THE APPROPRIATE PERCENTILE FOR THE WACC ESTIMATE

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EXECUTIVE SUMMARY

The Commerce Commission currently adds a margin to its WACC estimate because of uncertainty about the true value coupled with a belief that the adverse consequences of underestimating WACC are more severe than those of overestimating it. This approach is consistent with earlier advice provided by me. This paper has sought to review the empirical literature relevant to specifying a particular WACC margin for uncertainty, to consider some contrary views, and to offer my own views on this matter. My conclusions are as follows.

The best available analysis on this matter is provided by Dobbs (2011). Dobbs first offers percentiles applicable to each of existing investments, new non-deferrable investment, and new deferrable investment; for his base case, these are the 45^{th}, 86^{th}, and 97^{th} percentiles respectively. Dobbs also considers the case in which a regulator applies the same WACC to both existing and potential new investment, and his base case estimate is the 74^{th} percentile.

Dobbs's analysis is subject to the following limitations. Firstly, Dobbs's price elasticity range (-6 to -1.5) is unsuitable for the kind of services regulated by the Commission and recourse to a more suitable range (zero to -1.5) leads to the conclusion that the WACC percentile applied to assets in aggregate should be raised to at least the 86^{th} percentile. Secondly, the fact that firms don't know the true WACC implies that an even higher percentile should be used. Thirdly, in the event that their allowed WACC is too low, regulators will eventually become aware of this (particularly through observing inadequate investment by firms), and raise their point estimate or margin, and this implies that a lower percentile should be used. Fourthly, the fact that supernormal WACC allowances will risk inciting excessive investment by firms implies that a lower percentile should be used. Fifthly, in the presence of benefits received by the owner of a regulated business that flow from but are not part of the regulated business ('dual-till' operations), a lower percentile should be used. Sixthly, the effect of uncertainty about various parameter values used by Dobbs and various modelling assumptions implies that the results obtained should be viewed only as rough indicators. Seventhly, the appropriate WACC margin will vary across industries, depending upon factors such as the price elasticity, the risk of excessive investment arising from supernormal WACC allowances, the speed with which a regulator would eventually react to an underestimate of WACC, and the presence or absence of 'dual-till' operations.

All of this suggests that it would be difficult to be definite about the appropriate WACC margin in general, and even more so for specific industries and new versus existing assets, but my sense is that these points collectively suggest that the uniform WACC percentile currently used by the Commission (the 75th percentile) is likely to be too low.

Regarding the question of whether to apply a uniform WACC margin to both new and existing investment or to apply different margins to each type, application of a uniform WACC margin to both types of investment mitigates the potential problem of discouraging investment now by businesses that are not currently regulated but might be. In view of this point, I favour a uniform margin.

Finally, on the question of whether to apply different margins to different industries, the difficulties in estimating these differential rates preclude this course of action. The one exception that I would make would be to not use a margin in circumstances in which the appropriate margin is considered to be much lower than normal. A possible example of this would be 'dual-till' operations in which the flow-on benefits from regulated operations to unregulated operations with the same owner would be very substantial.

1. Introduction

The Commerce Commission currently adds a margin to its WACC estimate because of uncertainty about the true value coupled with a belief that the adverse consequences of underestimating WACC are more severe than those of overestimating it. This approach is consistent with earlier advice provided by me (Lally, 2008). This paper seeks to review the empirical literature relevant to specifying a particular WACC margin for uncertainty and to offer my own views on this matter. I start by reviewing the relevant legislation.

2. Legislation

The relevant legislation is section 52A of the Commerce Act 1986, which states that the purpose of regulating price and quality where there is little or no completion, and little likelihood of a substantial increase, is to "promote the long-term benefit of consumers…by promoting outcomes that are consistent with outcomes produced in competitive markets such that suppliers of regulated goods or services have incentives to innovate and to invest….and improve efficiency… and share with consumers the benefits of efficiency gains…and are limited in their ability to extract excessive profits."

The wording is clearly premised upon suppliers' costs (including WACC) being certain. Thus, if costs are certain, the regulated price should just cover those costs including the cost of capital except to the extent that a higher price provides the incentive to innovate. However the issue here is how a regulator should react to WACC uncertainty, and the wording of the legislation provides no clear guidance on that matter. This issue will be addressed further in section 5.

3. Literature Review

Wright et al (2003) is the first paper to consider the implications of WACC uncertainty for the regulator's choice of a WACC value. Wright et al argue that underestimating WACC will lead to firms failing to make desirable investments, leading to loss of the economic surplus (the sum of consumer and producer surplus) arising from these potential investments, whilst overestimating WACC will lead to output prices being set too high (monopoly pricing), and therefore loss of some of the maximum attainable economic surplus on the investment.

Wright et al argue that the optimal regulatory WACC estimate minimises the expected aggregate loss of these two surpluses, with the expectation over the probability distribution for the true WACC. As noted by Wright et al, this could lead to a regulatory WACC estimate that was below the point estimate or above it, depending upon the elasticity of demand and therefore on the particular firms that are regulated: highly inelastic demand implies that the loss in surplus on investments that do not proceed (because the regulator's WACC is too low) will be large, whilst the loss in surplus from reduced demand arising from the regulator's WACC being too high (and hence the output price being too high) will be minimal, and this implies that the optimal regulatory WACC estimate should be high. Furthermore the typical regulatory situation involves services that are likely to have low price elasticity ("necessities") and therefore the optimal regulatory WACC estimate should be high rather than low. Wright et al do not offer any estimates of these WACC values.

Wright et al's framework has a number of implicit assumptions. Firstly, Wright et al implicitly assumes that regulated firms know the true WACC and will therefore not undertake investments when the WACC allowed by the regulator is below the true WACC. Such an assumption is not credible; the crucial uncertainties in WACC are in the MRP and the beta, and regulated businesses are not only uncertain about these parameters but they are prima facie no better informed about these parameter values than the regulator.

Secondly, Wright et al assume that investment decisions are of the now or never variety, and therefore inadequate WACC allowances lead to loss of good investments for all time. However, typically, there will be a deferral option and a subsequent regulatory decision may be sufficiently favourable to induce the regulated business to invest. Furthermore, the failure of the regulated business to undertake the investment would be evidence to a regulator that their WACC allowance was too low and would therefore help to prompt an upward revision.

Thirdly, Wright et al assume that there is only one investment, which does or does not proceed and if it does is subject to some loss of the maximum possible surplus. However, at the time regulation is introduced, firms will have some existing investments and the loss of surplus arising from errors in setting price or revenue caps extends not only to new investment but also to existing investments.

Dobbs (2011) extends this analysis by allowing for existing investments and new investment that is deferrable as well as potential investments that are now or never, i.e. he deals with the last two limitations in the Wright et al analysis. Furthermore, unlike Wright et al, he also presents WACC values under various scenarios. In respect of potential investments that are now or never, he concludes that the optimal regulatory WACC estimate should be above the mean of the probability distribution for the true WACC unless demand is very elastic; this conclusion essentially matches that of Wright et al. As with Wright et al, there is a trade-off: higher regulatory WACC estimates increase the probability that the investment is undertaken but increase the loss in surplus from overpricing if the investment does proceed. Furthermore, as noted earlier, the typical regulatory situation involves services that are likely to have low price elasticity ("necessities") and therefore the optimal regulatory WACC estimate should be above the mean of the probability distribution. In respect of deferrable investments, the optimal regulatory WACC estimate should be even higher than for non-deferrable investment, to overcome the usual disinclination of firms to invest now when there is a deferral option. Finally, in respect of existing investments, for which the investment is 'sunk', errors in the regulator's choice of WACC lower the economic surplus in both directions: high WACC values imply monopoly profits and therefore the usual loss of surplus whilst low WACC values imply losses to producers that outweigh the gains to consumers. For this type of investment, the optimal regulatory WACC is therefore close to the mean of the probability distribution for the true WACC. Dobbs goes on to offer regulatory WACC estimates for each of these classes of investment, starting with some base case parameter values and then varying them (Dobbs, ibid, Table 2). In terms of WACC percentiles, his base case results are the 45th percentile for existing sunk investment, the 86th percentile for new non-deferrable investment, and the 97th percentile for new deferrable investment.

Dobbs (ibid, Table 3) also considers the case in which a regulator applies the same WACC to both existing and potential new investment, and he presents WACC percentiles for various combinations of relevant parameters. His base case result is the 74th percentile, and his results range from the 51st to the 90th. Naturally, the results depend upon the ratio of potential new investment to total investment. For the base case values of the other parameters, even when this proportion is as low as 5%, the WACC percentile is the 74th and rises to the 90th percentile when the investment ratio rises to 30%. So, even if this ratio of potential new investment to total investment is low, the potential new investment exerts a significant impact upon the WACC percentile.

The most important parameter in this analysis is demand elasticity, and Dobbs considers values from -1.5 to -6. Using base case values for other parameters in his Table 3, the WACC percentile rises from the 63rd percentile to the 90th as the demand elasticity changes from -6 to -1.5. However this elasticity range does not correspond well to empirical estimates. For example, Nicholson (1995, Table 7.3) presents estimates for various goods and services, which range from -0.18 for rental accommodation to -1.5 for marijuana. Furthermore, as noted earlier, the typical regulatory situation involves services that are "necessities", which have low price elasticities and the effect of a lower price elasticity is to raise the WACC percentile applicable to new investment. Thus the relevant elasticity values should be above -1.5. Both Covec (2014, page 7) and NZIER (2014, page 16) also make this point. Examining Dobbs's Table 3 for cases in which the elasticity is -1.5, the associated percentiles are at least the 86th. So, on this basis, the appropriate WACC percentile should be at least the 86th when a single rate is used. When different rates are used for the three classes of investment, Dobbs's results for cases in which the elasticity is -1.5 are at least the 44th, 77th and 91st percentiles.

LECG (2007, section 4) takes a different approach and argues that the choice of a percentile from the WACC distribution should be based upon a "loss function". LECG shows, by recourse to an asymmetric linear loss function, that the 75th percentile from the WACC distribution is consistent with losses from WACC underestimation being three times that of WACC overestimation. Clearly, there are a range of alternative loss functions and these would lead to different results. However, the crucial problem with this approach is that it gives no guidance as to the ratio of losses from underestimation versus overestimation, and therefore cannot specify the appropriate WACC percentile. By contrast, the analysis in Dobbs (2011) quantifies losses of both types (by positing demand and supply functions for the regulated service) and therefore can specify the appropriate WACC percentile (subject to various assumptions and parameter values). Accordingly, Dobbs's approach is superior.

4. An Example

Dobbs's approach is complex and the complexity may shroud the underlying intuition. Furthermore much of the underlying detail is not presented in the paper. Consequently I present an example designed to illustrate the process. Suppose that production of a new

product involves costs that are proportional to output and comprise \$1 of opex per unit of output, \$40 of capital per unit of output, a true WACC of 10% and no depreciation (capital has infinite life). The marginal cost per unit of output is then \$5. Suppose also that the demand function is

$$P = \$10 - .1Q \tag{1}$$

So, if the regulator correctly estimates WACC at 10% and invokes that rate, the price cap will be \$5 per unit, the project will presumably proceed (it is NPV = 0 for the firm), and the quantity sold will be 50 units. The resulting economic surplus (the area between the demand and supply functions up to the equilibrium units sold) will be the product of the average consumer surplus of .5(\$5) and the number of units sold (50), yielding \$125, and this is the maximum attainable. Now suppose the regulator estimates WACC, and the estimate is normally distributed about its true value of 10% with a standard deviation of 1.6%.[1] To make the resulting calculations more transparent, I approximate this probability distribution using the discrete probability distribution shown in the first two columns of Table 1 below.

In respect of the economic surplus, this depends upon the price charged. At the socially optimal price of \$5, the economic surplus is \$125 as noted above. However, if the price is less than this because the regulator has used a WACC of less than 10%, the project will not proceed and the economic surplus will be zero. Alternatively, if the price P is more than \$5 because the regulator has used a WACC in excess of 10%, leading to sales of Q units (Q will be less than 50), the economic surplus will be the sum of the consumer and producer surpluses (*CS* and *PS*) as follows:

$$ES = CS + PS = \left(\frac{\$10 - P}{2}\right)Q + (P - \$5)Q \tag{2}$$

For example, if P = \$6 whereupon sales will be Q = 40 units in accordance with equation (1), the average consumer surplus will be \$2 on the 40 units sold, totalling \$80, and the producer surplus will be \$1 per unit on the 40 units sold, totalling \$40. So, the economic surplus will be \$120, which is slightly less than the surplus of \$125 at the socially optimal price of P = \$5.

[1] Dobbs treats the true WACC as the random variable, which is the natural choice when viewing the matter from the regulator's perspective. However, since that perspective is not being adopted, the natural choice of random variable is the regulator's estimate.

Solving equation (1) for Q, and substituting it into equation (2), yields the economic surplus solely as a function of P:

$$ES = 5P(\$10 - P) \tag{3}$$

In addition, letting k denote the cost of capital allowed by the regulator, the allowed output price P is the sum of \$1 for opex and the cost of capital allowance of \$40k. In addition, the allowed cost of capital is the sum of the regulator's point estimate (k_p) and any margin for uncertainty that is added to this (m), with the regulator's point estimate being a random drawing from the probability distribution shown in Table 1. So, the allowed price is

$$P = \$1 + \$40(k_p + m) \tag{4}$$

So, the regulator estimates WACC at k_p, and adds the margin m. If $k_p \geq .10 - m$, and therefore $k_p + m \geq .10$, and therefore $P \geq \$5$, the project proceeds and the economic surplus will be as given by equation (3) for each value of P that is at least \$5, i.e., for each value of k_p that is at least $.10 - m$. The expectation over these possible ES values is the expected economic surplus, and the regulator should choose the margin m to maximise this expected economic surplus.

For example, suppose the regulator does not use a margin, i.e., $m = 0$. In this case, the project will proceed only if the regulator's point estimate of WACC (k_p) is at least .10. Thus, if the regulator estimates the WACC at .105, they will allow an output price of \$5.20 in accordance with equation (4) and the economic surplus will then be \$124.8 in accordance with equation (3). For higher WACC estimates, the resulting allowed output price will be higher and therefore the economic surplus will be lower as shown in the first and third columns of Table 1. The expected surplus is determined using the possible values for ES shown in the third column of the table and the probabilities shown in the second column, and is \$61.4 as shown at the bottom of the third column. This expected surplus is the product of the probability of the investment occurring (50%) and the expected surplus if it does proceed of \$122.8.[2] The latter figure is slightly below the maximum ES of \$125 because some of the WACC estimates

[2] The latter figure is the expectation over all positive values of ES shown in the third column of table 1, using the probabilities shown in the second column but scaled so that they add to 1. This involves dividing each of these probabilities by the probability of the project proceeding (.50).

are too high, and therefore some of the *P* values are too high leading to loss of some economic surplus.

Table 1: Expected Economic Surplus

k_p	*Prob*	$m = 0$	$m = .01$	$m = .02$	$m = .03$	$m = .04$
.055	.01	0	0	0	0	0
.065	.02	0	0	0	0	$124.8
.075	.08	0	0	0	$124.8	$123.2
.085	.16	0	0	$124.8	$123.2	$120.0
.095	.23	0	$124.8	$123.2	$120.0	$115.2
.105	.23	$124.8	$123.2	$120.0	$115.2	$108.8
.115	.16	$123.2	$120.0	$115.2	$108.8	$100.8
.125	.08	$120.0	$115.2	$108.8	$100.8	$91.2
.135	.02	$115.2	$108.8	$100.8	$91.2	$80.0
.145	.01	$108.8	$100.8	$91.2	$80.0	$67.2
E(*ES*)		$61.4	$88.6	$106.0	$111.9	$108.8
Prob (proceed)		.50	.73	.89	.97	.99
E(*ES*/proceed)		$122.8	$121.4	$119.1	$115.3	$109.9

Now suppose the regulator uses a margin of 1%, i.e., $m = .01$. In this case, the project will proceed if the regulator's point estimate of WACC (k_p) is at least .09. Thus, if the regulator estimates the WACC at .095, they will allow an output price of $5.20 in accordance with equation (4) and the economic surplus will then be $124.8 in accordance with equation (3). For higher WACC point estimates, the resulting allowed output price will be higher and therefore the economic surplus will be lower as shown in the first and fourth columns of Table 1. The expected surplus is now $88.6 as shown at the bottom of the fourth column.

As *m* rises, the expected surplus initially rises and peaks at $m = .03$, which corresponds to the 96th percentile. This arises from a trade-off between the probability of the project proceeding, which increases monotonically as *m* rises (this is the benefit from raising *m*), and the expected surplus conditional upon the project proceeding, which decreases monotonically

as *m* rises (this is the disadvantage from raising *m*). This example demonstrates that the losses in economic surplus from raising *m* (the reduction in *E*(*ES*) if the project proceeds) are small relative to the gains from raising *m* (the increased probability of the project proceeding), unless *m* is very large. Consequently a high value for *m* is optimal.

This result is contingent upon a number of other parameter values, of which the most significant is the slope of the demand function (and therefore the size of the consumer surplus if the project proceeds at the socially optimal output price). The demand function shown in equation (1) has an elasticity of -1 at the socially optimal price of $5, i.e., an increase in the output price of x% reduces quantity sold by the same percentage. For the kinds of services subject to regulation, this elasticity is more likely to be too low than too high, and a higher elasticity yields an even higher value for *m*. For example if the demand function became $P = \$20 - .3Q$, which involves a higher slope and therefore higher elasticity of -0.33, the optimal value for *m* rises from .03 to .04.

5. Further Analysis

In earlier analysis of this matter (Lally, 2008, pp. 94-95), I have expressed the view that the appropriate percentile is above the 50th for price control situations, and even higher for assessments of excess returns. Subsequently I expressed the view that it was likely to be above the 75th percentile (Commerce Commission, 2009, page 225). In respect of price control situations, this reflects a belief that the costs of underestimating WACC (discouraging desirable investment) is likely to significantly outweigh the costs of overestimation (monopoly profits, leading to loss of economic surplus). However, my conclusions were not based upon any formal analysis. Formal analysis, leading to a specific WACC percentile, has now been provided by Dobbs. However this analysis is subject to the following caveats.

Firstly, Dobbs considers ranges of values for various parameters. As noted above, the most important of these is the price elasticity and the range considered by Dobbs (-6 to -1.5) does not in my view include values applicable to the services that the Commission regulates (between zero and -1.5). Both Covec (2014, page 7) and NZIER (2014, page 16) share this view. The effect of this is that Dobbs's conclusions about the appropriate WACC percentile are too low. When different WACC rates are used for the three classes of investment, the

appropriate figures from Dobb's analysis should be at least the 44th, 77th and 91st percentiles for existing investments, new non-deferrable investment, and new deferrable investment respectively. When applying the same WACC to all classes of investment, the appropriate percentile from Dobbs's analysis is at least the 86th percentile.

Secondly, even when ranges for parameters are appropriate for the kinds of services regulated by the Commission, it is not possible to reliably estimate all of these parameters and therefore obtain a precise estimate for the WACC percentile. The most one can hope for is a rough estimate of the appropriate WACC percentile.

Thirdly, Dobbs makes a number of assumptions whose effects are examined by him. In general, they do not dramatically affect his results (Dobbs, ibid, section 4). However they amplify the point that the most one can hope for is a rough estimate of the appropriate WACC percentile.

Fourthly, Dobbs makes a number of assumptions (explicitly or implicitly) whose effects are never examined by him. This is further grounds to limit conclusions about the WACC percentile to a rough estimate. One of these is the assumption that the regulator's WACC estimate is a random drawing from a probability distribution. However, if a regulator's allowed WACC is too low, it will receive information from various sources on this matter and the effect will be to influence the regulator towards raising its allowed WACC. One such source would be regulated businesses advising the regulator that they were curtailing new investment because the allowed WACC was too low (discounted for the self-interest in regulated businesses making such statements). Another would be objective evidence of the curtailment of investment that would otherwise have proceeded, such as congestion or a catastrophic failure in the system. A third possibility is regulated assets selling for less than RAB. The effect of these points is that the probability of investments never proceeding due to WACC error is lower than Dobb's analysis would suggest, and therefore the appropriate WACC margin is smaller than Dobb's analysis would suggest. This point is stronger whenever failure to invest leaves time for a regulator to react, such as congestion resulting from failure to add to existing capacity rather than catastrophic failure (as discussed by Covec, 2014, page 13).

Dobbs also assumes that allowed WACC values in excess of the true value do not lead to inefficient investment (made purely in response to the supernormal WACC allowance), i.e., there is no Averch-Johnson effect (Averch and Johnson, 1962). Since some degree of such inefficient investment is likely, the downside to excessive WACC allowances is greater than Dobbs recognises. Consequently, the optimal WACC margin would be smaller than his analysis suggests, but the degree here is not open to quantitative analysis. External scrutiny of capex proposals by a regulator or major customers would ameliorate this problem.

Dobbs also assumes that the owner of the regulated business does not gain any benefits from unregulated activities that flow from the regulated business (no 'dual-till' operations), which might incline them to undertake a regulated investment even if the allowed WACC was below the true WACC. Thus, in the presence of 'dual-till' operations, the optimal WACC margin would be smaller than his analysis suggests, but the degree here is not open to quantitative analysis. Covec (2014, section 3.1) provides an example of 'dual-till' operations, in the form of Auckland International Airport.

Dobbs also assumes that a universal service obligation (USO) applies, and therefore treats all existing investment as 'sunk'. An alternative regulatory device is a quality standard, with criminal and civil penalties for contraventions. To the extent that some regulated businesses are not subject to either of these, if the regulator's allowed WACC is too low, firms will not replace investment as it reaches the end of its economic life. So, eventually all existing investments become new investments. Thus, over time, the appropriate WACC estimate applied to all assets would have to increase. Thus, whatever allowed WACC one chose today based upon Dobbs's analysis, that rate would have to be raised over time.

Dobbs also assumes that the regulated firm knows the true WACC of each potential project, and therefore will not undertake an investment if the rate allowed by the regulator is too low. This enables quantification of the losses in economic surplus from WACC being too low. However, regulated businesses do not know the true WACC values of their potential projects, and may not even know more about them than the regulator. However, it is reasonable to suppose that the estimation errors of the firm and the regulator are not perfectly correlated. If so, and the firm treats its WACC estimate as the true value and the regulator invokes a positive margin, the probability of the project not proceeding is even larger than Dobbs's analysis would suggest (because high estimates of WACC by the firm raise the probability of

project rejection by more than the decrease in the probability of rejection arising from low estimates of WACC by the firm).[3] Accordingly, the expected losses in surplus from the possible non-adoption of the project are larger than Dobb's analysis would suggest, and therefore the optimal regulatory margin is larger than Dobb's analysis would suggest.[4]

To illustrate this point, suppose that the firm's estimate of WACC (k_f) is completely uncorrelated with the regulator's estimate (k_p) but their estimates are drawn from the same probability distribution with mean .10 and standard deviation of .016. Suppose also that the regulator allows a margin of m. The firm will reject the project if the WACC allowed by the regulator ($k_p + m$) is less than the firm's estimate k_f, and therefore the probability of the project being rejected is

$$\Pr ob\left[k_p + m \le k_f\right] \tag{5}$$

Since k_p and k_f are each normally distributed with mean .10 and standard deviation .016, they can each be expressed as follows:

$$k_p = .10 + .016Z_p, \quad k_f = .10 + .016Z_f \tag{6}$$

where Z_p and Z_f are uncorrelated standard normal random variables. Substitution of (6) into (5) yields a probability on the project being rejected of

$$\Pr ob\left[.10 + .016Z_p + m \le .10 + .016Z_f\right] = \Pr ob\left[Z_p - Z_f \le -\frac{m}{.016}\right]$$

[3] This asymmetry requires only that the probability distribution for the regulator's WACC estimate is 'humped' around its mean. Thus, when the firm's estimate of the project's WACC is high, it raises the probability of project rejection more than the mitigation that occurs when the firm's estimate of the project's WACC is low.

[4] It might be argued that investors who overestimate WACC, and therefore undervalue companies, will tend to sell their shares to other investors, i.e., a 'winners' curse' operates, with the result that holders of shares tend to underestimate WACC. However, decisions about project acceptance are made by managers rather than owners and the former could overestimate WACC even if the latter don't. It could also be argued that managers who overestimate WACC, and therefore undervalue potential projects, will be filtered out by the owners of the company. However, managers who underestimate WACC, and therefore adopt projects whose NPV is negative, will also tend to be filtered out and there is no strong grounds to suppose other than the mean WACC estimate across managers is unbiased, i.e., some managers tend to estimate too low whilst others tend to estimate too high. Furthermore, the filtering out process is imperfect (in part because owners don't directly appoint managers) and the best it could hope to achieve is that all managers have unbiased estimates of WACC. This still admits the possibility that their estimates for some projects will be too high whilst their estimates for others will be too low. Even in this unlikely state, Dobbs's assumption that the regulated firm knows the true WACC of each potential project is too strong.

Since Z_p and Z_f are each normal with mean zero and standard deviation 1, and are uncorrelated, the difference between them is normal with mean zero and standard deviation of $\sqrt{2}$ (Mood et al, 1974, page 178). So the probability of the project being rejected is

$$\Pr ob\left[Z\sqrt{2} \le -\frac{m}{.016} \right] = \Pr ob\left[Z \le -\frac{m}{.016\sqrt{2}} \right]$$

Thus, for example, if m = .016, the probability of the project being rejected is 24%. By contrast, if the firm is certain about the project's WACC (of .10), the probability of project rejection is now

$$\Pr ob\left[k_p + m \le .10 \right] = \Pr ob\left[.10 + .016Z_p + m \le .10 \right] = \Pr ob\left[Z_p \le -\frac{m}{.016} \right]$$

So, if m = .016, the probability of rejection is only 16% compared to 24% above. The example reveals the importance of the margin m to the result. If m = 0, the probability of rejection is 50% regardless of whether the firm is certain about the WACC or not.

Finally, whilst Dobbs treats existing investment as 'sunk', and therefore assigns a lower WACC margin to it than new investment (when differential rates are used), such an approach may have a perverse effect if different WACC margins are applied to existing and new investment. In particular, in the event of them being regulated at future time T, any investments made by them from now until time T would be treated as sunk by the regulator at time T, and would therefore not receive the WACC margin. Accordingly, such future investment by these currently unregulated businesses would be discouraged in proportion to the perceived probability of these businesses being regulated. Application of a uniform WACC margin to both types of investment would mitigate this problem, and I therefore favour this.

In summary, Dobbs's analysis is subject to the following limitations. Firstly, Dobbs's price elasticity range (-6 to -1.5) is unsuitable for the kind of services regulated by the Commission and recourse to a more suitable range (zero to -1.5) leads to the conclusion that the WACC

percentile applied to assets in aggregate should be raised to at least the 86th percentile. Secondly, the fact that firms don't know the true WACC implies that an even higher percentile should be used. Thirdly, in the event that their allowed WACC is too low, regulators will eventually become aware of this (particularly through observing inadequate investment by firms), and raise their point estimate or margin, and this implies that a lower percentile should be used. Fourthly, the fact that supernormal WACC allowances will risk inciting excessive investment by firms implies that a lower percentile should be used. Fifthly, in the presence of benefits received by the owner of a regulated business that flow from but are not part of the regulated business ('dual-till' operations), a lower percentile should be used. Sixthly, the effect of uncertainty about various parameter values used by Dobbs and various modelling assumptions implies that the results obtained should be viewed only as rough indicators. Finally, the appropriate WACC margin will vary across industries, depending upon factors such as the price elasticity, the risk of excessive investment arising from supernormal WACC allowances, the speed with which a regulator would eventually react to an underestimate of WACC, and the presence or absence of 'dual-till' operations. All of this suggests that it would be difficult to be definite about the appropriate WACC margin in general, and even more so for specific industries and new versus existing assets, but my sense is that these points collectively suggest that the uniform WACC percentile currently used by the Commission (the 75th percentile) is likely to be too low.

Regarding the question of whether to apply a uniform WACC margin to both new and existing investment or to apply different margins to each type, application of different margins discourages investment now by businesses that are not currently regulated but might be. In particular, in the event of them being regulated at future time T, any investments made by them from now until time T would be treated as sunk by the regulator at time T, and would therefore not receive the WACC margin. Accordingly, such future investment by these currently unregulated businesses would be discouraged in proportion to the perceived probability of these businesses being regulated. Application of a uniform WACC margin to both types of investment would mitigate this problem, and I therefore favour this.

Finally, on the question of whether to apply different margins to different industries, the difficulties in estimating these differential rates preclude this course of action. The one exception that I would make would be to not use a margin in circumstances in which the appropriate margin is considered to be much lower than normal. A possible example of this

would be 'dual-till' operations in which the flow-on benefits from regulated operations to unregulated operations with the same owner would be very substantial.

6. Contrary Arguments

6.1 High Court Decision

In a ruling on an appeal against the Commission's Input Methodology determinations, the High Court (2013) ruled in the Commission's favour over the Commission's choice of the 75th percentile but nevertheless raised some concerns about that choice. Firstly, the Court claimed (ibid, para 1472) that supplier returns are "almost guaranteed" and therefore questioned the need for "higher likely returns". This argument involves conflating the point estimate with the merits of a percentile above the 50th. As the degree of certainty about equity returns increases, the point estimate for the cost of equity should decline towards the risk free rate (net of tax). However, so long as there is some uncertainty about returns and therefore the point estimate for the cost of equity is above the risk-free rate (net of tax), the point estimate for the cost of equity will reflect the market risk premium and beta, and the values for these parameters are subject to considerable uncertainty. So, if the adverse effects of underestimation exceed that of overestimation, a margin for uncertainty is warranted. Nevertheless, as the point estimate for beta shrinks towards zero, the WACC margin resulting from choosing the 75th rather than the 50th percentile (in WACC basis points) also shrinks towards zero. In short, the merits of the margin for uncertainty are invariant to the degree of uncertainty about equity returns but the size of that margin shrinks to zero as the degree of uncertainty about equity returns shrinks to zero.

Secondly, the Court argued (para 1473-4) that a WACC margin for uncertainty would raise prices and therefore could not enhance dynamic efficiency (innovation) because "necessity (not plenty) is the mother of invention." However, whilst it is true that necessity stimulates invention, it is not the only stimulant, and typical explanations of the proverb recognise this; the definite article "the" appears in the proverb for dramatic impact rather than to purposely exclude any other stimulants to invention. Smart phones were not invented because they were necessary but because those who undertook the R&D believed that the projects were NPV positive. However, if the prices of such devices are ever regulated (and particularly if the allowed WACC is through error set below the true value), one could reasonably expect

innovation in this area to decline. In short, WACC margins for uncertainty enhance dynamic efficiency. The Court seems to subsequently accept this (ibid, para 1479), when it states that "Future investment choices by suppliers must rationally be influenced by expected earnings on those future investments."

Thirdly, the Court argued (paras 1475-1476) that the outputs of regulated firms are inputs to other sectors of the economy as well as to final consumers and therefore WACC margins will (be likely to) induce allocative inefficiency throughout these other sectors of the economy. This is true but it is reflected in the price elasticity for the product in question, i.e., use of the product as an input in other sectors of the economy will likely raise the elasticity of demand of the product (bring it closer to zero), thereby lowering the allocative inefficiency arising from WACC errors, and therefore increase the appropriate WACC margin in accordance with Dobbs's analysis. Thus, so long as the price elasticity is properly estimated, and reflected in the choice of WACC margin, there is no need to additionally consider the extent to which the product is used as an input in other sectors of the economy.

To illustrate the point that use of the product as an input in other sectors of the economy will likely raise the elasticity of demand of the product (bring it closer to zero), suppose that a regulated business produces a product (A) for which half the sales are to final consumers (consumer group 1) and half is to another sector of the economy whose output (product B) is sold only to final consumers (consumer group 2). Suppose further that the price elasticities of consumer groups 1 and 2 are both -1, and that price increases for product A are fully passed through to the output price of product B. Finally, suppose that the cost of product A constitutes 10% of the price of product B. Under these conditions, a 1% increase in the price of product A will reduce demand from consumer group 1 by 1%, and it will also increase the price of product B by 0.1% thereby reducing demand for product B by 0.1% and therefore reducing demand for A as an input to B by 0.1%. Thus, a 1% increase in the price of product A reduces demand from consumer group 1 by 1% and reduces demand from the producers of B by 0.1%, thereby reducing aggregate demand for product A by 0.55%. Consequently, the price elasticity of product A is -0.55. By contrast, had A not been used as an input for B, the price elasticity of A would have been -1.

Fourthly, the Court argued (ibid, para 1479) that application of the WACC margin to the initial RAB (as opposed to future capex) is "unlikely to be necessary to promote incentives to

invest and innovate." Clearly, the initial RAB is sunk and therefore invariant to a WACC margin. However, at least some businesses that might be regulated at some future point could be expected to notice if the WACC margin was not applied to the initial RAB of currently regulated firms, and could be expected to conclude that, in the event of them being regulated at future time T, any investments made by them from now until time T would be treated as sunk by the regulator at time T, and would therefore not receive the WACC margin. Accordingly, such future investment by these currently unregulated businesses would be discouraged in proportion to the perceived probability of these businesses being regulated. In response to this point, which I have raised before, the Court (ibid, para 1481) states that "no evidence of such an effect was presented." However, it is hard to imagine what kind of evidence would be available and persuasive. Considerations of this kind are unlikely to be committed to writing and, in the event that they were, such documents would be unlikely to be available to the Commission. Furthermore, if the Commission had written to the CEOs of some businesses that are not currently regulated, but might be at some future point, and asked them whether their investment plans have been adversely affected by the possibility of regulation at some future point, and whether they would be even more adversely affected if investments made prior to the time at which regulation was introduced were granted a lower WACC than subsequent investments, the responses to such a letter are fairly predictable: businesses who had already pondered these matters would be likely to respond yes whilst those hadn't would be likely to offer the same response in the hope of discouraging regulation or a lower WACC for 'sunk' investment. The proposition that the future investment plans of some (currently unregulated) businesses would to some degree be discouraged by the Commission not applying the WACC margin to initial RAB seems to me to be so obvious that empirical evidence would seem to be redundant. The proposition requires only the belief that future investment plans are influenced by expected earnings on those investments, because the possibility of future regulation will reduce expected earnings, and the Court (2013, para 1479) clearly states that future investment plans are influenced by expected earnings on those investments.

In summary, the Court's belief that a WACC margin is unnecessary because supplier returns are "almost guaranteed" conflates the appropriate point estimate with the merits of a percentile above the 50^{th}; the merits of the margin for uncertainty are invariant to the degree of uncertainty about equity returns but the size of that margin shrinks to zero as the degree of uncertainty about equity returns shrinks to zero. In addition, the Court's belief that "necessity

(not plenty) is the mother of invention", and therefore that a WACC margin for uncertainty would not enhance innovation, is wrong because both necessity and the prospect of profit are stimulants to innovation. In addition, the Court's belief that the outputs of regulated firms are inputs to other sectors of the economy as well as to final consumers, and therefore WACC margins will (be likely to) induce allocative inefficiency throughout these other sectors of the economy, is true but reflected in the price elasticity for the product in question; so long as the price elasticity is properly estimated and reflected in the choice of WACC margin, there is no need to additionally consider the extent to which the product is used as an input in other sectors of the economy. Finally, on the question of whether the lack of WACC margins for 'sunk' investment would discourage future investment in sectors not currently regulated, the Court's claim that no evidence of such discouragement was presented would seem to be true but it is hard to imagine what kind of evidence would be available and persuasive; the proposition that such discouragement would arise requires only the belief that future investment plans are influenced by expected earnings on those investments, because the possibility of future regulation will reduce expected earnings, and the Court clearly believes that future investment plans are influenced by expected earnings on those investments.

6.2 Covec

Covec (2014, section 2.1) notes that the relevant legislation (Section 52A of the Commerce Act 1986) refers to the purpose of the legislation being to "promote the long-term benefit of consumers", and concludes from this that Dobbs's analysis ought to have maximised the expected consumer surplus rather than the total surplus, leading to a negative WACC margin for sunk investment. However, Covec fails to point out that the allowed WACC that maximises consumer surplus for sunk investment is zero. By the same reasoning, the allowance for depreciation on 'sunk' investment should also be zero. This is effectively confiscation. Clearly, this is not a viable policy and yet it is the logical consequence of maximising consumer surplus for 'sunk' investment. Furthermore, at other points, the wording of section 52A invites alternative interpretations to that of Covec. In particular, the wording also refers to promoting outcomes that correspond to those in competitive markets. In such markets, prices would presumably reflect the WACC point estimates of suppliers, which involves a zero WACC margin (if suppliers have the same point estimate as the Commission) rather than a margin that maximises consumer surplus. Furthermore, the wording of section 52A clearly does not reflect any appreciation of WACC uncertainty and therefore is not helpful in deciding how one should react to WACC uncertainty. If WACC is

certain, a regulator does not need to allow a margin to ensure that socially desirable investment will be undertaken. By contrast, WACC uncertainty implies that a WACC margin may be necessary to encourage socially desirable investment, and the usual meaning of 'socially desirable' is positive total surplus.

Furthermore, even if one interpreted section 52A in the way that Covec does, substitution of consumer surplus for total surplus in the Dobbs analysis would still lead to a substantial WACC margin for new investment. For example, in the analysis presented in section 3, choosing the WACC margin to maximise expected consumer surplus rather than expected total surplus leads to a WACC margin of .02, which corresponds to the 90th percentile, rather than .03, which corresponds to the 96th percentile. Both percentiles are well above the 75th percentile currently used by the Commission. NZIER (2014, page 15) makes the same point.

Covec (2014, section 2.1) also argues that the high WACC margins in Dobbs's analysis arise from new investment that can be deferred, that the margins here arise because of real options possessed by businesses, that recognition of such options has been rejected by the Commission, and therefore that the WACC margins for new investment should be rejected. This argument implies that, without the deferral option, the WACC margin would evaporate. However, this implicit claim is rebutted in Dobbs's analysis, in the course of him examining the appropriate WACC margins for new investment that can't be deferred and that which can be. As noted in Dobbs (ibid, Table 1), and in terms of WACC percentiles, his base case results are the 45th percentile for existing sunk investment, the 86th percentile for new non-deferrable investment, and the 97th percentile for new deferrable investment. Thus, the deferral option does not cause the WACC margin to be high, it merely raises it even further. As noted by Dobbs (ibid, page 24): "whether investment was deferrable or not, there is a significant incentive to set AROR above the mean value." Furthermore, the argument for rejecting "real options analysis" (that it unnecessarily rewards monopoly power) does not readily apply here: the consequence of the higher WACC allowance for deferrable investment is not an unnecessary reward to monopoly power but incentivising firms to make socially desirable investments.

In summary, I do not agree that the wording of section 52A of the Commerce Act implies that producer surplus should be ignored; the effect of doing so on new investment is limited in any event, and the effect on 'sunk' investment (de facto confiscation) is so extreme as to be

completely unviable. In addition, I do not agree that a rejection of "real options analysis" elsewhere by the Commission is relevant to the appropriate WACC margin. Even if it were relevant, the appropriate WACC margin would be that for non-deferrable new investment and the WACC margin here is still substantial.

6.3 NZIER

NZIER (2014, section 3.1) argues that producer surplus in Dobbs's analysis is illusory, and therefore should be ignored, because in the event of a proposed project in the regulated sector not proceeding investors will be able to invest elsewhere at only fractionally inferior NPV than any positive NPV that could be earned in the regulated sector. This argument implies that there is a fixed quantity of investment within any period, and therefore abandonment of a possible investment (A) in the regulated sector because the WACC allowed by the regulator is too low leads to other desirable investment (B) occurring in substitution. This claim is false. The corporate sector has access to both A and B. So, if both are NPV positive, both could be expected to proceed (with the required amount of capital raised to do so). Thus, if A does not proceed because the WACC allowed by the regulator is too low, B does not then proceed in *substitution* because it would be undertaken anyway. Thus, if a regulator sets WACC so low that a desirable investment does not proceed, the benefits of that project are lost in accordance with Dobbs's analysis.

NZIER (2014, section 3.2) also argue that the general equilibrium (economy wide) consequences of WACC margins should be considered. This would seem to be well beyond the scope of the Commission's responsibilities. In any event, these consequences are likely to be so contentious that the proposal is unviable.

In summary, NZIER's claim that the producer surplus in Dobbs's analysis is illusory is false and their recommendation to consider the economy-wide consequences of WACC margins is unviable because these consequences are likely to be very contentious.

7. Conclusions

This paper has sought to review the empirical literature relevant to specifying a particular regulatory WACC margin for WACC uncertainty, to consider some contrary views, and to present my own views on this matter. My conclusions are as follows.

The best available analysis on this matter is provided by Dobbs (2011). Dobbs first offers percentiles applicable to each of existing investments, new non-deferrable investment, and new deferrable investment; for his base case, these are the 45th, 86th, and 97th percentiles respectively. Dobbs also considers the case in which a regulator applies the same WACC to both existing and potential new investment, and his base case estimate is the 74th percentile.

Dobbs's analysis is subject to the following limitations. Firstly, Dobbs's price elasticity range (-6 to -1.5) is unsuitable for the kind of services regulated by the Commission and recourse to a more suitable range (zero to -1.5) leads to the conclusion that the WACC percentile applied to assets in aggregate should be raised to at least the 86th percentile. Secondly, the fact that firms don't know the true WACC implies that an even higher percentile should be used. Thirdly, in the event that their allowed WACC is too low, regulators will eventually become aware of this (particularly through observing inadequate investment by firms), and raise their point estimate or margin, and this implies that a lower percentile should be used. Fourthly, the fact that supernormal WACC allowances will risk inciting excessive investment by firms implies that a lower percentile should be used. Fifthly, in the presence of benefits received by the owner of a regulated business that flow from but are not part of the regulated business ('dual-till' operations), a lower percentile should be used. Sixthly, the effect of uncertainty about various parameter values used by Dobbs and various modelling assumptions implies that the results obtained should be viewed only as rough indicators. Seventhly, the appropriate WACC margin will vary across industries, depending upon factors such as the price elasticity, the risk of excessive investment arising from supernormal WACC allowances, the speed with which a regulator would eventually react to an underestimate of WACC, and the presence or absence of 'dual-till' operations.

All of this suggests that it would be difficult to be definite about the appropriate WACC margin in general, and even more so for specific industries and new versus existing assets, but my sense is that these points collectively suggest that the uniform WACC percentile currently used by the Commission (the 75th percentile) is likely to be too low.

Regarding the question of whether to apply a uniform WACC margin to both new and existing investment or to apply different margins to each type, application of a uniform WACC margin to both types of investment mitigates the potential problem of discouraging investment now by businesses that are not currently regulated but might be. In view of this point, I favour a uniform margin.

Finally, on the question of whether to apply different margins to different industries, the difficulties in estimating these differential rates preclude this course of action. The one exception that I would make would be to not use a margin in circumstances in which the appropriate margin is considered to be much lower than normal. A possible example of this would be 'dual-till' operations in which the flow-on benefits from regulated operations to unregulated operations with the same owner would be very substantial.

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