

Incorporating Real Options in Regulated Prices

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Executive summary

- i. This paper is a response to the New Zealand Commerce Commission's "Revised Draft Guidelines" for estimating the cost of capital ("GUIDELINES"). I focus my discussion on the Commission's proposed treatment of real options, and consider five closely related issues.
- ii. First, I briefly review what is perhaps the greatest problem facing a well-intentioned regulator: the **difficulty of credibly committing to full cost recovery**. Such commitment is an essential ingredient of dynamic efficiency.
- iii. Second, I explain why **some allowance for investment timing options is essential**. The question that the Commission should ask itself when setting prices is: "What would a welfare-maximizing social planner do?" The evidence from the academic literature is that a social planner would invest only when the payoff from investing exceeds some strictly positive threshold that reflects the value of the planner's option to delay the investment decision.
- iv. Third, I summarize the difficulties associated with estimating the value of real options and explain why **precise valuation is especially complicated for a social planner**.
- v. Fourth, I explain why **attempting precise valuation of real options is undesirable for a regulator**. It is entirely appropriate for a regulator to attempt to derive precise estimates of many regulatory parameters. However, the current state of the "art" that is real options analysis means that attempting too much precision when valuing real options exposes the regulator to the risk of being perceived as acting opportunistically.
- vi. Fifth, I outline a **sensible approach that the Commission might use** to incorporate real options in regulated prices. The only indication that the Commission has given of the approach that it will follow is the rather vague discussion in Section 5.1.5 of GUIDELINES. This vagueness is unhelpful for stakeholders wishing to participate in the regulatory process and does little to commit the Commission to allowing full cost recovery in the future. The approach I advocate is transparent, is not over-engineered, and recognizes the limitations of the modelling techniques available to stakeholders.

1 The challenge faced by a regulator

1. Even if a regulator attaches equal weight to consumer and producer surplus in principle, there are many reasons why it might attach greater weight to consumer surplus in practice.¹ Such a regulator has an incentive to transfer surplus from producers to consumers. It has the ability to implement such a transfer by setting regulated prices that allow firms to recover only a part of their sunk costs: all that is required to induce a regulated firm to continue in business is to allow it to recover its future avoidable costs, not its sunk costs as well. However, if firms anticipate such behavior, they will invest in ways that require low current sunk costs at the expense of greater future, and therefore avoidable, costs (Blackmon and Zeckhauser, 1992). That is, the *potential* for opportunistic behavior by a regulator will induce regulated firms to invest in ways that are not cost-minimizing.
2. The regulator thus faces an intertemporal conflict: what is good for its objective function in the short run (lowering prices faced by consumers) is bad for it in the long run (by raising prices faced by consumers, or perhaps discouraging investment altogether). However, once investment has occurred and capital has been sunk, all that matters is the short run. When viewed through this lens, disallowance of full cost recovery is not "misbehavior" by a regulator, but simply a natural response to the irreversible nature of much infrastructure investment. Unfortunately, it is not sufficient for a regulator to be well intentioned, because the problems remain as long as opportunistic behavior is *possible*.
3. Therefore, one of the most important issues in regulatory design, and one that has been thoroughly studied in the regulatory economics literature, is the need for regulators to be able to credibly commit to allowing full recovery of sunk costs, both those already sunk and those to be sunk in the future.^{2,3}
4. Unfortunately, while GUIDELINES recognizes the possibility that the regulator can act ex post, it treats this as an opportunity to be exploited, not as a problem to be overcome. For example, in paragraph 248, GUIDELINES states that

"regulators are in the unique position of being able to make ex post adjustments with the benefit of hindsight. Therefore a scheme that permits some flexibility in this regard is desirable."

While some discretion may be useful in some situations, the Commission needs to be aware that in making such statements it weakens its credibility with regards to allowing

¹See, for example, Section 6.1 of Guthrie (2006) for a review of some of these reasons.

²See Laffont and Tirole (1993) for a textbook treatment. Section 6.1 of Guthrie (2006) discusses the impact on firms' investment incentives, while Section 6.2 describes various ways in which overseas policymakers have attempted to make it difficult (or costly) for regulators to behave opportunistically.

³A similar issue arises in the design of effective monetary policy, where central banks must confront a similar intertemporal inconsistency, the famous "rules-versus-discretion" debate.

recovery of sunk costs. It could even be argued that the ability to “make ex post adjustments with the benefit of hindsight” is a hindrance to the regulator, not an opportunity to be exploited.

5. Establishing and maintaining such credibility is crucial, and it should be a serious consideration in designing the Commission’s treatment of real options. As I will argue below, I believe this requires the Commission to modify its proposed treatment of real options.

2 Allowance for investment flexibility is essential

6. There is now ample evidence that investment flexibility has an economically significant impact on hurdle rates chosen by firms, even those in competitive industries. This ranges from theoretical evidence that firms should set hurdle rates substantially in excess of their WACC (Dixit and Pindyck, 1994), to survey evidence that the premium is substantial (Poterba and Summers, 1995), to empirical analysis of firm-level investment behavior that identifies economically- and statistically-significant premia (Chirinko and Schaller, 2009).
7. Section 5.1.2 of GUIDELINES discusses factors that make allowance for investment flexibility essential for individual firms. This discussion motivates the list of questions in paragraph 276 of GUIDELINES, which the Commission proposes that regulatory-hearing submissions should address. This list of questions would serve as a good starting point for an investment appraisal by an individual firm, which can treat the parameters of its economic environment as exogenous, since the answers determine the value of any investment timing options.
8. The Commission seems to be proposing to estimate the value of investment timing options and then set prices that allow the recovery of this value. However, a regulator cannot treat the value of investment timing options as some sort of exogenous parameter, which is the treatment implicit in Section 5.1.5 of GUIDELINES (and in paragraph 276 in particular).⁴ The reason is that the value of investment timing options depends on the particular regulatory settings chosen by the Commission, which in turn depend on the Commission’s chosen “value” of investment timing options. One consequence of this circularity is that there are potentially many alternative values of the investment timing options in a particular regulatory situation.
9. For example, suppose that the Commission chooses an option value of zero; equivalently, it disallows any recovery of investment timing options. The Commission would implement this by allowing the firm to earn only its WACC on its investment. Then the payoff from investment—whenever it might occur—equals zero, since such a policy has the effect of setting the NPV of investment equal to zero at all times. However, if the firm can

⁴Paragraph 261 of GUIDELINES notes the impact of regulation on the determinants of real option value, but the issue is ignored where it really matters, in Section 5.1.5.

only ever break even when it invests, the option to delay investment must be worthless. That is, by *choosing* an option value of zero the Commission actually *ensures* an option value of zero.

10. At the other extreme, suppose that the Commission chooses an option value equal to the value a monopolist would achieve; equivalently, it allows the regulated firm to set its own prices without restriction. The firm will choose its investment policy in order to maximize the present value of its net cash flows. The option value implied by this investment policy is, again, equal to the one chosen by the Commission. That is, by *choosing* the “monopoly” option-value the Commission actually *ensures* that the monopoly option-value occurs.
11. Much the same thing happens between these two extreme cases. The Commission chooses its regulatory settings, then the regulated firm chooses its value maximizing investment policy (subject to any investment constraints imposed by the Commission), and the option value that emerges is consistent with the regulatory settings and the investment policy. That is, the real option value is an *output* of the regulatory process, not an *input* as assumed by GUIDELINES. In short, Section 5.1.5 of GUIDELINES puts the real-options cart before the regulatory horse.
12. This multitude of solutions means that the approach described in Section 5.1.5 of GUIDELINES is not suitable for regulatory price setting. Indeed, the framework proposed in Section 5.1.5 cannot provide useful information for this purpose.
13. Some sort of “circuit breaker” is needed to interrupt the circularity implicit in Section 5.1.5. A hypothetical social planner, which makes investment decisions and sets prices in order to maximize overall welfare, is one such circuit breaker. Rather than asking “What would an individual firm do?” (given unspecified, but relevant, regulatory settings), which is the question implicit in Section 5.1.5, the Commission should instead be asking “What would a welfare-maximizing social planner do?”
14. The problem facing a welfare-maximizing social planner is similar in many way to that facing a firm that takes its economic environment as given. It must decide when and how to invest, recognising that much of the investment expenditure is irreversible and that the future flow of benefits from the investment is uncertain. The social planner faces the same concerns, such as the risk of asset stranding, as the firm featured in Section 5.1 of GUIDELINES. The main difference is that the flow of benefits is the sum of consumer and producer surplus in the case of the social planner, rather than the surplus of just the asset provider.
15. Like the firm, the social planner will invest only when the present value of its flow of benefits exceeds the sum of the required investment expenditure and the value of any real options destroyed by investment.⁵ If the Commission seeks to set prices that maximize

⁵See, for example, Guthrie et al. (2006) and Guthrie (2009a).

total welfare—and it should—then it is essential that it makes appropriate allowance for investment flexibility, and investing timing options in particular.

3 Estimating option values is a complicated task

16. It is difficult for the manager of an individual firm to make an accurate allowance for investment timing options. There can be many interacting options embedded in a single firm, sometimes even within a single project. There will often be several sensible ways in which to model the underlying risk factors. There will be the usual problems of estimating parameter values. There will even be competing approaches for turning the same combination of interacting options, risk factors, and parameter values into usable outputs.⁶
17. A hypothetical social planner faces an even more difficult task. It faces all of the difficulties confronted by the manager of a firm, but has the additional problem of deciding how to measure the flow of total surplus (rather than just the flow of profit to the regulated firm).
18. A welfare-maximizing regulator faces a still more challenging task due to the difficulty in committing to full cost recovery, which I now discuss.

4 Attempting precision is undesirable

19. The difficulties described above should not prevent the manager of a firm from trying to obtain the most accurate estimate possible when evaluating an investment project. All involved parties should, in principle, have the same objective: to maximize the market value of the firm. They should, again in principle, have access to a common information set. While there may be many different models, and many different parameter combinations, the stakeholders should refine their estimates until the marginal cost of further refinement exceeds the marginal benefit.
20. The potential for agency conflicts within a firm is well known, but they are of second-order importance compared to the conflicts between stakeholders in any regulatory price-setting procedure. In a regulatory setting, there are multiple players, all with their own (typically conflicting) objectives. Managers of regulated firms want high prices; managers of access seekers want low prices; consumer advocates want low prices; the regulator will be trying to maximize some weighted-average of all of these individual objective functions, but the various parties will have their own view on what weights the regulator is using. There is also likely to be considerable asymmetry in the information available to the various participants.

⁶See, for example, Copeland and Antikarov (2003) and Guthrie (2009b) for an indication of some of the approaches available to practitioners.

21. If the regulator did not have such difficulty in credibly committing to full cost recovery, it should also refine its estimates until the marginal cost of further refinement exceeds the marginal benefit. However, the regulator needs to keep in mind that an opportunistic regulator could exploit the complexity of the models and the wide variety of alternative methodologies to justify prices that transfer surplus from producers to consumers. And what matters for investment incentives is what the regulator *could* do, not what it *intends* to do.
22. Of course, this could also be the case for other regulatory parameters. For example, setting an unreasonably low level for the market risk premium (MRP) used in the CAPM formula would be an effective means of transferring surplus from producers to consumers. However, in those cases there is less information asymmetry between stakeholders, there is greater agreement about the underlying procedure, and expertise is sufficiently widespread that the whole process is subject to more robust scrutiny. In contrast, any discussion of real options will inevitably lead to disagreement about models and parameters and even the fundamental concepts involved. And, unfortunately, we must recognize that for the time being expertise in the area is not widespread.⁷
23. It is clear that the Commission faces a difficult task in dealing with real options. However, the solution is not to ignore them altogether. For the reasons explained in Section 2 above, if the Commission is to attempt to maximize total welfare, then it must make some allowance for investment timing options.
24. Section 5.1.5 of GUIDELINES does not lay out a clear procedure for incorporating compensation for real options in regulated prices. Such vagueness is itself a barrier to committing to cost recovery, for all of the reasons just described. However, Section 5.1.5 suggests that the Commission intends to carry out a very detailed project-specific analysis of the real options involved. While this would be laudable for project evaluation by a firm, I believe it is inappropriate for a regulator attempting to maximize overall welfare. All of the ingredients for *perceived* regulatory opportunism—and the adverse investment incentives that result—will be in place if the Commission adopts such an approach.
25. I believe that the Commission should follow its own advice, when (in relation to a proposal on another matter) it wrote (paragraph 242 of GUIDELINES):

“Although conceptually interesting, the Commission does not favour this approach because there is no empirical data on the loss ratio. In other words, there is no way to know the true form of the function, and there is no way to reliably calibrate it. Instead, the Commission would have to make large theoretical assumptions, which could have a significant impact on the final cost of capital. In the Commission’s view, LECG’s recommended approach is too mechanical and suggests a misplaced sense of precision and mathematical rigour.”

⁷Even GUIDELINES displays only a partial understanding of the topic. Some examples are given in the appendix.

26. The Commission should incorporate real options in its price-setting procedure in a way that is transparent, that is not over-engineered, and that recognizes the limitations of the modelling techniques available to many of the participants in the regulatory process.
27. This will require the Commission to relax its “burden of proof”, which has currently prevented any allowance for real options being included in regulated prices. The Commission should treat estimation of the compensation of real options in much the same way that it currently treats estimation of the MRP. There are many different ways to estimate the MRP, using different data sets, different econometric techniques, even different underlying models of the variable’s behavior. Yet, at the end of the day, the Commission chooses a number. It does not set zero as a default value and only raise it if the regulated firm can present an MRP estimate that meets a demanding “burden of proof”. The default value for the MRP is not zero, and the default for real options compensation should not be zero either.
28. In the following section I describe an approach that I think the Commission should follow when dealing with real options. The approach is transparent, it is not over-engineered, and it recognizes the limitations of the modelling techniques available to stakeholders. At a conceptual level, it is comparable to the Commission’s approach to estimating other regulatory parameters, such as the MRP.

5 A “multiplier” approach to allowing for real options

29. In the past, various parties have suggested that the Commission should compensate firms for real options destroyed when they invest by adding an increment to the WACC. GUIDELINES proposes compensating firms by amortising the real option value over the expected economic lifetime of the assets and including it in the firms’ cash flows as just another expense.
30. In principle, the issue of whether compensation is allocated via the discount rate or the cash flows is largely irrelevant. However, given the points raised in Section 4 above, I believe it is essential that the derivation and delivery of the compensation is as simple and transparent as possible. This was one of the primary advantages of adding a premium to the WACC. However, if the Commission is reluctant to use this approach, I suggest that a simple way to achieve its goals would be to adjust the regulated asset base, as I now explain.

5.1 The proposal

31. My suggested approach is that the Commission simply scale up its regulated asset bases by a “real options multiplier”. All other parameters—indeed, the overall approach—

could continue as at present. For example, suppose that prices are currently set so that

$$\text{Revenue}_{t+1} = \text{Op.ex.}_{t+1} + \underbrace{\text{WACC} \times \text{RAB}_t}_{\text{return on capital}} + \underbrace{\text{RAB}_t - E_t[\text{RAB}_{t+1}]}_{\text{return of capital}}.$$

In principle, this ensures that the regulated firm's market value equals the regulated asset base (RAB). Under my proposal, prices would be set so that

$$\text{Revenue}_{t+1} = \text{Op.ex.}_{t+1} + \text{WACC} \times (M \times \text{RAB}_t) + (M \times \text{RAB}_t) - E_t[(M \times \text{RAB}_{t+1})],$$

where M is the real option multiplier. Equivalently,

$$\text{Revenue}_{t+1} = \text{Op.ex.}_{t+1} + M \times \underbrace{(\text{WACC} \times \text{RAB}_t)}_{\text{return on capital}} + M \times \underbrace{(\text{RAB}_t - E_t[\text{RAB}_{t+1}])}_{\text{return of capital}}. \quad (1)$$

In effect, the return on capital and the return of capital are each scaled up by this multiplier. The regulated firm will eventually be able to recover the sum of its actual investment of funds in the project and the estimated value of the delay option destroyed when the firm invested (net of any options created by investment).

32. It seems reasonable to suppose that the value of the delay option, net of any options created by investment, is approximately proportional to the amount of capital required to undertake a project, which is the assumption underlying my proposal. Indeed, this result occurs in many real options models. For example, the value of the option destroyed when a social planner installs the marginal unit of capital is proportional to the required expenditure (Dixit and Pindyck, 1994, p. 287), the value of the option destroyed when a social planner develops heterogeneous land for housing is proportional to the development expenditure (Guthrie, 2009a), and the option value when there are economies of scale in investment is proportional to various cost measures (Evans and Guthrie, 2006).⁸

5.2 Benefits of this approach

33. The principal advantage of the approach proposed in equation (1) is that, in any particular situation, all the Commission has to do is specify one number, the real option multiplier. In practice, the Commission might adopt industry-wide multipliers, in much the same way that it currently tends to adopt industry-wide betas. For some situations—principally telecommunications—where there is likely to be greater variation within different components of the industry, the Commission might wish to adopt a small number of different multipliers within a single industry.
34. This multiplier approach would be easily understood by stakeholders, which would reduce the potential for stakeholders to suspect regulatory opportunism: the Commission would be setting its estimate of the option value equal to some fixed percentage of the

⁸See the cited papers for the additional assumptions required for these results to hold.

regulated asset base and allowing the regulated firm to recover that additional cost. The approach could be implemented with no change to current price-setting procedures, except for the scaling of the regulated asset base.

35. Of course, the Commission would have to choose a value for this multiplier. It would presumably invite submissions to help it choose a value (or values).

35.1 By committing to use this multiplier approach rather than the current, rather vague, approach in Section 5.1.5 of GUIDELINES, the Commission would provide valuable leadership to stakeholders. Submitters could focus on accurately estimating an easily-interpreted parameter, rather than each pursuing their own (possibly orthogonal) approaches. They would no doubt use a wide variety of modelling approaches and data sets, but the ultimate output of the submissions—the estimate of the multiplier—would be comparable across submissions.

35.2 Individual stakeholders (or the Commission itself) would be free to estimate the multiplier using models such as those described in paragraph 32 above.

35.3 As well as making it easier for the Commission to assess the various submissions, this focus on a single relevant parameter would make it easier for stakeholders to determine the Commission's treatment of the various submissions. This must surely help reduce the potential for perceived regulatory opportunism.

36. However, the Commission needs to appreciate that finance theory will not calculate the multiplier for it. As I explained above, finance theory and practice has trouble calculating option values for unregulated firms, and it is currently incapable of yielding a multiplier estimate that meets the "burden of proof" that the Commission has demanded in the past. Ultimately, the Commission will have to choose a number, and that is why the transparency in equation (1) is so important.

37. The multiplier approach is similar to GUIDELINES's proposal to amortise an initial estimate of a real option value over the expected lifetime of the asset. Indeed, the cash flow streams would be the same if the regulated asset base equals the depreciated historical cost of the firm's assets. However, the multiplier approach can be applied to situations in which the regulated asset base is reoptimized periodically, such as when it is set equal to the replacement cost of a firm's assets. Simply spreading an initially-specified option value over a number of years would be inconsistent if the regulated asset base is fluctuating as part of the optimization process. The multiplier approach in equation (1) is a very simple modification, which can be applied regardless of the rate base rule.

5.3 Is this approach a "licence to print money"?

38. One issue that some stakeholders may raise is whether or not this approach gives the regulated firm a "licence to print money". The firm is allowed to recover M dollars in total for each dollar of capital expenditure. The suggestion will be that, as long as the

Commission sets M at a level greater than 1, the firm has an incentive to over-invest. Such concerns are unfounded, for three reasons.

39. First, when a firm invests it incurs capital expenditure and destroys valuable real options. The *total cost* of one dollar of capital expenditure is M dollars. Thus, according to this approach the firm is being compensated only for the total cost of its investment.
40. Second, the repeated interaction between regulator and firm means that the scheme need not give the regulated firm an incentive to over-invest. It is well known that this interaction can lead to equilibria in which the regulator continues to allow agreed cost recovery (due to the firm's ability to punish the regulator by ceasing investment if the regulator deviates from the agreed cost-recovery rule) and the firm continues to undertake agreed investment (due to the regulator's ability to punish the firm by restricting cost recovery if it detects over-investment).⁹
41. Third, the multiplier applies only to capital expenditure, not operating expenditure. The Commission is able to assess capital expenditure before allowing it into the regulated asset base. This monitoring restricts the firm's ability to exploit any undesirable incentives that survive the repeated firm-regulator interaction.

6 Conclusion

42. The current "burden of proof" imposed by the Commission simply means that no allowance for investment flexibility is likely to be granted. As explained in Section 2 above, this is not welfare-maximizing. If the Commission accepts that investment timing is important (and it should) then it must change the way that it approaches incorporating real options in the regulatory process.
43. Finance theory is not currently capable of calculating a precise allowance for investment flexibility, so that the Commission is ultimately going to have to choose a level of compensation without the security of robust supporting empirical evidence (and with the insecurity of seemingly-robust non-supporting evidence).
44. In doing so, the Commission needs to be wary of the costs of being perceived to act opportunistically. It is therefore important that the derivation, the delivery, and the consequences of compensating for investment flexibility are as transparent as possible. The "multiplier" approach proposed in Section 5 above would meet these goals.

⁹See Salant and Woroch (1992) and Gilbert and Newbery (1994) for formal models of such situations, and Section 6.2 of Guthrie (2006) for a general discussion.

7 Appendix: GUIDELINES' discussion of real options

45. In footnote 74, GUIDELINES claims that competition amongst firms means that “the value of the real option to wait for the competitive firm will be competed away to zero.” GUIDELINES does not mention that this result requires some very restrictive assumptions, and that when these restrictions are relaxed competition need *not* drive the value of investment timing options to zero. For example, Williams (1993) shows that delay options can be valuable if there exists a cap on the rate of development; Childs et al. (2002) show that they have positive value when the firm that invests first reveals information about the true state of demand; Novy-Marx (2007) shows that they can be valuable when there is cross-sectional variation in firm size; Guthrie (2009a) shows that they can be valuable when price-taking firms have different cost structures.
46. In paragraphs 255, 256, 257, and 261, GUIDELINES discusses real options only in the context of “significant uncertainty”. However, valuable real options can arise even in a setting where there is no uncertainty. See, for example, Section 5.1.A of Dixit and Pindyck (1994).
47. In paragraph 258, GUIDELINES lists the “major sources of uncertainty faced by firms” as costs, demand, and technology. This ignores interest rate risk, which is also known to contribute to option value (Ingersoll and Ross, 1992).
48. In paragraph 272, GUIDELINES suggests that the option value of waiting should be “amortised over the expected economic lifetime of the assets.” This proposal ignores the uncertainty in the assets’ economic lifetime and is guaranteed to under-compensate the regulated firm as long as the discount rate is positive. The following example demonstrates this result.

- Suppose that the discount rate is 15%, that the option value equals \$100, and that the assets are equally likely to last one or two or three years.
- The proposal in GUIDELINES would see payments set at \$53.49, so that they are fully amortised over the two-year expected lifetime of the asset—provided that the payments occur with certainty.
- However, the payments do not occur with certainty. The date 0 payment occurs with probability 1, the date 1 payment with probability 2/3, and the date 2 payment with probability 1/3. The present value of the cash flow stream is therefore

$$1 \times 53.49 + \frac{2}{3} \times \frac{53.49}{1 + 0.15} + \frac{1}{3} \times \frac{53.49}{(1 + 0.15)^2} = 97.98,$$

which is less than the option value.

49. In paragraph 273, GUIDELINES asserts that “[i]n the past some regulated businesses have submitted implausibly large claims for extinguished timing options and asymmetric risks”. It is not clear how it determines plausibility in this context. However, the Commission

might wish to consult Chirinko and Schaller (2009), who use sophisticated econometric techniques and a dataset comprising 127,863 observations on 16,140 US firms for the period 1980–2001 to estimate the premium added to the WACC to obtain the investment hurdle rate. Depending on firm characteristics, Chirinko and Schaller (2009) find premia ranging from 1.1% to 33.1%. These results are economically significant and suggest that a wide range of premia are plausible.

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