for a product in accordance with its income elasticity of demand, not its price elasticity. Remarkably, Colonial First State assert that I share their view about the relevance of the price elasticity of demand but they do not provide a citation and Lally (2008) does *not* assert that a higher price elasticity of demand raises beta.

Colonial First State (2016, section 2) also refers to the volatility in the demand for gas by Methanex in support of a higher asset beta for GPBs. However, as noted in Lally (2008, section 5.2), the transmission of gas to Methanex contributes little to the revenues of the gas businesses because the distance that the gas is piped is so short. In addition, since most of Methanex's output is exported, its demand is sensitive to GDP shocks in its export markets rather than in New Zealand.

Colonial First State (2016, section 2) also finds that the average estimated asset betas of US gas distributors materially exceeds that of US electricity distributors, over the most recent two-year period. However, betas estimated over such a short period have high standard errors and therefore are not persuasive evidence. The Commerce Commission (2010a, Table H17) uses data over a longer period, it does not find the same effect, and this evidence is much more reliable.

Maui (2016) argues that gas transmission businesses (GTBs) distributors should have a higher asset beta than electricity distribution businesses (EDBs) because the foreign set of comparators used by the Commission have lower betas than the GTBs in New Zealand. However this point is only relevant to the betas of GTBs versus EDBs to the extent that these foreign comparators are less suitable for the GTBs than the EDBs, and I henceforth presume that Maui hold this view where it is plausible to so. Proceeding in this way, Maui's first point is then that the GTBs have a much smaller set of customers, and therefore greater demand risk, than the EDBs. However, GTBs are revenue-capped and therefore are not exposed to demand risk, whereas the EDBs are price-capped and therefore are exposed to demand risk. Furthermore, whilst a smaller set of customers exposes the GTBs to greater firm-specific risks, such risks are not by definition systematic and therefore would not be relevant to beta. Maui's second point is that the GTBs should have a higher asset beta than EDBs because their residential customers account for a smaller proportion of their demand. However, as discussed above, this is true but the beta effect would not be material.

In view of all this, I do not favour a differential between the asset betas for the New Zealand electricity and gas businesses in the present regulatory situation.

2.2 Adjustment for the Form of Control

Regulation comes in many forms, including rate of return (ROR), price capping, revenue capping, and price/revenue capping of variable/fixed costs respectively. Furthermore, since there are too few regulated businesses in New Zealand to obtain reliable empirical estimates of beta, it is necessary to draw upon estimates from foreign markets, which are typically subject to different regulatory regimes. This raises the question of whether the form of regulation affects beta. If it does, only comparators subject to the same regulatory regime should be used. If it does not affect beta, the set of comparators can be expanded. As argued in Lally (2008, pp. 50-51), five-year price caps should give rise to a higher beta than rate of return (ROR) regulation because the latter effectively fixes prices for a much shorter period. In addition, price caps should also give rise to higher betas than revenue caps (and hybrid price/revenue caps) because price caps expose firms to volume risk and this is at least partly systematic. However, after reviewing the empirical evidence in respect of electricity and gas transmission and distribution, the Commerce Commission (2010a, para H8.161) concludes that the form of control does not materially affect beta and it therefore uses a set of comparators from Australia (price and revenue caps), the UK (hybrid price/revenue capped), and the US (ROR regulated and various incentive regimes including price caps).

Since there are large numbers of businesses subject to each of these regimes one might expect that empirical evidence would reliably quantify these effects. However there are considerable difficulties in doing so as follows. Firstly, while the betas for any particular regulatory regime are very large relative to the standard error, the same is not true of the differences in betas between regulatory regimes because the difference in betas is smaller than the absolute value and also because the standard error is larger. In particular, letting σ denote the standard deviation of an individual firm's asset beta estimate and N the number of firms used, the standard error of the average beta estimate will be[2]

$$\sigma(\bar{\hat{\beta}}) = \sigma\sqrt{\frac{1}{N}}$$

[2] This formula also assumes that the beta estimates of the individual firms are statistically independent, which is not the case. However, this issue applies to both the absolute values and the differences and therefore does not undercut the comparison being made here.

By contrast, when examining the difference in betas of two (equal) sized groups of firms, each equal in size to the former group, the standard error of the difference in the average beta estimates will be

$$\sigma(\bar{\hat{\beta}}_1 - \bar{\hat{\beta}}_2) = \sigma\sqrt{\frac{1}{N} + \frac{1}{N}} = \sqrt{2}\left[\sigma\sqrt{\frac{1}{N}}\right] \quad (1)$$

So, the standard error of the difference in the average betas is 40% larger than that of the standard error of the average beta. If the difference in betas is (say) one third of the absolute level, then the ratio of the difference in betas to its standard error is only 24% of that for the ratio of the absolute beta to its standard error. So, even if there is a true difference in the betas of two groups, obtaining a statistically significant difference will be much harder than finding a statically significant absolute beta.

Secondly, if beta estimates for the two sets of firms are drawn from different markets, the differences in the beta estimates will be contaminated by differences in market leverage in the two markets (Lally, 2002), differences in the composition of the market indexes against which betas are estimated (Lally, 2004), and exposure to different macro events that affect beta estimates. Thirdly, many such businesses are not listed. Fourthly, even when listed, many such businesses are members of diversified conglomerates which are also involved in unregulated activities, or regulated activities involving a different type of service, or regulated activities of the same type but subject to a different regulatory regime.

Before turning to the empirical evidence I first consider how regulation affects systematic risk. Consistent with most costs in this industry (electricity and gas transmission and distribution) being fixed, I assume that all of them are fixed. Suppose regulatory assets are purchased now for A, with a life of one period, the output level (Q) of the business (delivered at period end) is certain, opex (C) is uncertain, and the regulator sets the output price (P) to cover the cost of the assets, a cost of capital at rate k, and allowed opex of C_R. The net cash flows received by the business at period end will then be as follows:

$$NCF = PQ - C = \left[\frac{A(1+k) + C_R}{Q}\right]Q - C = A(1+k) + (C_R - C)$$

So, the only source of uncertainty in this future net cash flow is deviations of actual opex from that allowed by the regulator. Plausibly, opex is high (low) when GDP is high (low) and this in turn when market returns are high (low). So, the business's net cash flows are lowest (highest) when market returns are high (low), which is negative beta. If some cost shocks are passed through to consumers within the cycle, this effect is attenuated. The QCA (2012, pp. 14-15) makes the same point. Now suppose that output is also uncertain and the firm is price capped. The allowed price will reflect the output level expected by the regulator (Q_R) and therefore the net cash flows received by the business at period end will be as follows:

$$NCF = PQ - C = \left[\frac{A(1+k)+C_R}{Q_R}\right]Q - C = \left[A(1+k)+C_R\right]\frac{Q}{Q_R} - C$$

So, there are now two sources of uncertainty, relating to actual opex and to actual output. In respect of the output effect, net cash flow rises if actual output exceeds that expected by the regulator, this would tend to occur when GDP is high and hence market returns high, which is positive beta.[3] By contrast, if the business is revenue capped (via ex-post price adjustments by the regulator to neutralise output shocks), this volume effect will not arise. Essentially the same effect is also achieved if the businesses use a mix of fixed and variable charges to match their cost mix and most of their costs are fixed with respect to output; for example, the Queensland water businesses (QCA, 2012, page 20). A further source of risk relates to the allowed cost of capital, but in a multiperiod framework in which the regulator resets the allowed rate and may err in doing so. To model this, suppose the asset life is two periods, and regulatory resetting occurs at the beginning of each period. So, the first period's allowance will cover only part of the asset cost (say half) and the firm's payoff at the end of the first period will comprise the net cash flows above (subject to allowing only 50% depreciation instead of 100%) plus the value at that point (V_1) of the net cash flows to be received at the end of the second period. So, the payoff at the end of the first period will be as follows**:**

$$Payoff = PQ - C + 0.5A = \left[A(0.5+k)+C_R\right]\frac{Q}{Q_R} - C + V_1$$

[3] This analysis assumes that the price is set per unit of output. By contrast, the New Zealand electricity distribution businesses typically have a daily fixed charge and a charge per unit of usage, but most revenue is from the variable charge whilst most costs are fixed with respect to output (Electricity Authority, 2015, page G). So, the characterisation above of a price capped firm is only approximate, but sufficient for the present purposes.

If the regulator correctly assesses expected output, expected opex and the cost of capital, V_1 will equal the undepreciated asset cost ($0.5A$) and therefore the risks will be the same as before (from the first period's output and opex). However, if the regulator may err in setting the allowed cost of capital, then V_1 will be uncertain and therefore a third category of risk arises. Plausibly, the biggest source of potential error in setting the cost of capital is the risk premium in the cost of equity (the market risk premium and beta). Errors in assessing beta are not likely to be correlated with market returns but errors in estimating the MRP are likely to be so. In particular, if market returns over the first period are high (low), the MRP is likely to be low (high) at the period end but regulators do not tend to change their MRP estimates (because it is too difficult to estimate these changes). So, if market returns over the first period are high (low), the allowed cost of capital is likely to be too high (low), and hence V_1 will be high (low), which is positive beta. So, there are three principal sources of systematic risk for regulated businesses: opex risk, which is likely to reduce beta (but is attenuated by cost pass-throughs), output risk (but not for revenue capped firms or price-capped firms setting fixed charges to deal with their fixed costs) which raises beta, and cost of capital estimation risk, which is also likely to raise beta. Since revenue capped firms don't face output risk, and output risk raises beta, and they are otherwise alike price capped firms, then price capped firms should have higher betas. ROR regulation is most like price capping, but for a shorter period and therefore the exposure to all three sources of risk is reduced. Accordingly, firms subject to it should have lower beta than price-capped firms.

Turning now to the empirical evidence, starting with ROR regulation versus price-capping, Alexander et al (1996) presents asset beta estimates for numerous firms in a wide range of regulated industries, countries and regulatory regimes (ROR, price caps, and an intermediary system). The most fertile ground for analysis is ROR versus price capping (because they are the extreme cases), and in particular the electricity firms in the US (ROR regulation) and the UK (five-year price caps) due to the relatively large numbers of firms in each group (9 and 17 respectively). Further limiting the UK firms to the 12 regional electricity companies is also desirable because they were essentially involved in distribution and transmission rather than generation and only distribution/transmission were regulated (Green, 2005). Using data from the period 1990-1995, the average estimated asset betas were 0.30 for the US firms and 0.58 for the UK firms (Alexander, 1996, Appendix A2). The difference is then 0.28, and this is in the anticipated direction. Following the methodology in Lally (2002), Lally (2008, pp. 60-

61) corrects this estimate for differences in market leverages, thereby reducing the differential from 0.28 to 0.18 as follows:

$$.93\bar{\hat{\beta}}_{UK} - 1.2\bar{\hat{\beta}}_{US} = .93(.58) - 1.2(.30) = .18$$

Using the *t* test for the difference in means (Mood et al, 1974, page 435), the difference is highly statistically significant. However, Buckland and Fraser (2001) examine these 12 UK companies and empirically show that their beta estimates were raised by two events during the 1990-95 period, and the Commerce Commission (2010a, pp. 531-532) argues that these two events would have raised the beta estimates in Alexander et al (1996). Judging from Buckland and Fraser (2001, Figure 1a, Figure 1b), only the second event was material. It occurred on 9 April 1992 and Buckland and Fraser (reasonably) attribute it to the unexpected election of the Conservative Party (boosting the returns for regulated businesses). This could only raise the beta estimate of these businesses if the market return were unusually large on that day (which it was at 5.6%). Naturally, the same electoral event would not have affected the US beta estimates and therefore this event affected the estimated difference between the betas for price capped and ROR regulated firms.

However, whilst this event materially affected the beta estimates in Buckland and Fraser, it does not follow that the beta estimates in Alexander et al (1996) would have been similarly affected because the former are derived from a time-varying model whereas the latter are derived from a constant coefficient model (OLS), and the Commission's beta estimates are of the latter type. Furthermore, even if the UK results were excluded, Alexander et al (1996) still provide estimates across a wide range of countries and two regulatory regimes. In particular, removal of the UK companies (and the South American countries because their betas are equity rather than asset betas) essentially removes the first row in Alexander et al (1996, Table 6.4), leaving a comparison of "discretionary" regimes with ROR regimes. Across all five industries examined, the average beta for the "discretionary" regimes exceeds that for the ROR regimes and by an average of 0.23. Using the *F* test for the difference in means (Mood et al, 1974, page 437), the difference is highly statistically significant. No corrections are made for country differences (the different market indexes used to estimate betas may differ in industry composition and/or leverage) but the wide variety of countries used provides considerable protection against this factor explaining the results. Thus, *providing* that the betas for these "discretionary" regimes do lie between those of price capped and ROR firms, this estimated differential of 0.23 implies that the betas of price capped firms not afflicted with the problem identified by Buckland and Fraser would exceed those for ROR regulated firms by more than 0.23 and this is entirely consistent with the differential of 0.28 identified above for UK priced capped firms versus US ROR regulated firms (before correction for market leverage differences). The proviso noted above is important, but it seems likely to hold based upon the description of these regimes given by Alexander et al (1996, section 3.5.3).

An alternative approach to comparing the betas of price capped and ROR regulated firms would be to use only data from the US, because it still contains a large set of businesses subject to ROR regulation and in addition another set subject to price capping (due to changes since the Alexander et al study). The Commerce Commission (2010a, Table H17) identifies 18 firms subject to "incentive" regulation (including price caps), a further 11 subject to "non-incentive" regulation (ROR regulation), and also provides estimates of their asset betas over the period 1990-2010. The difference in the average betas of the two groups is only 0.01. Using the the *t* test for the difference in means (Mood et al, 1974, page 435), the difference is not statistically significant but the 95% confidence interval is from -0.06 to 0.08. Thus, although one could not reject the null hypothesis that the true betas of the two groups were the same, a range of alternative hypotheses (up to incentive firms having a higher beta by .08) could not be rejected either. Furthermore, this analysis assumes that the data are statistically independent, which is not the case; the data are positively correlated (due to common shocks), and therefore the estimated standard error for the mean difference is underestimated, implying that an even wider range of alternative hypotheses could not be rejected.

In addition to these statistical issues, the test is contaminated by three features of the data that give rise to a bias against finding a statistically significant difference between the betas of price-capped and ROR regulated firms. Firstly, the Commission's classification of firms by regulatory regime applies to the situation in 2009 rather than throughout the 1990-2010 period from which the data for the beta estimates was drawn, and the extent of incentive regulation has grown dramatically over this period. For example, Sappington et al (2001, Table 2) identifies 31 US electric utilities subject to incentive regulation as of 2001, but adoption did not occur until 1997 or later in over half of these cases (16/31). In addition, 80% of the firms appearing in the Commerce Commission's (2010a, Table H17) list of incentive regulated firms do not appear in Sappington's 2001 list (28/34 cases) and therefore will presumably have adopted this regime after 2001. Thus, much of the 1990-2010 data for firms classed as incentive regulated in 2009 may have been drawn from periods when they were actually ROR regulated. So, rather than a comparison of betas for incentive regulated and ROR regulated firms, the comparison is to a large extent between two sets of ROR regulated firms. Secondly, despite the question of interest being ROR versus price capping, the Commission's definition of incentive regulation accords with Kwoka (2009) and half of the states identified by Kwoka (2009, Table 1) as using incentive regulation use "earnings sharing" rather than price capping, and the two regimes are different. Plausibly, the beta for firms subject to earnings sharing lies between those for ROR and price capping. Thirdly, over half of the states identified by Kwoka (2009, Table 1) as using a price cap also use earnings sharing. If price caps do raise beta relative to ROR regulation, then earnings sharing in conjunction with price capping will produce betas between ROR and price capping. Thus, if price capping and ROR regulation do have different betas, the effect of all three of these points will be to reduce the possibility of detecting it.

A further test of this type is conducted by ACG (2008, Table 4.12), involving comparison of the estimated equity betas (adjusted to 60% leverage) of 5 US firms subject to "incentive" regulation and 16 others subject to ROR regulation. The difference in the average betas is again very small (0.03). Using the the *t* test for the difference in means (Mood et al, 1974, page 435), the difference is not statistically significant but the 95% confidence interval runs from -0.37 to 0.43. This is so wide that the result has no real value. In addition, ACG (2008, Table 4.3) identify the type of incentive regulation for the five affected firms, and only one of the five cases seems to be a pure price cap.

A further test of this type is conducted by CEG (2013, Table 11), involving comparison of the estimated asset betas of 22 US firms subject to "incentive" regulation and 12 others subject to ROR regulation, subject to the firms having regulated assets that constitute at least 50% of their total assets. CEG's beta estimates were drawn from SFG (2013, section 4.1.3), based on returns data from 2002-2013. The difference in the average betas is again very small (0.02). Using the *t* test for the difference in means (Mood et al, 1974, page 435), the difference is not statistically significant and the 95% confidence interval runs from -0.04 to 0.08. Using a more restricted sample of firms, with regulated assets constituting at least 80% of total assets, the difference in the average betas of the two groups is the same as before (CEG, 2013, Table 12) and so too is the 95% confidence interval. CEG use a different version of the *t* test (Welch's *t* test) to that used here, but the results are not materially different. CEG's 95% confidence intervals are similar to that arising from the Commerce Commission's data discussed above. Since the CEG returns data was from 2002-2013 and firms were classified according to their 2009 regulatory regime status, the possibility of their status changing during the period over which the data was collected is much less significant. However, the other problems afflicting the Commission's data remain. In particular, the 95% confidence interval is wider than the *t* test indicates, thereby potentially embracing a wide range of alternative hypotheses, and the test compares ROR firms with firms subject to a range of regimes rather than just price-capping. In respect of the latter point, CEG (2013, Table 10) discloses the US states in which the firms conduct regulated operations and therefore it is possible to determine how many of the 22 firms subject to incentive regulation that are used by CEG are subject only to price capping, by reference to Kwoka (2009). The result is only two firms: LG (Laclede Group), which conducts regulated operations in only Missouri (a price-capping state) and POR (Portland General Electric), which conducts regulated operations in only Oregon (a price-capping state). This is too small a set to test against the ROR firms. The Commission's data presumably suffers from the same problem. In short, using only US data, it does not seem to be possible to test the important question of whether the betas of ROR regulated firms differ from those of price-capped firms.

Gaggero (2010) examines 170 regulated companies operating in a range of industries, countries, and subject to a range of regulatory regimes, over the 1995-2004 period. He regresses the firm's estimated equity beta against dummy variables for regulatory regime and a large set of control variables. Using his preferred type of regression model (random effects), he finds that the equity betas of "medium incentive" regimes slightly exceed those of "low incentive" regimes (.028) and also slightly exceed those of "high incentive" regimes (by .016), but neither is statistically significant. He concludes that "..the methods of regulation have no impact on the level of systematic risk to which regulated firms are exposed" (ibid, page 233). He is sufficiently surprised by this to suggest that it occurs because price capped firms pressure regulators to pass through some unexpected costs (ibid, section VII). Gaggero's control variables include firm leverage (which is very similar to using asset rather than equity betas), industry (which obviates the need for examination of results from each industry), and also country (which deals with the problems of beta estimates from different countries discussed earlier).

Despite its sophistication in many ways, Gaggero's analysis and conclusions suffer from some significant drawbacks. Firstly, the lack of statistical significance for the coefficients described above does not imply that the variables have no effect, only that no effects can be detected because the data are too noisy. The reported standard errors on these coefficients are .054 and .060. Thus, one could not reject the hypothesis that the betas of firms subject to medium incentive regimes exceed those of low incentive regimes by as much as 0.14 and that the betas of firms subject to high incentive regimes exceeded those of medium ones by as much as 0.10, which implies betas for firms subject to high incentive regimes exceeding those of low incentive regimes by 0.24. This is a substantial margin, and would apply to asset betas because his regressions control for leverage.

Secondly, in classifying firms into his three regulatory categories, Gaggero includes "earnings sharing" along with ROR in the "low incentive" category, on the basis that (like ROR), all costs and revenues of the firm are controlled. However, Alexander et al (1996, section 3.5.2) considers that the incentives under these regimes place them between ROR and price cap regulation, Grout and Zalewska (2006, page 153) do likewise, and Kwoka (2009) classifies them amongst "incentive" regimes (along with price caps) that contrast with ROR regulation. In addition Gaggero includes "rate case moratoriums" in a lower category to price caps, despite stating that they are similar (ibid, footnote 3). All of this raises the possibility that Gaggero's classification of firms is incorrect and has substantially affected his results.

Thirdly, Gaggero classifies firms according to the incentives for efficiency gains that are present for firms and then assesses whether increased incentives are associated with higher betas. However, of the three principal sources of systematic risk for regulated businesses outlined earlier, only one of them relates to incentives for reducing costs and this particular one could be expected to reduce beta as discussed earlier in this section. So, any classification of regulated businesses according to the strength of the incentives to reduce costs will not necessarily correspond to increasing beta. For example, Gaggero includes "earnings sharing" firms amongst his "low incentive" group. However, if earnings sharing gives rise to betas (as opposed to incentives) that are comparable to price capping, the effect of Gaggero's classification will have been to mask a relationship between regulation and beta that might otherwise have been revealed. The better approach would have been to classify the firms according to the anticipated impact on beta. Alternatively, the use of dummy variables for each of the different regulatory regimes would allow the data to speak for themselves.

Fourthly, if Gaggero's model were used to estimate the equity beta of a regulated business, there would be serious implementation difficulties. The long-established approach to leverage amongst academics, analysts, and regulators is to combine it with the estimated asset beta using a gearing model that is theoretically based, such as Hamada (1972) or Miles and Ezzell (1985), and the effect of leverage in all of these models is to raise the beta. By contrast, in Gaggero's approach, the relationship between the equity beta and leverage is purely empirical, the empirical relationship is assumed by Gaggero to be linear (which conflicts with the theoretical models), and the estimated coefficient on leverage is negative (which also conflicts with the theoretical models). On both of the last two points, Gaggero's model is 'wrong' and would also conflict with long-established practice. In addition, most of the other independent variables in Gaggero's model (such as profitability, size and payout rate) are firm specific and would therefore lead to different equity betas for firms in the same industry and subject to the same regulatory regime, contrary to regulatory practice. Furthermore, none of these latter three variables (profitability, size, and payout rate) have any obvious intuitive connection to beta, and variations over time would induce variations in the betas estimates with no intuitive justification.

All of the above studies are cross-sectional. By contrast, Grout and Zalewska (2006) examine time-series variation in the betas of 15 regulated UK companies (mostly in water or electricity generation) during the period from mid 1997 (when a regulatory shift to profit sharing was proposed by the government) until mid 1999 (when the proposal was clearly moribund). They find a pronounced drop in beta in mid 1997 and a reversal in mid 1999, with no such effects in various control groups (ibid, Figure 1). Unlike the cross-sectional studies of Alexander et al (1996) and Gaggero (2010), the number of companies examined is small and the analysis limited to one country.

Amongst these papers, I consider that the best empirical evidence on the impact of regulatory regimes on beta is that of Alexander et al (1996), which suggests that price capping yields higher betas than ROR regulation. Furthermore, as discussed above, this conclusion survives even the concerns raised by Buckland and Fraser (2001). However, the study is now 20 years old and the period examined was only five years. So, there is room for doubt about the validity of the conclusion (a possibility acknowledged even by the authors) and its application to the present time. In the face of these doubts, and until better evidence becomes available, I consider that one should keep an open mind. Accordingly, the best course of action would be to limit the comparators for the New Zealand DPP (priced capped) firms to either US ROR regulated firms or price capped ones, depending upon which seems more appropriate. The Commerce Commission (2010a, pp. 539-542) argues that the New Zealand DPP regime has elements of both price capping and rate of return regulation, because of the option to seek a CPP and because of cost pass through provisions. However, I understand that the CPP option has only been exercised once (by Orion) and therefore the significance of this point would seem to be minimal. In respect of cost pass through, this is a common feature of price cap regimes (QCA, 2012, section 4.2). Thus, the New Zealand DPP regime is a price cap regime and therefore the best comparators would be US price-capped firms (including those also subject to earnings sharing in order to produce an adequate sample size), with the data used to estimate the betas being limited to the period in which the price capping prevailed. It would also be desirable to adjust for differences between the US and New Zealand for market leverage and the composition of the market indexes, as in ACG (2008, page 51), but comfort could be drawn from the fact that ACG concluded that the two effects (whilst individually substantial) largely netted out at that time for Australia and market leverage in New Zealand at the time (Bao, 2008, Table 3.3) was similar to Australia (ACG, 2008, page 51).

The last remaining issue is whether to use a different beta for the New Zealand revenue-capped (transmission) businesses compared to the price-capped (DPP) businesses. Consistency with the approach just recommended for the price-capped businesses would suggest identifying a set of revenue capped comparators and using their estimated betas. However, Alexander et al (1996) contains no such cases, and Gaggero (2010) does not identify the revenue-capped firms located by them (with their estimated betas). The UK regional electricity businesses switched to hybrid price/revenue capping in 1995, but all of them were shortly afterwards taken over by firms outside this sector (Fraser and Buckland, 2001, Appendix 2). In a subsequent report designed to estimate the WACC of these businesses, PwC (2009) identified only three listed energy businesses in the UK, two of which collectively owned four of these electricity businesses (ibid, Table 2), but the percentages of their profits earned from electricity or gas transmission or distribution were only 74%, 58% and 39%, and the percentages earned from only electricity transmission or distribution were even lower (PwC, 2009, Table 14).

Australia would seem to be more fertile ground, containing numerous electricity businesses of which some are revenue capped. However, virtually all of them are either government owned or members of diversified conglomerates (AER, 2009, Chapter 6). The Commerce Commission (2010a, Table H17) identifies three Australian listed firms involved primarily in electricity transmission or distribution. Of these, SPAusnet owned both electricity transmission and distribution businesses in Australia in 2009, with the former revenue capped and the latter price capped (AER, 2009, Chapter 6). In addition, DUET's (2010) principal investments in 2010 were in United Energy (a price capped Australian electricity distributor), DBNGP (a price capped Australian gas distributor), and Duquesne Light (a US electric utility operating in Pennsylvania, and hence ROR regulated as per Kwoka, 2009, Table 1). Finally, Spark Infrastructure (2010) comprised a set of investments in Australian electricity distributors and all of these businesses (ETSA, Powercor and Citipower) were subject to price capping at this time (AER, 2009, Chapter 6). So, none of these three Australian listed businesses would have been useful in 2010 for estimating the beta of a revenue-capped business.

Furthermore, even if a set of listed business that were subject to revenue capping could be located, using them to estimate an asset beta for the revenue-capped businesses whilst using a different set of comparators to estimate the asset beta for the price-capped businesses would produce a difference that was highly contaminated by the usual statistical difficulties in estimating asset betas. For example, if there were 15 firms in each group and the standard deviation of the individual estimates were 0.14 (see Lally, 2008, Table 11), the standard error for the difference in the average asset betas would be 0.05 in accordance with equation (1). So, the 95% confidence interval would have a width of approximately 0.20. Furthermore, any difference in the estimated betas of the two sets of comparators would reflect the extent to which the price-capped firms used a mix of fixed and variable charges to mitigate demand risk. So, if the New Zealand price-capped businesses did not act in substantially the same way, the estimated beta differential would not be relevant to them.

In view of these points, I recommend using the same asset beta for the New Zealand revenue-capped and price-capped businesses. This matches the view expressed in 2010 by the Commerce Commission (2010a, Para H8.161). However, my recommendation arises in spite of my belief that there is likely to be a beta margin (of unknown degree) for price capping, because those subject to it bear an additional source of risk (volume) that would elevate beta.

HoustonKemp (2016, section 2.1) argues that revenue-capped businesses warrant the same beta as price-capped ones. In support of this, they offer three arguments. Firstly, they argue that industry-specific factors are much more important sources of demand uncertainty than macro-economic shocks. However, this claim is not relevant to the question of whether macro-economic shocks create material demand risks for price-capped businesses, and therefore give rise to a materially larger asset beta for price-capped businesses relative to revenue-capped ones. Secondly, HoustonKemp argue that ACG (2008), CEG (2013), and Gaggero (2012) each find that the type of regulation does not affect beta. However, the limitations in these three studies have been noted above and HoustonKemp do not mention any of them. Thirdly, HoustonKemp recognise that Alexander et al (1996) reach different conclusions but claim that the use of asset betas from different countries would have likely led to overestimation of the effect of regulatory type on beta. However, even if this were the case, the effect of regulatory type might still be substantial after allowing for country differences. As noted above, Lally (2008, pp. 60-61) corrects the asset beta differences between US and UK electricity firms (subject to ROR and price-cap regulation respectively) for differences in market leverage, and the difference in asset betas is reduced but still substantial (at 0.18) and statistically highly significant. Furthermore, as noted above, the average asset beta for the firms in the Alexander et al (1996) study that are subject to "discretionary" regimes exceeds that for those subject to ROR regimes by 0.23, this too is statistically highly significant, and the wide variety of countries used provides considerable protection against the possibility of the result being due to country differences (differences in the industry composition and/or leverage of the market indexes against which the betas are estimated). So, HoustonKemp are unduly dismissive of the Alexander et al (1996) results that contradict their prior and unduly accepting of the results in the other three studies that support their prior.

CEG (2016a, para 62) argues that most volume-related variability in energy demand is weather related and therefore suggests that revenue-capped businesses would have similar betas to price-capped ones. However, this claim is not relevant to the question of whether macro-economic shocks create material demand risks for price-capped businesses, and therefore give rise to a materially larger asset beta for price-capped businesses relative to revenue-capped ones. CEG (2016a, para 64) refer to Gaggero (2010) and CEG (2013) in support of the claim that the regulatory type does not affect beta. However, as discussed above, there are significant shortcomings in both of these papers.

CEG (2016a, pp. 29-31) compares the estimated asset betas for US firms subject to a form of revenue capping ("decoupling") with those subject to price capping, and finds that the average betas are not materially different. This analysis suffers from a number of problems. Firstly, amongst the firms they identify as subject to decoupling (in their Appendix C), an examination of the source of information cited by them (Centre for Climate and Energy Solutions, 2016) indicates that their list of firms subject to decoupling is in fact a list of firms that are subject to decoupling merely in at least one of the states in which they operate. For example, the fourth firm listed in their Appendix C (AEP) operates in 11 states but only four of them (IN, MI, OH and VA) have a "decoupling" regime (Centre for Climate and Energy Solutions, 2016). So, even if there is a difference between the two regulatory regimes examined, the inclusion of firms with some operations not subject to the regime would dilute the effect and thereby undercut the value of the test. Secondly, the set of US firms that appear in CEG's list of firms subject to price capping is in fact a list of firms that are (at most) subject to price capping in at least one of the states in which they operate rather than in all of them.[4] For example, the first US firm in their list (ATO) conducts regulated operations in 8 states (CEG, 2013, Table 10) but only three of these (LA, MO, and MS) involve price-capping (Kwoka, 2009, Table 1). This too dilutes the value of their test. Thirdly, of the 19 US firms in CEG's list of price-capped firms, six of them (EE, HE, OGE, OKE, PNM, and WR) do not appear to have regulated operations in any states that apply price-capping (by reference to CEG, 2013, Table 10, and Kwoka, 2009, Table 1). This further dilutes the value of CEG's test. Fourthly, even within individual states, multiple forms of regulation are pursued. In particular, amongst the ten states identified by Kwoka (2009, Table 1) as adopting price capping, six of them also involve earnings sharing. In addition, of the 22 states identified by the Centre for Climate and Energy Solutions (2016) as engaging in decoupling, Kwoka (2009, Table 1) identifies two as engaging in price-capping, six others

[4] CEG does not identify these firms in their report but did so in a subsequent email.

engaging in earnings sharing, and six others for which no information is provided. This further dilutes the value of CEG's test. Fifthly, CEG does not provide any information on when the regulatory regimes first applied to firms and therefore one could reasonably suspect that much of the data used by them (2005-2015) is drawn from periods when firms were subject to a different regime to that applicable at the time they were classified. Sixthly, the source of the information on decoupling that is cited by CEG (Centre for Climate and Energy Solutions, 2016) reveals that most of the states classified as engaging in "decoupling" are merely beginning the implementation process, which aggravates the fifth problem. Seventhly, CEG does not provide a confidence interval for the difference in the average betas of the two sets of firms, and one might then suspect that the confidence interval is so wide that a wide range of hypotheses about the difference in betas could not be rejected. In respect of the first six points, CEG's test is rather like assessing the effectiveness of drug A versus drug B, not by comparing the health of a set of individuals over some period who used drug A over that period with those subject only to drug B over the same period, but by comparing the average health of families (over a ten year period) that contain at least one member currently using (or planning to use) drug A with the average health of families (over the same ten year period) that contain at least one member currently using (or planning to use) drug B. With such a test design, it would be unsurprising to find that the two sets of families have similar average health over the last ten years, even if one of the two drugs is much more effective. In short, CEG's test is of minimal value.

In summary, and notwithstanding the theoretical expectation that price-capped businesses have higher asset betas than both ROR regulated and revenue-capped businesses, there is no empirical study that provides a clear conclusion on the effect of regulation on beta. In the face of this uncertainty, and until better evidence becomes available, I consider that one should keep an open mind. Accordingly, in respect of the New Zealand price-capped (DPP) firms, the best course of action would be to limit the comparators for them to either US ROR regulated firms or price capped ones, depending upon which seems more appropriate, and I consider that the better comparators would be US price-capped firms (including those also subject to earnings sharing in order to produce an adequate sample size), with the data used to estimate the betas being limited to the period in which the price capping prevailed. It would also be desirable to adjust for differences between the US and New Zealand for market leverage and the composition of the market indexes although related work suggests that the two effects might net out. In addition, in the absence of a sufficiently large set of suitable firms to assess the beta differential between price capped and revenue capped firms, I recommend using the same asset beta for the revenue-capped businesses as for the price-capped (DPP) ones. Although this matches the Commerce Commission's 2010 view, my recommendation arises in spite of my belief that there is very likely to be a beta margin (of unknown degree) for price-capping over revenue-capping, because those subject to it bear an additional source of risk (volume) that would elevate beta.

2.3 Adjustment for Airport Businesses

The Commerce Commission (2010b, paras E8.72-E8.97) estimates the asset beta for regulated airport services from the estimated beta of listed airports (0.65), subject to a downward adjustment of 0.05 in recognition of the fact that the unregulated activities of airports would have a higher beta than the regulated activities. This adjustment of 0.05 is now assessed.[5]

Portfolio betas are value-weighted averages of their components. Consequently, the asset beta of an airport (β_A) is a value-weighted average of the asset betas for regulated (β_R) and unregulated activities (β_U), with value weights of w_R and 1-w_R respectively:

$$\beta_A = w_R \beta_R + (1 - w_R)\beta_U$$

Clearly, w_R will vary across airports and therefore so too will β_A. Furthermore, β_R and β_U might differ across airports, with β_R variations due to differences in regulatory regimes and also to the sensitivity of demand to GDP shocks (NZIER, 2010, section 4.2) whilst β_U differences would arise from different mixes of unregulated activities. However, so long as these beta differences across airports are not correlated with w_R (which is plausible), then cross-company average values for the parameters in the last equation can displace the firm-specific values, as follows:

$$\overline{\beta}_A = \overline{w}_R \overline{\beta}_R + (1 - \overline{w}_R)\overline{\beta}_U \qquad (2)$$

[5] In Lally (2001, section 6) I expressed my view on the appropriate asset betas for the airfield operations of New Zealand's international airports (at 0.50). This involved estimating the asset beta of ROR regulated activities, adjusting for regulatory differences between ROR and the regime applicable to the airports, followed by a further adjustment for the difference in the nature of the services provided. By contrast, my task in the current report is purely to evaluate the Commission's deduction of 0.05.

The Commission assesses $\overline{\beta}_A$ at 0.65 and therefore $\overline{\beta}_R$ at 0.60, which it then attributes to the New Zealand airports. Implicitly it must then have a view on $\overline{w}_R$ and either $\overline{\beta}_U$ or the difference between $\overline{\beta}_R$ and $\overline{\beta}_U$, but these views are not disclosed. For example, suppose $\overline{w}_R$ = 0.50 and $\overline{\beta}_U$ = 0.70. Insertion of the latter two parameter values into equation (2) along with $\overline{\beta}_A$ = 0.65 implies that $\overline{\beta}_R$ = 0.60. Alternatively, if one believed that $\overline{\beta}_U$ exceeded $\overline{\beta}_R$ by 0.10, substitution of this parameter value into equation (2) along with $\overline{w}_R$ = 0.50 and $\overline{\beta}_A$ = 0.65 implies that $\overline{\beta}_R$ = 0.60.

In respect of $\overline{w}_R$, Europe Economics (2010, Table 3.1) provides the proportions of revenue from non-aeronautical activities at six airports (all of which are included in the Commission's set of comparators), and the average is 39%. This is a small subset of the 25 comparator airports used by the Commerce Commission (2010b, Table E19). Furthermore, revenue proportions are a very imperfect proxy for value proportions, due to differences in costs relative to revenues and also to differences in the discount rates. So, I estimate $\overline{w}_R$ at 39%, but the precision of this estimate is very low.

In respect of $\overline{\beta}_U$, the underlying activities at AIAL include retail, levies on the providers of taxis and public transport to/from the airport, car parking, and property leases (AIAL, 2006, page 1). This is a very mixed bag, and therefore ought to be estimated by value weighting over beta estimates for the components. However, these value weights are not known (even at AIAL) and some of these activities have no apparent comparators amongst listed businesses. In the face of these difficulties, the best course of action would be to adopt a market average beta as a proxy for $\overline{\beta}_U$. The requisite market average is an average over the 13 countries from which the comparator firms are drawn (and the periods from which the data underlying the estimates are drawn). Pragmatically, a subset must be selected, on the basis of availability. ACG (2008, page 51) estimates average leverage for Australia over the 2003-2008 period as 34%. In addition Bao (2008, Table 3.3) estimates market leverage in New Zealand in 2005 at 33%. The average here is 33%. Using the Commerce Commission's (2010b, para E8.58, E9.1) gearing formula, the resulting average market asset beta would then be 67% as follows:

$$\overline{\beta}_U = \overline{\beta}_e(1-\overline{L}) = 1(1-0.33) = 0.67$$

As with the estimate for $\overline{w}_R$, the precision of the estimate is very low. Substitution of these estimates for $\overline{w}_R$ and $\overline{\beta}_U$ into equation (2), along with the Commission's estimate for $\overline{\beta}_A$ of 0.65, implies an estimate for $\overline{\beta}_R$ of 0.62. So, the deduction from the Commission's estimate for $\overline{\beta}_A$ is only 0.03, which is close to the Commission's deduction of 0.05. However, the precision of the estimates of $\overline{w}_R$ and $\overline{\beta}_U$ is very low. Coupled with the low point estimate for $\overline{w}_R$, this leads to a very imprecise estimate of $\overline{\beta}_R$ and hence for the estimated deduction. For example, by allowing $\overline{w}_R$ and $\overline{\beta}_U$ to each vary by ± 0.10, Table 1 below shows the resulting estimates of $\overline{\beta}_R$, and they vary from 0.36 to 0.85. Thus, the deduction from 0.65 ranges from 0.29 to -0.20. By contrast, if the estimate for $\overline{w}_R$ had been 0.90 rather than 0.39, then allowing $\overline{w}_R$ and $\overline{\beta}_U$ to each vary by ± 0.10 would have led to estimates of $\overline{\beta}_R$ that varied from only 0.61 to 0.66, and hence the estimated beta deduction from 0.04 to -0.01. I therefore have very little confidence in the estimated deduction of 0.03.

Table 1: Estimates of the Asset Beta for Airport Regulated Services

			$\overline{w}_R$	
		0.29	0.39	0.49
	0.57	0.85	0.78	0.73
$\overline{\beta}_U$	0.67	0.60	0.62	0.63
	0.77	0.36	0.46	0.52

In summary, the Commission's 2010 approach to estimating the asset beta for regulated airport services commences with an estimate of 0.65 for the average asset beta of a set of comparator airports and then deducts 0.05 to account for the presumed higher beta of the unregulated activities of these airports. This approach implicitly involves estimates for the average proportion of airport value arising from that of regulated services and also the average asset beta for the unregulated services of the comparator airports. However, the Commission does not reveal its estimates for the latter two parameters. I estimate these parameters at 0.39 and 0.67 respectively, which implies deducting 0.03 from the estimated asset beta of the comparator airports in order to estimate the asset beta of the regulated services. This is similar to the Commission's estimate of 0.05. However the estimates of the two underlying parameter values are very imprecise, and the point estimate for the average weight on regulated services is also low, leading to an extremely imprecise estimate for the beta deduction.

3. Black's Simple Discounting Rule

3.1 Price Cap Regulation

In seeking to value a project with uncertain cash flows, the usual approach is to invoke some version of the Capital Asset Pricing Model (CAPM), which requires an estimate of the unconditional expected cash flows of the project, its beta, and the market risk premium (MRP). All three are problematic. In response to this, Black (1988) has proposed a simpler rule, involving estimating only the expected cash flow conditional on the market return being equal to the risk-free rate, and then discounting this at the risk-free rate. Such a rule requires that the expected cash flow be linearly related to the market return. So, estimates of the beta and the MRP are not required.

Ireland Wallace (2015) argues that Black's Rule can be used as a cross-check on the allowed returns of regulated businesses. Before assessing their report, I consider a simple example. Suppose that a firm is contemplating a project that will deliver a cash flow in one year (C_1) that is linearly related to the market return over the next year R_m as follows:

$$C_1 = \$5m + \$10m(1 + R_m) \tag{3}$$

Using the CAPM, with R_p denoting the rate of return on the project relative to its value now, R_f the (tax-adjusted) risk-free rate, MRP the tax-adjusted market risk premium, and β_p the beta of the project, the value now V_0 of this future cash flow is as follows:

$$\begin{aligned} V_0 &= \frac{E(C_1)}{1 + R_f + MRP\beta_p} \qquad (4) \\ &= \frac{E(C_1)}{1 + R_f + MRP\left[\dfrac{Cov(R_p, R_m)}{Var(R_m)}\right]} \end{aligned}$$

$$= \frac{E(C_1)}{1 + R_f + MRP\left[\frac{Cov\left(\frac{\$5m + \$10m(1+R_m)}{V_0} - 1,\ R_m\right)}{Var(R_m)}\right]}$$

$$= \frac{E(C_1)}{1 + R_f + MRP\left[\frac{\frac{\$10mVar(R_m)}{V_0}}{Var(R_m)}\right]}$$

$$= \frac{E(C_1)}{1 + R_f + MRP\left[\frac{\$10m}{V_0}\right]} \qquad (5)$$

Solving for the value V_0 yields

$$V_0 = \frac{E(C_1) - MRP(\$10m)}{1 + R_f}$$

Assume that MRP = .07, and R_f = .03. Substituting these values and $E(C_1)$ = \$16m into the last equation, the project value is \$14.85m. Accordingly, following equations (4)…(5), the project beta is

$$\beta_P = \frac{Cov(R_p, R_m)}{Var(R_m)} = \frac{\$10m}{V_0} = \frac{\$10m}{\$14.85m} = 0.673$$

The standard approach to valuing this project would be to use equation (4) in conjunction with an estimate for beta obtained from returns data from another firm. If the beta estimated in this way were correct, and the estimates for $E(C_1)$ and MRP were also correct, the project would be correctly valued at \$14.85m as follows:

$$V_0 = \frac{E(C_1)}{1 + R_f + MRP\beta_P} = \frac{\$16m}{1 + .03 + .07(.673)} = \frac{\$16m}{1.0771} = \$14.85m \qquad (6)$$

Black (1988) argues (reasonably) that estimating the market risk premium, beta and the unconditional expectation for C_1 are difficult. His alternative is to estimate the expected cash flow conditional on $R_m = R_f$, and to discount this at the risk-free rate. Following equation (3), this conditional expectation is

$$E(C_1 | R_m = R_f) = \$5m + \$10m(1 + R_f) = \$5m + \$10m(1.03) = \$15.3m$$

and so

$$V_0 = \frac{E(C_1 | R_m = R_f)}{1 + R_f} = \frac{\$15.3m}{1.03} = \$14.85m \qquad (7)$$

So, the correct value is obtained, using a smaller set of parameters. This approach requires that the cash flow be linear in market returns and would be superior to (6) if it were easier to estimate the conditional cash flow expectation that it is to collectively estimate the unconditional cash flow expectation plus the MRP and beta.

If their underlying assumptions hold, both processes could be used for valuing a future cash flow, and they yield the same valuation result if their parameters are correctly estimated. Relative to (6), equation (7) uses a lower expected cash flow but this is perfectly offset by the lower discount rate. The important question here is whether (7) has any relevance to regulation, as claimed by Ireland Wallace (2015). Price cap regulation commences with an asset book value, and applies a cost of capital to it to generate the expected cash flows, which are then converted into an allowed output price (by deducting expected cash outflows to obtain expected revenues and then dividing by expected output). This is a reversal of the flow in (6). However, Ireland Wallace (2015) never addresses this question. Their paper is limited to arguing that Black's model can be used for valuation purposes, and has nothing to (directly) say about its application to regulation. Ireland Wallace (2015, section 6) imply that Black's model has application to regulation, but provide no details on this. Ireland Wallace (2015, para 5.4) also note that the Commission's allowed revenues for Transpower materially exceed the revenues conditional on the market return exceeding the risk-free rate, but this is a natural consequence of the difference in definitions. It does not follow that the Commission's allowed revenues are too high, and it is not even clear if Ireland Wallace are suggesting it.

Notwithstanding this point, Black's Model could be applied to regulatory situations. To illustrate this, suppose that the valuation of $14.85m matches that asset book value. So, applying the conventional approach, the cost of capital of 7.71% (estimated from the CAPM as above) would be applied to the $14.85m to generate the expected cash flows of $16m as follows:

$$E(C_1) = \$14.85m(1.0771) = \$16m \tag{8}$$

If there were no opex or taxes, this $16m would be expected revenue. Dividing by the expected output (say 1m units) would then yield the price cap of $16 per unit:

$$P = \frac{E(C_1)}{E(Output)} = \frac{\$16m}{1m} = \$16 \tag{9}$$

An alternative approach arises from Black's equation (7), i.e., apply the risk-free rate to the asset book value of $14.85m to produce a conditional expectation for the cash flow of $15.3m as follows:

$$E(C_1 | R_m = .03) = \$14.85m(1.03) = \$15.3m \tag{10}$$

The regulator would then have to convert this into a price cap, by dividing by the expected output level conditional upon $R_m = R_f$. Since the output price is fixed, this conditional expectation for the output level would have to be the same proportion of the expected output level as the conditional expectation for revenues was to expected revenues:

$$\frac{E(Output | R_m = R_f)}{1m} = \frac{\$15.3m}{\$16m}$$

and therefore the expected output level conditional upon $R_m = R_f$ would have to be 956,000 units. So, if the regulator correctly estimated this output level, they would set the price cap at $16 as follows:

$$P = \frac{E(C_1 | R_m - R_f)}{E(Output | R_m - R_f)} = \frac{\$15.3m}{0.956m} = \$16 \tag{11}$$

So, just as there are two approaches to valuation, corresponding to equations (6) and (7), there are two approaches to setting the price cap, corresponding to equations (9) and (11). Black's model in (7) will be superior to the conventional approach in (6) if the cash flow is linear in market returns and it is easier to estimate the conditional cash flow expectation than it is to collectively estimate the unconditional cash flow expectation plus the MRP and beta. Similarly, Black's approach to regulation as shown in equations (10) and (11) will be superior to the conventional approach in (8) and (9) if the output level is linear in market returns and it is easier to estimate the conditional expectation of the output level than it is to collectively estimate the unconditional expectation of the output level plus the MRP and beta.

The first issue is then whether the cash flow (or output level in a regulatory case) is linear in the market return. Ireland Wallace (2015) have nothing to say on this but Black (1988, section V) notes that the condition is not met for an option. Myers (1996, section III) makes the same point. However, it does not follow that options are the only exception. So, in respect of regulatory assets, the crucial assumption underlying the validity of Black's approach to regulation may not hold.

The second issue is that of estimating the expected cash flow (or output in a regulatory case) conditional on $R_m = R_f$. Loderer et al (2010) suggest seeking management advice on the 10th and 50th percentiles of the cash flow distribution, use this to construct the distribution, determine the percentile of the R_m distribution corresponding to R_f, and apply this same percentile to the cash flow distribution to obtain the expected cash flow conditional on $R_m = R_f$. For example, following the example in Loderer et al (2010, pp. 64-65), suppose that R_m is normally distributed, with mean .1139 and standard deviation .1558 (based on historical returns), and that the average one-year risk-free rate over the same historical period was .0513.[6] This R_f value corresponds to the 34.4th percentile of the R_m distribution. Suppose that the cash flow distribution is also normal, with 10th and 50th percentiles estimated at \$200 and \$500 (in 000s) respectively. This implies a standard deviation of \$234,000. So, the 34.4th percentile of the distribution corresponds to \$406,000. Thus the expected cash flow conditional on $R_m = R_f$ is \$406,000. Application of this approach to regulation would involve the regulator asking the management of the regulated business for the 10th and 50th percentiles of the distribution of output. Knowing that the purpose of the exercise was to set

[6] Loderer et al assume a lognormal distribution, which is more plausible. However, for the present illustrative purposes, it is easier to assume normality.

their price cap, management would be motivated to provide responses that maximised their price cap. So, the regulator could not rely on advice from the management of the regulated business.

In addition, the Loderer et al (2010) process assumes that the cash flow (or output in a regulatory case) is normally distributed, and this may not be the case. This limitation could be overcome but it would require more information about the probability distribution that the 10^{th} and 50^{th} percentiles.

In addition, the Loderer et al (2010) process assumes that the cash flow (or output in a regulatory case) is perfectly correlated with R_m, and this would not be the case. Loderer et (2010, page 60) asserts that R_m (or an alternative) must be "closely correlated" with the project's cash flow, which means close to 1. So, small departures from 1 would be acceptable, but in referring to R-squared values of 44%, Loderer et al (2010, page 65) imply that correlations as low as 66% would be acceptable. The significance of this point is that the 34.4^{th} percentile of the R_m distribution only corresponds to the 34.4^{th} percentile of the cash flow distribution if the two variables are perfectly correlated. As the correlation falls, by introducing variation in the cash flow distribution that does not arise from R_m, the distribution in the cash flow widens and the 34.4^{th} percentile corresponds to a lower cash flow. However the expected cash flow conditional on $R_m = R_f$ does not change. So, if the 34.4^{th} percentile of the cash flow distribution were estimated in the fashion proposed by Loderer, the result would be an underestimate of the expected cash flow conditional on $R_m = R_f$. To illustrate the problem, and letting Z_1 denote the standard normal random variable arising from Loderer's distribution for cash flow (before any additional source of variation is recognised), suppose that a (mean zero) residual e were added to Loderer's normal distribution, i.e.,

$$C_1 = \$500 + \$234 Z_1 + e$$

Suppose further that the residual also had a standard deviation of \$234 and was uncorrelated with the rest of the distribution, i.e.,

$$C_1 = \$500 + \$234 Z_1 + \$234 Z_2$$

where Z_2 is uncorrelated with Z_1. The standard deviation of the whole distribution would then be \$331 and the entire distribution could then be represented as

$$C_1 = \$500 + \$331Z_3$$

The 34.4th percentile of this distribution is \$367 rather than Loderer's figure of \$406. So, the desired parameter is underestimated by 10%. Furthermore, letting Z denote the standard normal random variable underlying the market return R_m, the supposition that the residual e has a standard deviation as large as that of Loderer's distribution implies a correlation coefficient between the cash flow and R_m of 0.64 as follows:

$$\begin{aligned}
CORR(Cash\ Flow, R_m) &= CORR(\$500 + \$234Z_1 + \$234Z_2, .1139 + .1558Z) \\
&= \frac{COV(\$500 + \$234Z_1 + \$234Z_2, .1139 + .1558Z)}{STDEV(\$500 + \$234Z_1 + \$234Z_2)STDEV(.1139 + .1558Z)} \\
&= \frac{\$234(.1558)COV(Z_1, Z) + \$234(.1558COV(Z_2, Z)}{\$331(.1558)} \\
&= \frac{\$234(.1558)(1) + \$234(.1558(0)}{\$331(.1558)} \\
&= 0.64
\end{aligned}$$

This correlation is close to the lower bound of 0.66 that Loderer et al (2010, page 65) imply would be acceptable for their analysis. So, the supposition that the residual e has a standard deviation as large as that of Loderer's distribution is consistent with Loderer's cutoff point. Accordingly, the underestimation of the expected cash flow conditional on $R_m = R_f$ of 10% obtained above by using the Loderer et al approach is plausible. In a price cap regulatory situation, the same would apply to the expected output conditional on $R_m = R_f$. So, following equation (11), the price cap would be set too low by 10%. If depreciation, opex and taxes consumed 60% of revenues, as suggested for Transpower by Ireland Wallace (2015, Appendix B), then effectively the cost of capital would have been underestimated by 25%, i.e., 10% would become 7.5%. This is a very serious error. The solution is to generate a probability distribution for cash flow (or output in a regulatory case) that reflects only systematic risk. However, this would be a much more challenging task for management, and even more so for regulators.

At points, Loderer et al (2010) appear to recognise this issue. For example, Loderer et al (2010, page 63) asserts that the cash flow variation sought from managers is that arising from "economy-wide causes of variation". If this were the case, the underestimation problem described above would evaporate. However, in discussing the ability of managers to provide the cash flow distribution, Loderer et al (2010, page 65) are optimistic because this is "the kind of information needed to provide VaR and cash-flow at-risk measures", and these measures relate to total variability rather than just that arising from economy-wide shocks. In addition, in testing whether cash flows are closely correlated with market returns, Loderer et al (2010, page 65) report some results that clearly involve total cash flow variability.

As described in Myers (1996, section II), a superior process would be to consider values for macroeconomic variables (such as GDP) consistent with various values for R_m, and then estimate the values for the cash flow (or output in a regulatory case) consistent with the values of this macroeconomic variable. However, this is a much more challenging exercise than that described in Loderer et al (2010) and, as before, would have to be performed by the regulator rather than the regulated business.

In summary, although Ireland Wallace does not explain how Black's model could be applied to a price cap regulatory situation, this model could be applied. However, there are three significant limitations in doing so. Firstly, the model requires that the output of the regulated business be linearly related to the market return and no evidence has been presented on this matter. Secondly, the regulator would have to estimate the probability distribution for output without assistance from the regulated business, because the latter would have a vested interest in the result. Thirdly, a process for estimating the expected output conditional on the market return being equal to the risk-free rate would underestimate that parameter, possibly to a very significant degree. In view of these limitations, I do not favour this approach. Accordingly, there is no relief from the beta estimation problems discussed in section 2.

3.2 Other Forms of Regulation

Revenue cap regulation differs from price capping only in that output levels above or below that expected by the regulator lead to subsequent price adjustments to offset the effect of the output shock on the regulated businesses. This is simply an additional step performed in addition to the analysis in the previous section and therefore does not undercut that analysis. However, since the businesses face less risk, the allowed cost of capital may be lower.

Information Disclosure regulation is quite different. In this case, the regulator merely estimates the WACC for comparison with the actual rate of return of the business. So, the expected cash flows of the regulated business (or expected output in a regulatory scenario) are never examined and therefore Black's Rule could not be applied in this case.

3.3 Review of Submissions

CEG (2016b) raise a number of the same concerns noted in section 3.1 above. In particular, CEG (2016b, para 54) argue that managers are unlikely to be able to provide estimates of cash flow distributions that reflect *only* systematic risk. In addition, CEG (2016b, para 59) argue that estimates of conditional distributions could not be drawn from management because regulatory processes require transparency. CEG raise a number of other concerns about Ireland Wallace's application of Black's model to valuing the future cash flows of Transpower New Zealand. However, none of this is relevant to the regulatory problem of setting a price or revenue cap, and CEG never consider the fundamental question of how Black's model could assist in doing so rather than assist in valuing future cash flows.

Frontier Economics (2016, section 5) argues that Black's Rule is concerned with the valuation of future cash flows and is therefore irrelevant to the regulatory task of setting a price or revenue cap. However, as discussed in section 3.1, the principles underlying Black's Rule can be applied in a regulatory situation. Frontier Economics (2016, section 5) also argues that the task of finding a stock index that is highly correlated with the business's net cash flows is complicated. However, as discussed in section 3.1, the task is instead to estimate the probability distribution for cash flows (or output in a regulatory case) that reflects only systematic risk.

HoustonKemp (2015, section 2) raise some of the same concerns noted in section 3.1 above. In particular, HoustonKemp argue that Ireland Wallace (2015) fail to explain how Black's Rule could be used in a regulatory situation. In addition, HoustonKemp also argue that Ireland Wallace's (2015, para 5.4) observation that the Commission's allowed revenues for Transpower materially exceed the revenues conditional on the market return exceeding the risk-free rate is a natural consequence of the difference in definitions and provides no indication of the merits of the Commission's allowed revenues.

4. Conclusions

This paper has examined a number of issues relating to the WACC of regulated businesses, and the principal conclusions are as follows.

Firstly, the Commission currently adds 0.10 to its estimate of the asset beta for electricity distribution businesses to obtain its estimate for gas pipeline businesses, in recognition of two points of distinction identified earlier by me that are relevant to beta: the option to expand the gas pipeline network and the higher proportion of gas being used by industrial and commercial customers rather than retail customers. The stronger of these two points is the expansion option (because the difference in the proportions of usage across the two user groups was not large). However my earlier analysis was conducted at the time these gas businesses were only subject to the threat of formal regulation rather than formal regulation per se. By contrast, they are now subject to formal regulation, this undercuts the value of expansion options in the regulated area, and therefore the argument for a higher asset beta for gas pipeline businesses is now significantly weaker. Furthermore, empirical evidence on the extent of any such beta differential is inconclusive. In view of all this, I do not favour a differential between the asset betas for the New Zealand electricity distribution and gas pipeline businesses in the present regulatory situation.

Secondly, and notwithstanding the theoretical expectation that price-capped businesses would have higher asset betas than both ROR regulated and revenue-capped businesses, there is no empirical study that provides a clear conclusion on the effect of regulation on beta. In the face of this uncertainty, and until better evidence becomes available, I consider that one should keep an open mind. Accordingly, in respect of the New Zealand DPP (price-capped) businesses, the best course of action would be to limit the comparators for them to either US ROR regulated or price capped businesses, depending upon which seems more appropriate, and I consider that the better comparators would be US price-capped businesses (including those also subject to earnings sharing in order to produce an adequate sample size), with the data used to estimate the betas being limited to the period in which the price capping prevailed. It would also be desirable to adjust for differences between the US and New Zealand for market leverage and the composition of the market indexes although related work suggests that the two effects might net out. In addition, in the absence of a sufficiently large set of suitable firms to assess the beta differential between price-capped and revenue-capped businesses, I recommend using the same asset beta for the revenue-capped as for the DPP (price-capped) businesses. This recommendation matches the view expressed in 2010 by the Commerce Commission. Nevertheless, my recommendation arises in spite of my belief that there is very likely to be a beta margin (of unknown degree) for price-capping over revenue-capping, because those businesses subject to it bear an additional source of risk (output) that would elevate beta.

Thirdly, and in relation to the Commission's 2010 estimate for the asset beta for regulated airport services, the Commission's approach commences with an estimate of 0.65 for the average asset beta of a set of comparator airports and then deducts 0.05 to account for the presumed higher beta of the unregulated activities of these airports. This approach implicitly involves estimates for the average proportion of airport value arising from that of regulated services and also the average asset beta for the unregulated services of the comparator airports. However, the Commission does not reveal its estimates for the latter two parameters. I estimate these parameters at 0.39 and 0.67 respectively, which implies deducting 0.03 from the estimated asset beta of the comparator airports in order to estimate the asset beta of the regulated services. This is similar to the Commission's estimate of 0.05. However the estimates of the two underlying parameter values are very imprecise, and the point estimate for the average weight on regulated services is also low, leading to an extremely imprecise estimate for the beta deduction.

Fourthly, in relation to Black's Simple Discounting Rule, this model could be applied to price and revenue-capping situations but there are significant limitations in doing so. Firstly, the model requires that the output of the regulated business be linearly related to the market return and no evidence has been presented on this matter. Secondly, the regulator would have to estimate the probability distribution for output without assistance from the regulated business, because the latter would have a vested interest in the result. Thirdly, a process for estimating the crucial parameter in Black's model that is referred to by Ireland Wallace would underestimate that parameter, possibly to a very significant degree. In view of these limitations, I do not favour this approach. Accordingly, there is no relief from the beta estimation problems discussed above. Information Disclosure regulation is quite different. In this case, the regulator merely estimates the WACC for comparison with the actual rate of return of the business. So, the expected cash flows of the regulated business (or expected output in a regulatory scenario) would never be estimated and therefore Black's Rule could not be applied in this case.

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