A Framework for Quantifying Estimation Error in Regulatory WACC

Report for Western Power in relation to the Economic Regulation Authority's 2005 Network Access Review

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Executive Summary

This paper has been prepared by the Strategic Finance Group for Western Power (WPC) to submit as part of the consultation process of the Economic Regulation Authority (ERA or "the Authority") in relation to the 2005 Network Access Review. It outlines a framework for quantifying the uncertainty surrounding the estimated return on capital – an issue that is particularly important in light of a number of recent legal and administrative decisions. The paper establishes a framework for quantifying the uncertainty in the estimated weighted-average cost of capital (WACC) of a regulated entity. That is, the regulator's *estimate* may differ from the true cost of funds of the regulated entity. We demonstrate how to identify and quantify the uncertainty in estimates of various WACC parameters and show how this aggregates into uncertainty about the estimated WACC. We also develop a framework for quantifying the uncertainty in the true cost of funds of the regulated entity. In particular, we use standard Monte Carlo simulation techniques to construct a full probability distribution around the WACC estimate. This can be interpreted as a probability distribution of the true cost of funds of an efficient benchmark entity. From this, it is possible to compute the probability that a given regulatory WACC will be sufficient to meet the true cost of funds of an efficient benchmark entity. This assists regulators to assess the possible financial impacts of their determinations.

This framework is structured to assist regulators in their obligations under relevant legislation. For example:

- the National Gas Code (Sec 2.24) requires the relevant regulator to take into account "the Service Provider's legitimate business interests and investment in the Pipeline," "the economically efficient operation of the Covered Pipeline," and "the public interest, including the public interest in having competition in markets (whether or not in Australia.)"

- The National Electricity Code 6.10.2 requires regulators to establish "a regulatory regime that establishes an environment which fosters an efficient level of investment and provides a sustainable commercial revenue stream."

- The Western Australian Electricity Networks Access Code sets as its objective "to promote the economically efficient investment in and operation and use of networks in Western Australia." Moreover, an access arrangement must give the service provider an opportunity to earn as revenue (Section 6.4) "an amount that meets the forward-looking and efficient costs of providing covered services including a return on investment commensurate with the commercial risks involved."

The framework that is developed in this paper measures the probability that a particular regulated WACC determination will be sufficient to cover the service provider's true cost of funds. The likelihood of the regulator's determination providing a sufficient return on capital is central to the service provider's legitimate business interests and to the public interest in ensuring that the provision of key infrastructure remains a viable business and that the appropriate incentives for future investment exist. Indeed it is difficult to see how the objectives of any of these regulatory codes can be met by a regulator that does not know the likelihood that the regulated WACC they set will cover the service provider's true cost of funds.

We apply this framework to the electricity distribution business of Western Power. We construct a probability distribution for the true cost of funds of an efficient benchmark WA

electricity distribution business. We show that the mean true cost of funds is 7.3% (median of 7.2%), real pre-tax. There is a 50% chance that the true cost of funds is between 6.7 and 7.8%, and a 90% chance that it is between 6.0 and 8.6%.

We argue that the Authority should set a regulatory WACC such that there is at least a 75-80% chance that the allowed return is sufficient to meet the true cost of funds of an efficient benchmark entity. A regulatory WACC of 7.8% provides a 75% chance of being able to recover the true cost of funds. A regulatory WACC of 8.0% provides an 80% chance of being able to recover the true cost of funds.

We argue that this is required to meet the Authority's objective of providing "a return on investment commensurate with the commercial risks involved."[1]

This is also consistent with a number of recent legal and administrative decisions in the Australian regulatory system as well as recent industry reviews conducted by the Productivity Commission. In this regard, we present arguments about the consequences of setting the allowed return too low and evidence about what is required to provide the right incentives for future investment.

We conclude that it is appropriate for the Authority to set the pre-tax real WACC in the range of 7.8 - 8.0%.

[1] Electricity Networks Access Code, Section 6.4.

1. Overview

Context

The Economic Regulation Authority (ERA) is responsible for the economic regulation of electricity distribution services in Western Australia. A revised network access arrangement is being reviewed by the Authority for the next regulatory period which will commence during 2005. The objective of the review is to determine the basis on which the electricity distribution businesses will be permitted to charge for their services in the next regulatory period, having regard to the level of service required by customers. To achieve this objective, the Authority has developed a review framework and the consultation process it will adopt in order to reach a well informed and balanced judgement in determining the price controls. This paper has been prepared for Western Power (WPC) to submit as part of the Authority's consultation process. It outlines a framework for quantifying the uncertainty surrounding the estimated return on capital – an issue that is particularly important in light of a number of recent legal and administrative decisions.

In the Australian regulatory environment, the regulated firm's revenue requirement is constructed using a building block approach. One important component of the revenue requirement is the return on capital. This often represents 30-40% or more of the regulated firm's revenue requirement. The return on capital is computed as the product of the regulatory asset base (RAB) and the weighted-average cost of capital (WACC). WACC is computed in accordance with one of the possible cost of capital formulas that have been proposed in the corporate finance literature and have been adopted in practice. There are various specifications of WACC depending on whether it is to be applied to real or nominal cash flows and whether various tax effects (notably, the deductibility of interest payments and the potential value of franking credits) are incorporated in the WACC or the cash flows. Whatever the specification that is chosen by the regulator, the WACC is estimated as a mathematical combination of several parameters. Each of these parameters is, itself, estimated with reference to market data.

The analysis in this paper is designed to quantify the uncertainty that is involved in estimating the WACC in a regulatory setting. The key issue here is that the firm must be allowed to earn a return that is sufficient to pay the returns that investors require before committing capital. If the allowed return is too low, there are implications for future investment and the long-term viability of the business. This requires the development of two key concepts. The firm's *true cost of funds* is a forward-looking opportunity cost of capital. It is the return that investors must expect to receive before committing capital to the firm. It is based on the returns that investors could expect to receive from other comparable investments. It cannot be observed by the firm or the regulator, but must be estimated from imprecisely estimated market data. The *regulatory WACC* is the regulator's estimate of the firm's true cost of funds. This is done by estimating a number of parameters using market data and aggregating them together to form an estimate of the firm's true cost of funds. This regulatory estimate may be higher or lower than the true value, with different consequences in each case. Before turning to the quantification of estimation error, we further develop these two key concepts.

The firm's true cost of funds

A firm's true cost of funds is the return that investors must expect to receive before committing capital to the firm. It is not a realized return over some historical period, but a forward-looking expectation. It is an opportunity cost in the sense that it depends upon the returns that investors could expect to receive from other comparable investments. Because it is an expected or required return, it cannot be observed or precisely measured. At best, it can be imprecisely estimated from an aggregation of various pieces of market data.

Australian regulators recognize that the true cost of funds for any firm is based on a forward-looking return that investors would expect to receive before committing funds. It is not based on past outcome returns (which may be able to be precisely calculated) but on a forward-looking expected return. For this reason, the WACC cannot be precisely computed, it can only be inferred from various pieces of market data.

For example, the Victorian Essential Services Commission (2002, p. 203) in the Review of Gas Access Arrangements Draft Decision discusses this at some length:

> "The opportunity cost of capital associated with an asset is the return investors would expect to receive form that project in order to justify committing funds. In turn, this depends upon the aggregate demand and supply of investment funds, as well as the risk of cash flows generated by the project relative to the risk associated with other assets. Unlike the price for most goods and services, the market price for investment capital cannot be observed. Rather it needs to be estimated from information available from the capital markets. It is important to note that neither the company, the regulator nor customers can determine the cost of capital, it is a market price for investment funds that can only be inferred from the available evidence.
>
> The cost of capital for an asset is often referred to as the weighted average cost of capital, given that the limited information available from capital markets implies that the costs of capital needs to be inferred from the returns required by the different forms of finance supplied, namely debt and equity.
>
> In its previous consultation papers, the Commission noted that estimating the cost of capital for regulated businesses has generated a degree of controversy, both for the Commission and other Australian economic regulators. In part, this reflects the fact that the cost of capital assumed in setting regulated charges can have a significant impact on prices, and hence revenue to the businesses. This controversy also reflects the fact that there is a degree of statistical uncertainty associated with any of the models drawn from finance theory and practice. Accordingly, some imprecision in deriving the estimate and the exercise of judgment is inevitable."

This demonstrates the regulator's recognition that there are two distinctly different concepts involved – the firm's true cost of funds, and the regulator's estimate of this. Moreover, it is also recognized that the regulator's estimate is statistically imprecise. In this paper, we develop a simple framework based on well-accepted statistical procedures to quantify this statistical imprecision.

The regulatory WACC: The allowed return is different from the true cost of funds

In a regulatory setting, the regulator seeks to *estimate* the true cost of funds. It is important to note that the regulator cannot *observe* or *measure* or *compute* the true cost of funds, nor does the regulator *know* the firm's true cost of funds. The regulator can only estimate it. This is because the true cost of funds is a forward-looking expectation or required return and is simply not observable.

In the Australian regulatory environment, regulators estimate the firm's true cost of funds using the procedures that have been developed for this purpose in the field of corporate finance. This involves estimating a number of WACC parameters from market data and aggregating them using a mathematical formula to produce a WACC estimate. Of course, this *estimate* may be higher or lower than the *true value*. In this paper, we seek to quantify the effect that the "statistical uncertainty" identified by the ESC has on the regulator's estimate of WACC, and the impact that a mis-estimated WACC might have on economic sustainability and the incentive for future investment.

Regulatory WACC Estimation

The standard regulatory approach for estimating WACC is to use a mathematical formula to aggregate a number of parameters, each of which is estimated from market data. Most (perhaps all) of these WACC input parameters are unobservable and have to be estimated or inferred from observable data. For example, CAPM betas are usually estimated by regressing the stock returns of comparable listed firms on stock market returns. The estimate of the slope coefficient then forms the basis for an estimate of beta. Of course, any differences between the comparable firm and the firm being regulated (e.g., a different capital structure) must also be accounted for. The point here is that betas are not *observed* nor *computed*, they are *estimated*. Even with the best of tools, the regulator's estimate of beta may be above or below the true value. No amount of analysis can ever identify the true value—the best that can be done is to identify a probabilistic range within which the true value is likely to lie.

Another example is the market risk premium (MRP)—the expected return on the market portfolio of risky assets in excess of the return on the risk-free asset. The key piece of data used to estimate the MRP is usually the mean of observed premia (stock market index returns less government bond yields) over some historical period. Perhaps the most basic statistical concept of all is that the mean of a sample is an *estimate* of the true value. In a large sample, the true value would be drawn from a normal distribution centered around the sample estimate. Again, we can never hope to identify the true MRP—the best that can be done is to identify a probabilistic range within which the true value is likely to lie. The same issue applies to many other WACC input parameters. These parameters cannot be observed or computed, but can only be estimated—often quite indirectly. For example, the value of franking credits is often inferred from observing how stock prices change on ex-dividend days.

The fact that a number of input parameters cannot be estimated precisely but can only be narrowed to a reasonable range, inevitably means that it is impossible to express the WACC estimate (which is a mathematical aggregation of the input parameters) as a single point estimate. The estimated WACC must be expressed as a reasonable range. The width of this range depends on the aggregated uncertainty of the imprecisely estimated input parameters.

Purpose of Paper

The purpose of this paper is to:

- Identify the sources of uncertainty in estimating WACC parameters.
- Quantify the uncertainty around the estimation of each WACC parameter.
- Demonstrate how uncertainty around each parameter aggregates into uncertainty about the true cost of funds of an efficient benchmark firm and quantify the uncertainty around this true WACC.
- Develop a framework for determining an appropriate regulatory WACC in light of estimation uncertainty.

2. WACC estimation error

Estimation Error

It is well recognized in corporate finance practice and in the relevant literature that a firm's cost of capital can only be estimated imprecisely. The leading paper on the quantification of this uncertainty is Fama and French (1997), who focus on estimation error in estimating the cost of equity. In particular they note that there can be substantial measurement error associated with estimating a firm's cost of equity. This uncertainty stems from two sources: the risk premium $\left(R_M - R_f\right)$ and the risk loading $\left(b\right)$ are both estimated with error. This estimation error means that we cannot be sure of the "true" parameter values. We are able to measure, however, confidence intervals from the estimated parameters' standard errors. To illustrate the issue, and quantify the uncertainty to some extent, Fama and French construct confidence intervals for cost of equity estimates at the industry level.

A further complication arises when we are interested in knowing an individual firm's cost of equity. This arises because industry standard errors for risk loadings are likely to understate the standard errors for individual firms due to the averaging process that a portfolio of firms affords. In this regard Fama and French (1997) state, "…the risk loadings for individual firms or projects are less precise than those of industries, the standard error of costs of equity for firms or projects are even larger."

As a minimum we can examine the effects on industry-average costs of equity resulting from the uncertainty surrounding the estimation of inputs into the cost of equity calculation.

For a variety of scenarios, Fama and French (1997) consider the individual and net contribution of risk factor (MRP) and risk loading $\left(b\right)$ uncertainty upon the implied uncertainty in the cost of equity. The results are not encouraging in the quest to precisely quantify a firm's cost of equity.

The authors state that, "large standard errors (in industry costs of equity) are driven primarily by the uncertainty about the true factor risk premiums, with some help from imprecise estimates of period-by-period risk loadings."

Taking the CAPM as our benchmark, the average standard error in the cost of equity resulting from uncertainty in the estimation of the market risk premium alone is at least three percent. The marginal contribution from uncertainty in estimating beta makes the total standard error even greater.

Even starting with the highly unlikely assumption that the risk premium is estimated without error, there is sufficient variation in risk loadings (betas) alone to warrant concern. Fama and

French (1997) report results that support a 95 percent confidence interval around the mean cost of equity of more than three percent.

What can we conclude from these results? It is safe to say that the CAPM does not provide any degree of comfort in being able to state precisely and without reservation what the cost of equity actually is. Confidence intervals around the estimated cost of equity are extremely wide. Furthermore, firm specific estimates would have even greater uncertainty than the industry results that are reported. The merits of the asset pricing approach to cost of equity estimation are perhaps best summed up by Fama and French (1997) themselves: "…uncertainty of this magnitude about risk premiums, coupled with the uncertainty about risk loadings, implies woefully imprecise estimates of the cost of equity."

In the Australian regulatory setting, the issue is even broader than Fama and French (1997) suggest. The Australian regulatory setting requires the estimation of a weighted-average cost of capital (WACC). This WACC is computed using a building block approach—the estimated WACC is the compilation of a number of parameters, each of which is measured with some uncertainty. The degree of uncertainty is lower for some parameters (e.g., the risk-free rate) and higher for others (e.g., the market risk premium).

Australian regulators have acknowledged this uncertainty in different ways. IPART, for example, uses a range, rather than a point estimate, for some parameters. IPART then produces a WACC range by aggregating parameters at one end of the range and then at the other. This process acknowledges uncertainty and estimation errors, but falls short of providing a probabilistic framework. Whereas, the process acknowledges the uncertainty about the aggregated WACC estimate and proposes a range, it provides no direction about where in the range the regulatory WACC should be set, nor any indication about the probability that a particular regulatory WACC is sufficient to cover the entity's true cost of funds.

Other Australian regulators acknowledge that certain input parameters cannot be precisely estimated and propose a range for some parameters. The more common process is for the regulator to then use some discretion or judgment to choose an appropriate point estimate from within the range. This too prevents the estimation uncertainty in the computed WACC from ever being explicitly recognized or properly quantified.

We conclude that:

- **There is significant uncertainty and estimation error involved when estimating a firm's cost of capital. Fama and French (1997) clearly and systematically document this uncertainty. The source of this uncertainty is that building block parameters cannot be estimated with great precision.**
- **A firm's WACC is *estimated*, not *computed*. The true cost of funds of an efficient benchmark firm may be higher or lower than this estimate.**

- **It is particularly important in a regulatory setting to not just recognize the existence of uncertainty and estimation error, but also to quantify it as precisely as is reasonably possible. That is, it is important to quantify the probability that the true cost of funds is higher or lower than the estimated WACC, and by how much.**

Quantification of Uncertainty

This section describes a process for modeling the uncertainty involved in the WACC estimation process. It also shows how to quantify the extent to which the estimated WACC may differ from the firm's true cost of funds[2].

In particular, we recognize that certain WACC input parameters are imprecisely estimated. For these parameters, we use a range or distribution rather than a point estimate. These parameter estimates and ranges are summarized in Table 1 below. The relevant parameters, data sources, and estimates are all consistent with other submissions to the Review by Western Power (WPC). The main purpose of this paper is not to provide great detail on the selection of parameter estimates and ranges, but to demonstrate that the complex relationships between parameter estimates and estimation uncertainty has a potentially important impact on the aggregated WACC calculation. We focus on how to quantify the impact on the estimated WACC using appropriate statistical techniques.

[2] Throughout this paper we use the term "firm's true cost of funds" to mean the true cost of funds of an efficient benchmark firm. This term should not be read as meaning the actual realized cost of funds of a particular firm.

Table 1: Proposed WACC parameter estimates

Parameter	Symbol	Source	Estimate	Distribution
Real risk-free rate of interest	r_f	Yield on 10-year Government bond (20-day average).	2.69%	—
Capital structure	D/V	Comparables and regulatory decisions.	60%	—
Debt margin	—	BBB-BBB+ corporate bond yields.	1.49-1.68%	Long-term debt spread: Uniform (1.11-1.21%) Demand/Supply Conditions: Uniform (0.25-0.35%) Debt Issuance Costs: 0.125% Fixed
Equity beta	b_e	Comparables and regulatory decisions.	0.9-1.1	Uniform
Market risk premium	*MRP*	Historical stock returns and 10-year govt. bond yields and regulatory decisions.	Mean=6% SD=1.8%[3]	Normal
Value of franking credits	g	Empirical evidence and regulatory decisions.	0.0 – 0.5	Uniform

Real risk-free rate

The real risk free rate is estimated as the average yield, over the 20-day period prior to the date of the decision, on Index Linked Government Bonds with a 10-year term to maturity. The current benchmark 10-year nominal government bond matures in April 2015. As there is no Index Linked bond with this maturity, an equivalent 10-year Index Linked yield is computed by linearly interpolating between the August 2010 and August 2015 Index Linked Government Bond yields.

Capital structure

There is a wide range of capital structures among comparable electricity distribution firms in Australian, U.S. and U.K. markets. On average, these comparables have around 50% debt financing. This issue has been addressed in many Australian regulatory determinations relating to gas and electricity distribution. Australian regulators have developed a strong precedent for the use of 60% debt as the benchmark financing assumption. As this assumption is reasonably consistent with market practice, we adopt a 60% gearing assumption for our analysis.

[3] Normal distribution with mean 6% and standard deviation 1.8%, consistent with historical variation in observed market risk premia.

Debt margin

The debt margin is a premium that is added to the risk-free rate to estimate the appropriate cost of debt financing. The debt margin reflects the creditworthiness of the entity, supply and demand conditions in the relevant debt markets at the time the debt is assumed to be raised, and any debt raising or establishment costs. Creditworthiness is usually quantified in terms of a credit rating that reflects the business risk of the entity and the benchmark level of gearing. Australian regulatory precedent is to use a credit rating of BBB to BBB+ for a regulated energy distribution business with 60% gearing. This is reasonably consistent with market practice. A number of commercial services provide estimates of the spread between risk-free government bonds and corporate bonds of various ratings. These services essentially use a dataset that contains the actual yields of traded corporate bonds and fit a curve through the available data points. It is not surprising that the estimates of different service providers can vary quite substantially. This is because different curve-fitting methodologies can be used and because the available Australian data is quite thin. For example, over the last six months, debt spreads reported by Bloomberg have been consistently been around 27 basis points higher than those reported by CBA Spectrum for long-term BBB and BBB+ corporate bonds. Debt spreads sourced from Westpac Institutional banking in relation to long-term BBB corporate bonds are even higher.

In a recent report to the QCA, the Allen Consulting Group (2004, p23) notes that:

> "While the CBASpectrum estimate of debt margins has been the dominant influence on Australian regulators setting regulatory debt margins, it has come under recent criticism, amongst others by NERA (on behalf of its client ACTEWAGL) which has argued that the CBASpectrum estimates result from an inaccurate, statistically based instrument that does not accord with reality. By way of example, it noted that on February 24, 2004, CBASpectrum estimated that a BBB+ 10 year bond should trade at 100 basis points over the government bond rate. The only bond with a similar maturity actually in the market is Snowy Hydro, which on that date was trading at 137 basis points."

The NERA report[4] referred to above provides an explanation for the understatement of debt spreads by CBA Spectrum. NERA argues that CBA Spectrum applies a methodology in which the term structure of (more liquid) high-rated bonds (AA and A) is essentially replicated when fitting the term structure of lower-rated bonds (BBB and BBB+). This is likely to arise from the fact that the AA and A corporate bond markets in Australia are more liquid than the market for lower-rated bonds. The result is that the shape of the CBA Spectrum curve for BBB and BBB+ bonds at the longer end (5-10 years) is flatter than occurs in practice. The anecdotal evidence relating to Snowy Hydro and the Westpac Institutional Banking quote are consistent with this explanation.

For these reasons, we adopt a range of 111-121 basis points as our estimate of the long-term BBB-BBB+ debt spread. This is computed as the CBA Spectrum estimates of corporate debt spreads on 14 February 2005, adjusted upwards by 13.5 basis points for BBB and BBB+

[4] Estimating the Debt Margin for ActewAGL, February 2004 by NERA.

bonds respectively. The 13.5 basis point adjustment represents half of the recent spread between CBA Spectrum and Bloomberg estimates.

In addition, the current demand/supply condition of the market for index-linked bonds (the assumed form of financing) does not favour additional issues. This issue has previously been raised in Australian regulatory determinations. In the Essential Services Commission's 2001 Electricity Distribution Price Review, for example, Westpac Bank noted that "the current capacity within the index-linked market is well short of meeting the funding requirements of the entire electricity distribution business" and that "Westpac's estimate of the incremental costs associated with index-linked funding is of the order of 25-30 basis points."[5] The market conditions have changed little since that time. Moreover, the alternative strategy of issuing nominal bonds and using some form of derivative securities to hedge inflation risk is itself a costly strategy and self-insurance is, of course, not free. Therefore, a premium of around 25-35 basis points should be added to the corporate bond spread.

Finally, consistent with the Australian Competition Tribunal's (ACT) decision on the GasNet appeal against the ACCC decision on transmission revenues, and with recent Australian regulatory practice, we include an allowance for debt establishment costs. Whereas an allowance of 25 basis points was ultimately adopted in this case, no explanation of the quantification of this amount was made available. Therefore, we have adopted recent Australian regulatory estimates of 12.5 basis points for debt establishment costs.

In summary, the debt margin is estimated as the sum of three components. To the extent that these components are estimated with uncertainty, a range, rather than a precise value, is more appropriate. The range that we have used in the table above reflects the aggregated uncertainty over the appropriate credit rating, the spread to government bonds, the supply/demand conditions in the relevant market and the debt issuance costs.

Equity beta

It is well known that equity betas cannot be *computed* or *measured* but can only be *estimated* from (noisy) market data. Having regard to beta estimates from comparable firms, differences in market and regulatory structures, differences in gearing, and the high degree of estimation uncertainty, Australian regulators have been remarkably consistent in using 1.0 as an estimate of the equity beta for gas and electricity distribution businesses. In almost every Australian gas and electricity distribution determination, Australian regulators have used a 60% gearing assumption and assigned an equity beta of 1.0. The few exceptions have used an equity beta close to 1.0 or a range that contains 1.0.

Recent statistical estimates of equity betas for some energy firms are low relative to historical averages. However, it must be remembered that these are not computations, but very imprecise estimates. In fact, it is not possible to conclude that the available data supports a conclusion that the equity beta of an Australian electricity distribution business is statistically

[5] Westpac letter of 19 July 2000, http://www.esc.gov.au/docs/electric/21westpac.pdf.

less than one. In addition, the average relevered equity beta of Australian comparable firms has been 1.0 until very recent times, characterized by unusual market circumstances that have a pronounced effect on the way betas are estimated. Also, the relevered equity beta of the much larger set of U.S. comparable firms is very close to 1.0.

For these reasons, and to reflect the uncertainty surrounding estimates of equity betas, we adopt a range of 0.9 to 1.1 for the equity beta. This is consistent with Australian regulatory precedent and with the totality of available market evidence.

Market risk premium

Most Australian regulators adopt a consistent approach to the estimation of the market risk premium, with a value of 6% being adopted in the vast majority of determinations. For example, this value has been used in recent determinations by the QCA, ESC, GPOC, ESCOSA and the ACCC. However, it is clear that the market risk premium is estimated with some uncertainty. IPART has recognised this uncertainty by using a range, rather than a point estimate, for the MRP. Further illustrating the difficulty of precisely estimating this parameter, IPART has used a point estimate of 7% (1997), a range of 5-6% (2000), and a range of 5.5-6.5% (2004) in its last three gas determinations, and a range of 5-6% in its last electricity and water determinations. We propose that this uncertainty and estimation difficulty should be recognized and quantified, and agree that a range around a mid-point of 6% is appropriate. Our proposal is to construct this range using standard statistical tools for quantifying uncertainty.

The Central Limit Theorem of statistics documents that, in a large sample, the estimate of the mean is normally distributed around the true mean. The mean historical market risk premium has been 7.2% over the last 100 years, 6.4% over the last 50 years, and 7.7% over the last 30 years. The standard error around the long-term mean is 1.8%. Depending on the time period of data that is used, the mean estimate of the market risk premium could be anywhere between 6% and 8%. An estimate of 6% for the MRP has been adopted in most Australian regulatory determinations. This is at the lower end of the 6-8% range that is computed as the empirical mean over historical data periods. The adoption of a value at the lower end of this range presumably reflects the weight regulators have given to other forms of evidence (including conceptual arguments about transaction costs, volatility and diversification; survey responses; and predictions from simple dividend discount models). Although we note that the historical MRP has been above 6%, our focus in this paper is on the effects of estimation uncertainty. In order to divorce arguments about estimation uncertainty from those relating to point estimates of particular parameters, we use a market risk premium centred around 6%. That is, we centre this distribution around a point estimate drawn from regulatory precedent rather than historical evidence in order to focus attention solely on the effects of estimation uncertainty. We use a point estimate from regulatory precedent and simply ensure that the appropriate statistical measure of uncertainty is also recognized.

Specifically, we propose that the market risk premium be modelled as normally distributed with a mean of 6.0% and standard deviation of 1.8%. In addition, we propose that the distribution be truncated at the 5^{th} and 95^{th} percentiles, (3.04% and 8.95%, respectively). This is done in order to prevent simulated values for the market risk premium being negative, implying an expected return less than the risk free rate, or being a very low number, which results in unreasonably high debt betas.

Gamma

The value of franking credits, gamma, is probably the most contentious of all WACC parameters. The dominant Australian regulatory practice is to set gamma to 0.5, suggesting that franking credits are worth half their face value when created. However, the most recent empirical evidence, the only evidence published in top-tier journals, and the dominant market practice all suggest that franking credits do not reduce corporate cost of capital. This implies that gamma should be set at zero.

Moreover, to the extent that the common regulatory estimate of g =0.5 can be tied to empirical estimates, it appears to be based on the aggregate tax statistics data that was analysed by Hathaway and Officer (1998, revised 2002). In that paper, the authors state that the "access factor is 80%" and that "about 60% of distributed credits are being redeemed." This same evidence was used as the basis for the "reasonable assumption" of 0.5 that appears in Schedule 6.1 of the National Electricity Code.

Hathaway and Officer (2004) contains updated data and more detailed and careful analysis. Their conclusion is that, "the access factor is 71% and about 50% of distributed credits are being redeemed. Overall, about 35% of company tax is actually a pre-payment of personal tax." This is consistent with an estimate of g = 0.35.

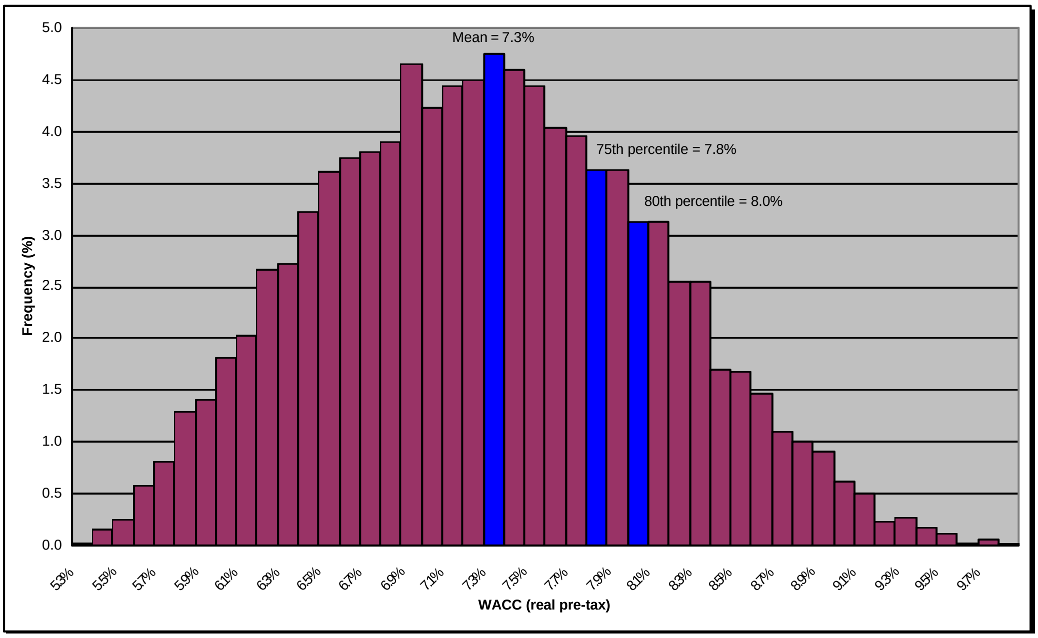
The purpose of this paper is not to review the detailed and complex arguments about how to empirically estimate gamma. Rather, the purpose is to recognise that gamma is indirectly and imprecisely estimated. This estimation error or uncertainty, and its inter-relationship with other parameters, should be accounted for in an accepted and robust manner. Therefore, in this paper, we consider a range that is bounded by zero (consistent with the most recent high-quality empirical evidence and market practice) and 0.5 (consistent with the Australian regulatory practice.)

Simulation framework

We model the market risk premium as being normally distributed around 6% and the other parameters for which a range is used in Table 1 are assumed to be uniformly distributed, implying that all points within the range are equally likely. For example, there is an equal chance that the equity beta will be 0.9, 1.1 or any value in between. Other parameters are held fixed at their estimated values.

We then take a random draw from the distribution for each uncertain parameter and compute the resulting pre-tax real WACC. This process is repeated 10,000 times yielding a histogram of WACC estimates, which is illustrated in Figure 1 below.

Figure 1: Distribution of pre-tax real WACC estimates for 10,000 simulations



The result of this procedure is a mean WACC estimate of 7.3%, with standard deviation of 0.8%.

Figure 1 should be interpreted as a probability distribution of the firm's true cost of funds (pre-tax real WACC). That is, the true equity beta is assumed to be between 0.9 and 1.1, the true market risk premium is assumed to come from a normal distribution with mean 6% and standard deviation 1.8%, and so on. This all aggregates up to a probability distribution for the firm's true cost of funds.

At this stage, it should be noted that the proposed approach involves nothing new. All Australian regulators recognize that there is uncertainty involved in estimating several WACC parameters. It is also quite standard to recognize this uncertainty by assigning a reasonable range for these parameters. The proposed approach simply uses standard statistical techniques to produce a full probability distribution for the WACC of an efficient benchmark firm in a manner that is entirely consistent with the parameter ranges that have been specified for the uncertain WACC parameters. This provides the regulator with a useful additional tool—the ability to explicitly measure the probability that a particular regulatory (allowed) WACC will be sufficient to meet the cost of funds of an efficient benchmark firm. This information will be useful to the regulator in setting an allowed return to balance (i) whether the costs paid by consumers are higher than they need to be, with (ii) whether the returns earned are sufficient to ensure the viability of the regulated entity and provide the appropriate incentives for future investment. Clearly, a key piece of information to be considered by the regulator when assessing these competing objectives is the probability that the allowed WACC will be sufficient to meet the true cost of funds. This, of course, is directly related to the ongoing viability of the business and to the incentives for future investment. This non-recovery probability would be set at 50% if these two considerations were ranked equally. But they are not. Setting the non-recovery probability at 20-25% for example, would reflect the fact that it is more important to ensure the viability of the business than to ensure that customers pay the minimum possible cost.

The following section explores the appropriate probability of the regulated entity being unable to meet its cost of funds—what is an acceptable probability that the return allowed by the regulator threatens the viability of the business and future investment? Our conclusion on this point is that the regulatory WACC should be set so that there is a 75-80% chance that it will be sufficient to cover the true cost of funds of the benchmark entity. Figure 1 shows that a regulatory WACC set in the range of 7.8 – 8.0% would provide this level of confidence to the regulated businesses.

That is, given the uncertainty surrounding the estimates of key WACC parameters, and the interaction between parameters, a regulatory WACC of 7.8 – 8.0% would provide WPC with a return that is sufficiently likely to meet the cost of funds so as not to threaten the long-term viability of the business or to provide a disincentive for future investment.

Proper interpretation of the probability distribution

This section discusses how the WACC probability distribution in Figure 1 should, and should not, be interpreted.

Correct interpretation

Figure 1 should be interpreted as a probability distribution of the firm's true cost of funds (pre-tax real WACC). That is, the return that is required to convince investors to contribute capital comes from somewhere within that distribution. For example, there is a 75% chance that a return of 7.8% would be sufficient to attract investors to commit capital to this business. A return of 7.3% has only a 50% chance of being sufficient to attract investors to commit capital.

This is not a probability distribution of what the actual return may turn out to be, or of what past returns have been. It is a distribution of the (unobserved) returns that investors require before committing capital to the firm. This distribution can be used to assess the probability that a proposed regulatory WACC will be sufficient to attract investors to commit capital to the firm.

Common errors

Error 1: Probabilities refer to the proportion of willing investors

Figure 1 should *not* be interpreted in terms of the *proportion* of investors who might be attracted at various returns. That is, it is *not* the case that a return of 7.3% will be sufficient to attract 50% of investors to commit funds. Rather, at a return of 7.3%, there is a 50% chance that the market will commit funds to the firm and a 50% chance that it will not. The firm's true cost of funds is a market-clearing price – the cost of capital. Of course investors have different perceptions and different attitudes towards risk. Consequently, some investors will require lower returns from such an investment and some will require higher returns. But the firm must pay the same return to all shareholders, for example. The firm cannot pay lower dividends to investors who it suspects may settle for less. There is one single return, one market-clearing price, for all shareholders. This is the price of attracting the required amount of finance from the market

Error 2: The firm is not bankrupt, so the regulatory WACC must be adequate

It is sometimes argued that if the regulatory WACC were set below the firm's true cost of funds it would cease to be viable and that, consequently, if the firm continues to operate after a regulatory determination the allowed return must be adequate. This argument confuses short-term and long-term effects.

First, a firm will be able to sustain periods over which it produces returns that do not meet the cost of funds. The result of this will be that the market re-values the firm's shares and bonds to the extent that the current low returns affect expectations of future returns. For example, suppose that a fair return on equity for a particular firm were assessed by the market to be 10% and this firm were expected to generate $10 per year for shareholders indefinitely. This firm's share price would then be $100. If the market then revised the expected future performance form $10 to $9 per year indefinitely (due to lower regulated prices, for example), the share price would fall to $90. Buyers of the shares would then still receive the required 10% return. The firm would remain trading. The decrease in regulated prices does not immediately destroy the firm, it simply destroys a component of shareholder value. This is rarely transparent in the Australian environment where most regulated entities are government owned or part of large foreign conglomerates. One recent case in which the stock price reaction to a regulatory determination could be isolated was the QCA's determination in relation to the Dalrymple Bay Coal Terminal operated by Prime infrastructure. Prime's stock price plunged on the news of the unprecedented low return that was allowed in the QCA Draft Determination and rose sharply when the QCA proposed a more standard return in the Final Determination.

The second point to note is that the value of the firm and its share price reflect the discounted present value of cash flows over the next regulatory period and all future regulatory periods. A low regulatory WACC may not cause the stock price to react as much as might be expected due to the market's perception that unreasonable regulatory determinations will be reversed on appeal, overturned by government intervention, or corrected at the next review.

Error 3: Asset sale prices exceed the regulatory asset base, so the regulatory WACC must be generous

From time to time, regulated assets are sold in the market place. These sales sometimes occur at prices that exceed the regulatory asset base (RAB), which has led some to argue that this implies that the regulated return exceeds that required by the market. The logic of this reasoning is as follows. The firm's cash flows are set so as to provide a return equal to the regulated WACC (in expectation). A potential purchaser would then value the stream of regulated cash flows by discounting them at the required return. If the result is a value greater than the RAB, the purchaser must have used a discount rate lower than the regulated WACC.

The reason that this argument is incorrect is that purchasers are buying more than the stream of regulated cash flows. They are paying for the regulated cash flow stream plus a series of valuable strategic options. One of the most important areas of corporate finance research and practice is that of Real Options Analysis. This field seeks to value the real (as opposed to financial) options that arise from management being able to implement strategic initiatives. For example, the option to expand a successful project or contract or abandon an unsuccessful one is valuable. The option to be able to switch input fuels or re-tool a factory to produce a different output are all valuable. Real Options Analysis seeks to identify and value these real or strategic options.

Purchasers of regulated assets are buying the regulated cash flow stream plus a range of real or strategic options. For example, the purchaser may be a foreign company gaining a toe-hold in the Australian market. Purchasing the regulated asset gains the company valuable information about operating in the Australian environment and provides a launching pad for further acquisitions and strategic alliances. Moreover, the purchaser may hold other similar assets such that economies of scale can be exploited. That is, the purchaser may be able to operate the regulated asset more efficiently than is assumed in the regulatory determination. Similarly, the purchaser may be able to structure their tax affairs more efficiently than is assumed for the benchmark firm. The purchaser may hold upstream or downstream assets that can be combined with the regulated asset to reduce the risk of both assets. For example, a regulated electricity retailer may be attractive to an electricity generator as a means of managing electricity price risk. The purchase of the retailer could potentially save the generator significant risk management costs and this could be reflected in the sale price. A purchaser may also have the ability to have the regulated asset removed from the regulatory environment in the future. To the extent that the asset may be unregulated in the future, the sale price is likely to be higher. Similarly, the buyer has the option of attempting to increase the regulated return in future determinations. The purchaser may be more willing than the current owner to lobby for political intervention or to engage in legal action to increase the regulated return.

In summary, the purchasers of regulated assets are paying for the regulated cash flow stream as well as a range of valuable real or strategic options. To compare sale prices to the RAB is to reject the notion that real options have any value whatsoever. This is quite inconsistent with the widespread practical adoption of real options analysis.

3. Regulatory adoption of this framework

The issue of using a Monte Carlo simulation framework to quantify the statistical uncertainty in WACC estimates has recently been addressed by four local regulatory bodies. Each of these is discussed in turn below.

New Zealand Commerce Commission

The New Zealand Commerce Commission (NZCC) has recently recognised the uncertainty and statistical imprecision in its WACC estimates in a formal probabilistic manner, as advocated in this paper.[6] Rather than producing a single point estimate, the NZCC constructs a probability distribution for the WACC and recognises that the firm's true cost of funds could come from anywhere within that distribution. The NZCC also notes the asymmetric consequences of regulatory error – that the costs of setting the regulatory WACC too low are much more severe than the costs of setting it too high. For this reason, the NZCC adopts the 75th percentile from the probability distribution as the appropriate regulatory WACC estimate. This reflects the statistical uncertainty of its WACC estimate and the balancing of the risks of regulatory error. Specifically, the NZCC describes its position on this issue as follows:

The point estimate on WACC reflects five parameters over which there is significant uncertainty i.e., the market risk premium and the four components of the asset beta. Such parameter uncertainty results in uncertainty over WACC and this can be formalised in a probability distribution for WACC…the percentiles of the WACC distribution are derived as shown in Table 9.2 below.

Table 9.2: Percentiles of the WACC Distribution

Percentile	50th	60th	70th	80th	90th	95th
WACC	.072	.075	.078	.082	.087	.092

Thus, if one wished to choose a WACC for which there is only a 20% probability that the true value was less than this (80th percentile), that WACC value would be 8.2%.

The Commission notes concerns about the asymmetric nature of errors in assessing WACC, i.e., underestimation is the more serious error because it may lead to underinvestment by the regulated companies…The Commission has used the 75th percentile of the WACC distribution.

Independent Pricing and Regulatory Tribunal

[6] New Zealand Commerce Commission, 2004, Gas Control Enquiry: Final Report, 29 November 2004, www.med.govt.nz/ers/gas/control-inquiry/final-report/final-report.pdf.

In the current Review of Gas Access Arrangements, IPART received submissions from AGL Gas Networks (AGLGN) proposing a framework for quantifying estimation error in the WACC similar to that proposed in this paper. A GLGN proposed that probability distributions rather than point estimates should be used for several parameters that are subject to estimation error, that Monte Carlo simulation should be used to aggregate these uncertain parameter estimates into a probability distribution for the WACC, and that the regulatory WACC should be set at the 80th percentile to provide the business with a sufficient probability of being able to earn a return sufficient to recover its cost of funds.

In its Final Decision,[7] IPART accepted the use of Monte Carlo simulation to construct a probability distribution to quantify the statistical uncertainty in WACC estimates. Specifically, IPART states that[8]:

> The Tribunal's view is that use of a Monte Carlo simulation framework does allow for uncertainty through the use of probability distribution for individual parameters, and thus meets the requirements of the Code in producing a range of returns that may reflect prevailing market conditions for funds.

AGLGN made further submissions as to the probability distributions that should be used to characterise the uncertainty in relation to the estimates of each WACC parameter. In the Final Decision, IPART adopts slightly different distributions and ranges than those proposed by AGLGN for some of these parameters. Nevertheless, IPART expresses four parameters, equity beta, market risk premium, debt margin, and the value of franking credits (gamma) in terms of probability distributions rather than using point estimates.[9]

The result of aggregating IPART's parameter distributions is a probability distribution for the WACC that ranges between 5.9% and 7.3% (pre-tax real). In selecting a point from within this distribution, IPART argues that a pre-determined and fixed percentile point in the distribution should not be used, but that each determination must be made with reference to the case at hand. In particular, IPART states that:[10]

> In practice, the aim of Monte Carlo simulation is to produce a wide range of possible outcomes for the rate of return. The Tribunal's view is that, in deciding where to determine the rate of return within this range, it must be guided by the factors in sections 2.24 and 8.1 of the Code. This assessment must be made on a case by case basis.

[7] IPART, 2005, Revised Access Arrangement for AGL Gas Networks: Final Decision, April 2005, http://www.ipart.nsw.gov.au/documents/RevisedAccessArrangementforAGLGasNetworks-AGLGN-April2005-FinalDecision-PDFversion.PDF
[8] Ibid, p.95.
[9] Ibid, Table 8.6, p. 104.
[10] Ibid, p. 95.

Although IPART rejects AGLGN's proposal to select the 80th percentile of the resulting WACC distribution to balance the asymmetric consequences of setting the regulatory WACC above or below the true cost of funds, IPART adopts a regulatory WACC of 7.0% (pre-tax real). Note that this value is 79% of the way between the lower and upper bounds of the WACC range constructed by IPART.[11]

In practice, IPART has accepted the Monte Carlo simulation framework to quantify the statistical uncertainty involved in estimating WACC. IPART recognises that its estimate may be higher or lower than the regulated entity's true cost of funds. It also recognises that the consequences of setting the regulatory WACC lower than the true cost of funds are more severe than the reverse. Consequently, IPART has adopted a regulatory WACC substantially above the mid-point of its WACC probability distribution. All of this is consistent with the submissions of AGLGN. IPART has adopted slightly different probability distributions for some WACC parameters than those proposed by AGLGN. This, of course, goes to the question of parameter estimation and not to the framework by which these estimates are aggregated into a WACC estimate (which is the focus of this paper).

Queensland Competition Authority

The Queensland Competition Authority (QCA) has also recently addressed the issue of using a Monte Carlo simulation framework to quantify the statistical uncertainty in its WACC estimates. In the QCA's recent electricity distribution price review, ENERGEX and Ergon Energy proposed the use of Monte Carlo simulation in order to construct a probability distribution for the true cost of funds for Queensland electricity distributors. This was proposed in order to estimate the distribution of their true cost of funds, given that the WACC used in regulatory determinations is an *estimate* of the cost of funds, drawn from an underlying distribution.

The objective of this exercise was to address two questions:

1. What is a reasonable range for the estimated cost of funds for Queensland electricity distributors?
2. Given a regulated return, what is the probability that a Queensland electricity distributor will earn its true cost of funds?

ENERGEX and Ergon submitted that it is important to address these questions because there may be asymmetric consequences of a regulated entity earning more or less than its true cost of funds. Specifically, if there is too great a probability that the entity will earn

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[11] That is, $\frac{7.0-5.9}{7.3-5.9} = 0.79$.

less than its cost of funds, there will be reduced investment in infrastructure, which will result in a loss of business productivity and poor service to customers.

In its Draft Determination[12], the QCA rejected this approach on advice from its consultants the Allen Consulting Group (ACG)[13]. It should be noted that this work was performed by the QCA without the benefit of seeing the analysis of the NZCC and IPART that is described above. The QCA provides four reasons for rejecting this approach, some of which are redundant in light of the more recent determinations above, and the rest of which are ill-conceived and demonstrably incorrect. Specifically, the reasons cited by the QCA are addressed in turn below.

1. The use of a Monte Carlo method would require the regulator to form a view on the probability distribution for the estimator for each input.

2. Most regulators would consider that the parameter inputs they adopt in determining the WACC already contain a degree of conservatism. Accordingly, if Monte Carlo simulation were to be used, it would not be based on unbiased estimates of the parameters and on inputs that already contained an element of conservatism.

3. No evidence has been presented to suggest that this technique has been used by other regulators.

4. The use of Monte Carlo simulation is likely to add to the degree of subjectivity rather than reduce it.

Reasons 1 and 2

The use of a Monte Carlo method would require the regulator to form a view on the probability distribution for the estimator for each input; Most regulators would consider that the parameter inputs they adopt in determining the WACC already contain a degree of conservatism.

Reasons 1 and 2 have to be considered together because they are inconsistent. It is not possible to consider an estimate to be conservative without specifying the unbiased or “mid-point” estimate, as well as the distribution underlying this estimate. Put another way, in any decision in which the regulator states that it has adopted a conservative estimate for a parameter, there is an implicit assumption that this is above or below its unbiased estimate, and that the difference between the actual and unbiased estimate is an appropriate hedge against the risk of underinvestment. That is, there is an implicit probability distribution already inbuilt into the regulator’s decision. The only difference with the proposed approach is that the range is not hidden but stated explicitly.

[12] QCA, 2004, Regulation of Electricity Distribution: Draft Determination, December 2004, http://www.qca.org.au/www/getfile.cfm?fid=841&lib=5&LibraryID=5&PageID=43.
[13] ACG, 2004, Queensland Distribution Network Service Providers Cost of Capital Study, December 2004, http://www.qca.org.au/www/getfile.cfm?fid=834&lib=5&LibraryID=5&PageID=43

The following example illustrates the point. It relates to the estimate for the market risk premium. But any other parameter could be used in the example, as can the WACC itself, which was the basis of the original submission by ENERGEX and Ergon Energy. The QCA's estimate of the market risk premium is 6%. There are two alternative interpretations of this estimate, either it is the QCA's unbiased or "mid-point" estimate of the market risk premium - so there is a 50% chance that the true market risk premium is above or below 6%- or this is a conservative estimate of the market risk premium, which is above the QCA's unbiased estimate. The only way this can be considered a conservative estimate is if (1) the QCA estimates some unbiased estimate that is less than 6%; and (2) the QCA determines that there should be some probability greater than 50% that 6% exceeds the true market risk premium, and this can only be achieved by specifying a probability distribution.

However, without specifying a probability distribution or even a range, it is difficult to see how the parameter estimate can be considered conservative. In reaching the conclusion that the market risk premium is 6%, the QCA has not specified whether this is an unbiased or conservative estimate. But this is irrelevant to the point at hand. The conclusion remains the same: An estimate can only be considered conservative if this includes a comparison with the unbiased estimate (e.g., 6% versus 7%). And we can only assess just *how conservative* the estimate is with a probability estimate, which of course requires a probability distribution.

It is simply impossible to determine the degree of conservatism without specifying a probability distribution, and it is impossible to argue that this actually reduces subjectivity. How can a parameter estimate be considered conservative if the regulator does not state what it considers to be a high estimate, or a low estimate?

Reason 3

No evidence has been presented to suggest that this technique has been used by other regulators.

Evidence of use by other regulators, of course, is not a pre-condition for use of a new technique – otherwise no progress would be possible.

In any event, we note that standard Monte Carlo simulation techniques *have* been used in relation to the estimation of WACC parameters in Australian regulatory settings even apart from the recent work on this issue by the NZCC and IPART that is described above.

Indeed the QCA itself has used a similar methodology (in relation to estimation of benchmark capital structure) in the BRIA and GAWB determinations. The QCA also recognizes Monte Carlo simulation as an appropriate technique in relation to capital structure estimation in their response to the Lally Report in the DBCT Determination where they state that (p.177) that an optimal capital structure can be determined "by using simulation techniques," describing this as "a more sophisticated approach."

Moreover, the QCA's engineering consultants have used simulation modeling extensively and this approach is referred to in three separate places in the DBCT Draft Determination alone.

Finally, we note that the Economic Regulation Authority has itself relied on simulation modelling in the context of analysing pipeline throughput and peaking charges.[14]

Reason 4

The use of Monte Carlo simulation is likely to add to the degree of subjectivity rather than reduce it.

It is difficult to understand how a simulation procedure adds to the subjectivity in estimating WACC. Regulators accept that the regulated WACC is only an estimate of the regulated entity's cost of funds, arrived at by assessing evidence on seven parameters - risk-free rate, debt premium, market risk premium, equity beta, leverage, corporate tax rate and the value of imputation tax credits – applying its judgement to the evidence presented in submissions, from other regulatory decisions and in the finance literature. This could be described as a subjective process because there is no simple formula to reconcile conflicting evidence. The regulator applies weights to difference pieces of evidence to determine a result.

But how does specifying probability distributions for the parameters make this a more subjective approach? All the distributions do is provide a mechanism for determining the weight placed on different evidence. For example, in estimating a parameter with a uniform distribution, the regulator is assuming that each point within a range carries equal weight in decision-making; in estimating a parameter with a normal distribution, the regulator is assuming that points closer to the mean carry greater weight than points further away; and in estimating a parameter with a gamma distribution, the regulator is assuming that points above the median carry greater weight than points below the median.

Specifying probability distributions can in no way increase the subjectivity with which parameters are estimated. They simply provide a clear mechanism for weighting alternative pieces of evidence.

By basing its regulatory decisions simply on point estimates for underlying parameters, the regulator has already assumed a very specific probability distribution – one which implies that the standard error of every parameter estimate is zero. This involves at least as much subjectivity as specifying probability distributions that more

[14] See , for example, ERA, 2001, Draft Decision: Proposed Access Arrangement Dampier to Bunbury Natural Gas Pipeline Part B, p.288, http://www.era.wa.gov.au/library/DBNGPDDr2.pdf.

realistically reflect the statistical uncertainty of parameter estimates that are known to be statistically imprecise.

Finally, it should be noted that the regulator can easily recognise the effect of parameter estimation uncertainty squarely within the current framework and procedures. The regulator can continue to select point estimates for each parameter and to estimate a point estimate for the WACC. The simulation approach can then be used to quantify the probability that this regulatory WACC provides the business with a return that is sufficient to meet its cost of funds. The regulator must already identify parameter ranges (in order to consider that a particular point estimate is "conservative") and the simulation approach is straightforward to implement. Thus, the approach is neither costly nor complex to implement. Moreover, quantifying the probability that the assigned regulatory WACC is sufficient to meet the true cost of funds is central to the implementation of the objectives of regulation. For example, a regulatory WACC that provides a 75% chance of meeting the true cost of funds is likely to be sufficient to provide "a sustainable commercial revenue stream," but a WACC that provides only a 25% chance does not.

Indeed it is difficult to understand how a regulator can meet the objectives of regulation without knowing the probability that the regulated WACC will be sufficient to meet the regulated entity's true cost of funds.

Essential Services Commission

In a recent Position Paper, the Victorian Essential Services Commission (ESC) reflects the advice of its consultant, ACG, on this issue.[15] Since the ESC uses the same consultant as does the QCA, the comments in the ESC's Position Paper essentially mirror those of the QCA above. Specifically, the ESC states that:[16]

> While the Commission recognises that all of the inputs into the estimation of the WACC have statistical imprecision – and hence the WACC has statistical imprecision – the Commission does not consider that the use of the Monte Carlo technique will assist in regulatory decision-making, nor does it consider that it will improve certainty or transparency.

The ESC must already have a view on an appropriate economically reasonable range for each WACC parameter. (To have no view on this would clearly be grossly incompatible with the regulator's most basic duties). The proposed simulation framework simply aggregates these parameter ranges in a probability distribution for the WACC. The only difference between the current and proposed approaches is that the current approach

[15] ESC, 2005, Position Paper - Electricity Distribution Price Review 2006-10, March 2005, www.esc.vic.gov.au.

[16] Ibid, p.168.

masks the range that the regulator believes to be appropriate while the proposed approach makes it transparent.

Again, it is difficult to understand how a regulator can meet the objectives of regulation without knowing the probability that the regulated WACC will be sufficient to meet the regulated entity's true cost of funds. The proposed approach simply demonstrates how to compute this most relevant piece of information by aggregating the economically reasonable parameter ranges that the regulator must develop as a basic part of the regulatory process anyway.

4. The probability that the regulated entity will earn a return that is sufficient to meet its cost of funds

Thus far, we have established that the regulatory WACC is an *estimate* of the entity's cost of funds. It is computed as the aggregation of a number of parameter estimates where some of these parameters are estimated with considerable estimation error. The entity's true cost of funds might be more or less than the regulator's estimate.

IPART has recognized this in the *2004 Electricity Distribution Pricing 2004/05 to 2008/09 (Final Report)*, p. 56, noting that the Tribunal "calculates a range for the weighted-average cost of capital (WACC). It then makes a judgement on what rate of return within this WACC range is appropriate, given the competing objectives in the Code. In particular, it aims to achieve an appropriate balance between the interests of customers and those of the DNSPs."

The Essential Services Commission also recognises estimation uncertainty in the *2003 Gas Distribution Review (Final Report)*, p. 313, "unlike the price for most goods and services, the market price for investment capital cannot be observed. Rather it needs to be *estimated* from information available from the capital markets. It is important to note that neither the company, the regulator nor customers can determine the cost of capital—it is a market price for investment funds that can only be inferred from the available evidence."

To assist the Authority to balance its competing objectives[17], we have illustrated a technique that produces a full probability distribution for the true cost of funds of an efficient benchmark entity. This probability distribution is entirely consistent with the uncertainty surrounding individual WACC parameter estimates. It also enables the Authority to compute the probability that a particular regulatory allowed WACC is sufficient to meet the cost of funds of an efficient benchmark entity. The likelihood of the regulator's determination providing a sufficient return on capital is central to the service provider's legitimate business interests and to the public interest in ensuring that the provision of key infrastructure remains a viable business and that the appropriate incentives for future investment exist. Under the Electricity Networks Access Code, the Authority is required to take all of these matters into account. Indeed it is difficult to see how the objectives of the Code can be met by a regulator that does not know the likelihood that the regulated WACC will cover the service provider's true cost of funds.

In this section, we propose that the regulatory WACC should be set so that there is at least a 75-80% chance that it is sufficient to meet the true cost of funds. This is based on the asymmetry in the consequences of erring on this matter. If the entity fails to earn a return that is at least equal to its cost of funds, there are implications for the ongoing viability of the entity and for future investment. These consequences can be severe, given that it is essential basic infrastructure businesses that are regulated. This regulatory risk must be balanced against the prices paid by consumers. There is a trade-off between

[17] The interests of consumers and the provision of a return on investment commensurate with the commercial risks involved.

price on the one hand and service and reliable supply on the other. Setting a 75-80% probability of being able to earn a return sufficient to cover the true cost of funds is consistent with the notion that ensuring the ongoing viability of the business and creating the right incentives for future investment is more important than keeping prices to a minimum, a view that is supported by the Productivity Commission. Note that if consumer prices and business viability are weighted equally, there is a 50% chance that the WACC will be sufficient to cover the entity's cost of funds.

Indeed, the Authority is required to exercise its judgment to achieve an appropriate balance between the interests of all stakeholders. The proposed approach provides a framework for quantifying exactly this trade-off—if prices (and returns) are to be lowered, how (quantitatively) will this impact the ability of the firm to meet its cost of funds and provide adequate returns to its investors?

Moreover, there are relatively long lead times for investment in electricity distribution infrastructure. This reinforces the argument in favour of allowing regulated distribution business a better than even chance of earning their cost of funds. If the regulatory WACC is set too low, there is a significant chance that the firm will be unable to recover its cost of funds. In practice, firms invest only when there is a relatively high probability of the investment earning a return that exceeds the cost of funds. Much of the evidence of this is reviewed below. Thus, a low regulatory WACC provides a disincentive for future investment. In addition, realized returns in the current period can be increased (perhaps enough to cover the cost of funds) by underspending against scheduled CAPEX. In both cases, the result is underinvestment in electricity distribution infrastructure. These factors are particularly relevant to the objective of giving the service provider an opportunity to earn as revenue "an amount that meets the forward-looking and efficient costs of providing covered services including a return on investment commensurate with the commercial risks involved."

Conversely, the regulatory WACC may be set so that there is a better than even chance of the entity recovering its cost of funds. Some would argue that in this case there is an incentive for firms to over-invest in CAPEX. However this is a much less severe problem for two reasons. First, the regulator approves prudent CAPEX. Any overspend will not (initially at least) generate any return on capital for the firm. Contrasted with this is the fact that any CAPEX underspend is retained by the firm as cash. Second, any CAPEX spending that really is beyond requirements is not simply waste. With a growing demand for energy, this additional CAPEX would eventually be required. That is, the issue is simply one of timing—was the CAPEX really required today, or could it have waited for a year or two? Thus, the effects of CAPEX overspending are minor, relative to CAPEX underspending. In one case, investment earns a return for a year or two longer than it should have. In the other case, underspending causes bottleneck and other problems from lack of sufficient infrastructure and a shortfall of energy supplies. The aggregate welfare effects are much more severe in this case.

This issue has recently been addressed in some detail by the Productivity Commission (PC), the Supreme Court of Western Australia and the Australian Competition Tribunal. For example, the Productivity Commission's Review of the National Access Regime recognises that the effects of too little infrastructure investment are far more severe than those associated with too much (or too early) investment. The PC states (p. xxii) that "Given that precision is not possible, access arrangements should encourage regulators to lean more towards facilitating investment than short term consumption of services when setting terms and conditions" and that "given the asymmetry in the costs of under- and over-compensation of facility owners, together with the informational uncertainties facing regulators, there is a strong in principle case to 'err' on the side of investors".

The PC goes on to quote from a submission to the review by NECG, which stated that "In using their discretion, regulators effectively face a choice between (i) erring on the side of lower access prices and seeking to ensure they remove any potential for monopoly rents and the consequent allocative inefficiencies from the system; or (ii) allowing higher access prices so as to ensure that sufficient incentives for efficient investment are retained, with the consequent productive and dynamic efficiencies such investment engenders. There are strong economic reasons in many regulated industries to place particular emphasis on ensuring the incentives are maintained for efficient investment and for continued productivity increases. The dynamic and productive efficiency costs associated with distorted incentives and with slower growth in productivity are almost always likely to outweigh any allocative efficiency losses associated with above-cost pricing. (sub. 39, p. 16)"

The PC Review highlighted the need to modify implementation of the regime and made 33 recommendations to improve its operation. In particular it identified as a "threshold issue, the need for the application of the regime to give proper regard to investment issues" and "the need to provide appropriate incentives for investment."

This view is supported by the Commonwealth Government, which has resolved to amend the Trade Practices Act in this regard. In particular, the access regime will be modified to include a clear objects clause: "The objective of this part is to promote the economically efficient operation and use of, and investment in, essential infrastructure services thereby promoting effective competition in upstream and downstream markets…"

In addition, a set of pricing principles will be included that requires "that regulated access prices should: (i) be set so as to generate expected revenue for a regulated service or services that is at least sufficient to meet the efficient costs of providing access to the regulated service or services; and (ii) include a return on investment commensurate with the regulatory and commercial risks involved…"

Finally, we note that using the 75^{th} percentile of the WACC distribution is consistent with regulatory precedent on this issue, having been recently used by the New Zealand Commerce Commission. Also IPART has recently adopted a regulated WACC that is 80% toward the upper end of its WACC range.

We argue that these views are consistent with the notion that the regulatory WACC should be set so that there is a better than even chance of the entity recovering its cost of funds.

We conclude that it is appropriate for the Authority to set the pre-tax real WACC in the range of 7.8 - 8.0%.

5. Asymmetric risk

Finally, we note that this report does not address asymmetric risks or extraordinary events—non-systematic risk of a significant loss. These asymmetric risks require an adjustment to the cash flows or the discount rate. That is, the proposed WACC will imply certain price or revenue targets which must be adjusted to account for asymmetric risk. Alternatively, for pragmatic reasons the regulated business and regulator may favour an increase to the regulated WACC to compensate for asymmetric risk. Neither of these adjustments is specifically addressed in this report.

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