Regulatory Risk

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by

Henry Ergas, Jeremy Hornby, Iain Little and John Small

Network Economics Consulting Group*

Abstract

Assets with a value of over $130billion are regulated in Australia. We define regulatory risk as being regulation that increases the cost of servicing this capital and analyse the sources of this risk. We show that unbiased and symmetric errors will generally create asymmetric risk for the firm, that investors cannot fully diversify against this risk, and that the CAPM beta may even fall when it occurs. The paper concludes with recommendations aimed at reducing regulatory risk.

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1 Introduction

When government agencies administer controls over the commercial activities of private firms, capital invested in those firms is exposed to an additional source of risk. Because the nature of these controls varies across industries and regulators, the resulting "regulatory risk" has many different forms and consequences. One consequence of this diversity of causes and effects is that the nature of regulatory risk is not well understood. This in turn limits the extent to which the costs of regulatory risk can be estimated, and measures can be designed to minimise these costs.

This paper begins by presenting some empirical evidence on the size of the regulated sector in Australia. We use these data to consider both the current costs of regulatory risk and its possible impacts on investment patterns. This section simply demonstrates that the scale of the impact of regulatory risk is very significant.

We then proceed to a more formal analysis, beginning with a definition of regulatory risk. Our definition is presented in section three and centres on the cost of attracting and retaining capital in the firm. Increases in this cost that are caused by regulation are defined as regulatory risk. We discuss the main sources of this risk, which include the length of the regulatory period, the amount of discretion accorded to the regulator, and the diversifiability of the resulting risk. In addition, we show how symmetric errors in setting the parameters of regulatory models induce outcomes for the regulated firm that are in general asymmetric.

In section four, we characterise the firm's information about regulatory preferences using a simple model of learning and signalling. The firm needs to form expectations about the outcomes from future regulatory decisions, and each decision results in an updating of these expectations. Using this framework, we are able to derive some qualitative predictions about the impact of this type of informational asymmetry. These point to the need for regulators to strive for consistent decision making and also suggest that regulatory risk could be lower in regimes where regulators have long tenure and wide jurisdiction, since these enhance both accountability and credibility.

Section five builds on this analysis by considering the impact of regulatory risk on investment. Two subsections address the decisions of portfolio investors, and the real investment analysis performed within individual firms. We use a simulation model and theoretical analysis to demonstrate the perverse predictions that arise from the frequently used capital asset pricing model in the presence of regulation. In respect of real investment, our analysis uses a real options framework and concludes that unpredictable regulation will generally deter investment.

The paper concludes with some thoughts about the extent to which some regulatory risk is inevitable, and positive suggestions about how unnecessary risk can be reduced without compromising other regulatory goals. These focus on the need for increased levels of credibility and accountability by regulators. We argue that increasing the scope and tenure of regulators may help them to develop multi-sector credibility and increase their sense of accountability for long-term performance.

2 The Scope of the Problem

Assets with a value of over $130billion are regulated in Australia, either under the terms of the Competition Policy Agreement or of statutory instruments (such as Part XIC of the Trade Practices Act) that share some similarities with that Agreement. The distribution of these assets across regulated industries is shown in Figure 1 for the 1998-99 year,[1] but these data exclude some assets (mainly water) for which data is not available.

Figure 1: Value of regulated utility sector 1998-99

Regulated industry	Indicative regulated asset base ($bn)	Indicative economic asset life	Annual depreciation based on indicative asset life ($m)	Return on capital -10% WACC ($m)
Electricity	32	20	1,600	3,200
Gas	13	50	260	1,300
Water	39	70	557	3,900
Telecoms	28	12	2,333	2,800
Rail	16	40	400	1,600
Ports	3	30	100	300
Airports	3	30	100	300
Total / average	134		5,350	13,400

Figure 1 also provides an indicative estimate of the associated capital related costs. Assuming a simple WACC of 10% and using straight line depreciation based on standard regulatory practice / decisions, we estimate that capital related costs are around $18 billion per annum. This is approximately 3% of GDP per annum. If regulatory risk were to increase the rental cost of this capital by 1%, total costs would rise by $180million per annum.

Apart from affecting the annual costs of funding assets that are currently sunk into regulated industries, the biggest danger of regulatory risk is that it can choke off otherwise desirable investment in new technologies and equipment. We explain below that a key deterrent of investment is the difference between typical asset lifetimes and the span of regulatory cycles. Figure 2 sets out, for each of the major regulated industries, the asset life of the predominant asset and compares this with the regulatory cycle. It shows that for most industries, the major asset has an asset life in excess of 8 times the standard regulatory period. As a result of this gap between asset lives and regulatory cycles, investors in these industries cannot secure a high degree of commitment, from regulatory authorities, about the manner in which the returns on long-lived assets will be determined.

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[1] This data was sourced from regulatory decisions, annual reports and the Productivity Commission report *Financial Performance of Government Trading Enterprises 1994-95 to 1998-99 - Performance Monitoring Report*

Figure 2: Relationship between asset life and regulatory cycle

Regulated industry	Major asset	Economic life major asset	Typical regulatory cycle	Ratio economic life to regulatory cycle
Electricity	Poles	45-55	5	9-11
Gas	Pipelines	80	5	20
Water	Mains	70-90	3-5	14-23
Telecoms	Copper pair	20	ad hoc/3	7+
Rail	Track	40	5	8
Ports	Channel improvements	30+	5	6+
Airports	Runway (ave)	30-40	3-5	8-10

Long asset lives are reflected in high average ages for the capital stock. The following figure shows the average age of the capital stock across a range of industries, and is notable for the relatively old capital being used in the regulated electricity gas and water sectors. Even in telecommunications, where technological progress is rapid, the capital stock is more than 10 years old on average.

High average ages of the capital stock may partly reflect relatively slow demand growth, though this is not apparent from the results of correcting for the growth rate of the net capital stock. Additionally, in some regulated industries, there may be an overhang of excess capacity resulting from uncommercial investments carried out under public ownership. Nonetheless, it is also likely that the industries at issue will face considerable investment demands in the medium-term, as now rather old assets come up for replacement. As a result, an increase in the cost of capital due to unnecessary regulatory risk could impose a significant burden on the community.

Figure 3: Average age of capital stock

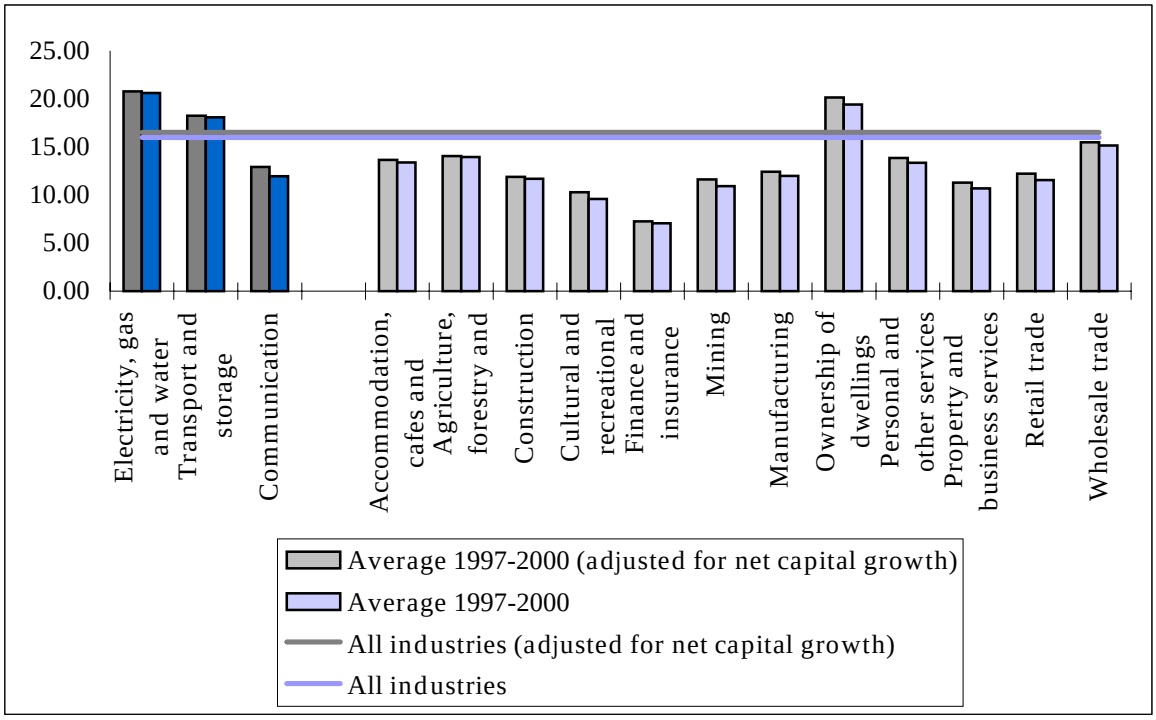

Figure 4 provides an estimate of the size of business revenue at stake in a number of recent regulatory decisions in Australia. The net present value of the gross[2] revenue stream initially proposed by the regulated business is compared to the net present value of the gross revenue stream subsequently allowed by the regulator. This difference is set out in NPV$ terms and as a proportion of the regulatory asset base to place these figures in perspective.

To the extent that the business proposals are cast as part of a negotiation process, the figures may represent an overestimate, but can nonetheless be viewed as indicative of the sums involved.

For example, the ORG decision on Victorian distribution businesses reduced the NPV of the gross revenue stream for the Victorian businesses to approximately $1.8 billion below that proposed by the businesses – equivalent to 38% of the regulated asset base.

Figure 4: Recent regulatory decisions – estimate of revenue at stake

			Estimate of gross revenue (NPV$bn)		Difference	
Regulator	Business	Date	Business proposal	Regulator decision	NPV$bn	as % of RAB
ORG	Victorian distribution	2000	12.7	11.0	1.8	38%
ACCC	EAPL	2000	1.0	0.7	0.3	64%
ACCC	SACL	2001	2.8	2.3	0.5	34%
ACCC	Telstra PSTN	2000	6.1	4.6	1.5	5%
IPART	AGLGN	1999	4.1	3.5	0.6	35%

This analysis assumes that gross revenue proposed or allowed in the final year of the regulatory period in question continues in perpetuity. Revenues are discounted using the WACC proposed by the businesses for that regulatory decision. The value of the regulatory asset base used for comparisons is the lower of the business proposal and the regulator's allowance where relevant

Care must be taken in comparing these estimates. For example, for the estimate of the impact of the ACCC-Telstra PSTN decision:

- this decision resulted in a reduction in gross revenue of 25%, but a smaller reduction when compared to Telstra's regulated asset base. However, this decision only directly affected a fraction of Telstra's regulatory asset base – compared with the other decisions in the table which related to all company activities;

- The ACCC - Telstra PSTN decision would have additional impacts on Telstra's business not included in the estimate in Figure 4. Given that terminating and originating access is an input price into other services

[2] ie inclusive of operating and maintenance costs

provided by Telstra – namely STD and IDD - this decision would have reduced the prices Telstra would be able to charge in these markets. Given that these markets are competitive, and that any reduction in input prices would be passed on to consumers, it is estimated that the overall effect of the ACCC's decision would be to reduce Telstra's revenue (in NPV terms) by $2.8bn from Telstra's initial proposal – a reduction in gross revenue comparable to 10% of its regulatory asset base.

For the decisions outlined above, Figure 5 provides an estimate of the major factors accounting for the differences in the two revenue streams[3]. The predominant factor in all these decisions is the importance of the regulator's decision on the return on asset – which reflects decisions with respect to asset valuation and WACC. The importance of these factors is disproportional to their respective importance in the annual revenue requirement. This is not unexpected, particularly in decisions where the value of the asset base is subject to review (eg SACL, EAPL).

Overall, these estimates highlight both the extent of the impact regulatory decisions can have and the range and significance of the economic activity thereby affected. Better understanding and managing the risks regulation can create is therefore likely to be of substantial importance.

Figure 5: Factors accounting for difference in revenue stream (%)

Regulator	Business	Return on capital	Depreciation	O&M
ORG	Victorian distribution	81%	-13%	31%
ACCC	EAPL	63%	37%	0%
ACCC	SACL	75%	13%	12%
ACCC	Telstra PSTN	100%	0%	0%
IPART	AGLGN	36%	30%	34%
Average of these decisions		80%	3%	17%

3 Definition and taxonomy of regulatory risk

We define regulatory risk through its effect on regulated firms. Regulatory risk arises when the interaction of uncertainty and regulation changes the cost of financing the operations of a firm. This definition is broad enough to include all of the important sources of uncertainty, but restricted to those for which the effect on the firm arises from, or is magnified by, the existence of regulation. Further, it excludes changes that induce windfall

[3] These figures should be considered as indicative as the variables included in the table are not necessarily mutually exclusive

capital gains and losses except to the extent that such changes also affect the discount rates of investors.[4]

An important advantage of this focus on discount rates is that it links the impact of risk on portfolio investors with decisions made within the firm over real investment opportunities. If a real investment project is to be undertaken, it is necessary, though not always sufficient,[5] that it be expected to cover the cost of capital.

Our definition imposes no particular "sign" on the effect of regulatory risk, so it is also possible for such risk to reduce the discount rate of a firm. For example, an increase in the level of regulatory risk faced by a firm subject to direct regulation, may lead investors to alter their portfolios in favour of some other firm (this is demonstrated below using a simulation study). An important question to be addressed below concerns the impact of such a shift on the distribution of capital costs across firms.

3.1 Types of uncertainty

Regulatory risk cannot arise without uncertainty, and it is useful to distinguish two broad categories of uncertainty. We define "market uncertainty" as being that which would remain if all relevant regulatory interventions ceased. Market uncertainty arises from the normal stochastic interaction between buyers and sellers across all markets. This includes the impact of external cost shocks, unanticipated technological advances, shifts in preferences, changes in the distribution of income across people, and changes in the distribution of people across regions.

Although the effects of market uncertainty are felt by all firms, irrespective of whether they are regulated or not, this does not make market uncertainty irrelevant in the assessment of regulatory risk. On the contrary, because this wider market uncertainty represents the alternative opportunities available to portfolio investors, the interaction between it and the returns required by investors in regulated assets is crucial to determining the effect of regulatory risk.

The second type of uncertainty arises from the existence of regulatory discretion. One of the most fundamental reasons for addressing competition issues through regulation rather than through legislation is that a complete set of rules is very difficult (if not impossible) to specify in advance, and the costs of adapting pre-specified rules to changing circumstances through legislative amendment are considered to be greater than those of relying on regulatory decisions made within the terms of more open-ended standards.[6] Thus,

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4 This could be achieved by a regulator who is about to be retire. If everyone knows that a new person will be responsible for policy in the future, and believed that the probability of a second value cut was extremely low, then the cost of capital might not increase appreciably.

5 Real options, which may increase the "hurdle rate" for projects beyond the cost of capital, are discussed in more depth below.

6 See especially D. J. Galligan (1986) Discretionary Powers: A Legal Study of Official Discretion, Oxford, who defines "discretion" as the power to take a decision when there is no pre-defined "right" answer (at page 7) or more precisely as the consequence of "an express grant of power conferred on officials where determination of the standards according to which power is to be exercised is left largely to them". In a famous analogy, the eminent legal theorist Ronald Dworkin has described discretion in terms of a doughnut – where discretion is the hole in the middle, while the doughnut itself constitutes

regulators always have some non-trivial decisions to make. As a consequence, the outcomes from the future stream of regulatory decision making processes cannot be predicted with certainty. We refer to this as "regulatory uncertainty" because it is a direct consequence of regulatory discretion.

Regulatory risk is the expected cost of the interaction of regulatory controls with uncertainty of both types. Thus, a high level classification of uncertainty types does not provide a complete taxonomy of the sources of regulatory risk. We propose such a classification in the next section.

3.2 Sources of regulatory risk

Market uncertainty is the constant companion of all commercial activity, whereas regulatory uncertainty only exists for those activities that are actively controlled by a regulator in some way. It is possible to impose regulations without allowing any regulatory discretion, however, and in this case there is no regulatory uncertainty. Accordingly, we consider two primary sources of regulatory risk, which are distinguished by the presence or absence of regulatory discretion.

3.2.1 Certain regulation

We begin with the polar case in which regulatory uncertainty is completely absent, though regulatory controls exist. A key feature of this form of regulation is that there is no future date at which the controls will be re-evaluated, since any such re-evaluation creates non-market risk. This longevity alone creates regulatory risk, because the evolution of costs and demand over medium to long periods is inherently uncertain. Example 1 illustrates this risk through a case study of the Kiwi Share.

Example 1: The Kiwi Share

When the New Zealand government privatised the state-owned telephone company in 1990, it retained a single share, dubbed the "Kiwi Share" which placed certain obligations on the new owners. In particular, Telecom New Zealand is required to offer to all residential subscribers, on an ongoing basis:

- Untimed and free local calls; and
- Geographically averaged line rentals that increase at no more than the rate of CPI inflation.

Telecom is only entitled to relief from these obligations if the profitability of the company is unreasonably impaired by them. There is no review date. Since 1990, and particularly since the advent of the internet, the demand for local calls has changed dramatically with average call durations more than doubling. The provision of capacity to serve this additional network load was obviously detrimental to the income of those investors who held Telecom stock at the time this capacity was required. This is a realisation of the risk embodied in the Kiwi Share obligation.

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the surrounding standards and constraints: his main discussion of discretionary powers is in R . M. Dworkin (1977) Taking Rights Seriously, London at pages 31-9, 68-71.

3.2.2 Uncertain regulation

When controls are administered by an active regulator, additional sources of risk arise from the fact that the future decisions of that regulator (and his successors) are not fully predictable. Any particular decision by the regulator will affect the payoff to the regulated firm, and its rivals. While individual decisions are therefore important to investors, it is the beliefs of investors about the future distribution of returns that feeds into the calculation of regulatory risk.[7]

Three factors directly effect the cost of regulatory risk. These are: the frequency of decision points; the level of discretion available at each decision point; and the diversifiability of the resulting risk. We discuss each of these in turn.

3.2.3 Frequency of decisions

Regulatory risk only arises in the presence of sunk costs. If no funds have been committed to long-lived assets, any regulatory decision that prevents the firm from covering its average costs will simply provoke immediate exit from the market. There would be no increase in future costs, unless a perverse regulatory outcome drove out relatively low cost suppliers.

Similarly, if long-lived assets are required to provide the regulated service, a regulatory contract of similar duration could eliminate this component of regulatory risk in respect of those assets. It is only when the terms of the (usually at least partly implicit) regulatory contract are able to be re-set before the end of the life of the relevant assets, that regulatory risk arises. In this case, regulatory risk increases with the frequency of the re-set dates.

3.2.4 Level of Discretion

If the regulator is required by law to follow an exact and complete set of rules when making decisions, non-market risk would be eliminated. This is generally not feasible, however, and regulators typically do have considerable freedom to make determinations that affect the payoff to the firm.

Even limited and incomplete regulatory rules can reduce the risk arising from discretionary powers, however. For example, suppose that the regulator is given the right to require the firm to invest or not invest in particular projects. This creates significant discretionary power but may not lead to a reduction in the value of the firm if the regulator is also required to ensure that the firm continues to earn a specified rate of return on capital.

Firms need to form expectations about the outcome of future regulatory decisions in order to evaluate the business case for investment projects. In forming these expectations, the firm will look to any past history of regulatory decision-making by the same people, and will update these expectations each time a new decision is observed. This learning process implies that regulatory uncertainty is highest, early in the tenure of a new regulator.

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[7] Investors' beliefs about the future distribution of returns, when combined with information on the returns available from alternative stocks, determine the cost to the firm of retaining financial support. Because our definition of regulatory risk is focussed on the cost of capital, the interaction between anticipated distributions of returns from the regulated firm and the market portfolio is central to this analysis.

3.2.5 Diversifiability of Risk

The incidence of regulatory risk is also relevant when considering the cost of this risk, for two reasons. First, the social cost of risk depends on its incidence, and will be minimised by allocating regulatory risk to those best equipped to deal with it. Secondly, the incidence of regulatory risk also affects its cost to investors, who have the ability to diversify some types of risk across a market portfolio. We address the diversifiability of regulatory risk further in section 4 below.

3.3 Estimation Error Effects

Regulators operate without full information about the regulated firm, and must therefore estimate the relevant parameters, such as the WACC. Any given determination of a regulator is therefore likely to include some estimation error. In this section we show that even if there is no bias in the regulator's estimation (so that the expected value of each parameter estimate is equal to the true parameter), the consequences of such errors are asymmetric, to the detriment of the firm's income. This result only relies on very weak assumptions about the properties of cost and revenue functions.

The economic profit of the firm can be written as follows:

$$\Pi(p) = R(p) - C(p)$$

where R(p) is the revenue function, C(p) is the cost function and p is the vector of prices. Under very general conditions, the revenue function is concave and the cost function is convex, so the profit function is concave in prices.[8] The regulator controls the firm's prices, either implicitly (for example by specifying a rate of return) or explicitly (as in a price cap), and thereby prevents the firm from optimising against the demand curve. The firm retains the ability to minimise production costs, though the minimum cost function is fixed in the short run.

Suppose for concreteness that the regulator attempts to set the price directly at the level that is consistent with the firm making zero economic profits. Let p_R be the price that achieves this goal exactly, so that $\Pi(p_R)=0$, and consider the effect of estimation error that results in a mean-preserving spread around p_R. For example, suppose that instead of correctly estimating p_R, the regulator instead sets $p_H = p_R + \delta$ or $p_L = p_R - \delta$, with equal probability. Over many estimates the regulator is correct on average, but any single estimate is always wrong. Although the average regulatory error is zero, the average consequence is an economic loss. This result derives exclusively from the concavity of the profit function. Using the definition in footnote 4 with $\alpha = ½$, this concavity implies that

$$\Pi(½p_L + ½p_H) > ½\Pi(p_L) + ½\Pi(p_H)$$

Since $p_R = ½p_L + ½p_H$ by construction, we can rewrite this as

$$\Pi(p_R) > ½\Pi(p_L) + ½\Pi(p_H)$$

Recall that p_R was defined to ensure that $\Pi(p_R)=0$. Thus

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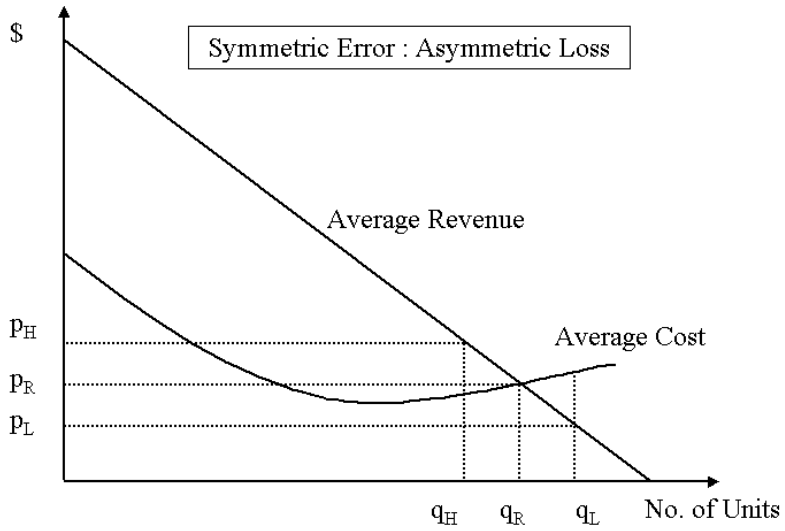
8 If f(x) is concave, then for any α (where $0 \le \alpha \le 1$), $f(\alpha x' + (1-\alpha)x'') > \alpha f(x') + (1-\alpha)f(x'')$.

$$0 > \tfrac{1}{2}\Pi(p_L) + \tfrac{1}{2}\Pi(p_H)$$

which says that the firm makes a loss, even when the regulator estimates p_R correctly on average. This result is nothing more than an application of Jensen's Inequality[9] to the (concave) profit function of a regulated firm.

3.3.1 Compensation for unbiased error

Because the loss arising from unbiased regulatory error is directly related to the curvature of the regulated firm's profit function, it is theoretically possible to estimate the size of the loss. To do so, we need to combine the probability distribution of the estimation errors with the firm's profit function. The following diagram, which is based on a uniform distribution of errors, illustrates the idea.



The diagram shows a simple case in which the firm charges linear prices (i.e. without fixed monthly charges or price discrimination), and the regulator estimates the regulated price that gives zero economic profit p_R imperfectly, selecting p_H and p_L with equal probability, where these are as defined above. Concentrating on the difference between the profit arising from p_H and the loss from p_L, allows us to ignore the large surplus rectangles $q_H(p_H - p_R)$ and $q_H(p_R - p_L)$, these being of equal size. The expected profit difference from this form of regulation is the difference in the area between the demand curve and the average cost curve over the region from q_R to q_H (which is the "upside" from a positive error) and over the region from q_R to q_L (which is the "downside" from a negative error). If the average cost function is convex, the downside is greater than the upside.

If we define the demand and cost properties as functions of the output level q, so demand is p(q) and cost if C(q), we can estimate the loss arising from random error as:

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9 Jensen, J.L.W.V. (1906) "Sur les fonctions convexes et les inegaites entre les valeurs moyennes" Actuarial Mathematics, 30, pp. 175-193.

$$L = \int_{q_R}^{q_L} (C(q) - p(q))dq - \int_{q_H}^{q_R} (p(q) - C(q))dq$$

The first term on the right hand side is the the loss arising from setting the price at p_L and the second term is the profit from setting the price at p_H.

3.3.2 Non linear pricing

Many utilities set two-part tariffs, comprised of a monthly fixed fee plus a usage sensitive charge, rather than a simple linear price. If this type of tariff structure materially affects the curvature of the profit function, it will also change the amount of compensation required. While a complete analysis of this issue is beyond the scope of the present paper, two points are relevant.

First, more sophisticated tariff structures will not alter the fact that the revenue function is concave. This follows from the very weak proposition that there is some limit to the average monthly outlays on service that can be achieved.

Secondly, it seems at least plausible that the revenue function will be more concave when non-linear tariffs are used than when they are not. This is because the firm is able to capture a greater share of the total surplus with non-linear tariffs. Since producer and consumer surplus are both concave functions of feasible output levels, it is at least plausible that their sum will be more concave than either one individually.

3.3.3 Competitive effects

The above analysis has implicitly considered monopolies, whereas some regulated firms face competition for the supply of the regulated service. Many incumbent telecommunications companies, for example, sell network access services at the wholesale level to their retail market competitors. In these cases, the asymmetric effect of unbiased (i.e. symmetric) errors in the setting of regulatory parameters is reinforced by competitive investment behaviour.

When the access price is set at p_L, renting access is unambiguously preferred to building infrastructure. This follows directly from the facts that $p_L < p_R$ and $\Pi(p_R)=0$. When the price is too high, however, potential access seekers face a non-trivial build/buy decision. They will not necessarily build when faced with an access price of p_H, because of the impact of real options (see below) and the effect of the additional capacity on the earning power of the asset under consideration. However, the fact that the investment decision is non-trivial suggests that investment will occur in some cases. The resulting decline over the long-term in expected demand for the services of the regulated asset reduces the value of that asset.

This effect reinforces the conclusion that symmetric errors in regulatory price setting have asymmetric impacts on the regulated firm.

4 Learning and Signalling

Inherent in any regulatory relationship are information asymmetries where the information known by one party is not shared with the other. These asymmetries may favour either party. The incentive regulation literature emphasises the case where the regulator is

disadvantaged in not knowing the firm's inherent efficiency (or "type"). In this section we consider the reverse case, in which the firm knows less than the regulator about the intentions of the regulator, or more generally, of what type the regulator is.[10]

Given this uncertainty, the firm must make an assessment of what it expects the regulator's type to be, in order to forecast its returns on existing and future investments (if a regulation is expected to be heavy-handed then the firm will expect to earn lower regulated returns than if the regulation is expected to be light-handed). The firm will construct its expectation using the information that it possesses, that is, the history of the regulator's decisions. Consequently, if the regulator has a history of imposing heavy-handed regulations then the firm will expect future regulations to be more heavy-handed than light.

The regulator, therefore, influences the firm's expectation of future regulations with its choice of present regulation. In this sense, current regulation has two roles: the first is the immediate realisation of social gains; and the second is "signalling" future regulatory settings to the firm. Because these future settings are key determinants of the return to regulated capital over the medium term, the regulator's signalling activity has a direct effect on investment. Two attributes of the regulator's signalling are particularly important: consistency and credibility. We discuss each of these separately.

4.1 Consistency of signals

The strength of the regulator's signal, which can be measured by the consistency of its decisions, influences the degree of regulatory risk faced by the firm. This is best explained in the following example.

Suppose the decisions of regulators can be classified into types situated along a continuum. At one end is a regulation that will expropriate all the firm's returns from sunk investments, and at the other end is a regulation that will allow the firm to operate without impediment.

If, in one extreme case, the regulator makes its decisions from a random draw from the continuum, its history will provide no guidance to the firm when it constructs its expectations of future regulation. The firm will expect that any forthcoming regulations are just as likely to be heavy-handed as light-handed or anywhere in between. This inability to make reliable predictions about the regulator's future decisions adds non-market risk and thereby increases the firm's exposure to regulatory risk.

Suppose, in the other extreme, the regulator commits to a place near the middle of the continuum and, henceforth, all its decisions are consistent with that commitment. After some history of regulation has developed, the firm will soon see that all regulation is of the same type and will not expect future regulation to deviate very far from its average. In this case the reliability of the firm's expectations is enhanced (relative to the previous case where the regulator made decisions randomly), and consequently the regulatory risk faced by the firm is reduced. This example has shown that the regulator can use signalling to make a commitment to its type, having the direct result of decreasing the regulatory risk that is otherwise imposed on the firm.

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[10] This section has some parallels with models of regulatory commitment as a game. See for example R.J. Gilbert and D.M. Newbery, 1994, The dynamic efficiency of regulatory constitutions, RAND Journal of Economics, 25, 538-54.

4.2 Credibility of signals

The strength of the regulator's signal is influenced by the credibility of the regulator's commitment, where "credibility" in this sense refers to the rational and statistical expectation of the firm. If a regulator attempts to signal that it will allow a fair return on sunk costs, but has a reputation of expropriating the surplus generated from other sunk costs, it will find it difficult to convince the firm that is will not act in this way once new funds have been sunk. The firm will recognise that history is likely to repeat itself and its future investment decisions will reflect this expectation.

If the regulator is able to credibly signal that it intends to allow the firm to recover its sunk cost, then efficient[11] investment will be forthcoming. Regulators may be able to build their own credibility in some ways. The provision of an efficient (e.g. speedy) and consistent regulatory service to the industry would, for example, send a strong and credible signal of good intentions. The credibility in this signal derives mainly from the fact that it requires considerable effort on the regulator's part, effort that would not be expended unless the regulator really understood the value firms place on certainty.

Assuming that the regulator is operating at maximum efficiency, what are the other constraints on regulatory credibility? Three questions would seem to be important:

1. How long does it take a firm to forget?

2. Does the firm take notice of the regulator's activities in other industries?

3. What is the regulator's tenure?

The answers to these questions are subjective, and can therefore not be determined merely by logical analysis. We can, however, draw some qualitative conclusions.

In respect of the first question, if the firm places a relatively heavy emphasis on the recent parts of the regulator's history when constructing an expectation of future regulation then the regulator will find it relatively easy to change signals. In this case, the effect of decisions made in the distant past will receive relatively small weights in the firm's decision making. However, if the firm puts equal weight on past decisions then any action by the regulator that deviates from its signal will have a longer effect on the investment decisions of firms.

The second question clearly depends on the scope of the regulator's jurisdiction. Suppose a single regulator has responsibility for two industries, A and B, and that he has to date consistently allowed firms in A to earn fair returns in one industry, but expropriated all returns in B. In this case, firms in industry A might reasonably expect to be regulated in a similar way to the later industry in the future. In this case the regulator's current signal to industry A lacks credibility because it is inconsistent with his actions in industry B. Example 2 demonstrates the relevance of these cross-industry effects.

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[11] At least with respect to this dimension of the investment decision. Information asymmetries may compromise the regulator's ability to elicit the overall efficient level of investment.

Example 2: Victorian gas and electricity regulation

Investors in the Victorian distribution assets, privatised by the Victorian Government in 1995, faced uncertainty through the interaction of:

- the creation of an independent economic regulator (the Office of the Regulator General); and
- the specification of a regulatory regime that provided:
  - a reasonable degree of certainty in regulatory policy for the first regulatory period; but
  - little guidance as to the regulator's decisions for subsequent review periods.

Given that such reform was new in Australia, investors in these utilities had little chance to learn about the likely actions of the regulator. In addition, the regulator had little opportunity to signal its intentions.

In this environment, the ORG's subsequent decision in a related market (gas) can be seen not only as a decision affecting the gas sector, but also as the ORG signalling its intentions as to its regulatory stance in its (then) forthcoming electricity distribution price review, with investors learning about the regulators actions in that review and adjusting expectations accordingly. A downwards revision in investors expectations appears to have accompanied the ORG/ACCC's draft gas decision (May 1998) given that in the three weeks following this decision, the share prices of electricity distributors United Energy and AGL fell by 15.7 and 14.2 percent respectively (http://www.ue.com.au/download/hambros.pdf).

This learning impact is also evident by the absence of any discernable shift in the share price of both companies following the ORG's final decision on electricity distribution.

Cross-industry signalling is not possible unless the regulator has cross-industry jurisdiction. In this sense, the pooling of regulatory functions makes it possible to reduce regulatory risk. The mere fact that a regulator has wide jurisdiction does not mean that the resulting potential for risk reduction will be realised of course. Indeed, society would be far better off with numerous industry specific regulators all generating strong (i.e. clear) signals about their future behaviour, than with one omnibus regulator behaving erratically.

The third question addresses the issue of accountability. The most important consequence of regulatory risk is a reduced level of real investment, the effects of which are unlikely to be apparent for several years. If the tenure of regulatory decision makers is sufficiently long, they will be personally required to confront any adverse consequences arising from their earlier decisions.

5 Investment Effects

As discussed above, regulatory risk influences the expectations of agents about payoffs received by the firm across the range of possible market outcomes. These expectations are used in capital allocation decisions at two levels: portfolio investment and real investment. In this section, we describe the effect of regulatory risk on each of these forms of investment.

The strategies of portfolio investors depend on their expectations about the future returns achievable across the entire range of possible securities. The result of many such investors optimising their allocations of capital can be summarised in several ways, the best known of which is the capital asset pricing model, or CAPM. Although this model does not enjoy the unanimous support of financial economists, it is well understood and widely used by regulators and business people alike. For this reason, our analysis of the impact of regulatory risk on investors, developed in the next sub-section, is based on the CAPM.

Real investment decisions are taken by the managers of firms, rather than a large number of portfolio investors. Managers are responsible for ensuring that the investment strategy of the firm results in the best possible flow of returns to investors. This requires careful attention to choices over technology, location, scale and timing. In the second subsection below we focus on just one of these choices: that of optimal investment timing.

5.1 Effect on beta

The capital asset pricing model[12] (CAPM) provides a method for estimating the risk associated with investing capital into all of the securities that make up the market portfolio.[13] Within the CAPM, risk associated with any given security is only compensated to the extent that it increases the risk of the market portfolio. This component of risk is referred to as "systematic risk". The rationale for this restriction is that systematic risk cannot be diversified by holding other securities.

While it is logically correct to argue that investors only require compensation for those components of risk that cannot be diversified, the systematic risk that is priced within the CAPM is not the only such risk. Firm specific risk which does not contribute to the risk of the market portfolio, (i.e. which is not systematic) is not priced by the CAPM, even if it cannot be mitigated by diversification.

5.1.1 Non-diversifiable, non-systematic risk

There are two important types of regulatory risk that are neither systematic nor diversifiable. For expository purposes, it is convenient to think of these as arising from

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12 W.F. Sharpe, 1964, Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk, Journal of Finance, 19, 425-42. J. Lintner, 1965, The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets, Review of Economics and Statistics, 47, 13-37.

13 The market portfolio is the universe of financial securities available to investors. Fully diversified investors can be thought of as holding a share of the market portfolio, meaning that the proportion of each security in the investor's own portfolio is equal to the weight that secuirty receives in the market portfolio.

"certain" and "uncertain" regulation respectively, where these terms are as defined in section 2 above.

Consider a long-lived regulation that caps the prices of a monopoly that serves the public directly, at levels that are known by all parties. For concreteness, we could think of this as a twenty-year CPI-X price cap combined with an obligation to serve all demand. Market conditions evolve stochastically, affecting the strength of demand for the firm's service and its cost of production. If there were no regulation, the firm would adjust prices to take advantage of these varying conditions. Indeed, provided the cost of making these adjustments were not too large, the stochastic market conditions may enable the firm to make higher profits than would otherwise be the case.[14]

The imposition of the price control completely reverses this effect. Now, rather than being able to optimise in the face of random market conditions, the firm's role is entirely passive. Its prices are fixed so it has no ability to regulate demand, and its inputs are priced in competitive markets which are subject to external shocks. Under these conditions, market risk is unambiguously harmful to the firm's expected profitability.[15]

Paradoxically, the imposition of regulatory controls of this type can reduce the contribution the affected firm makes to the risk of the market portfolio, thereby reducing the cost of capital as predicted by the CAPM.[16] When this occurs, the risk induced by certain regulation is not systematic. Equally important, this risk is not readily diversifiable. In the present example, the reasons are obvious. The regulated firm is a monopoly that serves the public directly, so no other firm gains when the regulated firm loses. The beneficiaries of regulation are final consumers, and since investors cannot directly[17] purchase claims on the residual income of final consumers, their ability to avoid this type of risk is limited.[18]

Investors will require compensation for exposure to risk of this type, but it is not priced by the CAPM. As a result, when regulators use the CAPM framework to estimate the cost of capital, they understate the required return by the amount of fair compensation for non-

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14 For an unregulated firm with low adjustment costs, the maximum profit function is convex in prices. In this case, Jensen's inequality implies that profits are higher when prices are random. See Richard Hartman (1972), The Effects of Pice and Cost Uncertainty on Investment, Journal of Economic Theory, 5, 258-66.

15 This is because the firm cannot maximise against fluctuating demand. The maximum profit that would be earned by an unregulated firm is not available. Under these conditions, the maximum profit function is identical to the profit function, and hence is concave rather than convex. Jensen's inequality therefore implies that uncertainty will reduce the average profit. This reduction needs to be taken into account when setting regulatory parameters.

16 This is demonstrated by Ergas and Small (1999) "The Rental Cost of Sunk and Regulated Capital", CRNEC Working Paper 17, University of Auckland (http://www.crnec.auckland.ac.nz)

17 Indirect diversification could be obtained by investing in firms that might enjoy increased business when final consumers are better off.

18 Investors may well hold other stocks regulated by the same authority, and if the transfers between regulated firms and consumers were purely random, investors would gain income from those stocks that receive transfers, offsetting losses on those stocks that pay the transfers. There is still a net loss in this case, because of the concavity of the profit function.

diversifiable, but non-systematic risk. As discussed further below, this amount can be thought of as an insurance premium.

5.1.2 Simulation study

The above analysis suggests that the CAPM understates the non-diversifiable risk faced by investors when final consumers (rather than other listed firms) are the beneficiaries of regulatory risk. In this section, we demonstrate this effect using a small simulation model.

We assumed that the regulated industry was a duopoly and that the market portfolio was a combination of the two duopolists plus one outside asset. Investors can buy the stock of each of the duopolists. All three assets evolve stochastically around a deterministic cycle over 200 time periods. In each of these periods, we estimate the CAPM beta for each of the duopolists under 12 different scenarios. The first scenario is an unregulated one. In each of the other scenarios, the regulator checks in each period to see whether the firm has made a profit, and if so he tosses a fair coin and removes 10% of firm A's return if the result is "heads", passes some fraction α to consumers, and gives the remaining fraction $(1-\alpha)$ to the rival firm B.

Most people would agree that, relative to the unregulated scenario, investors would require more compensation to invest in A and less to invest in B under this form of regulation. Yet the CAPM estimate of the appropriate compensation can reverse this ranking. In our simulation, the "beta" falls for firm A and rises for firm B. Table 1 shows the change in the CAPM estimate of beta for firms A and B as a function of the share of the tax α that is passed to consumers. These estimates are averaged over 100 replications of each scenario, and exactly the same sequence of random numbers were used to generate the data used in each scenario.[19]

Table 1: CAPM Predictions of Effect of Taxing Firm A

Consumer's percentage (α)	Change in beta for A	Change in beta for B
1.0	-0.92×10^{-4}	0.45×10^{-4}
0.9	-0.48×10^{-4}	0.26×10^{-4}
0.8	-0.38×10^{-4}	0.22×10^{-4}
0.7	-0.48×10^{-4}	0.34×10^{-4}
0.6	-0.57×10^{-4}	0.42×10^{-4}
0.5	-0.66×10^{-4}	0.53×10^{-4}
0.4	-0.82×10^{-4}	0.70×10^{-4}
0.3	-0.65×10^{-4}	0.58×10^{-4}
0.2	-0.81×10^{-4}	0.75×10^{-4}
0.1	-0.70×10^{-4}	0.67×10^{-4}
0.0	-0.75×10^{-4}	0.75×10^{-4}

[19] The return to each duopolist was generated as $r_t = 0.1 + \sin(t/6) + e_t$ where $t = 1,2,\ldots,200$, the sine function is denominated in radians and $e_t \sim N(0, 1/2)$. The third asset was generated as $r_t = 0.06 + \sin(t/6) + e_t$ and all three assets were added together to represent the market portfolio.

The changes reported in Table 1 are negative when beta falls as a result of regulation and positive when beta rises. Notice that the difference between the fall in firm A's beta and the rise in firm B's beta decreases with the share of the tax being passed to consumers. When consumers receive none of the tax, these changes are completely offsetting.

The conclusion that can be drawn from this simulation is that the CAPM does not provide a sufficient model for analysing risk arising from regulation. This is the case even when there is no uncertainty about the form of the regulation. The CAPM only prices those components of risk that are systematically related to the market portfolio. It makes no allowances for risk that is neither systematic nor diversifiable.

5.1.3 Theoretical results

To gain a more transparent illustration of the effect of firm specific regulation on the CAPM beta, we derived the effect on beta of the imposition of a tax on just one firm. This section reports on that analysis.

Suppose the returns of the only two firms in the market are given by x and y, and denote the market return by m=x+y. The CAPM beta of x is given by

$$\beta_x = \frac{\mathrm{cov}(x,m)}{\mathrm{var}(m)} = \frac{E(x-\bar{x})(m-\bar{m})}{E(x-\bar{x})^2}$$

where a bar over a variable denotes its expected value. Suppose that the return on firm x is taxed such that the new return is given by x'= αx. The new market return is

$$m' = x' + y = m - (1-\alpha)x$$

The CAPM beta for x' can be derived as follows

$$\begin{aligned}
\beta_{x'} = \frac{\mathrm{cov}(x',m')}{\mathrm{var}(m')} &= \frac{\mathrm{cov}(\alpha x, m-(1-\alpha)x)}{\mathrm{var}(m-(1-\alpha)x)} \\
&= \frac{E(\alpha x-\alpha\bar{x})(m-(1-\alpha)x-\bar{m}-(1-\alpha)\bar{x})}{E(m-(1-\alpha)x-\bar{m}+(1-\alpha)\bar{x})^2} \\
&= \frac{E(\alpha xm-\alpha\bar{x}m-\alpha x\bar{m}+\alpha\bar{x}\bar{m}-\alpha(1-\alpha)(\bar{x}^2+x^2-2x\bar{x}))}{E(m^2+\bar{m}^2-2m\bar{m}-2(1-\alpha)(mx-x\bar{m}-\bar{x}m+\bar{x}\bar{m})+(1-\alpha)^2(x^2+\bar{x}^2-2x\bar{x})} \\
&= \frac{\alpha\,\mathrm{cov}(x,m)-\alpha(1-\alpha)\,\mathrm{var}(x)}{\mathrm{var}(m)-2(1-\alpha)\mathrm{cov}(x,m)+(1-\alpha)^2\,\mathrm{var}(x)}
\end{aligned}$$

Comparing these two expressions, it is always the case that the numerator in the beta for x' is smaller than that for x. Thus, if the variance of the market portfolio remains constant, the beta for x will fall as a result of the tax. This effect is reflected in the simulation presented in the previous section, though it will not hold for all parameter values.

5.2 Real options

The modern theory of real investment is heavily focussed on the development of optimal timing rules which allow the firm to avoid much of the risk of asset write-offs. Known as the "real options" approach to investment, this theory is now being used by innovative firms to assist in maximising shareholder value. The theory is premised on the following three assumptions:

- the returns from the project are uncertain, but some of this uncertainty will be resolved in the future through the arrival of new information;
- funds committed to the investment project are "sunk" and so cannot be recovered in the event that the project turns out to not be viable; and
- the project can be delayed.

These assumptions are not particularly demanding: they will all apply to some degree for all real investment projects. Their collective implication is simple and compelling: the traditional investment rule (invest if the project is expected to return the cost of capital) is wrong. If the project can be delayed, and delay resolves some uncertainty, then costly errors might be avoided by delaying the commitment of capital.

Example 3: Real Options vs the NPV Rule

Consider a very simple investment problem. An infinitely lived asset can be purchased now, or in one period's time, for $1600. The asset can derive income of $200 this period, and the income in all subsequent periods will be either $300 or $100 with equal probability. The discount rate is 10%.

The net present value (NPV) of the investment project today is

$$V_0 = -1600 + 200 + 200/1.1 + 200/1.1^2 + \ldots \quad = 2200 - 1600 = \$600$$

Notice that the cashflows enter at their expected value of $200 = $(300+100)/2. Because the project is expected to return more than its cost, a simple NPV decision rule would suggest that investment should proceed. This disguises substantial downside risk, however, represented by the 50% probability that the earnings will fall to $100 and never recover.

Now consider an alternative strategy, which is to delay the decision for one period (i.e. until we know what the perpetual return will be) and then only invest if this is $300. The NPV of this alternative strategy is given by:

$$V_1 = 0.5(-1600/1.1 + 300/1.1 + 300/1.1^2 + \ldots) = \$773$$

This calculation takes into account the fact that there is only a 50% probability that investment will occur, with the other 50% of the weight going to zero. Clearly $V_1 > V_0$ so the "delay" strategy has a higher expected value. The difference in values $V_1 - V_0 = \$173$ is the value of the real option to delay investment. Whenever this value is positive, delay is profitable.

The real options approach recognises that optimal investment timing is really a choice between two mutually exclusive alternatives: invest immediately; or delay the decision by one period.[20] If the project can be delayed, it has the form of a call option: the firm has the right to invest, but is not obliged to do so. The flexibility afforded by this option has a non-negative value to the firm.[21] Example 3 illustrates this approach using a very simplified investment problem.

To develop the relationship between real options and regulatory risk, consider a situation in which a market is about to be regulated in a new manner. This could encompass any of the following changes:

- a new service has been declared under Part IIIA of the Trade Practices Act;
- a new regulator has been established with jurisdiction over some market(s); or
- senior appointments are made at an existing regulatory commission.

All of these changes create non-market risk. Those firms with assets that fall within the relevant jurisdiction need to form expectations about the impact of the new circumstances on their future earnings. And these expectations will be updated each time new information arrives about the likely impact of these new circumstances.

Real options analysis suggests that, in the absence of credible regulatory commitment, such a firm has an incentive to delay any investment for which delay is feasible.[22] This is because relevant information will be revealed once the regulator begins making decisions. The "regulatory induced" value of delay will not fall to zero unless the firm is confident that it has sufficient understanding of the regulator's views to predict the impact of that regulator's future decisions. Even then, if the lifetime of the assets being installed exceeds the expected tenure of the regulator (as will usually be the case), non-market risk will not be eliminated.

5.2.1 Granting options to access seekers

It may be argued that an access regime provides access seekers with an option to use capacity installed by others, and that the value of this option should be imputed into the access price. This validity of this reasoning depends on other circumstances, however. For example, if no additional costs are incurred by the access provider when the access option is granted, then there is no reason to charge access seekers for the option they receive. On the other hand, if the incumbent is either explicitly or implicitly required, as a direct consequence of the regulation, to install additional capacity, then costs are incurred. In this case, it will generally be efficient to pass these on to the access seeker(s).

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[20] Notice that this is <u>not</u> a choice between "invest now" and "invest next period", but rather a choice between "invest now" and "re-evaluate next period in the light of new information". Once the next period arrives and the additional information has been analysed, the managers face exactly the same choice, but are better informed.

[21] It is not possible to be worse off as a result of having more choice, at least for problems of the type discussed here.

[22] As discussed elsewhere, if the regulator can commit to paying the firm no more or less than WACC for the life of the relevant assets, delay will never be profitable.

In assessing regulatory arguments about option values it may be useful to distinguish between the costs and benefits of creating the option, and the costs and benefits of exercising the option.[23] In practice, access costs often arise primarily from the exercise of access options, rather than their creation. To the extent that this is so, the problem of setting cost reflective access prices reverts back to the determination of costs alone, with the flexibility enjoyed by access seekers having no direct bearing on theses costs.

5.2.2 Delay options for access providers

A more serious option-related problem arises in respect of capital investment decisions, particularly those of access providers. In considering this problem, the investment rule that real options analysis predicts must be borne in mind. This rule has two components. Firms will invest immediately if:

(a) the full cost of the required capital is expected to be recovered; and

(b) delaying investment is not expected to be profitable.

A regulator wishing to ensure immediate investment without over compensating the firm can (in theory) satisfy both of these conditions at once. This is achieved by committing to allowing the firm to earn its cost of capital in the current and all future time periods. This is a commitment to paying the firm exactly zero economic profits, taking into account the risk associated with the investment and the requirement to depreciate the asset to salvage value by the end of its service lifetime.

If the firm believes that a future determination may give it more than this return, condition (b) is violated and no investment will occur. Similarly, if the firm believes that the regulator has under-estimated its cost of capital, condition (a) will be violated and no investment will occur.

Effectively, this policy requires the regulator to fully insure the firm against capital losses. The intuition is both simple and heuristic: since the possibility of economic profit has been eliminated, the firm will only invest if the possibility of loss is also eliminated. This full insurance regulatory policy raises two further problems. The first relates to the feasibility of full insurance and the second to its efficiency. We discuss these separately.

5.2.3 Full insurance regulation: Feasibility

The most obvious difficulty with "full insurance regulation" is that of regulatory commitment. In almost all real world cases, the expected tenure of the regulator is shorter than the expected service life of the regulated assets. And since it is not possible to bind future regulators, it is not possible for any regulator to guarantee the firm any particular terms and conditions of trade.

We show above that regulated asset lifetimes are typically many times longer than the relevant regulatory cycles. Even allowing for the fact that many regulators have careers that span multiple regulatory cycles, the ongoing participation of particular senior people inside

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[23] There is, of course, an unbreakable statistical link between the benefit generated by the option and the probability and value of its exercise.

regulatory organisations cannot be relied upon beyond the relatively short employment contracts that such people typically have.

5.2.4 Full insurance regulation: Efficiency

Even if regulators could guarantee that the firm would receive the WACC in all future time periods, this is unlikely to be an efficient strategy. The reason relates to the information asymmetries that exist between the regulator and the firm. The efficient level and pattern of capital investment can only be reliably estimated with detailed knowledge of the relevant markets (i.e. those for final products and productive inputs including capital goods). Most people would agree that the firm is a better able to determine these *ex-ante* than the regulator.[24]

Because of this, the firm should be incentivised to make efficient capital investment decisions. Partial insurance is the standard remedy for this problem, which is formally equivalent to the moral hazard problem faced by insurance companies. Effectively, this requires that the firm "self-insure" against the possibility that some of its capital stock may be written off in subsequent time periods.

The fair cost of this self insurance must be added into the cashflows that the regulated firm is allowed to earn.

5.3 Summary of Investment Effects

In this section, we have considered the effect of regulatory risk on portfolio and real investment. Given competitive debt markets, portfolio investors determine the cost of capital faced by firms. Using statistical theory and a simulation study we showed that the required compensation for regulatory risk may be understated when the CAPM is used to predict the constraints imposed by portfolio investors. This is most likely to happen when final consumers are the direct beneficiaries of regulation, since in this case investors cannot readily diversify against the risk that income will be redistributed away from the regulated firm.

Our analysis of real investment suggests that a complete measure of the cost of capital (i.e. including regulatory risk) is necessary, but not sufficient to induce ongoing investment. Two additional factors are particularly important. The first is regulatory commitment over the time periods approximately equal to the life of the relevant assets. Without such commitment, firms face significant barriers to investment. Second, in any regulatory model that uses *ex-post* optimisation tools to adjust asset values, the firm must be allowed a "self-insurance premium" that is just sufficient to compensate for the additional risk that optimisation entails.

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[24] The optimisation processes within the DORC and TSLRIC asset valuation methods can be viewed as delivering an ex-post estimate of efficient capital stocks.

6 Conclusion

This paper has studied the issue of regulatory risk from empirical and theoretical perspectives. We demonstrated the significance of the issue using aggregate data that show that assets worth around $130billion are subject to regulation in Australia and that the rental cost of this capital is about $18billion per annum.

It is clear that regulatory risk is the inevitable companion of regulatory discretion. While it may be tempting to argue that this discretion should therefore be eliminated, this would be an over-reaction. There are good reasons for allowing discretion. These arise from the inability to write complete contracts that can be relied upon to obtain socially desired outcomes at the lowest cost. Assuming therefore that some regulatory discretion is allowed, it is important to understand the consequences of this for the cost of capital and real investment behaviour. Otherwise the desired social benefits of regulation may be compromised through a lack of investor confidence. In this paper, we have attempted to set out the impact of regulatory risk on various aspects of the provision and funding of capital.

The paper demonstrates three consequences of regulatory risk. The first is that unbiased regulatory errors were shown to generate asymmetric risk for investors. We explained why investors cannot full diversify against this risk, and then demonstrated the possibility that the frequently used CAPM measure of risk may not reflect this risk.

A common theme of the paper is that regulatory commitment reduces regulatory risk. We argued that the following factors would mitigate the impact of this risk and thereby promote efficient investment:

6.1 Speed and consistency of regulatory decision making

It is difficult for the regulator to earn a reputation for fast and consistent decisions, so this "signal" will not occur by chance. It will only occur if the regulator believes that the rapid realisation of uncertainty is valuable to firms and/or consumers. Thus, a regulator that gains such a reputation will, in so doing, have demonstrated a commitment to stability.

6.2 Broad regulatory scope

When one regulator is responsible for several sectors, informational asymmetries are reduced. The regulator's performance across sectors can be benchmarked more reliably than would be the case for an industry specific regulator. As a result, it is easier for the regulator to develop a reputation for consistency.

6.3 Long regulatory tenure

A key problem identified above is that the typical lifetime of a regulated asset greatly exceeds the tenure of regulations. Longer tenures for the key staff of regulatory offices, and the use of controls that remain in place for longer periods both reduce the uncertainty associated with resetting regulatory parameters and changes in staff.

This tenure recommendation has an additional advantage, which is to enhance the personal accountability of regulators. Given that problems arising from insufficient investment may take many years to become apparent, a regulator who expects to have a new job in a few

years time may be inclined to place too much weight on the immediate benefits from lower prices. The longer they expect to be responsible, the greater is likely to be their sense of accountability.

In conclusion, we note the need for further research in this area. It seems particularly important to assess the empirical relevance of the convexity arguments presented above, and to further model the important effects that govern diversifiability. Our analysis has provided an initial step in several relevant directions, but we believe that much more remains to be done to enhance our understanding of this topic.