QUEENSLAND COMPETITION AUTHORITY

Discussion Paper

Risk and the Form of Regulation

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SUBMISSIONS

Public involvement is an important element of the decision-making processes of the Queensland Competition Authority (the Authority). Therefore submissions are invited from interested parties concerning the matters covered in this Discussion paper. The Authority will take account of all submissions received.

Written submissions should be sent to the address below. While the Authority does not necessarily require submissions in any particular format, it would be appreciated if two printed copies are provided together with an electronic version on disk (Microsoft Word format) or by e-mail. Submissions, comments or inquiries regarding this paper should be directed to:

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The **closing date** for submissions is 29 March 2013.

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Information about the role and current activities of the Authority, including copies of reports, papers and submissions can also be found on the Authority's website.

GLOSSARY

ACT, Tribunal	Australian Competition Tribunal
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
BT	British Telecom
CAPM	Capital Asset Pricing Model
CPI	Consumer Price Index
DORC	Depreciated Optimised Replacement Cost
ESC	Essential Services Commission
FAC	Fuel Adjustment Clause
GAWB	Gladstone Area Water Board
JIA	Joint Industry Association
MEU	Major Energy Users Inc
NEL	National Electricity Law
NGL	National Gas Law
QCA, the Authority	Queensland Competition Authority
RAB	Regulatory Asset Base
TFP	Total Factor Productivity
TNSP	Transmission Network Service Provider
UK	United Kingdom
US	United States
WACC	Weighted Average Cost of Capital
WAPC	Weighted Average Price Cap

FOREWORD

The Authority is currently undertaking a comprehensive review of its cost of capital methodology for regulated businesses. A series of discussion papers covering various aspects of the cost of capital will be released for public comment. The Authority will then prepare position papers on the key parameters for the cost of capital.

This discussion paper principally addresses the form of regulation, and its potential impact on the regulated firm's risk and cost of capital. The form of regulation refers to the nature and specifics of the regulatory arrangements in relation to the setting of prices and the scope for investors to earn their expected rate of return on capital invested.

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EXECUTIVE SUMMARY

The regulation of public utilities can be viewed as a form of long term contract between the monopoly service provider of the essential service or infrastructure and its customers, overseen by an independent third party, the regulator. This long term contract is, in effect, a governance mechanism that functions to protect and incentivise relationship-specific, sunk investment between these parties. Once the investment is sunk, its value to investors depends on receiving an appropriate rate of return on, and of, capital, and its value to customers depends on access to the service at a reasonable price and expected standard of service.

In Australia, regulators typically apply the 'building blocks' model to balance these competing requirements. In applying this approach, the first step is determining a revenue requirement that comprises estimates of the firm's efficient capital costs and operating costs. Given this revenue requirement, the second step involves choosing the *form* of regulation (e.g. price cap, revenue cap, etc.) and any ancillary mechanisms, such as cost pass-throughs and/or unders-and-overs accounts, to enable the firm to recover its costs and earn its expected rate of return.

The choice of a form of regulation and ancillary mechanisms, at least implicitly, requires assumptions about the trade-offs among competing economic objectives, such as revenue sufficiency, cost minimisation, and risk allocation.

For example, if the regulator chooses a mechanism that involves pure cost reimbursement then the objective of revenue sufficiency is met but the firm has no incentive to reduce costs under such a mechanism. Given information asymmetries, costs are therefore likely to be above efficient levels. On the other hand, if the regulator chooses a strictly fixed price cap then the firm has an incentive to reduce its costs but there is a possibility of the firm's revenues being insufficient. These two objectives, along with other considerations, can guide the selection of the form of regulation.

There is a growing body of theoretical work that supports the proposition that the specific form of regulation can affect the variability and hence the risk of the regulated firm's returns.

It is beyond the scope of this paper to explore an 'optimal' form of regulation; that is, regulation that seeks to maximise economic efficiency, taking into account the constraints placed on that objective by additional considerations of revenue sufficiency, cost reduction, and risk allocation. Rather, this paper identifies and develops key propositions that relate to how different forms of regulation affect risk, risk allocation, and the regulated firm's cost of capital.

Key Propositions

(a) Theoretical and empirical research demonstrates that, under a variety of conditions, the form of regulation and ancillary mechanisms affect the regulated firm's revenues and costs and, to the extent that these elements of the firm's cash flows co-vary with the market, the form of regulation must have an impact on the regulated firm's beta in the CAPM.

The firm's return can be divided into revenue and cost components, each of which has its own covariance with the market portfolio. Various regulatory controls (e.g. the form of regulation) unquestionably affect the regulated firm's revenues and costs. To the extent that these mechanisms either insulate the firm's cash flows from, or expose them to, non-diversifiable risk, then they must have an impact on the firm's beta.

(b) The regulated firm's beta should not be determined independently from the form of regulation and other ancillary mechanisms, as they impact the firm's cash flow volatility and the associated non-diversifiable risk.

Specifically, the form of regulatory control (e.g. revenue cap or price cap) affects the allocation of risk between the regulated firm and its customers. Therefore, in considering the choice of control, the regulator should take into account the effect of that control on risk allocation. If it transfers risk away from the firm and to customers (or *vice versa*) and a component of that risk is non-diversifiable, then the regulator should adjust the firm's beta accordingly to reflect the actual, non-diversifiable risk borne by the firm's investors.

(c) In Australia, the 'building blocks' form of regulation as applied in practice varies across both regulator and industry, but it typically is closer to cost-of-service regulation than price cap regulation and implies relatively 'low' risk for several reasons: (i) there is strong certainty of revenue recovery, particularly when the form of regulation is a revenue cap; and (ii) in terms of costs (i.e. operating, maintenance, and capital expenditure costs), the type of cost benchmarking applied involves only modest, and sometimes minimal, modification to the regulated firm's cost proposal.

A relevant example is the use of revenue caps in conjunction with unders-and-overs accounts. Under a revenue cap, if the firm under- (over-) recovers revenue from customers, then it receives (repays) the difference between the actual and allowable revenue. Since the total variability of revenue is eliminated from a net present value perspective, there is no meaningful revenue risk - either diversifiable or non-diversifiable. While the firm will bear some residual (i.e. cost) risk when actual costs diverge from allowed costs, this risk is typically low due to the type of cost benchmarking applied and the other mechanisms in place to assist the firm in managing those risks (e.g. cost review 'triggers').

(d) Proposition (c) leads to consideration of the regulated firm's risk profile with respect to the risk of its existing regulatory asset base (RAB) on the one hand and the risk of its operating, maintenance, and capital expenditure activities on the other.

Relevantly, UK economist, Dieter Helm, has identified this demarcation between relevant risks and proposed to apply a 'split' cost of capital for regulatory purposes. The split cost of capital concept recognises that a firm's RAB activity is a fundamentally different activity than its operating and capital expenditure activities. Specifically, the RAB requires only passive asset management - there is nothing that asset managers can do to increase the 'locked-in' value of the RAB. Once assets are included in the RAB, the regulatory arrangements then effectively guarantee a return on, and of, capital on those assets.

In contrast, the operating and capital expenditure functions involve some equity risk, as they require day-to-day active asset and cash flow management in undertaking the relevant activities associated with them. Accordingly, Helm proposes that the RAB should receive a return at, or close to, a cost of debt with very low default risk, while the operating and capital expenditure functions should receive a weighted average cost of capital that includes a material equity return component.

(e) The form of regulation chosen should ideally allocate risks in the regulated market in an optimal manner among the relevant parties i.e. (the regulated firm, customers, and taxpayers). Important analytical findings are that the firm's (investors in the CAPM) and customers' attitudes toward risk are important determinants of the allocation of risk and, therefore, of the choice of the form of regulation. The relevant beta and cost of capital are then outcomes that follow from these choices. A key finding from the risk allocation literature is that some form of cost-sharing between the firm and customers is almost always more efficient in practice than one of these extremes.

These propositions are considered to be well established by the theoretical and empirical literature and will provide clearer guidance for the Authority in its future decisions. However, it would be useful to show how they could be applied more explicitly. A following paper will focus on developing principles and a framework for making explicit allowances for the impact of the form of regulation on risk and its incorporation in the allowed cost of capital for firms regulated by the Authority.

Given the importance of these matters, the Authority would like to provide stakeholders an opportunity to comment on issues raised in this paper, as set out in the following key considerations, and on any related matters.

Key Considerations:

- **Given that regulated firms have a fundamentally different risk profile from unregulated firms (i.e. they are a different 'risk class'), how should regulators take this factor into account, particularly with respect to choosing beta comparators and estimating the regulated firm's beta?**
- **To what extent does the *form* of regulation (e.g. price cap, revenue cap, cost pass-throughs, unders-and-overs accounts) affect the risk of a regulated firm, its asset beta, and its expected cost of capital?**
- **How should the Authority take into account investors' and customers' attitudes toward risk in choosing the form of regulation?**

1. INTRODUCTION

The Authority is currently undertaking a review of its cost of capital methodology for regulated businesses. A key aspect of this methodology is determining an appropriate rate of return on the regulated firm's equity. The Authority applies the Capital Asset Pricing Model (CAPM) to determine the cost of equity. As is well known, central to the estimate of the cost of equity is an appropriate value for 'beta', which reflects the non-diversifiable (i.e. 'systematic' or business) risk that investors in the regulated firm bear.

In Australia, estimates of beta for regulated firms are typically obtained by identifying the primary, underlying drivers of the regulated firm's non-diversifiable risk and subsequently identifying suitable 'comparator' firms, on the basis that they share the most relevant of these principal drivers. This approach of using external benchmarks is consistent with the 'comparables analysis' applied in setting other regulatory parameters.

The regulated firm functions in an environment in which its operations and investment are circumscribed by both the broader regulatory framework and the more specific form of regulation or regulatory control. In the former case, the regulatory framework can, in general, be defined to encompass the legislative and institutional arrangements that prescribe the relevant regulatory objectives and processes that apply to the regulated firm. In the latter case, forms of regulation can be thought of as the different types of mechanisms that apply directly to the regulated firm in the context of setting its allowable revenue and price. For example, forms of regulation include price caps, revenue caps, and their variants. The form of regulation is also often complemented by ancillary mechanisms, such as cost pass-throughs and unders-and-overs accounts.

While both the broader regulatory framework and the form of regulation are important, this paper principally addresses the second aspect of the regulatory environment, the form of regulation, and its potential impact on the regulated firm's risk and cost of capital. As current regulatory practice in Australia applies some version of the CAPM to estimate the regulated firm's cost of equity, the key emphasis in this paper is necessarily on non-diversifiable risk. However, the paper also recognises that the form of regulation, as it often applied in practice, affects both diversifiable and non-diversifiable risk, raising questions about the appropriate, allowed regulatory cost of capital.

There is a growing body of theoretical work that supports the proposition that the specific form of regulation can affect the variability of the regulated firm's returns. Specifically, the firm's return can be divided into revenue and cost components, each of which has its own covariance with the market portfolio. Various regulatory controls (e.g. the form of regulation) unquestionably affect the regulated firm's revenues and costs. Therefore, to the extent that the firm's revenues and costs co-vary with the market, the various regulatory controls will affect the firm's beta. Formally, if the form of regulation reduces the covariance of returns with the returns on the market portfolio, then this impact, in turn, affects the firm's asset beta.

The direct implication is that an appropriate estimate of beta cannot be determined independently of the form of regulation. If upside and downside variability of returns is moderated by the form of regulation, the implication is that total risk (diversifiable and non-diversifiable) is reduced. In addition, different forms of regulation are likely to affect both diversifiable and non-diversifiable risk differently.

The purpose of this paper is to explore these issues further and, in particular, how different forms of regulation can have different implications for estimating the firm's beta. Basic elements presented in this paper can also be found in Blake and Fallon (2012).

2. BACKGROUND

2.1 The CAPM

The relationship between the regulated firm and its customers effectively takes the form of a regulatory contract. Given regulatory oversight, customers receive the regulated product or service at a reasonable price and certain quality. In return, investors in the regulated firm receive a return on, and of, their capital. The return on capital should reflect the opportunity cost of capital, taking into account the risks of the investment. In Australia, New Zealand, and the United Kingdom, it is common for regulators to assess the cost of equity capital using the CAPM.

The CAPM commonly refers to a class of models that specify the expected rate of return on an asset to compensate investors for the time value of money and relevant risk. The original model is jointly attributable to Sharpe (1964), Lintner (1965), and Mossin (1966) (i.e. the 'standard' CAPM), and the model generates an expected return on equity, defined as:

Equation 1 $$\boldsymbol{k_e = R_f + \beta_e(k_m - R_f)},$$

where k_e is the expected rate of return on equity, β_e is the equity beta, k_m is the expected rate of return on the market portfolio of risky assets, and R_f is the risk-free rate of return.

As is evident from equation (1), the standard version of the CAPM specifies a linear relationship between the expected return on a risky asset and a risk parameter known as 'beta.' Beta is defined as the covariance of an asset's return with the return on the relevant market portfolio of risky assets, expressed as a proportion of the variance of the return on that market portfolio. The market portfolio is typically assumed to be a national equity index.

In this investment context, the term, 'risk', whether diversifiable or non-diversifiable, is the possibility that the actual return to an investor from holding an asset deviates from its expected return. A measure of this deviation is the variance of the asset's return (van Horne, 2002: 37)[1]. The total risk of an asset can be decomposed into non-diversifiable (i.e. 'systematic') risk and diversifiable (i.e. 'non-systematic') risk. As is well known, beta only compensates investors for bearing non-diversifiable risks; that is, those risks that they cannot diversify away by holding a sufficient number of assets in the market portfolio.

2.2 Asymmetric Risk

Consistent with Markowitz (1952), a key assumption of the CAPM is that asset returns are distributed multivariate normal or alternatively, that the mean and variance of asset returns are the only parameters relevant to investors. The implication of this assumption is that the CAPM does not compensate investors for 'asymmetric' risk. In a regulatory context, asymmetric risks include asset stranding and exposure to unlikely (and typically uninsurable) events such as certain natural disasters.

This issue has arisen in regulatory submissions on the cost of capital as it is variously argued that regulatory constraints limit firms' earning potential (i.e. 'upside') while exposing them to losses (i.e. 'downside'), resulting in an asymmetric distribution of the regulated firm's expected returns. It is also argued that, for these risks to be ignored in the calculation of the cost of equity for a regulated firm, it is therefore important that either such extreme downsides do not exist, or that the costs associated with financial distress be incorporated

[1] This definition is in contrast to the seminal finance work in the 1920s of Frank Knight, who defined risk as: [probability of an event x expected impact of that event]. Knight contrasted this concept of risk with the concept of an 'uncertainty', which Knight considered to be unquantifiable (Black, 2010: 310).

into the expected cash flows for the investment. The preferred approach in theory is to address asymmetric risk by making explicit adjustments to the cash flows rather than by adjusting the WACC parameters or adding a margin to the WACC.

However, a counterbalancing point is that various regulatory mechanisms, such as accelerated depreciation, cost pass-throughs, revenue and asset base guarantees, and/or review triggers, function to reduce the downside risk of the regulated firm. These mechanisms, in effect, restore some symmetry to the firm's distribution of returns. To date, there appears to have been minimal, explicit acknowledgement that these various measures are often implemented by regulators to reduce the scope for large losses and have been approved because of regulators' underlying concern about asymmetric risk.

Further, for many regulated businesses that provide 'essential services' to the community, a reasonable proposition is that governments will ensure that there is sufficient revenue to avoid severe financial distress, either through the regulatory arrangements or more direct interventions. To the extent that this proposition holds, it in effect significantly limits the downside risk of regulated firms.

2.3 Estimating Beta in a Regulatory Context[2]

In applying the CAPM in a regulatory setting, standard practice typically does not rely on estimates of the regulated firm's actual beta (assuming that its returns data are available), as doing so might provide the regulated firm with an incentive to manipulate its returns in response. Rather, and consistent with the approach to estimating other regulatory parameters, the regulator applies 'comparables analysis', by referencing firms in the same, or similar, industry to the regulated firm on the basis that they provide a relevant benchmark.

Major steps in applying this process for assessing beta include: (i) identifying the primary, underlying drivers of the regulated firm's non-diversifiable risk; (ii) identifying firms with similar drivers of non-diversifiable to obtain a relevant set of 'comparable' firms; and (iii) estimating the betas of the identified comparators in order to infer an estimate of the underlying asset beta to apply to the regulated firm. This paper does not address (iii), as this step is a matter of statistical research design[3].

In terms of the first two steps, Lally (2000, 2004) considers that key factors affecting a firm's beta include: the nature of the firm's output, the duration of the firm's contracts, its degree of monopoly power, the form of regulation, operating leverage, the firm's weight in the market, and the firm's real options. Having identified the most important determinants of the regulated firm's non-diversifiable risk, the extent to which an identified firm will be comparable (i.e. a 'comparator') will depend on the extent to which these underlying determinants match. However, even if firms are drawn from the same industry, or are similar in other respects, these 'similarities' almost certainly will not be a full proxy for the underlying factors that affect the regulated firm's beta. This distinct possibility raises the questions of how, and to what extent, to adjust the beta of the regulated firm to reflect differences between the firms with respect to these factors (Lally, 2000: 26-29).

There are two general approaches to making such adjustments. The first is empirical and involves using econometric techniques to isolate and estimate the effects of such factors on

[2] Some material in this section is drawn from Lally (2000, 2004).

[3] The standard process is to conduct a time series regression to estimate the equity beta. While the concept is straight forward, there are a number of technical issues, including, for example, how to measure firm returns, the relevant estimation period, the sampling interval, beta stationarity over time, etc. The estimated equity betas are subsequently converted to asset betas by applying a de-levering formula. Once asset beta estimates are obtained through these procedures, they are pooled to improve the estimator. Brailsford *et al* (1997) provide a detailed discussion of these technical research design issues.

beta. Rosenberg and Guy (1976) argue that the current values of a firm's 'fundamental' variables (e.g. growth in earnings per share) are likely to be more relevant indicators of a firm's *expected* (i.e. future) non-diversifiable risk than an historical estimate of its beta and, as such, these fundamental variables provide useful information with which to make a more accurate estimate (Rosenberg and Guy, 1976: 62-70). However, this econometric approach is vulnerable to data mining, and this problem is not easily resolvable.

The second possible approach is to posit a theoretical relationship between a causal variable that affects beta (e.g. financial leverage) and then seek to develop a formula for quantifying this explanatory factor. Relevant progress has been made using this approach in adjusting for differences in financial leverage (Hamada, 1972) and operating leverage (Rubinstein, 1973)[4]. While this method requires a theoretical prior and a valid functional relationship for linking the identified factor to the firm's non-diversifiable risk, this method is free of the previously noted concern about potential data mining.

2.3.1 Real Options

Closely related to the concept of asymmetric risk is the theory of real options (Dixit and Pindyck, 1994). Real options theory predicts that firms facing investment decisions that are largely irreversible and subject to significant uncertainty will not invest when the conventional net present value of the investment is zero. The reason is that, when a firm makes an investment, it extinguishes the opportunity to wait for new information that might affect the desirability of the investment. Further, if the investment is largely irreversible, the firm cannot disinvest if market conditions change unfavourably. Therefore, the ability to defer that investment has value[5]. The implication is that a firm undertaking an investment of this type will require a rate of return that exceeds the conventional cost of capital by a margin that compensates it for the value of delay (Dixit and Pindyck, 1994: 3-9).

Dixit and Pindyck (1994) identify three features of investment that suggest when a real options approach might be relevant: (i) irreversibility, in that investment costs are totally or partially sunk and cannot be recovered in full if the project is later abandoned; (ii) the possibility of delay, in that if a firm decides not to invest in the current period it retains the option of carrying out the project at a later date; and iii) continuing uncertainty over future revenue. In terms of relevance to a regulatory context, regulated utilities and infrastructure businesses typically satisfy conditions (i) and (ii). However, with respect to (iii), uncertainty over future revenue, it is arguable that there is relatively minimal uncertainty about the future value of the regulated firm's existing asset base once capital expenditure (i.e. the 'investment') is approved and included in that asset base.

Relevantly, Australian regulators have generally rejected 're-optimising' existing regulatory asset bases by applying new DORC values at a subsequent date (the exception seems to be for telecommunications). As a result, once actual capital expenditure is rolled into the existing regulatory asset base and prices are reset at the start of the next regulatory period, the investment receives the same implicit guarantee as applies to the regulatory asset base[6]. Thus, the returns on the existing regulatory asset base for the vast majority of regulated utilities with large and relatively secure customer bases are, in effect, *de facto* guaranteed. The work of Helm *et al* (2009) has highlighted this critical point, as the regulatory asset base

[4] Lally (1998) additionally recognises that estimation bias with respect to the firm's beta can arise from changes in the leverage of the equities comprising the market portfolio over the sampling period, as the firm's returns are estimated with respect to this portfolio's returns. Lally models the theoretical relationship between beta and firm and market leverage over time and develops an estimator for beta that corrects for these factors.

[5] Specifically, the opportunity to invest can be characterised as a call option, which itself has value.

[6] The capital expenditure is subject to an *ex ante* prudency review but not an *ex post* prudency review when it is rolled into the regulatory asset base under the *ex ante* arrangements that apply for electricity networks (AER, 2008b: 193).

can conceptually be thought of as a guarantee that the sunk costs of a specific investment will be paid by the existing and future users of the assets (see the later discussion in chapter 5). As a result, there is minimal scope for revenue uncertainty.

2.3.2 The Form of Regulation

Myers (1972) was an early proponent of using the CAPM for the purpose of determining the appropriate cost of capital for regulated firms[7]. In an early and important paper, Myers (1972) recognised that such firms comprised their own, distinct 'risk class', with risk being modified by the regulatory arrangements.

In a response to Myers, Breen and Lerner (1972) raised the question of whether regulatory decisions themselves affect the value of beta and, as a consequence, the firm's rate of return. Along the same lines, in an early survey article on regulation and modern finance theory, Robichek (1978) observed that:

> *...for a regulated company, the business (and, hence, investment) risk depends on the regulatory decision. To require that the rates be set after giving due consideration to "risk" is circular when such "risk" is determined to a large extent by the rate-making process (Robichek, 1978: 699).*

Subsequently, in their seminal paper on regulation and risk, Marshall *et al* (1981) address the issue of 'circularity' raised by Robichek (1978) by explicitly modelling the effect of the regulatory decision on the regulated firm's cost of capital in the specific context of the CAPM and beta. They argue that the firm's systematic risk is endogenous to regulation itself; that is, the measurement of beta cannot be separated from regulatory decisions:

> *We argue that conventional approaches to price regulation are incapable of attaining the economically desirable objectives of efficiency and an equitable return to investors. The deficiencies in current practices are attributable to the separation of the risk measurement-return determination and price setting activities in the conventional approach (Marshall et al, 1981: 909).*

This observation explicitly recognises the beta is endogenous to the regulatory decision. The potential implication is significant as the form of regulation is the central platform on which the regulated revenues and prices are determined. To give a simple example, suppose a regulatory policy implements a two-part tariff to assist the regulated firm in managing its revenue variations, which are beyond the firm's control. To the extent that such revenue variations are non-diversifiable, such a policy has implications for the firm's risk and rate of return, as measured by the CAPM. In this case, it would be inappropriate to set the firm's beta independent of the regulatory policy. In addition, such regulatory arrangements might reduce diversifiable risk as well.

This paper seeks to investigate the implications of the form of regulation on the regulated firm's risk in more detail.

[7] This idea was novel at the time as returns were generally determined using observable average rates of returns on past investments (i.e. book rates of return) of comparable firms (Myers, 1972: 58-63).

3. KEY FEATURES OF COST-OF-SERVICE AND PRICE CAP REGULATION AND IMPLICATIONS FOR RISK

There are two basic forms of discretionary regulation: cost-of-service regulation and incentive regulation, the latter of which includes price cap regulation and its variants[8][9]. In their 'pure' forms, cost-of-service regulation and price cap regulation conceptually sit at opposite ends of a stylised spectrum of forms of regulation (i.e. control mechanisms).

The discussion in this chapter involves three stages. The first stage involves describing these two polar forms of regulation in some detail. Relevantly, forms of regulation approximating these extremes were first implemented in the United States (US) and United Kingdom (UK) respectively; therefore, it is relevant to consider US and UK-specific research in characterising the risks associated with each form. Second, given these descriptions, the chapter discusses two principal points of distinction between them which have implications for the regulated firm's risk exposure.

Taking these two opposites as end points, the remainder of this chapter discusses intermediate (i.e. 'hybrid') forms of regulation, the ancillary mechanisms that support them, and some implications for risk. With this framework and analysis in hand, it is then possible to progress the discussion to consider the form of regulation in Australia, where it fits within this framework, and the implications for the regulated firm's risk.

3.1 Background

3.1.1 Traditional US-Style Cost-of-Service Regulation

Traditionally, cost-of-service regulation is most frequently associated with US-style rate-of-return regulation, as applied to US electric and gas utilities. As the name implies, this form of regulation is based on the cost of providing the specific service. The requirements of cost-of-service regulation originated from the judicial interpretation of 'reasonable' rates. In Federal Power Commission vs. Hope Natural Gas Company (1944), the US Supreme Court observed that:

> *[T]he fixing of 'Just and reasonable' rates involves a balancing of the investor and the consumer interests.... From the investor or company point of view it is important that there be enough revenue not only for operating expenses but also for the capital costs of the business.... [T]he return to the equity owner should be commensurate with returns on investments in other enterprises having corresponding risks (USSC, 1944: 603).*

Other countries that have used a similar style of regulation to regulate essential infrastructure utilities include Canada, Spain, and Germany.

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[8] While some authors in the academic literature distinguish between cost-of-service and rate-of-return regulation, for the purpose of this paper, these terms are used interchangeably. One characterisation in the economics literature is that cost-of-service regulation involves price being set to average cost *ex post*, while rate-of-return regulation involves price being initially set to expected average cost, but then reset if the firm's earnings are too high or too low (Lyon, 1996).

[9] The two extremes of cost-of-service regulation and price cap regulation have been used to highlight the relevance of incentive mechanisms. Essentially, the problem of incentive regulation is devising a regulatory design that addresses the trade-off between providing the regulated firm with incentives to reduce costs and pursue efficiency improvements, while at the same time ensuring the firm's viability (see chapter 7 and the discussion of Schmalensee (1989)). While incentive regulation has an important place in the economics of regulation in its own right, this paper only considers it further to the extent that it affects the issue of risk. The seminal reference in this field is Laffont and Tirole (1986), and for a moderating perspective, see Schmalensee (1989).

The basis of traditional cost-of-service regulation, as applied in the US, is to balance the regulated firm's and customers' interests by setting total revenue to cover all of the firm's costs of providing the service (i.e. average revenue is set to average cost). Prices set by the regulator to cover the firm's costs impute a rate of return to the firm's capital.

The costs of service comprise a return on capital, a return of capital (i.e. a depreciation allowance), and operating costs, all of which the firm submits, and the regulator audits. The return on capital is determined by multiplying the value of the regulatory asset base by an estimate of the cost of capital, where the asset base is adjusted for any 'imprudent' capital expenditure and inflation[10]. Typically, straight-line depreciation is applied to determine the return of capital. In the original formulation, operating costs are estimated on the basis of historical (i.e. accounting) costs of the firm for a 'test' year or an extrapolation of them. In effect, the entire cost determination process is 'backward-looking' (Joskow and MacAvoy, 1975: 295-96). However, subsequently there has been some consideration of the efficiency of operating costs.

Actual operating costs and allowed operating costs will differ, which has several implications. First, for costs deemed to be beyond the control of the firm, the regulator will typically agree to make an adjustment to future revenues to allow recovery of material cost differences. Second, there will be considerable pressure from the firm to allow automatic cost pass-through such that some adverse shocks to costs are reflected immediately in prices.

Given this information, the regulator determines the firm's total revenue requirement. With assumptions about demand, the regulator then approves the regulated price(s) on a service-by-service basis. This process necessarily involves some decision about how to allocate the common costs of service. The result is a price that is set on an *ex ante* basis to equal average cost.

The price remains fixed until the next scheduled regulatory review. However, the regulated firm, customers, or the regulator can request a review when prices are inadequate to recover costs or if the realised rate of return appears to be significantly above the regulated rate of return. Given the costs and the distribution of benefits from holding a review, it might be expected that the firm is more likely to initiate a review to change the price than other parties (discussed in detail later).

3.1.2 Ideal Price Cap Regulation

At the opposite end of the spectrum is price cap regulation. Price cap regulation rose to prominence in 1983 when Professor Stephen Littlechild proposed its use to the British government for the purpose of regulating British Telecom (BT) immediately prior to BT's privatisation. Price caps were designed to be antithetical to cost-of-service regulation, which was perceived as providing few efficiency incentives[11]. Since that time, price cap regulation has been adopted across a range of industries, including airports, electricity, natural gas, postal services, railways, telecommunications, and water, in many different countries.

Under a pure price cap, the only element of the firm's profit subject to regulatory control is the firm's output price(s). The idea behind regulating price rather than profit is that capping the price should give the regulated firm the incentive to produce in a cost-efficient manner and to promote innovation, as the firm retains any cost reductions until the next review. This regulatory objective is in contrast to that of cost-of-service regulation, under which the regulator effectively reimburses the firm for its realised costs.

[10] The 'prudency' test is one important reason that cost-of-service regulation is not a pure cost-plus contract with the regulated firm. See Joskow and Schmalensee (1986: 12-14).

[11] In addition, cost-of-service regulation provides strong incentives for over-investment where the allowed rate of return is in excess of the true cost of capital (the Averch-Johnson (1962) effect).

The regulator imposes a price limit, or cap, on the firm's product, and the firm is then free to charge any price at, or below, the ceiling. There can be multiple products or services subject to the cap, and it is the resulting weighted average of prices that is subject to the cap. Consequently, there is scope for the regulated firm to increase or decrease individual prices as long as the constraint on the average price is satisfied. The weighted average price changes each period, with the weight on a given product's price being the quantity produced in the previous period (i.e. year).

The price cap is based on expected future cash flows and demands with minimal reference to historical costs (Beesley and Littlechild, 1989: 461). Once the price cap is set, the (average) rate of growth in prices is determined by two factors, namely an inflation-based index (i.e. the 'CPI-factor') and a total factor productivity (TFP) (i.e. the 'X-factor')[12][13]. An important aspect of ideal price cap regulation is that these factors are set with reference to exogenous benchmarks and not firm-specific values that are vulnerable to manipulation by the regulated firm (Beesley and Littlechild, 1989: 461; Laffont and Tirole, 1994: 17).

In terms of the CPI-factor, the price cap must increase to reflect inflation-linked changes in input prices. The regulator typically applies a generalised consumer or retail price index for this purpose, rather than an industry-specific index because the former cannot be manipulated by the regulated firm (Armstrong *et al*, 1995: 168).

Given the inflation adjustment, the rate at which the inflation-adjusted prices must decline is the X-factor. The X-factor adjusts prices downward to reflect the firm's potential to achieve efficiency improvements. In productivity-based regulation, the X-factor is estimated using total factor productivity indices or cost data that exclude the influence of the regulated firm. Assuming that all firms have similar starting point productivity levels, the X-factor should be a forecast of average industry productivity growth.

When prices are indexed by CPI-X rather than by an industry cost index, the X-factor has to be defined so that it takes account of differences between productivity growth rates and input price growth rates for the industry of the regulated firm and the economy as a whole. The CPI is an output price index that reflects the effects of economy-wide productivity and input price growth. Thus, the X-factor is defined as follows:

Equation 2 $$\boldsymbol{X = (\Delta TFP - \Delta TFP_E) - (\Delta W - \Delta W_E),}$$

where a Δ indicates a growth rate, and ΔW is the input price growth rate[14]. The first term shows the difference between the industry's total factor productivity and that for the economy as a whole. The second term shows the difference between the firm's input prices and those for the economy as a whole. Therefore, if the firm has the same TFP growth rate and same input price growth rate as the economy as a whole then X = 0.

The (weighted average) price cap is calculated each period using a base period (or prior period's) quantities, and then the cap is adjusted for inflation and the X-factor:

Equation 3 $$\boldsymbol{\sum_{i=1}^{n} p_i^{t+1} q_i^t \leq (\sum_{i=1}^{n} p_i^t q_i^t)[1 + CPI_t - X],}$$

[12] In the UK, price cap regulation is known as 'RPI-X' regulation; that is the Retail Price Index less X%.

[13] Bernstein and Sappington (1999) show that the regulated firm will earn a zero profit if the rate of growth in its output price, on average, is constrained to be the difference between: the rate at which the firm's input prices increase; and the rate at which the firm's productivity increases. In other words, the firm will earn a zero profit if the growth rate in the output price equals CPI-X.

[14] This definition of the X-factor is known as the differential of a differential formula, as developed by Bernstein and Sappington (1999).

where there are *n* products or services, q_i^t is the output of product *i* in period *t*, while p_i^t and p_i^{t+1} are the prices of product *i* in periods *t* and *t*+1 respectively. CPI_t is the indexation factor for year *t*, and X is the X-factor.

Intuitively, the constraint means that the price changes such that the customer is able to purchase the same set of products in the next period (*t*+1) as the customer purchased in the current period (*t*) for the same real expenditure - or possibly less. To see this point, assume there is one customer and, to simplify further, only a single product. Setting aside the CPI-X factor, equation (3) becomes:

Equation 4 $$\boldsymbol{p_i^{t+1} q_i^t \leq (p_i^t q_i^t).}$$

Equation (4) states that, at time *t*+1, the customer can always afford to purchase the amount purchased at time *t* and, as a result, is no worse off[15]. This result is an important property from an economic welfare perspective.

The regulator sets the price cap *ex ante* for a fixed review period, and if the firm achieves cost savings that are greater than the net effect of the inflation and productivity adjustments in the formula then it retains them for a specified period, at which point the parameters are reset. This property of price caps gives the firm the incentive to reduce costs and to promote innovation, as it is able to retain the short term (i.e. interim) cost savings.

3.2 A Framework for Analysis

Given this background, there are two principal characteristics that delineate the potential for differential risk exposure under cost-of-service regulation and price cap regulation:

(a) the extent of de-coupling of allowable revenues from costs; and

(b) the length of regulatory lag and the timing of reviews.

3.2.1 De-coupling of Allowable Revenues from Costs

The first characteristic reflects the extent to which regulatory discretion ‘covers’ different elements of the regulated firm’s profit: price, output, controllable costs, and uncontrollable (i.e. exogenous) costs. Table 3.1 lists some major forms of regulation and the ‘coverage’ of profit components by the regulator, where *P* is the regulated price, *Q* is quantity, *C* is controllable cost, and $\tilde{C}$ is uncontrollable cost (Alexander *et al*, 1996: 8).

[15] This property in effect reflects that the use of prior period weights is equivalent to a Laspeyres price index.

Table 3.1: Profit Elements Controlled by the Form of Regulation[1]

Regulation Type	***Regulated Elements***	***Unregulated Elements***
Cost-of-Service	$P, Q, C, \tilde{C}$	
Revenue Cap	P, Q	$C, \tilde{C}$
Price Cap w/Cost Pass-through	$P, \tilde{C}$	Q, C
Price Cap	P	$Q, C, \tilde{C}$

1 Alexander et al, 1996: 8.

Under cost-of-service regulation, the regulator initially sets a price based on the firm's cost of providing the service. Cost-of-service regulation naturally covers all profit elements such that the firm's total revenue equals its total costs *ex post*. Accordingly, the firm's revenues are aligned with to the firm's realised costs.

Under perfect cost-of-service regulation, the regulated price would instantaneously and continuously change so that the firm's allowable revenues always matched its realised costs at any point in time. Such a mechanism would eliminate all deviations from expected outcomes, and the regulated firm would bear no meaningful risk, either non-diversifiable or diversifiable. The realised return would always equal investors' expected return, and returns would effectively look like those from a risk-free bond. Such regulation theoretically implies no risk (either diversifiable or non-diversifiable) and a zero asset beta for the regulated firm.

In practice, cost-of-service regulation is imperfect as prices cannot change continuously to match costs even if such a property was desirable (e.g. regulation is not costless). The firm's realised costs will differ from its forecast costs during the interim period before the next review, for example, due to unanticipated input price changes. As the regulator's price changes at the next review *follow* the realisation of actual costs, the regulated firm bears some short term variability over the interim period prior to that review.

However, in the event of deviations from expected outcomes, cost-of-service regulation effectively immunises shareholders from long term cash flow volatility, and accordingly protects the associated rate of return (implied by the initial prices). This outcome occurs because the regulator increases the initial price when given an application from the firm operating at a loss and decreases the price when given an application by either customers who can demonstrate excessive profit or the regulator when it audits the firm's costs.

In either case, regardless of the identity of the party that initiates the review, the 'close' tracking of the firm's profit elements under this form of regulation significantly bounds the variance of the firm's return from the initially set level. As a result, while there is some scope for short term cash flow volatility (some of which will be non-diversifiable), the scope for long term volatility is relatively low.

Under the opposite extreme of a pure price cap mechanism, the regulator sets a strictly fixed price cap (i.e. a single price or weighted average) *ex ante*, and there is no cost pass-through or price reset. If the price cap is fixed then, in a world of demand and cost risk, the firm's exposure to that risk can be material. This exposure arises because any variance in profit and returns due to such shocks is absorbed by the firm's shareholders. For example, if the firm experiences unanticipated fluctuations in its actual operating costs, then any resulting revenue windfall gain or loss is borne by the firm's shareholders. This idealised form implies a positive asset beta for the regulated firm under general conditions, the magnitude of which depends on the other underlying factors that affect beta (e.g. the nature of the industry).

In practice, price caps are not fixed in this way, and there is some link to costs. Armstrong *et al* (1995) observe that, in setting the cap, rate of return considerations are implicit, as the regulator must take into account the regulatory value of the asset base and cost of capital in ensuring the firm can finance its operations and capital investment program (Armstrong *et al*, 1995: 182-183). For this reason, the base price cannot be completely de-coupled from cost considerations.

In addition, firms subject to price caps typically operate in conjunction with cost pass-through mechanisms, which transfer certain costs to customers (discussed in more detail later). Specifically, costs that the regulator deems to be "uncontrollable" by the firm are subject to automatic pass-through to customers, where price adjusts immediately to reflect the revised costs.

Further, if the price cap has downward flexibility (i.e. it is a ceiling only) then it can provide the firm with some scope to manage risk. This scope arises because the firm has some flexibility to change prices (subject to an overall constraint) in response to changing demand and cost conditions. For example, given an adverse demand shock with respect to one product or service, the firm might have the scope to increase price for another service to compensate for lost revenue from the former. This flexibility provides the firm with some ability to manage cash flow variability.

In comparison to cost-of-service regulation, the firm's investors will likely bear more overall variance in the firm's expected cash flows (i.e. arising from cost or demand shocks). Under the CAPM, investors will demand a higher return for bearing such additional risks, to the extent these risks are non-diversifiable. The implication is that the firm will have an asset beta that is, in general, higher than the beta of a firm with prices more closely linked to its costs.

3.2.2 Regulatory Lag and Endogenous Timing of Reviews

Regulatory Lag

'Regulatory lag' refers to the length of time between a significant economic change in a regulated market and the regulator's reset of one or more regulatory parameters in response to that change. In a regulated market with significant volatility, regulatory lag tends to be shorter as parameters must be realigned to address that volatility; otherwise, parties can suffer from protracted and costly risk exposure[16].

More commonly, the concept of regulatory lag is context-specific. With cost-of-service regulation, it is the elapsed time between a change in the firm's costs and the regulator's change in prices to reflect the change in costs. In the context of price cap regulation, it is typically the time between the reset of the price cap (i.e. the time between formal reviews).

Both of these definitions are consistent with the proposition that the length of regulatory lag is directly proportional to the firm's risk exposure. The shorter (longer) the fixed period between reviews, then *ceteris paribus*, the lesser (greater) is the regulated firm's exposure to risk. In the US, the average period prior to a price reset is about two years, while in the context of UK price cap regulation, the period between regulatory resets of the X-factor is

[16] Price caps can be useful forms of regulation in industries where regulatory lag is particularly costly (e.g. due to rapid technological change or volatile demand conditions). In these cases, the flexibility of a price cap allows the firm to change the price without waiting for a review in order to respond to exogenous shocks.

four to five years (Cowan, 2002: 167, 180). While this difference in the length of the regulatory lag is material, the implication for risk is likely to be one of degree rather than kind. This is because price caps are often coupled with cost pass-throughs, and the latter serve as a substitute for more frequent reviews (Armstrong *et al*, 1995: 172).

Endogenous Timing of Reviews

There is a second consideration that reduces risk exposure under cost-of-service regulation relative to price cap regulation. Under cost-of-service regulation, the timing of reviews is endogenous as the firm or customers can initiate it, while under price cap regulation, it is fixed and exogenous to the stakeholders. Relevantly, in this context, a 'review' does not necessarily have to connote a 'full' reassessment of all aspects (price and non-price) of the arrangements. Rather, it can reflect a 'partial' review where the regulator reviews a specific element of the arrangements given a trigger (e.g. an adverse shock to the firm's costs).

This point of difference is a critical factor in distinguishing risk profiles of the two forms of regulation. Suppose that the regulated firm can initiate a review with relative ease but customers cannot do so, either because they do not have the right to initiate a review or they cannot organise themselves sufficiently to pressure the regulator. With endogenous review timing, this imbalance effectively allows the regulated firm to retain the benefit from a positive shock (for example, to actual costs) while shifting at least some of the cost of a negative (i.e. adverse) shock to its customers. The critical implication is that, if the timing of reviews is endogenous then the allocation of risk between the regulated firm and its customers is potentially altered.

In terms of practice, under cost-of-service regulation, the firm has considerable rights to seek reviews prior to the next scheduled review in the event of adverse cost movements against it. Braeutigam and Quirk (1984) report that for US electric utilities during the period 1948-1978, 350 out of 363 rate cases were initiated by the regulated firms, while the residual 13 cases were initiated by public utility commissions on behalf of customers. Additionally, empirical work by Joskow (1974) supports the proposition that cost-of-service regulation in the US provides firms with power to actually manipulate the timing of price reviews.

Under price cap regulation, the timing of reviews is exogenous and set prior to the commencement of regulation. In fact, under UK price cap regulation, the timing of reviews is set as part of the entire package of measures that affect the revenues, costs, and risks of the firm[17]. These conditions and obligations are made precise and finalised as part of the lead-up process to privatization and are ultimately fixed as part of the license conditions for the firm, with the knowledge of the firm and all stakeholders (Beesley and Littlechild, 1989: 456-458). Given these arrangements are exogenous to the regulated firm and its customers as part of this process, the risk to the firm is higher than it would otherwise be if the firm could trigger a review.

In conclusion, cost-of-service regulation is associated with endogenous timing of reviews, as either side can request a review, while under price cap regulation the date of the next review is fixed in advance. The effect of endogenous review timing is to reduce the risk of the regulated firm relative to the risk of an otherwise comparable firm operating with exogenous review timing.

[17] These measures include, for example, the design and scope of the price control itself (including the values of key parameters, such as the X-factor), the duration of the control period, and any allowances for cost pass-through. They also include non-price conditions and obligations related to providing the product or service.

4. INTERMEDIATE FORMS OF REGULATION

This chapter discusses intermediate forms of regulation and related ancillary mechanisms and their implications for risk.

4.1 Revenue Caps

As the majority of regulated firms have high fixed costs that are invariant to the level of output, this feature potentially exposes them to material demand (i.e. volume) risk. Such risk can be reduced by non-regulatory mechanisms such as, for example, take-or-pay contracts. However, material demand risk raises the possibility of using a mechanism between pure cost-of-service regulation and a pure price cap, namely a revenue cap.

A revenue cap places a limit on the revenue that the regulated firm can earn rather than on the firm's price per unit. There are several different forms of revenue caps, but only the two more common revenue caps are described here. The first is a total revenue cap, which involves either a single cap on the total revenue of the regulated firm as a whole, or it involves individual caps applied to the total revenue allowed for each product. The second is an average revenue cap, which is also known in the literature as a 'revenue yield' cap. This type of revenue cap involves placing a cap on the average revenue per unit of output and is often applied when there is a common unit of sales (e.g. kWh)[18].

Conceptually, one can think of a revenue cap as a special case of average cost pricing, where the price changes in response to a change in demand to keep the regulated firm's revenue constant. Further, with full information and no regulatory lags, average cost pricing of this type fully insures the firm against risk.

In practice, *ex post* realised demand is either higher or lower than forecast demand, and as a result, the firm will either over- (under-) recover the revenue cap if prices are not adjusted. Such a situation will trigger an adjustment of the regulated price to keep revenue constant, although such adjustments typically occur with a lag[19]. As a result of such lag, the regulated firm can experience some deviation from its expected revenues in the interim period (i.e. prior to any adjustment).

There are several important implications that arise from applying a revenue cap[20]. First, if demand is relatively and locally unresponsive to changes in price, the regulated firm's revenue should be fully recoverable via price adjustments - independent of realised demand. As a result, a revenue cap largely insulates the firm from deviations in its expected profit that arise from demand variance. This key aspect of revenue caps clearly differentiates them from pure price caps, which can expose the firm to material risk.

Second, when actual demand deviates from expected demand, the 'flow-through' effect on total variable cost dampens the impact of the revenue variance on profit. Specifically, if actual demand is lower (higher) than forecast demand then the firm's actual variable cost is lower (higher) than it would be than if forecast and actual demand were equal. As a result, the decrease (increase) in total variable cost will dampen the impact of the variance in the firm's revenues on its profits.

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[18] In both cases, the revenue cap is typically indexed over time to reflect inflation.
[19] One mechanism that addresses this issue is an unders-and-overs account, which ensures that realised revenues are aligned with the (allowed) revenue cap over time.
[20] Importantly, economists have criticised the application of revenue caps to natural monopolies on an allocative efficiency basis, in that they enable the regulated firm to price excessively and possibly above the monopoly price. This chapter does not address this issue as it is not directly related to the primary focus of this paper. See Crew and Kleindorfer (1996) for a discussion.

To illustrate these points, suppose that a firm is subject to a revenue cap of $400, based on expected demand of 50 units. The price is, therefore, set at $8 per unit. Variable cost per unit is $2. If realised demand is 50 units then revenue is $400, total variable cost is $100, and profit is $300. Suppose now that there are only two possible realisations of demand, either 40 units or 60 units, each with equal probability. If realised demand is 40 units, the price will adjust to $10 per unit to keep revenue constant at $400. Profit will be $400 less the total variable cost of $80, which is $320. Conversely, if realised demand is 60 units then revenue would be $400. The price will adjust to $6.67 and profit would be $280 ($400 less $120). The standard deviation of actual profit from expected profit is $20.

Suppose the same set of assumptions and variables applies to a firm subject to a price cap. If actual demand is 50 units and the price cap is $8 per unit then revenue is $400, total variable cost is $100, and profit is $300. Alternatively, if realised demand is 40 units, the firm would earn revenue of $320 (40 units at $8 per unit) and incur total variable cost of $80. Profit would be $320 less $80 or $240. On the other hand, if realised demand is 60 units, its revenue would be $480 and total variable cost would be $120. Profit would be $480 less $120 or $360. The standard deviation of actual profit from expected profit is $60. Therefore, this example illustrates how a pure price cap is associated with higher volatility of profit than a revenue cap.

To illustrate the potential implications of a revenue cap in the context of the CAPM, recall that beta is the parameter in the CAPM that measures non-diversifiable risk, and the market risk premium is the price of that risk. Since beta is a statistical measure of the sensitivity of the returns to equity relative to variations in returns to the market, it will be closely related to the sensitivity of revenues to returns to the market.

More generally, returns can be decomposed into revenue and cost elements. In their widely used textbook on the theory and practice of corporate finance, Brealey *et al* (2000) specify the relationship between an asset beta and its components as follows:

Equation 5

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

where β_A is the asset beta, *A* is the present value of the forward-looking value of the asset, *R*, *FC*, and *VC* are the present values of the forward-looking revenues, fixed costs, and variable costs of the firm respectively. The ‘beta’ for each of the latter three streams reflects the sensitivity of that component to the returns on the market portfolio of risky assets (Brealey *et al*, 2000: 257-258).

The intuition of this equation is that, as an asset beta is a weighted average of equity and debt betas (with the weights being the shares of equity and debt in the total value of the asset), the asset beta can be expressed as a weighted average of its underlying revenue and cost components. The weight for each of the betas for the revenue and cost components reflects the importance of that component in terms of its contribution to the present value of the underlying asset.

Brealey *et al* (2000) argue that the fixed cost beta is zero as, if a part of the cost stream does not vary when market returns change, then that part has no sensitivity to the market (i.e., a zero beta). Using this definition, the above equation becomes:

Equation 6

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

Thus, it is clear that an asset beta is fundamentally dependent on the revenue beta. Furthermore, in a situation where revenue variability is effectively zero, or near zero, the asset beta could, in fact, be negative for a positive variable cost beta[21]. However, for regulated industries with large sunk costs, the impact of the variable cost beta on the asset beta would likely be secondary to the impact of the revenue beta, as the weighting of the variable cost beta is relatively low (i.e. the share of variable cost as a proportion of total cost). These relationships highlight how a revenue cap has fundamental implications for an asset beta.

In conclusion, a revenue cap is a form of average cost pricing. Given that a revenue cap allows the firm to recover the same revenue independent of variations in demand, it effectively insures the firm against demand risk[22]. To the extent that the firm bears residual risk, such risk can arise from the firm's realised costs diverging from its allowed costs. However, as only a minority of the firm's costs are truly variable costs (i.e. variable costs are a relatively low proportion of the firm's total asset value), such variance has a relatively small weighting in terms of the effect on the firm's asset beta. Consequently, while the implication is that the firm bears some diversifiable and non-diversifiable risk under a revenue cap, that risk would be relatively low. As a form of regulation, a revenue cap is, therefore, closer to cost-of-service regulation than to price cap regulation.

4.2 Cost Pass-throughs

It is common practice for regulators to use cost pass-throughs in conjunction with both revenue caps and price caps. Cost pass-throughs allow specifically identified costs beyond the firm's control to be passed through to users via price changes prior to the next formal regulatory review. The intent of such a mechanism is to insulate the firm's cash flows from external shocks (positive or negative). The mechanics of the pass-through allow the regulated firm to adjust the price charged to users whenever the cost of the input subject to the pass-through deviates from a fixed base price, the latter having been previously approved by the regulator[23].

One can characterise a pure price cap as providing no cost pass-through and a cost-of-service form of control as allowing full cost pass-through. The basic motivation for cost pass-throughs is the potential inefficiency from a risk management perspective for regulated firms to bear risks that they cannot control or manage. But assuming the CAPM applies, the degree of pass-through should depend essentially on the way in which shocks affect non-diversifiable risk and the degree of risk aversion of the shareholders and the firm's customers.

On this point, Guthrie (2006) considers that allowing the firm to automatically adjust prices in response to shocks can be desirable if it allows the regulator to hold less frequent reviews. However, Guthrie (2006: 967-968) cautions that, as such automatic adjustments shift risk from shareholders to consumers, they should only be allowed if customers do not find bearing the risk in question too costly. This issue is discussed further in the context of optimal risk allocation in chapter 7.

[21] The variable cost beta could be positive or negative depending on the nature of shocks to the economy and the covariance of variable cost with the market. In the case of a large energy price shock during a recession, variable costs are more likely to be counter-cyclical and, therefore, imply a negative variable cost beta. However, if input costs are pro-cyclical, which is typically the case in the absence of large price shocks (when one recognises the co-variability of both the quantity and price components of a variable input with overall economic activity) a positive variable cost beta is possible.

[22] This outcome is subject to the existing customer base paying a higher price if output declines and subject to no side constraints on the firm increasing its price. In practice, these conditions are typically satisfied.

[23] An early and prominent example is the fuel adjustment clause (FAC), implemented in regulatory circles in the US in the 1970s in response to unexpected increases in energy costs. Clarke (1980) finds empirical support for a material reduction in the systematic risk of 50 regulated US electricity companies over the period, 1965 to 1974, in comparison to the utilities' 'pre-FAC' non-diversifiable risk levels as a result of adopting FACs.

Importantly, the effect of coupling a revenue or price cap with a cost pass-through on the regulated firm's systematic risk will depend, *inter alia*, on the nature of the cost risk that is the subject of the pass-through. That risk will either be diversifiable or non-diversifiable, and only in the latter case will the cost pass-through have implications for the firm's beta[24]. Appendix A shows how providing an allowance for cost pass-through can either amplify or attenuate the impact of a shock on the regulated firm's returns.

4.3 Ancillary Mechanisms

Depending on the regulatory environment, there are a number of mechanisms that often complement the principal form of regulation. These are collectively referred to as 'ancillary' mechanisms. In general, such mechanisms function to reduce both the diversifiable and non-diversifiable risk of the regulated firm. Four mechanisms that often accompany revenue caps and price caps are cost pass-throughs, review 'triggers', and 'unders-and-overs' accounts.

The first ancillary mechanism is a cost pass-through, which allows specifically identified costs beyond the firm's control to be passed through to users through price changes prior to the next formal regulatory review. As these have been discussed in the previous section they will not be discussed further in this section.

Most regulatory undertakings contain provisions that allow the regulated firm to trigger a review prior to the next scheduled review. The triggers for a review differ across regulatory regimes, but common triggers are unexpected events (e.g. an unanticipated and adverse shock to operating costs). Conceptually, review triggers are close substitutes for cost pass-throughs. They basically allow the firm to have elements of its revenues and costs reconsidered in the event of an unfavourable outcome. To the extent that the outcome of such a review reduces any systematic deviation from expected cash flows, such a mechanism affects the firm's non-diversifiable risk exposure and asset beta.

Importantly, a final mechanism is an 'unders-and-overs' account, which can apply to part, or all, of a regulated firm's allowable revenue. Under a revenue cap, if the firm under- (over-) recovers revenue from customers, then it receives (repays) the difference between the actual and allowable revenue. Since the total variability of revenue is eliminated from a net present value perspective, there is no meaningful revenue risk - either diversifiable or non-diversifiable. It, therefore, operates as a compensatory cash flow mechanism and provides a guarantee against risk.

In contrast, the CAPM specifies a return that compensates investors for systematic deviation from expected cash flows, with the risk-adjusted discount rate consistent with the non-diversifiable risk of the cash flows. Clearly, an unders-and-overs account that eliminates variance in the firm's revenues is fundamentally inconsistent with the concept of providing a risk-adjusted rate of return with respect to that component of the firm's returns. Further, depending on the mechanics of the compensatory mechanism, finance charges can be used to ensure lagged effects are eliminated as well.

These ancillary mechanisms have their place in regulatory arrangements as they are used to manage and allocate risk. However, to the extent that such mechanisms affect the regulated firm's non-diversifiable risk, the regulator should take this factor into account when setting the regulatory cost of capital using the CAPM.

[24] A principal criticism of pass-throughs is that they weaken the incentives of the regulated firm for productive efficiency. If the firm can pass on input cost increases, then it might not have an incentive to select the least cost combination of inputs (Baron and De Bondt, 1979: 246-247).

4.4 The Form of Regulation in Australia

In Australia, the standard approach to regulating natural monopolies and access to essential facilities is commonly referred to as the 'building blocks' model. Under this approach, there are two basic steps:

(a) estimating the revenue requirement; and

(b) determining the form of regulation to apply to the regulated firm given the revenue requirement.

4.4.1 Estimating the Revenue Requirement

First, and independent of the form of regulation, the building blocks form of regulation takes as its starting point a 'build-up' of the regulated firm's costs, including both capital and operating costs, to establish an *ex ante* total revenue requirement. The annual revenue requirement is the sum of a number of underlying elements, or 'building blocks'. These include a return on capital, a return of capital (i.e. depreciation), operating costs, and a tax allowance.

The return on capital is calculated as the weighted average cost of capital multiplied by the opening regulatory asset base (RAB) for the year. The return of capital is typically calculated by applying straight–line depreciation to the regulated firm's opening asset base on the basis of the assets' estimated remaining life. The operating costs provide compensation for the operating and maintenance costs of the assets and the tax allowance compensates the firm's owners for the expected tax liability.

In terms of determining the specific values for the individual blocks, the regulatory process typically involves an assessment of the cost of capital and operating costs with reference to comparable, private sector firms on the basis that they are 'efficient' benchmarks (i.e. 'comparables analysis'). For the return on capital, the key parameters subject to such analysis are the asset beta, the cost of debt, and the level of financial leverage (i.e. the appropriate weights for the debt and equity in the firm's capital structure). For operating costs, the key elements subject to such analysis are the firm's administrative, operational, and maintenance related costs.

With respect to the cost of capital, the costs of firms with similar underlying cash flow profiles are referenced as relevant benchmarks, perhaps with some adjustments to reflect differences in cash flow risks. In terms of operating costs, the typical approach applied involves adjusting the regulated firm's proposed (expected) costs by invoking comparables analysis as the basis for any adjustments to the regulated firm's proposal[25].

The basic building blocks approach is similar to traditional cost-of-service regulation in the US, as the regulator effectively determines a cost of service, including a reasonable return on capital. However, a point of divergence is in estimating certain cost components. US regulators' assessments are backward-looking as they examine costs already incurred by the regulated firm and have the authority to disallow expenditures that are 'imprudent or unnecessary' (Joskow and Schmalensee, 1986: 8).

In Australia, the assessment is more forward-looking, in that it invokes comparables analysis to adjust the firm's proposal to reflect estimates of 'efficient' costs. While this approach does not exclusively reference the firm's actual costs, it is typically far from relying on

[25] Estimating the return of capital is essentially a mechanical exercise given the opening value of the asset base and the approach to depreciation. Subject to an assumption about the utilisation rate of dividend imputation credits, the estimate of the tax allowance follows from the other parameter values.

totally exogenous costs either. For example, Mountain and Littlechild (2010) observe that the Australian Energy Regulator (AER) typically relies on 'bottom-up' reviews of electricity distribution expenditure proposals by consultants that frequently recommend the distributors' actual cost proposals with only minor variations (Mountain and Littlechild, 2010: 5776).

It is considered that the typical building blocks approach in Australia still gives significant weight to the regulated firm's cost proposal in contrast to price cap or productivity-based regulation, where an X-factor is set predominantly by reference to external information. This deficiency in benchmarking and reliance on the regulated firms' actual cost proposals in certain industries (e.g. electricity distribution) has also been documented by external observers (Mountain and Littlechild, 2010: 5775-5776).

Under the building blocks approach, once the regulator has made an estimate of the total revenue requirement, the starting point prices (P_0 and the X-factors) are typically set such that the present value of the revenue based on the prices and forecast output equals the building blocks revenue requirement. Since there are a number of combinations of P_0 and X that will satisfy this condition, the P_0 is set to approximately equate the revenue streams based on the most recent information, and X is determined in a way (in conjunction with a CPI index) that provides smoothed prices. The implication is that the X-factor is not set to reflect an exogenous productivity improvement. This practice has been highlighted in the work of Economic Insights (2010) and Mountain and Littlechild (2010).

4.4.2 Applying the Form of Regulation

Given the determination of the building blocks and therefore, the revenue requirement, the second step in applying the building blocks model involves choosing the mechanism by which the firm recovers its revenue requirement. In broad terms, the form of regulation applied in Australia is typically either a revenue cap or a price cap, with regulators in different jurisdictions applying them in slightly different ways and in conjunction with different ancillary mechanisms. As these differences span regulators and industries, this section does not seek to discuss these individualised forms of regulation and their implications for risk, but rather attempts to provide an overview of the forms of regulation, drawing on relevant examples as appropriate.

Revenue Caps

Under a revenue cap, given the revenue requirement, the regulator uses a forecast of demand to set the regulated price. Broadly, the mechanism involves choosing the price that, when multiplied by forecast demand, equals the annual revenue requirement. In practice, the forecast of demand diverges from actual demand over the course of the year, and as a result, the firm over- (under) recovers the revenue requirement. Differences between the actual revenue recovered and the requirement are then taken into account in future years through the operation of an 'unders and overs account', where any over- (under-) recovery is deducted (added) from (to) the revenue requirement in future years of the regulatory period. Revenue caps that apply to the electricity transmission network service providers, three electricity distributors, and to QR Network operate in this way, with a two-year lag in adjusting the revenue requirements for any over- (under-) recovery[26].

As a result, this control mechanism provides the regulated business with a *de facto* guaranteed revenue requirement for the existing assets over the regulatory period (albeit with a lag), as it transfers the demand/volume risk to customers. Setting aside the lagged adjustment, there is minimal risk that the firm will not achieve its revenue requirement over

[26] The three electricity distributors are Energex, Ergon Energy (Queensland) and Aurora Energy (Tasmania). Confirmed by the AER in an e-mail on 3 September 2012.

the span of the regulatory cycle. However, while the firm's total revenue is effectively fixed over the year, cost deviations can cause the firm's actual profit, and therefore its return, to deviate from its expected value. This issue is discussed further in a later section in this chapter on cost pass-throughs.

Price Caps

Some regulated firms in Australia are subject to a form of price cap, rather than revenue cap. These include a group of the electricity distributors, which are subject to a weighted average price cap (WAPC). The price caps are again derived from the underlying building blocks using forecasts of demand. The price is chosen such that the present value of: the price for each year multiplied by the forecast demand for each year of the regulatory period equals the building blocks revenue requirement. However, once the price is set, the forecasts of demand are no longer relevant. The regulated firm's actual revenue is the product of the regulated price and the realised demand. There is no unders-and-overs-account to return (recover) any excess (deficit). As a result, the regulated firm, in principle, bears demand (i.e. volume) risk. This difference from the revenue cap is fundamental, but it might be of no consequence given the scope for the regulated firms to benefit from persistent under-estimation of forecast demand.

The use of forecasts of demand provides an incentive for the regulated firm to materially under-estimate the demand forecast. This incentive arises because, if the regulated firm can successfully argue for a lower demand forecast, the regulated price given the building blocks will be higher than it would be in the case of a higher forecast. That higher price will then be earned on all of the firm's actual, not forecast, sales. Therefore, if realised sales are higher (lower) than the forecast, the firm's annual revenue will be greater (less) than the building blocks revenue requirement. Again, in contrast to the revenue caps, there is no unders-and-overs settlement.

In theory, assuming that there is no bias in the forecasts, such a mechanism implies higher variance in the regulated firm's profit and return relative to a revenue cap with an unders-and-overs account. In Australian practice, however, there are several considerations that mitigate against this difference. The energy distributors subject to weighted average price caps have significant scope for price flexibility. First, the side constraints on individual prices in the price 'basket' do not apply in the first year of the regulatory cycle. Second, the distributors have the scope to create new tariff classes and therefore, prices, which again gives them greater scope for price flexibility. In the face of lower than forecast realised demand, the practical effect of these arrangements is to allow them to increase prices for certain products experiencing sales growth above forecast to make additional, compensating revenue (AER, 2012b: 128).

As a result, this flexibility allows them to eliminate downside variance in revenues, and the evidence to date supports this claim and appears to be of significant concern to the AER[27]. For example, the AER reports that, for the 2006-2010 control period, the Victorian electricity distributors over-recovered revenue relative to the forecast by $568 million (in 2010 real dollars). Under the WAPC mechanism, such an outcome is possible because the regulatory price is based on forecast demand while the actual revenue earned is based on realised demand. However, if the forecasts are unbiased, it would be expected that over time, any over-recovery would be offset by under-recovery of revenue. On this point, available evidence supports persistent bias in the forecasts and over-recovery of revenue by the electricity distributors that are subject to a WAPC (AER, 2012b: 54-56, 124-130).

[27] Such flexibility is consistent with the efficient management of risk (Guthrie, 2006: 937-939).

In Queensland, both the Gladstone Area Water Board (GAWB) and SunWater are both subject to price caps. GAWB supplies both raw and treated water to industrial customers and treated water to the Gladstone Regional Council. GAWB has individual price caps for raw and treated water by defined classes of customer. While GAWB bears demand risk, this risk is relatively low. Demand from existing customers is highly predictable and accounts for about 75% of total demand.

Relevant demand risk is largely mitigated through GAWB's two-part tariff structure. A volumetric charge based on long run marginal cost applies to actual water use, with most major customers being subject to take-or-pay requirements for contracted demand. The (fixed) access charge is based on contracted volume, where the charge is calculated to achieve the revenue requirement (after allowing for the revenue earned under the volumetric charge). As a result, demand risk is low, and any residual demand risk primarily relates to demand growth of new industrial customers.

SunWater is a government-owned corporation that supplies water and related services throughout rural and regional Queensland (excluding southeast Queensland) to irrigators, mines, power generators, industry, and local governments. The irrigators account for the majority of Sunwater's customers but represent a relatively lower share of SunWater's revenue. SunWater has price caps for each of its 30 irrigation schemes, and these are subject to a two-part tariff structure. Specifically, the fixed access charge is based on irrigator entitlements and is designed to recover SunWater's total fixed costs, which are 93% of total costs for the bulk schemes and about 65% of costs for the distribution schemes. The variable charge is a volumetric charge based on expected variable operating costs, which mainly relate to electricity.

As with GAWB, applying a two-part tariff structure in these circumstances materially protects the firm from risk, as it effectively guarantees the recovery of fixed costs. Further, there is a provision for SunWater to apply to recover material increases in its actual variable costs when they are above expected levels. This mechanism to recover higher variable costs also materially reduces the risk of under-recovery of variable costs (QCA, 2012: 53-64).

Cost Pass-throughs

Under either a revenue cap or a price cap in Australia, a potential source of risk in the regulated firm's returns is the divergence of the firm's realised costs from its expected, or allowed, costs. One way in which such variance can arise is if actual costs diverge from expected (i.e. forecast) costs due to a greater scope of operations and/or maintenance activity than expected (i.e. as the result of higher volumes than anticipated). A second way in which actual costs can diverge from expected costs is if realised input prices are higher than forecast. The implication is that, while the firm's total revenue is effectively fixed over the year, cost deviations can cause actual profit, and therefore the firm's actual return, to deviate from its expected value.

In Australia, regulated firms subject to revenue and price caps typically also have cost pass-through mechanisms, which typically reduce these types of cost variations. These function to share the risk between the regulated firm and its customers. Both the National Electricity Rules and National Gas Rules have provisions under which regulated firms can apply for a cost pass-through. Under the former, for example, potential cost pass-through events for electricity transmission network service providers (TNSPs) include, *inter alia*, events related to changes in regulation (i.e. regulatory obligations or requirements resulting in, for example, a material increase in costs), service standards, tax liabilities, and insurance. The rules also give the TNSPs the scope to apply for other types of pass-throughs of costs (AEMC, 2012: 706-710).

In electricity distribution, the New South Wales distributors, for example, are permitted a 'high' degree of cost pass-through. Subject to certain conditions, they are allowed to pass through costs associated with retail projects, smart meters, emissions trading, aviation hazards, terrorism, regulatory changes, and tax changes. In addition, a more general provision permits these distributors to pass through costs that were unforeseeable at the time of the AER's decision, are uncontrollable by the distributors, and exceed 1% of annual revenue. In comparison to the nature of cost pass-through in the UK, for example, these provisions are expansive (Mountain and Littlechild, 2010: 5776-5777).

In Queensland, the Authority has approved the use of cost pass-throughs and similar mechanisms to assist the regulated firms in managing certain risks. For example, QR Network, the below-rail network service provider, is subject to a revenue cap. Its undertaking allows it to apply to recover maintenance costs that were the result of a change in maintenance practice due to the request of a user (subject to a materiality test), and more generally, any additional (i.e. unexpected) maintenance costs, as long as QR Network can demonstrate that it incurred such costs in a 'prudent and cost efficient' manner (QCA, 2010c: 173-174). This mechanism clearly reduces risk for QR Network, but the issue is whether these arrangements are economically efficient and whether appropriate adjustments have been made to the allowed cost of capital.

Reviews

Finally, in Australia, the time between successive reviews of the regulatory arrangements is typically four to five years. In the interim, however, there is considerable scope within the approved regulatory arrangements for the vast majority of the regulated firms to trigger a review of prices under a number of circumstances, given the occurrence of events that materially or adversely affect the financial position of the firm. For example, in its 2010 decision, the Authority approved a price review trigger if there is, or is expected to be, a variation in GAWB's revenues of 15% or more (QCA, 2010a: 181).

Further, certain businesses in the electricity and gas sector have an option to initiate a merits review process with the Australian Competition Tribunal (ACT). Parties can appeal individual elements on their own merits without a full *de novo* review of the regulator's decision. The regulated firms are the dominant appellants due to the difficulty consumer groups have in obtaining standing. Successful appeals result in the firms increasing their prices, while unsuccessful appeals are only associated with the cost of litigation. As a result, there is an argument that the regulated firms 'cherry-pick' the process to increase returns (see Appendix B for a more detailed discussion).

As a result of 'review event' and merits review provisions, the practical implication for regulated firms is that the regulated price is 'reviewed' more often than every four to five years, particularly if the circumstances are adverse to the firm. These provisions, in effect, act like an insurance policy in that they provide a hedge against the firm's cash flow risk, some of which has a systematic effect.

4.4.3 Summary

The building blocks form of regulation in Australia differs from traditional cost-of-service regulation as typically practised in the US and from price cap regulation in the UK (as they were originally intended to operate). The building blocks model is a hybrid approach that will reduce risk depending on the extent to which revenues are guaranteed and costs are passed through to customers. In theory and in practice, it is likely to be closer to cost-of-service regulation for several important reasons, namely:

(a) revenue caps and price caps as applied in Australia provide strong certainty of revenue recovery, especially when coupled with a revenue guarantee (including in the form of an unders-and-overs mechanism);

(b) allowed costs are only partially de-coupled from actual costs as a result of the type of cost benchmarking applied, and to the extent some costs are completely exogenous, cost pass-through mechanisms are available to reduce material variations that arise; and

(c) reviews of regulated prices effectively occur more frequently than the (scheduled) four to five years due to the scope for firms to 'trigger' unplanned reviews in adverse circumstances.

5. THE 'SPLIT' COST OF CAPITAL

The majority of a regulated firm's costs are typically sunk costs, with the residual costs being variable operating costs. The regulatory arrangements in Australia and the UK have evolved to emphasise 'revenue adequacy' or full cost recovery as a priority principle. It can be argued that once capital expenditure has been approved and rolled into the regulatory asset base, recovery of the economic cost embedded in that asset base is effectively guaranteed.

On the basis of this characteristic, UK economist, Dieter Helm, has advanced the concept of a 'split' cost of capital (Helm, 2008, 2009, 2010; Helm *et al*, 2009). This concept recognises that a substantial part of the regulated firm's cost structure has low risk as a result of the regulatory arrangements while other parts might have higher risk. The regulatory and public policy issue is determining the extent to which the regulatory arrangements lower risk for some activities of the regulated firm and to take account of that effect in regulating prices.

The 'split' cost of capital also recognises that the overall cost of capital for a regulated firm can be split into high risk and low risk components and that this disaggregated focus would enable a more accurate reflection of the true risks of the regulated firm's activities. In particular, in describing the 'split' cost of capital concept, Helm draws a distinction between the assets that comprise the existing regulatory asset base (RAB) and the firm's operating costs and proposed capital expenditure. Helm argues that potential sources of equity risk arise primarily in the latter two 'non-RAB' areas.

Helm's proposal to address the existence of differential risk has three principal components:

(a) the government or regulator provides the regulated firm with an explicit 'duty to finance' and, in return, the regulated asset base (RAB) earns a cost of debt equal to the government debt rate plus a 'small' premium;

(b) the 'non-RAB', or higher risk, activities of the firm earn a WACC that contains an equity return component, specifically:

   (i) *opex* - the regulator places a risk/reward mechanism on this part of the business as the potential for efficiency incentives is highest for operations and maintenance; and

   (ii) *capex* - the firm earns a WACC - possibly with a significant cost of equity component depending on the risks - while capital is being installed, but once the project is accepted by the regulator into the RAB, the project commences earning a RAB return on debt; and

(c) indexation of the firm's cost of debt by updating the risk-free rate on a more frequent basis than every five years (Helm, 2010).

The cornerstone of Helm's proposal is the efficient allocation of risk. Helm argues that the three principal areas of the regulated firm's activities - the RAB, opex, and capex - have different risk profiles, with the RAB's risk being materially lower than the risk associated with the other two functions. Helm argues that the RAB is essentially a 'passive' management activity, associated with little, if any, risk under certain guarantees. In contrast, the opex and capex activities require active management, which is associated with equity-related risk.

Specifically, Helm contends that the RAB is associated with no, or very low, risk when the RAB is coupled with what Helm characterises as a regulatory 'duty to finance'. While this 'duty to finance' is, in part, context-specific, one interpretation is that, regulatory approval of assets for inclusion in the RAB is effectively equivalent to providing the regulated firm a guarantee of that asset value (i.e. that there will be no *ex post* regulatory expropriation of the regulatory asset value). Conceptually, it is a guarantee that the customers will pay for the sunk assets in the RAB[28].

Helm argues that such a guarantee of the assets' value effectively removes all real equity risks, with the residual remaining risks being political and regulatory risks. Further, Helm considers that these risks are beyond the control of the managers of the regulated firm, and efficient risk allocation implies that they be borne by users or taxpayers. In this respect, the explicit 'duty to finance' guarantee has effectively transferred those risks to users (or taxpayers). As such, there is virtually no scope for active asset management and accordingly, no (or very little) role for equity capital. Therefore, Helm concludes that the RAB assets should earn a rate of return at, or slightly above, the cost of debt:

> *The RAB is an accounting construct, representing the sunk investment in the business. The existing RAB at any particular time does not require managerial effort to continue to be rewarded, and future RAB is determined by adding CAPEX, efficiently conducted. The RAB, then, has very little risk attached. And if it has very little risk, it is more suitably financed through debt rather than equity. If, in addition, it is assumed that the duty to finance functions placed upon the regulators guarantees a return on the RAB, there is strictly no function for equity to fulfil...(Helm, 2008: 9).*

Second, and in contrast, Helm considers that the operating and capital expenditure activities of the business typically involve active asset management. In these areas, there are real managerial risks associated with the day-to-day running of the business in terms of performance and delivery. Such risks are reflected in the profile of the service companies that support the opex and capex functions - including for example, maintenance, engineering, and construction - and in the types of contracts that are invoked to manage them (e.g. competitive tendering and fixed price contracts)[29]. As these functions require a significant degree of active management, Helm considers that they should be remunerated with a WACC or other reward mechanism containing a material equity return component.

In terms of opex, this activity is comparable to a range of asset management tasks in the private sector, which are often packaged and contracted out at fixed prices. If the contractor out (under) performs the contract, the contractor is rewarded (penalised). Further, as the outcomes of opex activity are observable and assessable, Helm argues that the opex activity is best suited to incentive-based regulation. The reward/risk trade-off arises from outperforming the regulatory contract for these activities, while delivering the required outputs, subject to service quality standards.

In terms of capex, this activity typically involves equity (and possibly project) finance as there is material risk in undertaking and managing capex projects. Specifically, the risk is predominantly incurred from project start and through project completion, involving engineering pre-feasibility, construction, and management. However, as project completion and commissioning draw nearer, the role for equity diminishes as the majority of the risk has been realised during establishment and construction of the project[30].

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[28] Helm notes that, in the UK, regulators have interpreted the 'duty to finance' as a duty to ensure that the regulated business maintains an investment grade credit rating in order to finance its functions (with adjudication contracted out to the credit rating agencies (Helm, 2008: 6).

[29] It is notable that debt in these service companies is usually for working capital purposes.

[30] In the context, and interest of, reducing the debate over the cost of capital, Biggar (2011) considers several different options in Australia, including user-funded expansion of networks and competitive tendering for major expansion projects (Biggar, 2011: 48-49).

While in the private sector, some equity risk might remain during operation, Helm argues that the regulatory framework effectively removes this risk. Specifically, the regulatory capex assessment process allows for an approved project to be transferred into the RAB upon commissioning, possibly subject to a regulatory 'prudency' review of costs and potential optimisation. In this context, the completed project is effectively 'purchased' by the RAB at an agreed value - the regulatory value at which it enters the RAB (Helm, 2009).

Relevantly, Helm argues that once the project is approved for inclusion in the RAB, there is nothing further management can do to affect the capex 'number' and the approved regulatory capex value. As such, the transfer into the RAB eliminates any further role for equity at that point and, accordingly, the project should earn the cost of debt once it enters the RAB. In other words, the project only earns a capex-type WACC during feasibility, pre-engineering, and construction.

Helm further argues that it is a fundamental flaw to apply a single WACC to remunerate two very different types of activities – the RAB on the one hand and the opex and capex functions on the other. By definition, the WACC is an average – it is higher than the cost of debt and lower than the cost of equity. As a result, Helm submits that the effect of applying this 'single WACC' approach in the UK to date has been to encourage financial engineering, such that equity holders increase the firm's leverage (i.e. debt to total assets) to arbitrage the difference between the regulatory WACC and a near risk-free rate for most of the capital base.

This financial engineering has not focused on financing new investment but re-financing the RAB. In contrast, the WACC is too low to finance the equity needed to fund new capex, with the marginal cost of equity increasing as higher levels of gearing have been pursued. If the situation persists, Helm concludes that the end result will be cost-of-service regulation with equity risk in effect almost fully transferred to customers.

In terms of the third principal component of Helm's framework, Helm argues that there is no rationale for regulators to fix a cost of debt for the regulated firm *ex ante* (i.e. at the regulatory cycle start). Specifically, as the cost of debt is largely beyond the firm's control, it is inefficient to fix an *ex ante* cost of debt for five years when interest rates vary continuously. While some regulators consider that this design gives the regulated firm the incentive to 'beat the market', Helm argues that regulated firms' treasurers have no knowledge of what decisions monetary authorities will take on interest rates; that is, they cannot possibly 'know better' than the market (Helm, 2009: 23-25).

Helm argues that this practice in the UK has, in general, led regulators to systematically over-estimate the cost of debt for regulated firms to the detriment of their customers. Helm recommends that, in the context of the RAB, the regulator should:

(a) set an *ex ante* cost of debt on an annual basis that is equal to a government bond rate plus a 'small' premium (although Helm does not elaborate on how to determine that premium); and

(b) make an *ex post* error correction on an annual basis for the divergence between the assumed cost of debt and the actual cost of debt outcome.

For many regulatory arrangements in Australia (e.g. electricity networks), the risk to shareholders largely relates to the difference between opex and capex allowances and actuals incurred within the regulatory period. Once actual capex is rolled into the regulatory asset base and prices are reset at the start of the next regulatory period, the regulatory asset base is effectively guaranteed in real WACC terms. For these capital-intensive industries, risk is significantly diminished but to date there seems to have been minimal recognition of Helm's view.

Adopting Helm's proposal in whole or, in part, would have fundamental implications for both the regulated businesses and their customers. Given the importance of this issue and its implications not only for the cost of capital but for the existing regulatory paradigm, the Authority intends to release a separate consultation paper on this matter in the near future.

6. EMPIRICAL EVIDENCE AND IMPLICATIONS

The previous discussion has provided a theoretical context for the form of regulation and its implications for the risk of the regulated firm. The purpose of this chapter is to examine relevant empirical evidence on these points. Specifically, this chapter considers available evidence in relation to three closely related, but equally important, empirical questions, namely:

(a) whether or not firms subject to regulation bear positive, non-diversifiable risk as measured by the beta coefficient in the CAPM;

(b) the extent to which regulation, irrespective of its form, increases or decreases the risk, and in particular, the non-diversifiable risk, of the regulated firm; and

(c) whether different forms of regulation affect the regulated firm's non-diversifiable risk differently.

As a logical starting point, a relevant empirical question is whether firms bear (any) positive, non-diversifiable risk due to the presence of regulation. Unsurprisingly, empirical evidence supports the proposition that beta values are positive for listed, regulated firms across a range of industries and countries. In the UK, relevant empirical work in regulated industries includes electricity distribution (Robinson and Taylor, 1998), and water and sewerage distribution (Europe Economics, 2009). Empirical evidence on regulated industries in the US includes electricity and natural gas distribution (Riddick, 1992; Binder and Norton, 1999). Also, Damodaran (2012) reports that US electric utilities subject to rate-of-return regulation and US water utilities are among the lowest asset beta industries.[31] Finally, in Australia, evidence for positive betas of regulated firms in regulated industries includes, for example, electricity transmission and distribution (ACG, 2008; Henry, 2008, 2009).

While these empirical results are not surprising (the above is a relatively small sample), they raise the question of why regulated firms bear any risk at all given the presence of regulation. In other words, if regulation alters the nature of risk or transfers risk away from the firm, then why wouldn't the regulator reduce the firm's exposure to 'zero risk'? The answer is that a scenario in which the regulated firm bears zero risk is unlikely to involve an efficient allocation of risk between the firm and its customers.

Specifically, from an economic perspective, if regulation fully insures the firm against risk then such regulation would imply average cost pricing in every state of nature to insure the firm in the event of any deviation from expected outcomes. In such a world, the customers and/or other parties again would be bearing the risk in every state of nature. Cowan (2004) shows that, as long as customers are averse to either price risk or income risk (or both), it will not, in general, be optimal to fully insure the firm in this way. The issue of the optimal allocation of risk is a fundamental reason that, in practice, regulated firms are observed bearing risk. This issue is discussed further in Chapter 7.

Further, even if the regulatory objective was to fully insure the firm against risk, achieving such a state in practice is not possible because regulation is costly and imperfect. Regulation, *inter alia*, involves a price setting and review process that imposes costs on all parties and, as a result, occurs only over discrete intervals of time. Unless information and technology were sufficiently advanced to allow the regulator to continuously adjust regulatory parameters, the regulated firm will bear some residual risk, some of which is non-diversifiable in nature.

[31] Based on data as at January 2012, Damodaran (2012) reports US electric utility unlevered (i.e. asset) betas of 0.49 and water utility betas of 0.43.

Also, work by Campbell (1991) and Campbell and Mei (1993), implies that it is possible for investors to have very low, non-diversifiable cash flow risk but higher overall non-diversifiable risk due to changes in future real interest rates and returns (i.e. discount rates) affecting the market value of the firm. In the context of US equity portfolios, Campbell and Mei (1993) find that the value of excess return betas is significantly larger than the values of cash flow betas, which reflects the proposition that a large proportion of the variability in a firm's returns is attributable to changes in future expected discount rates (Campbell and Mei, 1993: 574-575).

On the second empirical question, it is intuitively appealing that regulation reduces the regulated firm's non-diversifiable risk as it effectively bounds the firm's gains and losses. However, the finding of positive beta values is not generally determinative of the *direction of the effect* of regulation on a regulated firm's risk. Plausible arguments exist that regulation can either increase or decrease the firm's non-diversifiable risk relative to its risk in the absence of regulation.

If regulation, in fact, *increases* the non-diversifiable risk of the regulated firm, all else equal, then one plausible explanation is that the presence of regulation in some way constrains the firm such that it is unable to react to changing market conditions. A simple illustration is a pure price cap that is strictly fixed. This control exposes the firm to cost risk, for example, which an identical, unregulated firm might be able to mitigate by, for example, increasing its price in response. In this case, to the extent that relevant market conditions are positively correlated with the business cycle, the effect would be to increase the firm's beta[32].

The alternative possibility, that regulation *decreases* the firm's non-diversifiable risk, is also a relevant hypothesis. In this respect, a plausible explanation is that regulation acts to insulate or protect the firm from 'adverse' market conditions and, to the extent these conditions are positively correlated with the business cycle, regulation reduces the firm's beta. As regulation is context specific, the circumstances of a regulated firm and the nature of the regulatory arrangements are likely to be joint determinants of the any effect on a particular firm. However, this issue is ultimately an empirical matter, and the relevant literature provides some guidance.

In a seminal paper, Stigler (1971) argues that regulation is a 'good' that consumers demand and that regulators 'supply' to maximize their support. Building on the work of Stigler (1971), Peltzman (1976) argues that, in the face of an exogenous shock to the firm's cash flows, the regulator will act to maximise the general support of consumers and producers for its regulatory arrangements, which results in them sharing the gains or losses resulting from the shock (unless one party is completely powerless).

An important implication of Peltzman's model is that the presence of regulation acts to 'buffer' shocks to the regulatory cash flows of the firm by reducing both the regulated firm's asset beta and the variance in the firm's returns (i.e. the Peltzman 'buffering' hypothesis). There have been a number of empirical tests of this specific proposition, although some of these tests are not directly relevant, as they do not deal with natural monopoly regulation[33]. The most relevant studies are briefly discussed below.

In the context of US electricity and gas retail, natural gas distribution, and water supply, Fraser and Kannan (1990) find direct, empirical support for the Peltzman hypothesis - that regulation reduces the non-diversifiable risk of the regulated firm. A number of relevant studies empirically test the contrapositive of the Peltzman hypothesis, namely that the

[32] This statement is broad, and the actual effect depends on the specific nature of the non-diversifiable risk and its covariance with the market portfolio.
[33] For example, Mitchell and Mulherin (1988) test the buffering hypothesis in the context of the effects of the 1970 US ban on cigarette advertising on television and radio.

absence of regulation causes an *increase* in non-diversifiable risk. For example, Nwaeze (2000) finds that profit variance and non-diversifiable risk were materially higher for US electricity utilities after the introduction of competitive reforms in the power generation market. Chen and Sanger (1985) provide evidence that the non-diversifiable risk of US natural gas producers and distributors increased after deregulation, while Chen and Merville (1986) find empirical support for the same proposition in the context of the deregulation of AT&T from 1981-1984.

Other authors obtain ambiguous results or contrary evidence when testing the direct hypothesis, but the findings of most of these studies are not directly relevant to natural monopoly regulation. For example, Allen and Wilhelm (1988) find no change in the non-diversifiable risk of different portfolios of US banks, whose competitive relationship with each other was potentially impacted by the Depository Institutions Deregulation and Monetary Control Act (1980). Sundaram *et al* (1992) find evidence against the hypothesis in the context of new banking regulation on US savings and loan institutions. While evidence shows higher non-diversifiable risk for these firms post-regulation, the authors caution that this result could be due to continued, negative news about savings and loan businesses that occurred during that period (Sundaram *et al*, 1992: 1119-1121).

However, in one of the most important empirical papers on this topic, Binder and Norton (1999) argue that most tests of the Peltzman hypothesis are misspecified because they fail to control for other factors affected by regulation (e.g. financial leverage) that also determine the regulated firm's estimated beta. After controlling for these factors, Binder and Norton (1999) find evidence that supports the (direct) Peltzman hypothesis, namely that the presence of regulation insulates the firm from economic shocks, which implies a reduction in the firm's non-diversifiable risk and beta (Binder and Norton, 1999: 257-261).

Further, in a related study, Norton (1985) finds that the firm's asset beta decreases (increases) when the 'intensity', of the regulatory control increases (decreases). In Norton's context, 'intensity' refers to the degree of regulatory control over the regulated firm's activities, and Norton's result holds whether regulatory intensity is measured in terms of conferred authority (e.g. statutes and judicial opinions), inputs devoted to regulation (e.g. regulatory staff), or outputs (e.g. the regulated price) (Norton, 1985: 682). Davidson III *et al* (1997) confirm this result in a subsequent study (Davidson III *et al*, 1997: 178-179).

On the third empirical question, there are several studies that attempt to assess the *differential* impact of the form of regulation on non-diversifiable risk. In a frequently cited study, Alexander *et al* (1996) estimate and compare betas across a number of regulated utilities in 135 different countries for the period 1990-1994, with particular focus on the forms of regulation in the UK and the US. The types of regulated firms include airports, electricity, natural gas, postal services, rail, telecommunications, and water.

Their results show that, *inter alia*, UK utilities subject to price cap regulation for a fixed five-year period have materially higher average asset betas than US utilities subject to rate-of-return regulation for a one to two year regulatory period (at which point there is a review). They attribute this result to the fact that rate-of-return regulation in the US provides a relatively safe operating environment for utilities (Alexander *et al*, 1996: 30-32). Alexander and Irwin (1996) conclude that the differences in the betas imply that investors in firms subject to price cap regulation require a return about 100 basis points more relative to rate-of-return regulated firms (Alexander and Irwin, 1996: 3).

As with any empirical study, there are reasons to interpret the Alexander *et al* (1996) results with caution. First, the study does not report standard errors of beta estimates with the exception of British Telecom. As, in general, standard errors of monthly beta estimates tend to be material, it is unclear whether the identified difference in US and UK beta estimates is statistically significant and therefore whether the beta estimates can be empirically distinguished.

Second, the estimates might reflect ‘intervalling bias’. Specifically, Hawawini (1983) shows that as the return interval is shortened, equities with a smaller market value tend to be biased down, while equities with a relatively larger market value tend to be biased up. US utilities tend to be small relative to the US market and UK utilities tend to be large relative to the UK market. As a result, if the ‘intervalling’ effect is material, then the US beta estimates will be biased down and the UK beta estimates will be biased up. The implication is that the US (UK) utilities appear less (more) risky than their true systematic risk levels (Alexander *et al*, 1996: 26-32)[34].

Third, and perhaps most significantly, the study does not appear to take a rigorous approach to controlling for cross-country differences among countries. Cross-country beta comparisons introduce a number of empirical hurdles, the most important of which is ensuring that the identified difference in betas across countries is strictly attributable to the difference in the forms of regulation and not to other factors, such as differences in market-specific financial leverage. One common econometric approach that addresses this issue involves specifying both random and fixed effects models, but Alexander *et al* (1996) do not appear to have undertaken such an approach.

In another cross-country study that addresses the same empirical research issue as Alexander *et al* (1996), Gaggero (2012) uses a sample of 170 regulated firms across a range of countries, operating in the electricity, natural gas, water, telecommunications, and transport industries for the period 1995-2004. In contrast to Alexander *et al* (1996), Gaggero (2012) finds that different forms of regulation do not result in significantly different betas for the regulated firms.

In explaining this result, Gaggero (2012) hypothesises that, while forms of regulation differ in theory, the behaviour of regulated firms and regulators results in convergence to a similar level of risk. Specifically, firms subject to high incentive regulation (e.g. a price cap) pressure the regulator to pass-through unexpected costs to customers (Gaggero, 2012: 235-236). This conjecture has some support as, for example, Beesley and Littlechild (1989) acknowledge that the two forms of regulation can converge given repeated regulation of monopoly facilities (Beesley and Littlechild, 1989).

The advantage of Gaggero’s model over previous studies is that it explicitly attempts to control for cross-country differences (other than the variable of interest, i.e. the form of regulation) that can affect beta. Whether the construction of the model is sufficiently robust to control for all possible factors across a range of countries remains an open research question, as the empirical difficulties in these cross-country studies are high.

Finally, in an empirical analysis of UK regulation, Grout and Zalewska (2006) examine the effect on regulated firms’ returns of changing the form of regulation from a price cap to a profit-sharing mechanism between the firms and their customers. Their results show that this change in the form of regulation causes a material reduction in the firms’ betas, after controlling for other explanatory factors such as financial leverage. This result is consistent with the proposition that profit-sharing entails lower risk than a price cap, as any divergence of actual profit from expected profit is ‘shared’ symmetrically between the firms and their customers through the profit-sharing mechanism.

[34] For example, as the interval length is increased from one day to weekly, and finally to monthly, the estimated betas of the US water utilities increase, while the betas of the UK gas utilities decrease.

While this study is in a different regulatory environment than Australia, it is important for two principal reasons. First, as it examines a case in which regulation was specifically introduced to change the risk between the regulated firm and customers (rather than to create a wealth transfer), it provides a 'clean' case that isolates the effect of the form of regulation on the regulated firm's beta. Second, it is free from the empirical difficulties posed by cross-country comparisons confronted by Alexander *et al* (1996) and Gaggero (2012).

To summarise the empirical discussion:

(a) evidence supports the proposition that firms subject to regulation bear positive non-diversifiable risk, as measured by the beta coefficient in the CAPM;

(b) evidence also generally supports the proposition that regulation, in general, insulates the firm from risk; and

(c) the evidence of how the specific form of regulatory control affects non-diversifiable risk is mixed, although the most robust of the relevant studies (Grout and Zalewska, 2006) finds support for the proposition that the form of regulation matters.

7. OPTIMAL RISK ALLOCATION

7.1 Background

The previous discussion in this paper has highlighted the important relationship between the form of regulatory control and the regulated firm's risk, both diversifiable and non-diversifiable. Specifically, the greater the extent to which the form of regulation insulates the firm's cash flows from risks, the lesser the extent to which the firm bears those risks (and *vice versa*). The direct implication is that, given the form of regulatory control, the regulator should take such effects into account when setting the firm's beta and return on equity.

However, this implication does not say anything about the basis on which the regulator should select the form of regulation. For example, a revenue cap might imply a lower beta than a price cap depending on the context, but on what basis should the regulator select a revenue cap over a price cap? The answer to this question requires the regulator to consider the over-arching objective of economic efficiency, including optimal risk allocation between the firm and its customers as one component affecting economic efficiency[35].

Economic efficiency requires maximising social surplus, which is the sum of producer and consumer surplus. In a world without market failures, the basic competitive model with consumers maximising utility and firms maximising profits leads to this result. If natural monopoly is present, then the outcome diverges from the competitive outcome for well known reasons, namely that one firm provides the product at a price that exceeds the allocatively efficient price (i.e. the price that equals marginal cost).

If risk is introduced into the basic model, the economic framework can be extended to encompass all possible 'states of nature' (i.e. contingencies), where a state of nature is defined to be a complete description of the environment[36]. Importantly, in terms of that environment, the possible states of nature cannot be controlled by the economic agents (i.e. consumers and producers)[37].

For example, when input costs are uncertain, there might be two possible states of nature - one where profit is high (low input cost) and one where profit is low (high input cost). By assumption, the firm and its customers are unable to affect which state of nature occurs. In a world with risk, the regulatory objective is still economic efficiency, although achieving it now involves taking into account the optimal allocation of risk as part of that calculus. The way to take risk into account is to define goods not only by their physical characteristics but by their state of nature as well[38].

7.2 Risk Allocation and Regulation

In considering risk allocation in the context of regulation, two key strands of the regulatory economics literature are most relevant. The first involves research that introduces risk, such as unexpected variability in the regulated firm's costs, into the regulatory environment. Papers in this area then consider how the exogenous risk affects the regulator's policy

[35] In a 'CAPM world', the allocation is between the firm's investors (rather than the firm itself) and the firm's customers. However, the discussion at this point in the chapter is in a more general framework than the CAPM so the benchmark used is the firm.

[36] For the purpose of this discussion, 'risk' involves contingencies with known probabilities.

[37] This extension of the basic general equilibrium model is in the spirit of Arrow and Debreu (1954). Other extensions include allowing consumers and producers to have different estimates of the probabilities of the states of nature (see Radner (1968)).

[38] If efficient markets exist for all goods and all contingencies then it means that it must be possible to purchase actuarially fair insurance such that each individual's utility remains constant regardless of the state of nature that actually occurs.

choices, including the choice of control, for achieving regulatory objectives. Relevantly, in these models, the economic agents (i.e. the firm and its customers) are indifferent, or 'neutral', to risk, which simplifies the regulator's assessment of the trade-offs in achieving the regulatory objectives.

The second strand of the literature extends the previous framework by introducing risk preferences for the regulated firm and its customers. In these models, the agents are no longer neutral to risk. In other words, at least one party either likes some risk or is averse to risk (at least to some extent). The addition of risk preferences to the framework is fundamental to understanding the implications of risk attitudes of agents on the choice of regulatory policy. Importantly, consideration of risk attitudes of the parties (other than risk neutrality) changes many of the standard results in the regulatory economics literature.

A key paper in the first area is Schmalensee (1989), who investigates the optimality of different forms of regulation when there is: i) moral hazard in the context of the firm's effort to reduce its per unit costs, specifically the regulator cannot observe the cost-reducing effort of the firm; and ii) the possible occurrence of exogenous shocks (positive or negative) to the firm's costs. In this model, the regulator cannot observe the amount of the effort or the magnitude of the shock before it chooses the regulatory parameters, which are a base price and a cost pass-through ('cost-sharing') parameter.

Within this framework, and consistent with the previous discussion in this paper, Schmalensee considers two polar forms of regulation: i) a pure cost-plus regime where the regulator reimburses the firm *ex post* for its realised costs; and ii) a strictly fixed price cap (i.e. with no downward price flexibility)[39]. However, by permitting different degrees of 'cost-sharing' between the regulated firm and its customers, Schmalensee effectively allows the regulatory regime to vary between these polar extremes (Schmalensee, 1989: 417-418).

Schmalensee obtains several important results that can be generalised in the following way. First, fixed price caps provide superior incentives to the firm to exert effort to reduce its costs (this result is well known), but this prescription is, in general, only optimal when there is little, or no, risk. With risk, if the regulator holds the regulated price fixed to provide the firm with incentives to reduce its costs, then the firm cannot change the (fixed) price to respond to realisations of the cost shock parameter. Therefore, the riskier the firm's operating environment, the higher the regulator must set the price cap in order to ensure the financial viability of the firm[40]. Second, as risk increases, some degree of cost pass-through is optimal because the larger the variability of actual costs, the higher the social cost of holding the price cap fixed. The implication is that it is important for price to track cost when cost is highly volatile.

Schmalensee's work in this area does not seek to find 'optimal' regulatory solutions to these complex problems. While Schmalensee recognises that such approaches might be theoretically superior, he also recognises that they are often not practical to implement in the real world. These solutions can involve complex non-linear pricing, regulatory imposition of taxes and/or transfers among the parties, and/or exceptionally demanding informational requirements. Consequently, Schmalensee limits his consideration to 'linear' regulatory regimes, where the regulator controls only two parameters (i.e. the base price and the cost pass-through parameter).

Subsequent work, for example, by Lyon (1996) confirms these results, namely that when there is uncertainty, allowing prices to depend in part on costs improves welfare relative to

[39] In other words, in Schmalensee's model, the price cap functions as both a ceiling and a floor. In a true price cap regime, the firm would have at least some downward flexibility to lower its price.

[40] The term, 'viable' is used in this context to mean that expected (economic) profit is zero. If profit is any less than zero then the firm is unwilling to provide the good or service.

pure price caps. Specifically, Lyon (1996) examines ‘profit and loss sharing’ in the context of balancing the competing objectives of allowing price to track marginal cost and providing incentives for cost reduction. A key result is that some degree of profit-sharing generally increases total welfare relative to the benchmark of pure price caps, as ‘sharing’ leads to a first order allocative gain (i.e. from a reduction in the firm’s cost being passed on, leading to an expansion of output at the margin) but only to a second order loss from weakened incentives (from the firm not having full incentives to minimise costs due to the ‘sharing’). Simulation results indicate that the optimal sharing rule involves significant refunds of profits to consumers through price reductions (Lyon, 1996: 236-238).

While this discussion paper is not concerned with the ‘moral hazard’ feature of the Schmalensee (1989) and Lyon (1996) models, the results provide insight into optimal profit and/or cost-sharing rules between the firm and its customers when there is risk. The next step to consider is the optimal allocation of risk when the firm’s and its customers’ attitudes toward risk matter - this consideration is the subject of the second strand of the literature.

In one of the most important papers to date on the optimal allocation of risk in the context of regulation, Cowan (2004) examines the trade-offs that arise in the context of achieving efficiency when there is risk to allocate and the firm’s and customers’ attitudes toward risk matter (i.e. they are not ‘neutral’ or indifferent to risk). Cowan’s model has symmetric information so the focus is on risk allocation, not on the incentive issues that arise when the regulator has less information than the firm.

Cowan (2004) provides a number of insights into the problem because he explicitly models two different types of exogenous risk in the regulatory environment (i.e. cost risk and demand risk) while also explicitly considering shareholders’ and consumers’ attitudes toward risk[41]. Specifically, the regulated firm is neutral or averse to price risk (i.e. price variability), while customers might either like, or are averse to, price risk[42]. Specifically, customers who like some price risk view the risk as an opportunity to adjust quantity demanded given volatility in the price. Attitudes to risk are also likely to be influenced by the ability of the party to manage the risk.

Within this framework, Cowan (2004) considers the regulator’s optimal choice of a single price in the presence of marginal cost risk to the firm, where the regulator must ensure that the regulated firm remains viable (i.e. expected profit is zero) so that it is willing to produce the good or service[43]. In this situation, suppose that the regulated firm faces an exogenous shock to its input cost (i.e. input cost risk), and the regulator has only a single regulatory control (i.e. the price).

First, Cowan (2004) shows that the extreme possibilities of a strictly fixed price cap and average cost pricing are special cases, as the price cap fully insures the customer, and the average cost price fully insures the firm. The conditions for the regulator to use one of these instruments (i.e. providing either party with full insurance) are likewise extreme, namely that that the party in question is entirely averse to risk. The implication is that some form of cost-sharing between the firm and customers is almost always more efficient in practice than one of these extremes.

Second, in the same context (i.e. a single price), Cowan (2004) then examines intermediate cases that involve different combinations of the firm’s and customers’ risk preferences. With the single price, a key regulatory benchmark is ‘standard’ Ramsey pricing. Under this

[41] The model is more general than the CAPM, the latter of which is one way to price risk.

[42] Shareholders and customers, in general, are assumed to be averse to income risk (i.e. variations in their incomes) caused by price changes.

[43] In Cowan’s model, customers cannot own shares in the firm so they cannot hedge risk in this way. Cowan (2004) also examines demand risk, but this discussion does not consider this risk.

benchmark, the firm is risk neutral, and the standard result requires the regulator to apply a constant mark-up (in inverse proportion to the value of the elasticity of demand). Relevantly, a standard result is that when demand is inelastic, the firm's realised profits can increase when marginal cost increases[44]. The reason is that when cost increases, price increases to maintain a constant mark-up. As demand is inelastic, revenue increases by more than costs and, therefore, profit increases[45]. The implication is that when customers face high costs of service, the firm does not 'share the pain' (i.e. profit is high) (Cowan, 2004: 296).

With this benchmark, Cowan (2004) then introduces risk attitudes, specifically the realistic case that the firm is averse to risk but customers prefer some price variability[46]. Recall that, from the standard Ramsey result with inelastic demand, increases in the firm's cost positively affect the firm's profits. However, if the firm is risk averse, the firm will be sensitive to changes in its price-cost margin because they increase the variability of its profits. For example, when marginal cost increases with inelastic demand and a risk averse firm, the regulator should (optimally) reduce the price-cost mark-up to reduce the variability of the firm's profit. The reverse would be true with inelastic demand if cost decreases. These outcomes are contrary to the standard Ramsey results, which are based on risk indifference or neutrality (Cowan, 2004: 295-297).

The principal point in considering Cowan (2004) is that his rigorous analytical framework illustrates that the firm's and customers' attitudes toward risk have fundamental implications for the allocation of risk and accordingly, the choice of the form of regulation.

Consistent with Cowan (2004), Guthrie (2006) also observes that regulation alters the allocation of risk between the regulated firm's shareholders and its customers, and it does so in several different ways. First, under traditional US-style cost-of-service regulation, the regulated firm is effectively guaranteed to recover all of its costs, provided that the firm has prudently incurred them. Guthrie (2006) argues that this arrangement shifts the firm's business risk onto its customers. In contrast, the firm bears materially more risk under modern incentive-based regulation, which does not reimburse the firm's actual costs (Guthrie, 2006: 968).

However, Guthrie (2006) considers that the ability of customers to diversify risk is important. If customers have significantly more difficulty than shareholders in bearing and/or diversifying risk then, all else equal, the regulatory control should use benchmark costs rather than actual costs. Instead, if the regulator allows recovery of actual costs, customers are exposed to the risk of demand fluctuations since prices will have to increase (decrease) at future reviews if demand decreases (increases).

Along similar lines, allowing firms to automatically adjust prices in response to cost shocks beyond the firm's control might be desirable if it allows regulatory reviews to be held less frequently (i.e. it increases the time between regulatory reviews). However, Guthrie (2006) notes that any such adjustments shift risk from firms to customers and should only be allowed by the regulator if customers do not find bearing such risk too costly. This point has been previously recognised in the discussion on cost pass-through.

[44] Inelastic demand is consistent with the demand elasticity of essential services or goods like, for example, water.

[45] If the regulator has initially set a Ramsey price then, by construction, that price is chosen to ensure that the regulated firm's expected profit is zero. If the firm's cost subsequently increases, the regulator must reset the Ramsey price in the context of the higher cost.

[46] Cowan (2004) also looks at cases where the firm is risk neutral; however, these are not discussed in this chapter as applying the CAPM in the Australian regulatory context implicitly assumes investors in the firm are risk averse.

In summary, the implications of this discussion are:

(a) the risk attitudes of both the firm (investors in the context of the CAPM) and customers should affect the optimal allocation of risk;

(b) some form of cost-sharing between the firm and customers is almost always more efficient in practice than one of these extremes;

(c) the optimal allocation of risk determines the type of regulatory control mechanism that, when applied, results in that allocation of risk; and

(d) the type of regulatory mechanism put in place to allocate risk, in turn, determines the appropriate compensation for investors for the risks that they, in fact, bear under that mechanism.

8. RECENT REGULATORY PRACTICE

To date, there have been varying degrees of acknowledgement by regulators in Australia, New Zealand, and the UK that the *form* of regulation can affect non-diversifiable risk. This chapter seeks to synthesise some of the regulators' views on this topic.

In terms of broad views in relation to beta, the AER has stated:

> *Market data suggests a value lower than 0.8. However, the AER has given consideration to other factors, such as the need to achieve an outcome that is consistent with the NEO..., the revenue and pricing principles (in particular providing the service providers with a reasonable opportunity to recover at least efficient costs, providing service providers with efficient incentives for efficient investment, and having regard to the economic costs and risks of the potential for under and over investment), the importance of regulatory stability. Having taken a broad view, the AER considers the value of 0.8 is appropriate (AER, 2009: xvii).*

The AER, therefore, appears to be taking a more general approach with respect to the beta estimate, attributing to it the potential impact of a number of factors that relate to the regulated firm's non-diversifiable risk (and also possibly to diversifiable risk)[47].

In terms of more specific views on the form of regulation and risk, the UK regulator, Ofgem, in its comprehensive review of the regulatory framework for UK electricity and gas networks (i.e. RPI-X@20 Review), observes that:

> *...the allowed rate of return embedded in the regulatory settlement would relate to the riskiness of the network company's revenue and cost streams, assuming that it operates in an economic and efficient manner (i.e. its cost of capital). The allowed return could vary across a regulated sector, driven by factors such as the size of the investment programme and the incentive structure provided by the regulatory regime (Ofgem, 2010: 36).*

This statement clearly recognises that the cost of capital could, in principle, be adjusted to take account of a range of factors that affect risks and incentives.

In the context of the form of regulation and its implications for risk allocation, the Essential Services Commission (ESC), in its draft decision on the 2008 Water Price Review, states:

> *The form of price control adopted can assist businesses to offset the impacts of uncertainty. The various forms of price control have differing advantages and disadvantages in terms of risk sharing between businesses and their customers, price certainty for customers and business flexibility to adjust prices to reflect changes in circumstances (ESC, 2008a: 220).*

In relation to revenue caps, the ESC further states:

> *A revenue cap is often an effective mechanism for assisting businesses to deal with demand and supply uncertainty. This form of price control is more appropriate when most of a business's costs are fixed and do not vary significantly with the level of demand or supply. The revenue cap would be set to recover the business's efficient costs. Under a revenue cap, businesses would raise prices to offset the impact of lower than forecast sales of water services – due to lower than expected demand or supplies of water (due, for example, to drought and the imposition or tightening of water restrictions) – to ensure approved revenues are achieved. Conversely, when sales of water services are higher than expected, businesses would reduce prices to ensure revenues stayed within the cap (ESC, 2008a: 221).*

It is significant that the ESC specifically recognises that the form of price control and, in particular, the existence of a revenue cap "can assist businesses to offset the impacts of uncertainty" and that the various forms of price control have different implications for risk-sharing between businesses and their customers.

[47] The AER also appears to be adjusting the beta parameter for diversifiable risk as well.

In its 2005 Water Price Review for Metropolitan and Regional Businesses Water Plans, the ESC did not adjust the businesses' revenues if out-turn expenditure diverged from expected expenditure, where the latter included capital expenditure within the regulatory period. On this matter, the ESC noted:

> *An important feature of incentive regulation is that once the prices for prescribed services are set, the regulator does not adjust them within the regulatory period to reflect differences between the actual and forecast costs of service provision. Businesses must manage any differences between actual and forecast costs during the regulatory period. To the extent that costs end up being lower than forecast, the business retains the benefits during the regulatory period; similarly, where costs are higher than forecast, the business bears the loss. This is one of the central tenets of incentive based regulation and provides businesses with an incentive to efficiently manage their costs during the regulatory period (ESC, 2005: 147).*

Most of the 17 water businesses were subject to individual price caps, with the exception of two that were subject to a tariff basket. The ESC also approved an efficiency carry-over mechanism that provided a gain (loss) to a business when actual expenditure was less (more) than the expenditure benchmarks used to set prices. As a result, the businesses were free to pursue efficiencies that enabled them to outperform the revenue benchmarks.

In its reviews, the ESC clearly recognises the possible implications of the prescribed mechanisms for the regulated firm's risk. However, the ESC did not discuss in its decisions how different provisions for risk management might impact on the allowed beta estimate, and it does not appear to have made any adjustments in the firms' estimates to reflect these factors.

In its 2009 decision on QR Network, the Authority recognises that the regulatory arrangements can impact non-diversifiable risk:

> *The Authority also believes that there are strong arguments that other measures that QR Network has introduced into the 2009 DAU, and which the Authority proposes to accept, will further reduce its exposure to covariance risk. These include, for example, annual updates to volume forecasts and indexing maintenance costs annually with reference to a special purpose index of maintenance costs (rather than to CPI).*
>
> *The latter measure has been introduced by QR Network to reduce its exposure to an over-heated labour and materials supply market in central Queensland. These measures complement existing risk mitigation measures such as the revenue cap and take-or-pay contracts. In the case of the take-or-pay contracts, the weaker terms of the pre-2006 undertaking will be increasingly unwound as the older contracts expire and are replaced with the terms of the post-2006 undertaking arrangements.*
>
> *Accordingly, the Authority believes there is a strong case for an equity beta lower than 0.80 (QCA, 2009: 20).*

This statement clearly recognises that the suite of regulatory arrangements potentially protect QR Network from risk and contemplates an adjustment to the beta on this basis.

Given the large number of electricity transmission and distribution providers that are subject to a revenue cap under the AER, it is important to highlight the AER's views in this area. Specifically, in its review of the WACC parameters for electricity transmission and distribution, the AER sought comments on the extent to which the regulatory environment affects the sensitivity of the regulated firms to non-diversifiable risk (AER, 2008a: 56-57).

In response, the Joint Industry Association (JIA) argued that regulation creates risks and that these risks are non-diversifiable[48]. It also contended that the type of regulation is likely to be

[48] The Joint Industry Association comprises the Energy Networks Association, the Australian Pipeline Industry Association, and Grid Australia.

a second order consideration in terms of the level of risk (JIA, 2008: 123). On the basis of analysis by the Allen Consulting Group (ACG) of betas of US incentive versus rate-of-return regulated firms, the JIA concluded that, at this stage, it is not possible to empirically distinguish that the form of regulation has an impact on non-diversifiable risk (JIA, 2008: 124).

At the same time, the Major Energy Users (MEU) considered:

> *At its most basic level, revenue control has a lower risk profile than price control. Under price control, the firm is faced with the risk of lower volume, but equally it has the ability to manage this risk through tariff rebalancing and has the potential to increase its rewards by encouraging greater usage. Through regulatory gaming the price controlled firm has the incentive to minimise the expected usage (MEU, 2008: 51).*

The MEU concluded that, on balance, there is only a marginal difference between the two forms of regulatory control (MEU, 2008: 51).

The AER concluded that, on the whole, the regulated firm faces less non-diversifiable risk than the market due to, *inter alia*, the protections of the regulatory environment but that there is not compelling evidence that the equity beta differs based on the form of regulation (AER, 2008b: 194-195).

In terms of specific points on differences in the form of control (i.e. revenue caps versus the other forms of control available for the distributors, including price caps), the AER made the following points:

(a) the difference between the control mechanisms relates to volume risk;

(b) the relevant volatility is volatility in returns rather than volatility in revenue and to the extent that demand and cost are related, a price cap would lead to lower, or at least equivalent, exposure to non-diversifiable risk; and

(c) the relevant risk is non-diversifiable risk, and it is arguable as to whether volume risk is a systematic risk factor (AER, 2008b: 194).

Point (a) is correct and leads to revenue risk, some of which might be non-diversifiable. In relation to point (b), it is correct that the relevant volatility is volatility in returns but as discussed previously in this paper, revenue caps have fundamental implications for the firm's asset beta, particularly when the cap operates with an under-and-overs mechanism. In contrast, price caps expose the firm to demand risk, although the use of cost pass-throughs can reduce this risk.

In relation to point (c), it is correct that the relevant risk for choosing an appropriate beta is non-diversifiable risk. However, when a guaranteed revenue cap applies it means that the sensitivity of volumes to market conditions is offset by a price adjustment to ensure revenues are maintained (albeit with a lag). This effect, in turn, reduces the sensitivity of the firm's returns, some of which will be non-diversifiable.

More recently, the AER has commenced a more detailed consideration of the form of regulation and risk. The National Electricity Rules give the AER the scope to choose the form of control to apply to the electricity distributors. The majority of these are subject to weighted average price caps (WAPCs), and the AER is considering changing the form of control to a revenue cap. A primary consideration of the AER appears to be the recovery of efficient costs, with an additional consideration being the distributors' persistent over-recovery of forecast revenue (AER, 2012b: 50-54).

In submissions on this review, Ausgrid, for example, argued that a key issue is the efficient allocation of volume risk. On this point, Ausgrid argued that it should reside with the distributors because they are in the best position to manage that risk (Ausgrid, 2012: 2). On this basis, Ausgrid argued for retaining the *status quo* WAPCs, as their flexibility enables the distributors to manage risk. While the AER agrees that the distributors are the parties best able to manage volume risk, it considers that revenue caps are more appropriate for the distributors:

> *Ausgrid and Essential Energy submitted that volume risk should rest with the DNSP, not the consumer. This is because DNSPs are the best party to manage that risk. The AER agrees with this view and considers this a negative feature of revenue caps...Ausgrid submitted that the profit risk under the revenue cap is determined by the DNSPs cost function. The AER considers that a large proportion of a DNSP's costs are not responsive to small variations in the volume of sales. Consequently, profit under a revenue cap is likely to be more stable and revenue is closer to efficient costs. The AER considers that a WAPC provides a low likelihood of a DNSP recovering their efficient costs (AER, 2012b: 54-55).*

Clearly, both Ausgrid and the AER acknowledge that the form of regulation affects the allocation of risk. Since different forms of regulation will allocate risk differently among the parties, and an element of this risk will be non-diversifiable, the implication of these acknowledgements is that different forms of regulation have different implications for risk-sharing and non-diversifiable risk[49].

Such acknowledgements in this area are significant, especially from the regulated businesses, as it reduces the controversy to the optimal form of control for allocating risk and the associated adjustments to the regulated firm's beta that are required to reflect the firms' actual, non-diversifiable risk. An analytical framework to support specific adjustments has not been developed to date. However, the Authority considers that such a framework has significant merit and warrants further investigation.

[49] However, it is also notable that the AER is not recognising that, under the CAPM, the risk-mitigating feature is the ability of shareholders to eliminate diversifiable risk.

9. CONCLUSIONS

An important conclusion of this paper is that the balance of evidence to date supports the proposition that the form of regulation, in general, serves to change the non-diversifiable risk of the firm as it affects both upside and downside risk. The implication of this proposition for cost of capital estimation in the context of the CAPM is that the regulated firm's beta is affected by the form of regulation and by ancillary mechanisms. In showing that the presence of regulation reduces a regulated firm's non-diversifiable risk, Riddick (1992, p. 151) observes:

> *The implication of these results is that regulators should consider that their actions are reducing the risk of equity in the firm when they set the required, or allowed, rate of return for the firm. This will lower the required return, the revenue requirement, and ultimately lower the rates that the firm charges for its products. Further, any attempts to determine the cost of equity for a regulated firm by using the cost of capital of an unregulated firm as a benchmark are suspect.*

Further, the empirical evidence available shows that this reduction in risk becomes more significant the greater the intensity, or degree of stringency, of the form of regulation itself.

Therefore, given the importance of the form of regulation in determining the regulated firm's returns, it is considered that this issue warrants further exploration.

A following paper will focus on developing principles and a framework for making explicit allowances for the impact of the form of regulation on risk and its incorporation in the allowed cost of capital for firms regulated by the Authority.

APPENDIX A: COST PASS-THROUGH AND NON-DIVERSIFIABLE RISK

Consider now the concept of a cost pass-through - basically, it simply allows the firm to pass through certain, unexpected cost changes to its customers. *A priori*, it would seem that a cost pass-through would reduce the risk, both diversifiable and non-diversifiable (i.e. systematic), of the firm and its investors. However, the effect of a cost pass-through on the firm's non-diversifiable risk fundamentally depends on whether the cost of the input subject to the pass-through co-varies positively or negatively with the market. In the discussion below, the case where the pass-through decreases non-diversifiable risk is given, but the accompanying proof shows that an increase or decrease in non-diversifiable risk is possible.

By way of background, recall that the firm's input cost is negatively, or inversely, related to the firm's profit (i.e. profit = revenue - cost). Therefore, when the input cost is high, the firm's profit is low (and *vice versa*), all else constant. Suppose that the firm's input cost is vulnerable to macroeconomic (i.e. non-diversifiable) shocks; therefore, an economy-wide cost shock will affect the input cost.

For illustrative purposes, suppose that the covariance between the market return and the input cost is *negative*. In other words, when there is a shock that increases the market return, the input cost decreases (i.e. it 'moves against' the market). Analogously, when there is a shock that decreases the market return, the input cost increases. Therefore, regardless of whether the shock has a positive or negative effect on the market return, the input cost moves in the *opposite* direction - this is what it means for the input cost to have negative covariance with the market.

First, assume there is no cost pass-through and an adverse, macroeconomic shock occurs that lowers the market return but input costs increase. This scenario is consistent with input price inflation during a recession. The firm's revenue volatility is negatively affected by the shock, while the firm's cost volatility is positively affected. The effects on volatilities are in opposite directions and so do not mitigate against each other. This is because the input cost enters the firm's profit negatively (i.e. profit = revenue - cost). Consequently, the total (i.e. profit or return) volatility increases.

If a cost pass-through is now put in place, it functions to pass through some of the cost volatility to customers. As a result, it reduces the cost volatility and decreases the firm's covariance of profit with the market return relative to the case of no cost pass-through (i.e. it 'closes the gap' between revenue and cost volatility). The results are reversed if the covariance of the input cost with the market return is positive. In other words, if the cost pass-through affects non-diversifiable risk then beta is affected.

For purposes of this appendix, assume there is a regulated firm that operates in a CAPM world. Following Marshall *et al* (1981), demand is uncertain and unaffected by price. In addition, input costs are uncertain. Suppose under the regulatory regime, and consistent with the 'building blocks' model, the regulator sets the allowed price as the sum of certain costs, specifically: capital (k), labour (l), and a second variable input (z)[50]. The regulator sets the regulated price on the basis of forecast estimates of these input costs such that the regulated price (P) is the sum of the *allowed* costs:

Equation 7 $$\boldsymbol{P = k_A + l_A + z_A,}$$

where the subscript 'A' denotes 'allowed'. The regulator sets the allowed costs, and therefore the price, *ex ante* the realisation of any risk. The firm's uncertain profit ($\tilde{X}$) is the firm's uncertain revenue less its uncertain costs:

[50] Without any loss of generality, the model ignores asset depreciation, taxes, and other complicating factors.

Equation 8 $$\tilde{X} = P\tilde{Q} - (\tilde{k} + \tilde{l} + \tilde{z})\tilde{Q},$$

where $\tilde{Q}$ is the firm's uncertain output and $\tilde{k}$, $\tilde{l}$, and $\tilde{z}$ are the risky per unit costs of capital, labour, and the variable input, z. Using equation (7), equation (8) can be rewritten as:

Equation 9 $$\tilde{X} = [(k_A - \tilde{k}) + (l_A - \tilde{l}) + (z_A - \tilde{z})]\tilde{Q}.$$

If the regulated firm has no provision for cost pass-through then its uncertain profit is given by equation (9). In this case, the firm's investors will absorb any fluctuations of actual costs from the allowed costs. The net effect on the firm's underlying profit depends on whether or not the term in [ ] is positive or negative.

Suppose that the regulator deems the input cost (z) to be unmanageable by the firm and makes it subject to a cost pass-through, where α ($0 \leq \alpha \leq 1$) is the proportion of the input cost that is passed through to customers. Therefore, if $\alpha = 0$ there is no cost pass-through, and if $\alpha = 1$ there is full cost pass-through. Suppose in this case, there is partial pass-through and, therefore, $0 < \alpha < 1$. The risky profit for the firm with the pass-through is:

Equation 10 $$\tilde{X}_{PT} = [(k_A - \tilde{k}) + (l_A - \tilde{l}) + (1 - \alpha)(z_A - \tilde{z})]\tilde{Q},$$

where the '*PT*' subscript denotes the risky profit of the firm with the cost pass-through. In words, the firm is allowed z_A but faces the random cost, $\tilde{z}$. Once the random cost $\tilde{z}$ is realised then the allowance is adjusted (instantaneously) such that the variability of the realised cost from the allowed cost that the firm bears is $(1 - \alpha)(z_A - \tilde{z})$. The difference in risky profits between the firm without, and with, the pass-through is then:

Equation 11 $$\tilde{X} - \tilde{X}_{PT} = \alpha(z_A - \tilde{z})\tilde{Q}.$$

The next step is to invoke the CAPM to show the implications of this difference for the firms' non-diversifiable risks. Specifically, under the Sharpe-Lintner-Mossin CAPM, the measure of non-diversifiable risk is:

Equation 12 $$\beta = \frac{cov(\tilde{X}, \tilde{X}_M)}{var(\tilde{X}_M)},$$

where:

β	the systematic risk of the firm (i.e. 'beta')
cov (•)	the covariance operator
var (•)	the variance operator
$\tilde{X}$	the risky profit of the firm
$\tilde{X}_M$	the risky profit of all assets (i.e. the market portfolio).

Substituting equation (8) for $\tilde{X}$ into (12), gives the beta of the firm without a cost pass-through:

Equation 13 $$\beta = \frac{cov([P - (\tilde{k} + \tilde{l} + \tilde{z})]\tilde{Q}, \tilde{X}_M)}{var(\tilde{X}_M)}.$$

Analogously, the beta for the firm with a cost pass-through is:

Equation 14 $$\beta_{PT} = \frac{cov([P - (\tilde{k} + \tilde{l} + \tilde{z}) - \alpha(z_A - \tilde{z})]\tilde{Q}, \tilde{X}_M)}{var(\tilde{X}_M)}$$

After expanding equations (13) and (14) using covariance operations and then rearranging terms, the difference in non-diversifiable risk given the pass-through is:

Equation 15 $$\boldsymbol{\beta - \beta_{PT} = \alpha \left[\frac{cov(z_A\tilde{Q},\tilde{X}_M)}{var(\tilde{X}_M)} - \frac{cov(\tilde{z}\tilde{Q},\tilde{X}_M)}{var(\tilde{X}_M)}\right]}$$

The first term inside the brackets of equation (15) can be rewritten:

Equation 16 $$\boldsymbol{\frac{z_A cov(\tilde{Q},\tilde{X}_M)}{var(\tilde{X}_M)}}.$$

For the second term, let $\Delta z = \tilde{z} - E(\tilde{z})$, $\Delta Q = \tilde{Q} - E(\tilde{Q})$, and $\Delta\tilde{X}_M = \tilde{X}_M - E(\tilde{X}_M)$.

Using these definitions, the second term on the right side of equation (15) can be expanded by applying the rule for the covariance of products of random variables (Bohrnstedt and Goldberger, 1969: 1441):

Equation 17 $$\boldsymbol{\frac{cov(\tilde{z}\tilde{Q},\tilde{X}_M)}{var(\tilde{X}_M)} = \frac{E(\tilde{z})cov(\tilde{Q},\tilde{X}_M) + E(\tilde{Q})cov(\tilde{z},\tilde{X}_M) + E(\cdot)E[(\Delta\tilde{z})(\Delta\tilde{Q})(\Delta\tilde{X}_M)]}{var(\tilde{X}_M)}}.$$

Given the assumption of multivariate normality, all third moments are zero. Therefore, equation (17) becomes:

Equation 18 $$\boldsymbol{\frac{cov(\tilde{z}\tilde{Q},\tilde{X}_M)}{var(\tilde{X}_M)} = \frac{E(\tilde{z})cov(\tilde{Q},\tilde{X}_M) + E(\tilde{Q})cov(\tilde{z},\tilde{X}_M)}{var(\tilde{X}_M)}}.$$

Substituting this equation, along with equation (16) into equation (15) gives:

Equation 19 $$\boldsymbol{\beta - \beta_{PT} = \alpha \left[\frac{z_A cov(\tilde{Q},\tilde{X}_M)}{var(\tilde{X}_M)} - \frac{E(\tilde{z})cov(\tilde{Q},\tilde{X}_M) + E(\tilde{Q})cov(\tilde{z},\tilde{X}_M)}{var(\tilde{X}_M)}\right]}$$

Let $E(\tilde{z}) = z_A$. Then this equation simplifies to:

Equation 20 $$\boldsymbol{\beta - \beta_{PT} = -\alpha E(\tilde{Q})\frac{cov(\tilde{z},\tilde{X}_M)}{var(\tilde{X}_M)}}.$$

From this equation, if the covariance of the input cost, z, with the market return is negative then the difference in betas is positive. The implication is that the beta of the firm without the pass-through is greater than the beta of the firm with the pass-through. In other terms, if the covariance of the input cost with the market is negative then the pass-through reduces non-diversifiable risk. On the other hand, if the covariance of the input with the market is positive, the implication for beta is reversed.

APPENDIX B: MERITS REVIEW UNDER THE AUSTRALIAN COMPETITION TRIBUNAL

In Australia, certain businesses in the electricity and gas sectors have an option to initiate a merits review of regulatory decisions with the Australian Competition Tribunal (ACT, the Tribunal)[51][52]. Individual elements can be appealed on their merits. To date, appeals have been made predominantly by the regulated firms. In general, successful appeals result in the firm being able to increase its price, while for unsuccessful appeals, the AER's decision stands, and the only cost to the firm is the litigation cost.

For the purpose of review, the Tribunal can exercise all the powers of the original decision-maker and can affirm, set aside, or vary the original decision. The Tribunal does not consider the entire decision of the original decision-maker but is limited to only those matters where it is claimed that a ground of review can be substantiated.

The current provisions for seeking a merits review in electricity and gas were introduced into the legislation in 2008. Since their introduction, a majority of the revenue determinations made by the AER have been appealed to the Tribunal. Relevantly, Fels (2012) reports that, from 2008 to 2011, 20 of 24 (15 in electricity and 5 in gas distribution) decisions made by the AER were appealed to the Tribunal.

The appeals raised 87 substantive issues with the Tribunal, with issues relating to the cost of capital being most commonly appealed, accounting for 37% of all issues appealed, followed by RAB/valuation at 23%, and opex/capex at 16%. Of the 87 issues appealed to the Tribunal, 67 were raised by the regulated businesses, 10 by the relevant Victorian Minister, and 10 by consumer groups[53].

As at March 2012, of all decisions necessary to resolve (i.e. given leave and/or not withdrawn), the Tribunal either varied or remitted the decision 56% of the time, while rejecting the appeal 44% of the time. In decisions in which the Tribunal has made a final determination, about $3 billion in revenue across those decisions has been at stake.

Increasingly, affected parties are raising concerns with the Tribunal's merits review process, particularly with respect to two aspects. The first concern with the current process is that it is not conducive to robust consumer representation and participation. One reason cited for this situation is that the National Electricity Law (NEL) requires that applicants demonstrate that the issues to be heard might result in a revenue change of $5 million or 2% of the average revenue. Customers might not have the skills or resources to quantify the amount in dispute and, if not, are unable to participate in the process. This concern has been raised frequently (see, for example, Biggar (2011: 16-18)). Further, Fels concludes that "the current institutional framework for consumer participation in the energy sector is inadequate" (Fels, 2012: 66).

The second concern is that the process under the current legislation gives the regulated firms the incentive to 'cherry-pick' the AER's decisions by applying for review only with respect to issues

[51] Merits review is a process that allows a second governmental decision-maker, often a tribunal or similar panel of experts, to 'step into the shoes' of the primary decision-maker and re-determine administrative decisions according to the merits of each individual case. It is a fundamentally different process to judicial review, where a court determines whether an administrative decision was lawful. Judicial review does not involve the decision being re-determined, and does not require a judge to make an assessment as to the merits of each individual case.
[52] The Australian Competition Tribunal is a review body established under the Trade Practices Act 1965. The ACT hears applications for review of determination of the AER, under the merits review provisions in the National Electricity Law (NEL) and the National Gas Law (NGL). Under the NGL, decisions of regulators other than the AER might also be subject to review by the ACT, however the majority of appeals to date have related to the decisions of the AER.
[53] The Tribunal denied leave to 2 of the 20 matters raised by groups other than the regulated firms.

where they believe they have the strongest case and for which there is a material, commercial payoff[54]. The argument is that an appeal is a 'one-way bet' for the regulated firm, as legal costs aside, the impact of an appeal is, at worse, financially neutral for the regulated firm. The use of the process by the regulated firms to shift regulatory outcomes further in their favour has been observed by Biggar (2011) and other prominent parties that are external to that process (for example, see Mountain and Littlechild (2010)).

Fels (2012), however, argues that there is a lack of evidence supporting the occurrence of 'cherry-picking' and it would be inconsistent with notions of good governance to remove it entirely (Fels, 2012: 52). Fels (2012) further argues that, in any event, the asymmetric correction of errors (i.e. correction of only those errors in favour of the applicant) is preferable to an alternative where all errors remain uncorrected (Fels, 2012: 52).

On this last point, it is not necessarily correct that an outcome where some errors are selectively corrected is preferable to an outcome where all errors remain uncorrected. If the objective of the over-arching regulatory process is to get the final price 'right' then correcting a certain subset of errors might move the final price farther from the 'right' price. This possibility occurs because the decision that is subject to review is likely to contain errors that have countervailing effects on the final price. In other words, it will contain a subset of errors that increases the price away from the 'right' value, and another subset of errors that decreases the price away from the 'right' value. If the two subsets of errors are equally likely to occur and comparable in magnitude, then the net effect of only correcting the subset of errors that biases the price down is to move the revised price farther from the 'right' price than if no corrections were made.

To illustrate this point, suppose that a complex regulatory determination provides a final price of $5.00 per unit. However, in arriving at that price, the regulator errs by making two sets of mistakes, each of which has the effect (across each subset of mistakes) of changing the price by $1.00 - but in opposite directions. As a result, if all mistakes are corrected then the outcome would still be $5.00 because correcting one set of mistakes increases price by $1.00, while correcting the second set of mistakes decreases price by $1.00. However, if the regulated firm now selectively and successfully appeals one subset of errors, the correction of which benefits the firm, then the price increases by $1.00. This outcome is worse than the *status quo*, as the new price of $6.00 is higher than the 'right' price of $5.00.

[54] This circumstance arises, in part, because the review process is legally restrictive with respect to subject matter, standing, and evidence that can be brought to the Tribunal. As a result, of this relatively narrow scope of review, claims are that the Tribunal does not appreciate the interrelationship between the subject of the appeal and matters that are not the subject of appeal (known as the "in context concern"). Proposed alternatives include changing the legislative process to allow a full *de novo* review. In this circumstance, it is not possible for the 'cherry-picking' or the 'in context' concerns to arise, as in such a review, the Tribunal would re-make the entire decision, including by making any necessary trade-offs (Fels, 2012: 52).

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