

# **THE APPROPRIATE TERM FOR THE RISK FREE RATE AND THE DEBT MARGIN**

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This report has greatly benefited from comments received from Michael Blake of the QCA. However, the opinions expressed are those of the author and all errors remain his responsibility.

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## EXECUTIVE SUMMARY

The QCA has recently proposed, for the purposes of determining WACC, to set the term of the risk free rate within the cost of debt and the first term within the cost of equity, along with the term of the debt premium, equal to the regulatory cycle of five years, and to continue to estimate the market risk premium within the cost of equity using a ten year risk free rate. This paper has reviewed these proposals and the conclusions are as follows.

In respect of the risk free rate within the cost of debt and the first term within the cost of equity, along with the term of the debt premium, the available options are as follows. The first option would be to act as if the regulated firms engage in five yearly debt re-financing. In this event the total cost of debt that should be allowed every five years would be the five year risk free rate, the five year debt premium, and the annualised issue costs of five yearly debt issues (about 0.20%). In addition, the first term within the cost of equity is the five year risk free rate. The second option would arise only if the average debt term used by relevant comparator firms (term  $T$ ) materially exceeded five years, and would then assume that regulated firms will borrow for  $T$  years and use swap contracts (interest rate swaps and credit default swaps) to effectively match their debt to the regulatory cycle. Accordingly, the total costs of debt that should be allowed every five years would be the five year risk free rate, the five year debt premium, the annualised debt issue costs arising from  $T$  yearly debt issues (0.125% if  $T = 10$  years), and the transaction costs of the swap contracts (in the form of the spread between the “mid rate” and the price). In addition, the first term within the cost of equity is still the five year risk free rate. The third option would also only arise if the average debt term used by relevant comparator firms (term  $T$ ) materially exceeded five years, and would then assume that regulated firms will borrow for  $T$  years and use interest rate swap contracts to effectively convert the risk free rate that is embedded in their average debt term into the five year risk free rate. However, they would not be assumed to use credit default swaps to convert the debt premium that was embedded in their average debt term into a five year debt premium. In this event, the total costs of debt that should be allowed every five years should be the five year risk free rate, the debt premium on  $T$  year debt, the annualised debt issue costs arising from  $T$  yearly debt issues (0.125% if  $T = 10$  years), and the transaction costs of the interest rate swap contracts (in the form of the spread between the

“mid rate” and the price). In addition, the first term within the cost of equity is still the five year risk free rate. The fourth option would also only arise if the average debt term used by relevant comparator firms ( $T$  years) materially exceeded five years, and would then assume that regulated firms will borrow for  $T$  years but use neither interest rate swap contracts nor credit default swaps to convert the  $T$  year debt into five year debt. In this event, the total costs of debt that should be allowed every five years would be the  $T$  year risk free rate, the  $T$  year debt premium, and the annualised debt issue costs arising from  $T$  yearly debt issues (0.125% if  $T = 10$  years). In addition, the first term within the cost of equity is still the five year risk free rate. Finally, the fifth option differs from the fourth option only in extending the use of the  $T$  year risk free rate to the first term within the cost of equity as well as the cost of debt.

The first option satisfies the  $NPV = 0$  test but treats the additional refinancing risk arising from the use of five year debt rather than any longer term as inconsequential. The second option also satisfies the  $NPV = 0$  test but may be subject to implementation difficulties in respect of credit default swaps. The third option violates the  $NPV = 0$  test but only trivially and not in any consistent direction. The fourth option also violates the  $NPV = 0$  test, and to a larger degree although again not in any consistent direction. Finally, the fifth option embodies the same violations of the  $NPV = 0$  test as the fourth option, in respect of the cost of debt, and also violates the  $NPV = 0$  test consistently positively in respect of the cost of equity, i.e., equity holders would be consistently over compensated by about 0.20% in the risk free rate if  $T = 10$  years. The fifth option can then be dismissed. The fourth option rests upon the very unrealistic assumption that firms borrowing for significantly more than five years would not engage in interest rate swaps in order to remove the interest rate risk arising from the mis-match between their borrowing term and the length of the regulatory cycle. A good example of the problem resulting from failure to hedge in this way would arise if a regulator set a price cap for five years in January 2004, using the prevailing ten year risk free rate of 5.70%, and reset it five years later in January 2009 using the then prevailing rate of 4.09%. In the absence of such hedging, the firm would experience a significant drop in its revenue in January 2009 whilst its costs remained at the higher level from earlier years. In view of the implausibility of the assumption that firms would *not* seek to hedge against this kind of risk, I think that option four should also be dismissed.

In relation to the remaining three options, I do not have sufficient information to choose between them but I can specify the conditions under which each should be chosen. The first option is favoured if the average debt term of relevant comparator businesses is not significantly larger than five years. If it is significantly larger than five years, then such firms will have suffered a higher cost of debt from adopting the longer debt term (because the maturity premium on the longer term debt will exceed the saving in annualized debt issue costs), and their willingness to do so would then indicate a concern with the incremental refinancing risks from the use of five year debt. So, if the average debt term of relevant comparator businesses is significantly larger than five years, the use of the first option would be inappropriate because it assumes that these refinancing risks are trivial. This leaves the choice between the second and third options. The second option would be favoured if the relevant credit default swaps are available and their transaction costs are objectively determinable. If these conditions do not hold, then I favour the third option.

In respect of the appropriate choice of the risk free rate for the purposes of estimating the market risk premium, this depends upon the across-investor average period between successive portfolio reassessments. If this period is believed to be five years, then the CAPM would require use of the five year risk free rate within the first term of the model and the market risk premium, whilst the NPV = 0 requirement also mandates use of the five year risk free rate within the first term of the CAPM. No inconsistency then arises. Furthermore, despite the fact that the QCA bases its estimate of the market risk premium from studies that use ten rather than five year bonds, the QCA's (rounded) estimate of 6.0% would not be affected by the use of five year bonds. Alternatively, if the across-investor average period between successive portfolio reassessments is believed to be as little as one year, then the CAPM would require use of the one year risk free rate within the first term of the model and the market risk premium, whilst the NPV = 0 requirement would still mandate use of the five year risk free rate within the first term of the CAPM. The apparent conflict here is illusory because the two models are concerned with different periods, and is resolved by successive application of the one year CAPM to the five individual years for which a cost of equity is sought. This effectively leads to use of the five year risk free rate within the first term of the CAPM and the one year risk free rate within the

market risk premium, and use of the latter would likely increase the QCA's estimate of the market risk premium by 0.5%. Finally, if the across-investor average period between successive portfolio reassessments is believed to be as much as ten years, then the CAPM would require use of the ten year risk free rate within both the first term of the model and the market risk premium, whilst the NPV = 0 requirement would still mandate use of the five year risk free rate within the first term of the CAPM. As before, this apparent conflict arises from the fact that the two models are concerned with different periods, but it cannot now be resolved in the same way. Thus, we face a choice between abandoning the CAPM and adapting it to the scenario in question, and the lack of a credible alternative to the CAPM demands that it be adapted. Following the principle that one should minimize the modifications that are required to any model to adapt it to a particular scenario, the first term within the CAPM should be the five year risk free rate whilst the market risk premium should continue to be defined and therefore estimated relative to the ten year risk free rate. Since the QCA's estimate of the market risk premium reflects the use of this ten year risk free rate, then no alteration to the QCA's estimate of the market risk premium would be required.

Across these three scenarios, the first term within the CAPM is always the five year risk free rate, in conformity with the CAPM or the NPV = 0 requirement, whilst the risk free rate used within the market risk premium varies. However, unless the across-investor average period between successive portfolio reassessments is believed to be significantly less than five years, no change to the QCA's (rounded) estimate of the market risk premium would be likely to arise. The QCA's proposal is to use the five year risk free rate within the first term of the CAPM and estimate the market risk premium using the ten year risk free rate. Consistent with the analysis above, such a position is perfectly defensible if the QCA believes that the across-investor average period between successive portfolio reassessments is ten years. Furthermore, even if the QCA holds no view on this question, the lack of a sufficiently long time series of Australian risk free rate yields for any other bonds with a term of at least one year would complicate efforts to estimate the market risk premium using the Ibbotson methodology. Coupled with the fact that this average portfolio reassessment frequency would have to be appreciably less than five years in order to affect the (rounded) estimate of the market risk premium, this argues for the status quo.

This paper has also reviewed a number of submissions. The only credible arguments here relate to the possible need to allow for the cost of swap contracts required to effectively convert a firm's cost to debt to five year debt. If the first option described above is favoured, there is no need for this. If the second option is favoured, such hedging costs for both interest rate and credit default swaps should be allowed for. Finally, if the third option is favoured, such hedging costs on interest rate swaps should be allowed for and the debt premium should be defined relative to the average term for the debt of relevant comparator firms.

## 1. Introduction

The QCA (2009) has recently proposed, for the purposes of determining WACC, to set the term of the risk free rate within the cost of debt and the first term within the cost of equity, along with the term of the debt premium, equal to the regulatory cycle of five years, and to continue to estimate the market risk premium within the cost of equity using a ten year risk free rate. In response to this, the QCA has received a number of contrary submissions. This paper seeks to review these proposals and recommend a course of action to the QCA. We commence by presenting an analysis of these issues and then review the submissions.

## 2. Analysis

### *2.1 The Risk Free Rate and the Debt Premium*

We start by focusing upon the debt premium and the risk free rate within both the cost of debt and the cost of equity, but without consideration of any impact upon the risk premium within the cost of equity. The next section will consider the implications of using the CAPM to estimate the cost of equity.

In a regulated environment, in which output prices are set or capped so as to cover costs, these prices should have the property that the present value of the future cash flows equals the initial investment (Marshall et al, 1981; Schmalensee, 1989), i.e.,  $NPV = 0$ . The choice of the term for the risk free rate and the debt margin are part of this price setting decision. Consequently, they too must be chosen to satisfy this  $NPV = 0$  principle. Setting these terms to match the regulatory cycle satisfies this  $NPV = 0$  requirement. Both Schmalensee (1989) and Lally (2002) provide proofs of this result, in the case of no debt and no source of risk except future risk free interest rates. Lally (2004) proves the same result under the more realistic situation in which there are cost and demand risks, and aggregate depreciation can deviate from the initial cost of the asset. Lally (2007) goes on to consider the implications of corporate debt, and shows that the only scenario in which the  $NPV = 0$  rule can be satisfied is that in which the regulator sets the terms on the risk free rate and the debt premium to match the regulatory cycle whilst the regulated firm chooses its borrowing to match the regulatory cycle. Departures from either of these conditions will induce violations of the  $NPV = 0$  rule. Furthermore, any contrary policy adopted by the firm

will inflict interest rate risk upon it. Thus, the firm would seem to have strong incentives to match its borrowing to the regulatory cycle.

Such reasoning omits any consideration of “refinancing risk”, i.e., the risk of exposure to unusual conditions in credit markets at the time of rolling over debt, most particularly the non-availability of credit at any price, and exposure to the market power of credit providers when much of a firm’s debt is rolled over at the same time. In response to this potential problem the firm might seek to stagger the roll-over of their debt, so that approximately the same proportion is rolled over each year, and also seek a sufficiently long average term on their debt that the proportion rolled over each year is sufficiently small. For example, a firm might seek an average debt term of 10 years so that, in conjunction with staggering of the maturity dates, approximately 10% of its debt requires roll-over in any one year. Prima facie, the first of these processes (staggering of maturity dates) is inconsistent with firms setting the issue and maturity dates on all of its debt issues to match the regulatory cycle, and the second (choosing a sufficiently long average debt term) will also be inconsistent if the desired average debt term deviates from the regulatory cycle. However, such processes followed by firms are not necessarily inconsistent with the matching of all debt issues with the regulatory cycle, because swap contracts might be available to convert the firm’s actual schedule of debt issues to one that aligns with the regulatory cycle.<sup>1</sup>

This gives rise to a number of possible options. The first option would be to act as if the regulated firms engage in five yearly debt re-financing. In this event the total cost of debt that should be allowed every five years would be the five year risk free rate, the five year debt premium, and the annualised issue costs of five yearly debt issues. In so far as firms acted otherwise and therefore possibly incurred different costs or risks, the incremental cost or risk incurred by them could be ignored on the grounds that the firm could have acted in the way assumed here. In addition, the first term within the cost of equity is the five year risk free rate. Such an approach satisfies the  $NPV = 0$  test but treats the incremental refinancing risk from the use of five year debt rather than whatever alternative term might have been used by them as inconsequential.

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<sup>1</sup> The use of interest rate swaps would deal with the risk free rate component and the use of credit default swaps would deal with the debt premium.

The second option would arise only if the average debt term (from issuance to maturity) used by relevant comparator firms materially exceeded five years. For example, suppose that the average debt term of such firms is ten years. Relative to five year debt, this would raise the firm's borrowing costs (due to the maturity premium) but reduce its annualized debt issue costs and also reduce its refinancing risk. Since the net effect of the first two factors is positive, the motivation for the firm's action would be to reduce refinancing risk at some cost. The refinancing risk is not compensated for by a regulator, and therefore borrowing for the longer term could be an efficient strategy<sup>23</sup>. The second option would then assume that regulated firms will borrow for ten years (with staggering of repayments) and use swap contracts to effectively match their debt to the regulatory cycle. Accordingly, the total costs of debt that should be allowed every five years would be the five year risk free rate, the five year debt premium, the annualised debt issue costs arising from ten yearly debt issues, and the transaction costs of the swap contracts (in the form of the spread between the "mid rate" and the price). In addition, the first term within the cost of equity is still the five year risk free rate. Such an approach also satisfies the  $NPV = 0$  test so long as the swap contracts are available and their transaction costs are correctly assessed. However, in respect of the credit default swaps, there are potential implementation difficulties. In particular, contracts may not exist in respect of relevant firms, and the size of the transactions required may be so large in relation to normal market volumes that no objective evidence on the transaction costs would be available. The second of these difficulties is referred to by the New Zealand Commerce Commission in their recent determination of an appropriate cost of capital for the Telecommunications Service Obligation

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<sup>2</sup> No parallel concern arises in respect of firms borrowing for less than five years, because this would have to be motivated by a desire to lower the cost of debt (whilst being exposed to higher annualized debt issue costs, greater refinancing risks, and interest rate risk over the period from the roll-over point on the firm's borrowing to the end of the regulatory cycle). However, since the borrowing cost for five years is fully compensated for, a firm's desire to lower this cost at the expense of various other costs and risks need not concern a regulator. By contrast, a firm's desire to borrow for more than five years in order to reduce refinancing risk should be of concern to a regulator because the regulatory process does not fully compensate for this refinancing risk.

<sup>3</sup> Ten rather than five year debt involves less refinancing risk because, assuming the firm staggers its repayments evenly across time, only 10% rather than 20% of its debts require repayment in any one year. The cost consequences of unusually high interest rates during a year would then be less. In addition, the consequences of debt markets freezing up for a short period would be less severe because the smaller sum requiring repayment within any year might be capable of being financed internally (through elimination of dividends and reduced capex). Finally, the likelihood of lenders attempting to charge above normal rates, in the belief that the firm is desperate, would be lower because the smaller sum requiring repayment within any year might be capable of being financed internally.

(Commerce Commission, 2009, paras 142-163), and was critical in their decision not to follow this approach.

The third option would also only arise if the average debt term used by relevant comparator firms materially exceeded five years. Again, for example, we suppose that the average debt term is ten years. In this event, the third option would be to assume that regulated firms will borrow for ten years and use interest rate swap contracts to effectively convert the ten year risk free rate that is embedded in their average debt term into the five year risk free rate. However, they would not be assumed to use credit default swaps to convert the ten year debt premium that was embedded in their average debt term into a five year debt premium (due to the difficulties in doing so). In this event, the total costs of debt that should be allowed every five years would be the five year risk free rate, the ten year debt premium, the annualised debt issue costs arising from ten yearly debt issues, and the transaction costs of the interest rate swap contracts (in the form of the spread between the “mid rate” and the price). In addition, the first term within the cost of equity is still the five year risk free rate. However, with five yearly resetting of the ten year debt margin, the resulting process would violate the  $NPV = 0$  test because the allowed premium would sometimes diverge from that actually incurred by a firm. For example, suppose the firm is established now and partially funds itself with ten year debt involving a current debt premium of 1.5%. The regulator will set prices for the first five years using the same ten year debt premium, and therefore no difference arises in the first five years. However, in five years time, the regulator will reset prices using the ten year debt premium prevailing at that time and this may differ from the current debt premium. In that event, the price allowed by the regulator for that second five year period will diverge from the costs incurred by the regulated firm. Nevertheless, the divergence could be in either direction. Furthermore, as discussed in Appendix 1, the violations of the  $NPV = 0$  principle would be very slight. In particular, they would be unlikely to exceed 0.40% of the book value of the firm, which is equivalent to an error in assessing WACC each year of about 0.04%.

The fourth option would also only arise if the average debt term used by relevant comparator firms materially exceeded five years. Again, for example, we suppose that the average debt term is ten years. In this event, the fourth option would be to assume that regulated firms will

borrow for ten years but use neither interest rate swap contracts nor credit default swaps to convert the ten year debt into five year debt. In this event, the total costs of debt that should be allowed every five years would be the ten year risk free rate, the ten year debt premium, and the annualised debt issue costs arising from ten yearly debt issues<sup>4</sup>. In addition, the first term within the cost of equity is still the five year risk free rate. However, with five yearly resetting of both the risk free rate and the debt margin, the resulting process would violate the  $NPV = 0$  test because the allowed costs would sometimes diverge from those actually incurred by a firm. For example, suppose the firm is established now and partially funds itself with ten year debt involving a current risk free rate of 5% and a debt premium of 1.5%. The regulator will set prices for the first five years using the same cost of debt, and therefore no difference arises in the first five years. However, in five years time, the regulator will reset prices using the ten year risk free rate and ten year debt premium prevailing at that time and these may differ from the current figures. In that event, the price allowed by the regulator for that second five year period will diverge from the costs incurred by the regulated firm. Nevertheless, the divergence could be in either direction and equally likely to be positive or negative. Furthermore, as discussed in Appendix 2, the violations of the  $NPV = 0$  principle would not be large. In particular, they would be unlikely to exceed 1.20% of the book value of the firm, which is equivalent to an error in assessing WACC each year of about 0.12%.

In the interests of completeness, it is useful to mention a fifth option, which differs from the fourth option only in extending the use of the longer term risk free rate to the first term within the cost of equity as well as the cost of debt. In respect of the risk free rate and the debt margin used in determining the cost of debt, as just discussed, the resulting process would violate the  $NPV = 0$  test but the maximum violation would be equivalent to a WACC error of only about 0.12% and would be equally likely to be positive or negative. In respect of the cost of equity, the situation is quite different. Whether or not the firm borrows for more than five years or not has no implications for the appropriate risk free rate to use within the cost of equity, which can be assessed merely by considering a firm without debt (as in Lally, 2002, 2004). In this case, a regulatory cycle of five years requires use of the five year risk free rate within the first term of

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<sup>4</sup> The regulator's use of the ten year risk free rate is simply a consequence of the firm incurring that cost under its assumed course of action. However, it may not be efficient for a firm to follow this strategy. If that is judged to be the case, the option will be dismissed. We will analyse the merits of these options shortly.

the cost of equity to satisfy the NPV = 0 test. Consequently, use of the ten year risk free rate would over compensate equity holders by the excess of the ten year rate over the five year rate. In the last forty years this excess has averaged about 0.20%.<sup>5</sup>

If any option except the first were used, the annualized debt issue costs would be those arising from debt issues at the frequency implied by the average term of the debt of relevant comparator firms whilst the first option requires annualized debt issue costs for five yearly debt issues. The QCA's (2009) proposal is for an annualized debt issue cost of 0.125% in the context of five yearly debt issues, but I understand that the figure derives from an analysis based upon ten yearly debt issues. So, if the first option is used, then the appropriate figure for debt issue costs would be higher than 0.125% and equivalent to it in present value terms. Denoting this annualized equivalent amount from five yearly debt issues as  $X$ , the issue cost as  $C$ , and the appropriate discount rate for the present valuing as  $k$ , it follows that

$$X \left[ \frac{1}{1+k} + \dots + \frac{1}{(1+k)^5} \right] = C = .00125 \left[ \frac{1}{1+k} + \dots + \frac{1}{(1+k)^{10}} \right]$$

With a discount rate  $k$  of .09 (QCA, 2009, Table 1.3), the result is  $X = 0.00206$ , i.e., 0.21%. Alternative values for  $k$  do not materially change this result. So, with an annualized issue cost of 0.125% assuming ten yearly debt issues, the appropriate annualized cost would be about 0.20% assuming five yearly debt issues. The same process would yield the appropriate annualized amount for the second, third and fourth options. For example, if these involved a debt term of ten years, the annualized amount would be 0.125%.

In summary, five options are available in this area. The first would be to act as if the regulated firms engage in five yearly debt re-financing. In this event the total cost of debt that should be allowed every five years would be the five year risk free rate, the five year debt premium, and the annualised issue costs of five yearly debt issues (about 0.20%). In addition, the first term

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<sup>5</sup> The relevant table is F2 from the Reserve Bank's website ([www.rba.gov.au](http://www.rba.gov.au)), which provides constant maturity series for various bond terms. The average yields on five and ten year bonds over the period January 1972 to November 2009 are 8.95% and 9.14% respectively, with a differential of 0.19%. These figures reflect simple rather than compound interest (as per [www.rba.gov.au/mkt-operations/tech-notes](http://www.rba.gov.au/mkt-operations/tech-notes)) but correction for this would only raise the differential between the five and ten year rates by about one basis point.

within the cost of equity is the five year risk free rate. The second option would arise only if the average debt term used by relevant comparator firms (term  $T$ ) materially exceeded five years, and would then assume that regulated firms will borrow for  $T$  years and use swap contracts (interest rate swaps and credit default swaps) to effectively match their debt to the regulatory cycle. Accordingly, the total costs of debt that should be allowed every five years would be the five year risk free rate, the five year debt premium, the annualised debt issue costs arising from  $T$  yearly debt issues (0.125% if  $T = 10$  years), and the transaction costs of the swap contracts (in the form of the spread between the “mid rate” and the price). In addition, the first term within the cost of equity is still the five year risk free rate. The third option would also only arise if the average debt term used by relevant comparator firms (term  $T$ ) materially exceeded five years, and would then assume that regulated firms will borrow for  $T$  years and use interest rate swap contracts to effectively convert the risk free rate that is embedded in their average debt term into the five year risk free rate. However, they would not be assumed to use credit default swaps to convert the debt premium that was embedded in their average debt term into a five year debt premium. In this event, the total costs of debt that should be allowed every five years should be the five year risk free rate, the debt premium on  $T$  year debt, the annualised debt issue costs arising from  $T$  yearly debt issues (0.125% if  $T = 10$  years), and the transaction costs of the interest rate swap contracts (in the form of the spread between the “mid rate” and the price). In addition, the first term within the cost of equity is still the five year risk free rate. The fourth option would also only arise if the average debt term used by relevant comparator firms ( $T$  years) materially exceeded five years, and would then assume that regulated firms will borrow for  $T$  years but use neither interest rate swap contracts nor credit default swaps to convert the ten year debt into five year debt. In this event, the total costs of debt that should be allowed every five years would be the  $T$  year risk free rate, the  $T$  year debt premium, and the annualised debt issue costs arising from  $T$  yearly debt issues (0.125% if  $T = 10$  years). In addition, the first term within the cost of equity is still the five year risk free rate. Finally, the fifth option differs from the fourth option only in extending the use of the  $T$  year risk free rate to the first term within the cost of equity as well as the cost of debt.

The first option satisfies the  $NPV = 0$  test but treats the additional refinancing risk arising from the use of five year debt rather than any longer term as inconsequential. The second option also

satisfies the  $NPV = 0$  test but may be subject to implementation difficulties in respect of credit default swaps. The third option violates the  $NPV = 0$  test but only trivially and not in any consistent direction. The fourth option also violates the  $NPV = 0$  test, and to a larger degree although again not in any consistent direction. Finally, the fifth option embodies the same violations of the  $NPV = 0$  test as the fourth option, in respect of the cost of debt, and also violates the  $NPV = 0$  test consistently positively in respect of the cost of equity, i.e., equity holders would be consistently over compensated by about 0.20% in the risk free rate if  $T = 10$  years. The fifth option can then be dismissed. The fourth option rests upon the very unrealistic assumption that firms borrowing for significantly more than five years would not engage in interest rate swaps in order to remove the interest rate risk arising from the mis-match between their borrowing term and the length of the regulatory cycle. A good example of the problem resulting from failure to hedge in this way would arise if a regulator set a price cap for five years in January 2004, using the prevailing ten year risk free rate of 5.70%, and reset it five years later in January 2009 using the then prevailing rate of 4.09%.<sup>6</sup> In the absence of such hedging, the firm would experience a significant drop in its revenue in January 2009 whilst its costs remained at the higher level from earlier years. In view of the implausibility of the assumption that firms would *not* seek to hedge against this kind of risk, I think that option four should also be dismissed.

In relation to the remaining three options, I do not have sufficient information to choose between them but I can specify the conditions under which each should be chosen. The first option is favoured if the average debt term of relevant comparator businesses is not significantly larger than five years. If it is significantly larger than five years, then such firms will have suffered a higher cost of debt from adopting the longer debt term (because the maturity premium on the longer term debt will exceed the saving in annualized debt issue costs), and their willingness to do so would then indicate a concern with the incremental refinancing risks from the use of five year debt. So, if the average debt term of relevant comparator businesses is significantly larger than five years, the use of the first option would be inappropriate because it assumes that these refinancing risks are trivial. This leaves the choice between the second and third options. The

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<sup>6</sup> The data are drawn from Table F2 on the Reserve Bank's website ([www.rba.gov.au](http://www.rba.gov.au)), for January 2004 and January 2009.

second option would be favoured if the relevant credit default swaps are available and their transaction costs are objectively determinable. If these conditions do not hold, then I favour the third option.

## *2.2 Implications of using the CAPM*

We now turn to consider the implications of using the CAPM to estimate the cost of equity. The model involves a risk free rate in the first term within the model and also within the market risk premium. Inter alia, the CAPM assumes that investors share a common investment horizon (the period between successive reassessments of their portfolios) and the relevant risk free rate implied by this feature of the model (at both points within the model) is the rate whose term matches the common investment horizon. However, there is clearly variation across investors in this investment horizon. In the face of this, the appropriate course of action would be to use the across-investor average period between successive equity portfolio reassessments. Froot et al (1992, Table 1) gives “average holding periods” for a wide range of US investor classes, and the weighted average of these is 3.4 years.<sup>7</sup> However, these “average holding periods” for each investor class are determined by simply inverting the average turnover rate and this will significantly underestimate the average holding period. On the other hand, any investor’s average holding period will significantly overstate the period between successive reassessments of their portfolio because a reassessment will not in general induce sale of all assets held at that time. In the face of these considerations, there are a wide range of possible values for the across-investor average period between successive portfolio reassessments.

We therefore consider a number of possible values for this across-investor average period between successive portfolio reassessments, ranging from one to ten years. We start with the simplest case, involving five years because it coincides with the regulatory cycle. In this case, the CAPM would require use of the five year risk free rate within both the first term of the model and the market risk premium, whilst the NPV = 0 principle examined in the previous section mandates use of the five year risk free rate within both the cost of debt and the first term of the CAPM. Accordingly, there is no conflict between these two prescriptions, and it therefore remains only to comment upon the estimation of the market risk premium using the five year risk

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<sup>7</sup> Estimates of this type for Australian investors do not seem to be available.

free rate. The QCA (2009, pp. 13-14) estimates the market risk premium using six different approaches, of which four are the most significant and involve the Ibbotson (2004) methodology (6.99%), the Siegel (1992) methodology (5.27%), the Cornell (1999) methodology (5.68%), and survey evidence (6.00%). The median of these estimates is 5.84%, which is rounded to 6.0% by the QCA.

In respect of the Ibbotson methodology, the data is drawn from Officer (1989) with updating to 2009, and therefore uses bond yields over the period from 1882-2009. The bonds used have terms of at least five years for some periods, ten years for others, and at least seven years for the rest. This suggests an average term of between five and ten years, rather than the five years desired here. We therefore seek to determine the average difference between the yields on five and ten year Australian Commonwealth Government bonds over the period 1882-2007, and this differential will enable an upper bound to be placed on the change in the estimated market risk premium from using five year bonds rather than the bonds actually used by the QCA. Data on the yields of both five and ten year Australian government bonds seem to be available only from January 1972 (on the Reserve Bank's website), and the average difference in yields over this period is 0.19%.<sup>8</sup> A longer series of five and ten year bond yields is available for US government bonds, back to 1953. For the present purposes, the significant part of this US series is 1953-1971 inclusive, and the average differential between five and ten year bond yields here is 0.06%.<sup>9</sup> Collectively, this information suggests that the average differential in five and ten year yields on Australian Government bonds over the period 1953-2009 was about 0.15%, and we extrapolate this figure to the entire 127 year historical period over which the market risk premium was estimated by the QCA. Thus, had the QCA estimated the market risk premium in

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<sup>8</sup> The relevant table is F2 from the Reserve Bank's website ([www.rba.gov.au](http://www.rba.gov.au)), which provides constant maturity series for various bond terms. The average yields on five and ten year bonds over the period January 1972 to November 2009 are 8.95% and 9.14% respectively, with a differential of 0.19%. These figures reflect simple rather than compound interest but correction for this would only raise the differential between the five and ten year rates by about one basis point.

<sup>9</sup> The relevant tables are GS5 and GS10 from the website of the Federal Reserve Bank of St Louis ([www.research.stlouisfed.org/fred2/](http://www.research.stlouisfed.org/fred2/)), and they provide constant maturity series for five and ten year bond yields. The average values for these yields over the period 1953-1971 are 4.32% and 4.38% respectively, and therefore the differential is 0.06%.

the Ibbotson fashion using five year bonds, the estimate would have risen by about 0.15%, to 7.14%.

Table 1: Australian Government Bond Yields

Date	Conventional		Conventional		Inflation-adjusted		Inflation-adjusted	
	Maturity	Yld	Maturity	Yld	Maturity	Yld	Maturity	Yld
31-7-1992	n/a				8-1995	4.70	8-1998	4.70
1-7-1993	9-1994	5.11	8-2003	7.39	8-1995	3.79	8-1998	4.00
1-7-1994	9-1995	7.23	9-2004	9.64	8-1995	4.41	8-1998	5.15
30-6-1995	7-1996	7.68	7-2005	9.21	8-1995	2.60	8-1998	4.50
1-7-1996	9-1997	7.79	11-2006	8.79	8-1998	4.60	8-1998	4.60
1-7-1997	8-1998	5.13	10-2007	6.97	8-1998	3.96	8-2005	4.62
1-7-1998	7-1999	4.97	8-2008	5.49	8-1998	4.90	8-2005	3.46
1-7-1999	7-2000	4.70	9-2009	6.15	8-2005	3.47	8-2005	3.47
30-6-2000	11-2001	5.87	9-2009	6.16	8-2005	2.99	8-2005	2.99
2-7-2001	10-2002	5.06	6-2011	6.10	8-2005	3.44	8-2005	3.44
1-7-2002	8-2003	5.25	5-2013	6.08	8-2005	2.93	8-2005	2.93
1-7-2003	9-2004	4.38	5-2013	5.00	8-2005	2.06	8-2010	2.73
1-7-2004	7-2005	5.34	4-2015	5.91	8-2005	3.11	8-2010	3.15
1-7-2005	11-2006	5.17	4-2015	5.05	8-2005	2.86	8-2010	2.44
30-6-2006	10-2007	5.84	2-2017	5.78	8-2010	2.64	8-2010	2.64
2-7-2007	8-2008	6.36	2-2017	6.19	8-2010	3.52	8-2010	3.52
1-7-2008	9-2009	6.94	3-2019	6.49	8-2010	2.91	8-2015	2.84
1-7-2009	8-2010	3.38	3-2019	5.50				
Average	1.1 yrs	5.66%	10.2 yrs	6.58%	2.4 yrs	3.46%	5.1 yrs	3.60%

In respect of the Siegel methodology, the QCA estimates the long-term expected real risk free rate by averaging over the yields on the longest term inflation-protected bonds for the period

1992-2008 inclusive, resulting in 3.62%. The use of five year inflation-protected bonds would lower this average yield to 3.60% as shown in the last column of Table 1 above<sup>10</sup>. Thus, had the QCA estimated the market risk premium in the Siegel fashion using five year bonds, their estimate would have risen by only 0.02% to 5.29%.

In respect of the Cornell methodology, the QCA used ten year bond yields averaged over the period 15 October to 11 November 2009. Substitution of five for ten year bonds would have lowered the risk free rate by 0.19%<sup>11</sup>, and therefore raised the estimate of the market risk premium by 0.19% to 5.87%. Finally, in respect of survey evidence, the relevant survey (Fernandez, 2009, Table 2) does not specify the future time period to which the estimate relates or the underlying bonds, and therefore no adjustment to this estimate for the market risk premium for Australia (6.0%) arises. Thus, with these adjustments, the QCA's median estimate for the market risk premium would have risen from 5.84% to 5.94%. Thus, the QCA's rounded estimate (of 6.0%) would not have been affected by the use of five rather than ten year bonds.

We now suppose that the across-investor average period between successive portfolio reassessments is less than five years. For example, suppose this period is as low as one year. Use of the CAPM would then require use of the one year risk free rate within both the first term of the model and the market risk premium, whilst the NPV = 0 principle examined in the previous section mandates use of the five year risk free rate within both the cost of debt and the first term of the CAPM. Accordingly, there would be an apparent conflict between these two prescriptions, i.e., the CAPM requires use of the one year risk free rate within the first term of the model whilst the NPV = 0 principle requires use of the five year risk free rate here. However, this apparent conflict arises merely because the two models are concerned with different periods. If the CAPM applies to a one year period, but the issue in question requires a cost of equity over

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<sup>10</sup> Table F2 from the Reserve Bank's website ([www.rba.gov.au](http://www.rba.gov.au)) does not provide data on yields for five year inflation-protected bonds. Consequently it is necessary to construct one from Table F16 for five year bonds (or those closest to this) at each of the chosen points in time. The points in time chosen are 1 July in each year from 1992 to 2008 inclusive, or the nearest such time if there were no trades on 1 July. The average term to maturity of these bonds is 5.1 years, as shown in the penultimate column of Table 1.

<sup>11</sup> The QCA used the bonds maturing in March 2019 (TB122), whose average yield over the period in question was 5.59%. In respect of the period 15.10.2009 to 11.11.2009, the nearest bond to a five year maturity is that maturing in June 2014 (TB125), with an average yield over the period in question (15.10.2009 to 11.11.2009) of 5.40%. (data from Table F16 from the Reserve Bank's website: [www.rba.gov.au](http://www.rba.gov.au)). The differential is then 0.19%.

the next five years, then the usual practice in valuation is to apply the CAPM for the successive one year periods involved here. Thus, we would invoke the CAPM for each of the first, second, third, fourth and fifth years. For the first year, we would use the current one year risk free rate and a market risk premium defined relative to that one year risk free rate. For the second year, we would use the expected one year risk free rate for that year and a market risk premium defined relative to that one year risk free rate, etc. As shown in Appendix 3, the result of combining these costs of equity over the five year period is equivalent to simply using one cost of equity within the first term of the model, equal to the average of the relevant one year risk free rates (the current one year rate and the expected rates for the following four years), whilst the market risk premium is defined relative to the one year risk free rate. Furthermore, repeated application of the CAPM in this way requires that investors ignore risk surrounding future reinvestment opportunities, and therefore requires that they ignore interest rate risk (Fama, 1977). Thus, the expectations hypothesis would have to characterize the term structure of interest rates. Accordingly, the average of the current one year risk free rate and the expected rates for the following four years would be equal to the current five year risk free rate. So, the five year cost of equity determined from repeated applications of the one year CAPM would involve the five year risk free rate within the first term of the model and the market risk premium defined relative to the one year risk free rate.

It remains to comment upon the estimation of the market risk premium using the one year risk free rate rather than the ten year rate used by the QCA. So, we repeat the process discussed above except that one and ten year yields are compared rather than five and ten year yields. We start with the Ibbotson methodology. Australian data on both one and ten year bonds seems to be available only since July 1992, and the average difference in yields between one and ten year bonds is 0.92%.<sup>12</sup> This is supplemented with US data from 1953-1992, with an average

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<sup>12</sup> Table F2 from the Reserve Bank's website ([www.rba.gov.au](http://www.rba.gov.au)) does not provide a constant maturity series for one year bonds. Consequently it is necessary to construct one from Table F16 for one year bonds (or those closest to them) at each of the chosen points in time. The points in time chosen are 1 July in each year from 1992 to 2009 inclusive, or the nearest such time if there are no trades on 1 July. For comparison with the yields on ten year bonds, the same process is applied to them. The results are shown in the first five columns of Table 1 above and the average difference in yields is 0.92%.

differential of 0.62%.<sup>13</sup> Collectively, this suggests that the average differential in Australian one and ten year risk free rate yields over the period 1953-2009 was about 0.70%. If this figure is extrapolated to the entire 127 year historical period over which the market risk premium was estimated, the QCA's Ibbotson-type estimate of the market risk premium would be raised by 0.70%, to 7.69%<sup>14</sup>. In respect of the Siegel methodology, Table 1 gives the time series of yields on inflation-protected bonds closest to one year, and the average such yield over the period 1992-2008 was 3.46% compared to the QCA's figure of 3.62% using longer term bonds. Thus, the QCA's Siegel-type estimate of the market risk premium would have risen by 0.16% to 5.43% if the QCA had used one year bonds.<sup>15</sup> In addition, the QCA's Cornell-type estimate would have been raised by 1.11%, to 6.79%<sup>16</sup>. Finally, as before, the QCA's survey-based estimate of 6.00% would not be affected. The median of the QCA's estimates would then rise from 5.84% to 6.40%. If the QCA rounds to the nearest 0.50%, then its rounded estimate would rise from 6.0% to 6.5%. If the QCA rounds to the nearest 1.0%, then no change in its estimate would arise.

We finally suppose that the across-investor average period between successive portfolio reassessments is greater than five years. For example, suppose that this is as much as ten years. Use of the CAPM would then require use of the ten year risk free rate both in the first term of the model and the market risk premium, whilst the NPV = 0 principle examined in the previous section mandates use of the five year risk free rate within both the cost of debt and the first term

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<sup>13</sup> The relevant tables are GS1 and GS10 from the website of the Federal Reserve Bank of St Louis ([www.research.stlouisfed.org/fred2/](http://www.research.stlouisfed.org/fred2/)), and they provide constant maturity series for one and ten year bond yields. The average values for these yields over the period April 1953 to June 1992 are 6.25% and 6.87% respectively.

<sup>14</sup> Dimson et al (2010, p 55) provide rates of return on long term (approximately ten year) and very short term (approximately three months) Australian Government bonds over the period 1900-2010, and the average difference is 1.30%. However, this will be likely to overestimate the differential between one and ten year bonds.

<sup>15</sup> This estimate of the change is too low because the bonds used to proxy for one year bonds have an average term to maturity of 2.4 years (as shown in Table 1 above). However, estimating the result for one year bonds by extrapolation would not materially change the result.

<sup>16</sup> For November 2009, the nearest conventional bonds to a one year maturity are those maturing in August 2010 (TB121), with an average yield over the relevant period (15.10.2009 to 11.11.2009) of 4.35% (data from Table F16 from the Reserve Bank's website: [www.rba.gov.au](http://www.rba.gov.au)). Since the term structure at this point is markedly upward sloping, we also determine the average yield over the same period for the next longest maturing bonds (TB117 maturing in June 2011), which is 4.75%. Forming an appropriately weighted average of these two yields generates the figure of 4.48%, which is an interpolated estimate of the average yield on one year bonds over the same period. As noted in footnote 11, the average yield on ten year bonds over the same period was 5.59%. So, the differential is 1.11%.

of the CAPM. Accordingly, there would again be an apparent conflict between these two prescriptions, i.e., the CAPM requires use of the ten year risk free rate within the first term of the model whilst the NPV = 0 principle requires use of the five year risk free rate here. As before, the apparent conflict arises because the two models are concerned with different time periods. However, unlike before, repeated application of the CAPM cannot now resolve the apparent conflict because the ten year period to which the CAPM is believed to relate exceeds the five year period for which a cost of equity is required. Thus, we face a choice between abandoning the CAPM and adapting it to the scenario in question, and the lack of a credible alternative to the CAPM demands that it be adapted. Following the principle that one should minimize the modifications that are required to any model to adapt it to a particular scenario, the first term within the CAPM should be the five year risk free rate whilst the market risk premium should continue to be defined and therefore estimated relative to the ten year risk free rate. Since the QCA's estimate of the market risk premium reflects the use of this ten year risk free rate, then no alteration to the QCA's estimate of the market risk premium would be required. The result here is simply a consequence of a real world scenario being more complex than that assumed in the CAPM. However, if one felt that both risk free rates within the CAPM should be equally modified to fit the scenario in question, in which case the market risk premium would be defined and therefore estimated relative to the five year risk free rate, this takes us back to the first scenario discussed above in which the QCA's (rounded) estimate of the market risk premium would not be changed.

In summary, the implications of using the CAPM to estimate the cost of equity depend upon the across-investor average period between successive portfolio reassessments. If this period is believed to be five years, then the CAPM would require use of the five year risk free rate within the first term of the model and the market risk premium, whilst the NPV = 0 requirement also mandates use of the five year risk free rate within the first term of the CAPM. No inconsistency then arises. Furthermore, despite the fact that the QCA bases its estimate of the market risk premium from studies that use ten rather than five year bonds, the QCA's (rounded) estimate of 6.0% would not be affected by the use of five year bonds. Alternatively, if the across-investor average period between successive portfolio reassessments is believed to be as little as one year, then the CAPM would require use of the one year risk free rate within the first term of the model

and the market risk premium, whilst the  $NPV = 0$  requirement would still mandate use of the five year risk free rate within the first term of the CAPM. The apparent conflict here is illusory because the two models are concerned with different periods, and is resolved by successive application of the one year CAPM to the five individual years for which a cost of equity is sought. This effectively leads to use of the five year risk free rate within the first term of the CAPM and the one year risk free rate within the market risk premium, and use of the latter would likely increase the QCA's estimate of the market risk premium by 0.5%. Finally, if the across-investor average period between successive portfolio reassessments is believed to be as much as ten years, then the CAPM would require use of the ten year risk free rate within both the first term of the model and the market risk premium, whilst the  $NPV = 0$  requirement would still mandate use of the five year risk free rate within the first term of the CAPM. As before, this apparent conflict arises from the fact that the two models are concerned with different periods, but it cannot now be resolved in the same way. Thus, we face a choice between abandoning the CAPM and adapting it to the scenario in question, and the lack of a credible alternative to the CAPM demands that it be adapted. Following the principle that one should minimize the modifications that are required to any model to adapt it to a particular scenario, the first term within the CAPM should be the five year risk free rate whilst the market risk premium should continue to be defined and therefore estimated relative to the ten year risk free rate. Since the QCA's estimate of the market risk premium reflects the use of this ten year risk free rate, then no alteration to the QCA's estimate of the market risk premium would be required.

Across these three scenarios, the first term within the CAPM is always the five year risk free rate, in conformity with the CAPM or the  $NPV = 0$  requirement, whilst the risk free rate used within the market risk premium varies. However, unless the across-investor average period between successive portfolio reassessments is believed to be significantly less than five years, no change to the QCA's (rounded) estimate of the market risk premium would be likely to arise. The QCA's proposal is to use the five year risk free rate within the first term of the CAPM and estimate the market risk premium using the ten year risk free rate. Consistent with the analysis above, such a position is perfectly defensible if the QCA believes that the across-investor average period between successive portfolio reassessments is ten years. Furthermore, even if the QCA holds no view on this question, the lack of a sufficiently long time series of Australian risk

free rate yields for any other bonds with a term of at least one year would complicate efforts to estimate the market risk premium using the Ibbotson methodology. Coupled with the fact that this average portfolio reassessment frequency would have to be appreciably less than five years in order to affect the (rounded) estimate of the market risk premium, this argues for the status quo.

### **3. Review of Submissions**

#### *3.1 CEG*

CEG (2010) argues that infrastructure businesses have an average debt term of about ten years, that this strategy presumably minimizes their WACC, and therefore that any alternative strategy must have a higher WACC. In particular, a strategy of five rather than ten year debt must have a higher WACC, and therefore any reduction in the cost of debt from five rather than ten year debt *must* be associated with a more than offsetting increase in the cost of equity (ibid, paras 3, 9, 27), with Miller and Modigliani (1958) being cited repeatedly in support of this claim (CEG, ibid, paras 3, 28, 40). Accordingly, the QCA's proposed adoption of a five year risk free rate and debt premium are inappropriate.

CEG's claims are incorrect for the following reasons. Firstly, whilst a firm that switches from ten to five year debt may lower its cost of debt in the sense of avoiding the maturity premium on ten relative to five year debt, it will thereby expose itself to greater re-financing risk and incur greater annualized debt issue costs, and these disadvantages from five year debt alone are sufficient explanations for firms using ten rather than five year debt. One does not need to suggest any counterbalancing increase in the cost of equity to explain a preference by firms for debt with a term in excess of five years. Consequently, CEG's conclusion that the cost of equity *must* increase when debt maturity is reduced does not therefore follow. Somewhat remarkably, CEG repeatedly refers to the role of refinancing risk in explaining firm behavior (CEG, ibid, paras 8, 16, 34) but without appearing to realize that this undercuts their claim that the use of shorter term debt *must* induce an increase in the cost of equity.

Secondly, CEG's references to Miller and Modigliani (1958) in support of their claim that lower debt maturity raises the cost of equity are completely unwarranted because Miller and

Modigliani make *no* reference whatsoever to any such connection or even to the debt maturity decision by firms<sup>17</sup>. Their paper is concerned with the effect of leverage (rather than debt maturity) on the cost of equity, WACC and the value of the firm. Furthermore, Miller and Modigliani's analysis assumes away numerous real world complications including refinancing risk and debt issue costs, whose presence provides the obvious explanation for firms electing to borrow for ten rather than five years. Thus, the Miller and Modigliani paper neither discusses the issue of the optimal debt maturity decision nor does it have any implications for this decision. CEG appears to have completely misunderstood the Miller and Modigliani paper.

Thirdly, in the face of a regulatory process that sets a firm's output price every five years, based inter alia upon the prevailing five year risk free rate, a switch by the firm from ten to five year debt (via the issue of five year debt or the use of relevant swap contracts) would *reduce* the risk faced by its equity holders because the firm's costs would now be better aligned with its revenues (determined by the regulator). Accordingly, any impact upon the firm's cost of equity from such a change in debt policy could be *downwards*, contrary to CEG's claim.

CEG (2010) also appears to view a regulator's function in this area as one of determining the optimal debt strategy for an unregulated firm, and then reproducing this in its price setting process for a regulated firm. However, the appropriate course of action for the regulator is to set an output price for the firm that just covers the costs that would be incurred by an efficiently operating firm, which is the  $NPV = 0$  test. Furthermore, in this context, efficient means not simply the avoidance of "gold-plating" but also the avoidance of actions that, given the regulatory situation, would expose the firm to unnecessary risks. Thus, the efficient action for the firm and the appropriate regulatory policy must be simultaneously determined, and will reflect both the length of the regulatory cycle and factors exogenous to regulation such as refinancing risk. By contrast, CEG appears to (wrongly) consider that the efficient action for the firm should be determined first, and the appropriate regulatory policy then follows from it.

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<sup>17</sup> The only even vaguely related comment by Miller and Modigliani is merely to observe in passing that interest rates vary with maturity (ibid, p 273).

In the event that the average debt term of relevant comparator firms diverges from five years, the question of whether it is efficient for a regulated firm to undertake the interest rate swaps that effectively align the risk free rate component of its cost of debt with the regulatory cycle arises. Doing so eliminates interest rate risk that would otherwise be faced by the firm, and therefore is equivalent to purchasing insurance<sup>18</sup>. Of course, a regulated firm could elect not to “purchase this insurance” but this is not a matter that a regulator should be concerned with; it is sufficient for the regulator to allow for the cost of the “insurance” in setting the output price and it would be efficient for the firm to purchase the “insurance”. In the same way, a regulator would typically allow for the cost of property insurance in setting prices, and a firm could choose not to purchase such insurance. However, even if it chose not to purchase the insurance, the regulator’s action would still be appropriate.

CEG (ibid, p 20) also argues for use of a consistent risk free rate within the CAPM, and therefore the first term in the model should be the ten year risk free rate to align it with the rate used in estimating the market risk premium. However, even if such consistency was judged to be important, it is attainable by the alternative means of estimating the market risk premium using five year rather than ten year bonds. This latter approach has the advantage of avoiding any conflict with the NPV = 0 requirement. Furthermore, whilst sufficiently long-term Australian data does not seem to exist to enable the market risk premium to be estimated relative to five year bonds, the available evidence indicates that it would raise the (unrounded) estimate by about 0.10% and therefore would not change the QCA’s estimate of 6.0% so long as the QCA continues to round its estimate to the nearest 1% or even the nearest 0.50%.

### *3.2 QR Network*

QR Network (2010) repeats the arguments raised by CEG and no further comment is necessary.

### *3.3 Queensland Government*

The Queensland Government (2010, p 1) argues for the use of the ten year risk free rate on the grounds that other regulators use this rate, use of the five year rate will lead to lower revenues for

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<sup>18</sup> The risk that would otherwise be faced arises from prices being set every five years in light of the prevailing risk free rate whilst the firm undertakes borrowing over a longer term, leading to the possibility of costs diverging from revenues at some point.

the QRN, and therefore place it at a disadvantage relative to other regulated entities when competing for investment capital. This line of argument presumes that there is a fixed quantity of investment capital available to regulated firms. If this were the case, QRN would face difficulties of the kind alleged here. However, there is not a fixed quantity of investment capital available to regulated entities or even entities in general. Regulated entities will be able to raise investment capital so long as the prices allowed by the regulator covers their costs, i.e., the  $NPV = 0$  requirement is satisfied. Thus, if other regulated entities are treated *more* generously than is needed to satisfy the  $NPV = 0$  requirement, this does not provide any justification for the QCA to act likewise.

The Queensland Government (2010, p 2) also claims that the actions of other regulators are indicative of how investors determine WACC. Thus, if other regulators typically use the ten year risk free rate in setting the allowed output price, this will be indicative of how investors determine WACC. No evidence is provided for this rather bold claim.

The Queensland Government (2010, p 2) also claims that the QCA's proposed switch from the use of a ten to a five year risk free rate will raise concerns amongst investors as to the future predictability of the regulatory regime. This is equivalent to arguing that consistency is more important than accuracy. I do not agree. If a regulator is underestimating WACC, and has been doing so for a prolonged period, the incentive for investors to continue investing in the business is undermined. Consequently, it is essential that the error be rectified. Alternatively, if the regulator is overestimating WACC, and has been doing so for a prolonged period, consumers will be subject to unnecessarily high prices and this error should also be rectified. Accuracy is more important than consistency.

The Queensland Government (2010, p 3) also argues that the QCA's proposed use of the five rather than ten year risk free rate forces QRN to choose between the transaction costs of hedging its longer term debt to match the regulatory situation, and issuing shorter term debt with a consequently increased exposure to refinancing risk. So long as the average debt term of relevant comparator firms is greater than five years, the choice referred to here is present but the correct conclusion to draw from this is that the QCA should allow for these hedging costs in

setting QRN's prices (so long as the average debt term of relevant comparator firms is significantly greater than five years). It does not follow that the QCA should use the ten year risk free rate. Furthermore, the claim that the QCA's choice of the term for the risk free rate gives rise to the choice referred to is not correct. Even if the QCA used a risk free rate longer than five years to match the debt term of relevant comparator firms in its five yearly resetting of the price cap, regulated firms would *still* face a decision whose options included the two referred to here by the Queensland Government; the difficulty for such regulated firms is induced by the mis-match between the length of the regulatory cycle and the term of their debt rather than by the QCA's choice of the term for the risk free rate (the regulator's choice of the risk free rate term is simply a consequence of the length of the regulatory cycle).

### *3.4 Queensland Treasury Corporation*

The Queensland Treasury Corporation (2010, p 1) argues that the QCA's proposed use of the five rather than the ten year risk free rate will force QRN to shorten its debt maturity to five years and therefore raise its refinancing risk. This claim is not correct. QRN will have a choice between this course of action and using interest rate swap contracts to effectively convert the ten year risk free rate within its cost of debt to a five year rate. The crucial issues are whether the increase in refinancing risk is significant and whether the QCA allows for the cost of these swap contracts in the case of the increased refinancing risk being significant. These costs should be allowed for in the latter case. If the QCA does so, the natural response by QRN would be to undertake these swap contracts, and therefore not experience any increase in its refinancing risk.

The Queensland Treasury Corporation (2010, p 1) also argues that the QCA's proposed use of the five rather than the ten year debt margin will under compensate QRN for the debt margin that it actually incurs on longer term debt. This argument presumes that the average debt term of relevant comparator firms is significantly in excess of five years. Even in this case, the argument also presumes that the QRN cannot undertake credit default swaps to effectively convert the debt premium on longer term debt into a debt premium on five year debt, or that the QCA fails to allow for the transaction costs of such contracts in the event that they are feasible. Under these conditions, the point raised is valid and the third option described above would then be appropriate.

The Queensland Treasury Corporation (2010, pp. 1-2) also argues that the QCA’s proposed use of the five year risk free rate will under compensate QRN for the cost of capital in respect of capital expenditures during the regulatory period, in the (typical) case of an upward sloping term structure. Consequently, the regulated firm is “not currently over compensated by the full amount of the term premium between five and ten year interest rates”.<sup>19</sup> This claim is correct but the extent of the under compensation from the use of the five year rate will almost certainly be much less than the over compensation from the use of the ten year rate. Accordingly, this claim does not support the use of the ten year rate over the five year rate.

To illustrate this point, consider the following example. A regulated firm currently has assets with a regulatory asset value of \$1000m and is expecting to undertake capital expenditures of \$200m in three years time (consistent with depreciation of 2% per year and growth in the network of 2% per year). The current one year risk free rate is 5%, the expected future one year rates are all 5%, and the maturity premium is 14 basis points per year for the first five years and 3 basis points per year for the following five years. So, the current risk free rates for two, three, four, five, and ten year terms would be 5.14%, 5.28%, 5.42%, 5.56%, and 5.71% respectively<sup>20</sup>. Accordingly, the forward rates for the fourth and fifth years into the future would be 5.84% and 6.12% respectively. So, if the firm locked in the cost of financing the \$200m capital expenditure in three years time, from that point until the end of the regulatory cycle in five years time, it would incur the forward rates of 5.84% and 6.12% for those two years. In dollar terms, the risk free rate cost component of its costs would then be as follows:

$$Cost = \$1000[(1.0556)^5 - 1] + \$200m[(1.0584)(1.0612) - 1] = \$335.3m$$

This is equivalent to a rate of 5.59% applied uniformly to both the current and new investment. So, a regulator setting prices using the five year risk free rate of 5.56% would under compensate the firm by three basis points per year. However, a regulator setting prices using the ten year risk

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<sup>19</sup> The reverse situation holds if the term structure is downward sloping.

<sup>20</sup> The maturity premium on five year bonds relative to one year bonds is then 56 basis points, and that on ten year bonds relative to five year bonds is 15 basis points, consistent with the empirical analysis in section 2.2.

free rate of 5.71% would over compensate the firm by 12 basis points per year. Thus, not only is the five year rate closer than the ten year rate to the appropriate rate but the under compensation is very small at three basis points per year.

These calculations assume that the capital expenditures over a regulatory cycle are 20% of the regulatory asset value at the beginning of the cycle. If the capital expenditures were as much as 50% of the regulatory asset value at the beginning of the cycle, the appropriate rate applied to both existing and new investment would be 5.63%. So, a regulator setting prices using the five year rate of 5.56% would under compensate the firm by seven basis points per year whilst use of the ten year rate of 5.71% would over compensate by eight basis points. So, even in this extreme case, the use of the five year rate would still offer a better approximation than the use of the ten year rate.

Despite the superiority of the five over the ten year rate, the presence of capital expenditures within a regulatory cycle does raise the question of whether the five year risk free rate should be modified. One possibility would be for the regulator to assume that firms are sufficiently unconcerned by the (relatively small) interest rate risk on these capital expenditures that they do not seek to hedge the risk and simply incur the prevailing risk free rate at the time of the capital expenditures (which would be the prevailing two year rate if the capital expenditures occurred in three years time). This prevailing rate (on debt with a term less than five years) would typically be less than the five year rate fixed at the beginning of the regulatory cycle, in which case firms would generally experience over compensation. A second possibility would be for the regulator to assume that firms do hedge this interest rate risk but for the regulator to nevertheless apply the five year risk free rate prevailing at the beginning of the regulatory cycle to both the regulatory asset value at the beginning of the cycle and the capital expenditures during the cycle, on the grounds that the resulting understatement in the risk free rate would on average be about three basis points per year (see above) and that this is sufficiently small to warrant ignoring it. Variations in the capital expenditure level around this typical situation will tend to offset over time and might therefore be ignored for this reason. A third possibility would be for the regulator to assume that firms do hedge the interest rate risk and for the regulator to therefore modify the risk free rate in the fashion indicated in the penultimate paragraph. However, this

would require accurate forecasts of the size and timing of the capital expenditures and these are difficult to attain. A fourth possibility would be for the regulator to eliminate the interest rate risk faced by firms, as follows. The regulator would apply the five year risk free rate at the beginning of the regulatory cycle to the prevailing regulatory asset value, forecast the size and timing of the capital expenditures during the regulatory cycle, and apply a forecast of the risk free rate that was relevant to these capital expenditures (for example, the two year risk free rate expected in three years if the capital expenditures were expected in three years). In this event, the forecast risk free rate might be based upon the forward rate determinable at the beginning of the regulatory cycle. If any of these forecasts proved to be inaccurate, the impact on the firm would be determined at the end of the regulatory cycle and compensation for this error could then be incorporated into the new price cap set at the beginning of the next regulatory cycle. Thus, the firm would face no risk from simply waiting until the capital expenditure occurred and financing this at the prevailing market rate, whereupon the firm's incentive to hedge the interest rate risk would evaporate. I favour the second option over the first option, because it (properly) acknowledges a risk that firms may wish to hedge. I favour the second option over the third and fourth options on the grounds of simplicity and the small size of the resulting error.

Finally, it should be noted that this line of argument from the Queensland Treasury Corporation clearly implies that the five year risk free rate would be the correct rate in the absence of any additional investment during the regulatory cycle. This is a significant acknowledgement, because it reduces the room for disagreement merely to the implications of additional investment within the regulatory cycle, and these implications appear to be very small in most cases.

#### **4. Conclusions**

The QCA has recently proposed, for the purposes of determining WACC, to set the term of the risk free rate within the cost of debt and the first term within the cost of equity, along with the term of the debt premium, equal to the regulatory cycle of five years, and to continue to estimate the market risk premium within the cost of equity using a ten year risk free rate. This paper has reviewed these proposals and the conclusions are as follows.

In respect of the risk free rate within the cost of debt and the first term within the cost of equity, along with the term of the debt premium, the available options are as follows. The first option would be to act as if the regulated firms engage in five yearly debt re-financing. In this event the total cost of debt that should be allowed every five years would be the five year risk free rate, the five year debt premium, and the annualised issue costs of five yearly debt issues (about 0.20%). In addition, the first term within cost of equity is the five year risk free rate. The second option would arise only if the average debt term used by relevant comparator firms (term  $T$ ) materially exceeded five years, and would then assume that regulated firms will borrow for  $T$  years and use swap contracts (interest rate swaps and credit default swaps) to effectively match their debt to the regulatory cycle. Accordingly, the total costs of debt that should be allowed every five years would be the five year risk free rate, the five year debt premium, the annualised debt issue costs arising from  $T$  yearly debt issues (0.125% if  $T = 10$  years), and the transaction costs of the swap contracts (in the form of the spread between the “mid rate” and the price). In addition, the first term within the cost of equity is still the five year risk free rate. The third option would also only arise if the average debt term used by relevant comparator firms (term  $T$ ) materially exceeded five years, and would then assume that regulated firms will borrow for  $T$  years and use interest rate swap contracts to effectively convert the risk free rate that is embedded in their average debt term into the five year risk free rate. However, they would not be assumed to use credit default swaps to convert the debt premium that was embedded in their average debt term into a five year debt premium. In this event, the total costs of debt that should be allowed every five years should be the five year risk free rate, the debt premium on  $T$  year debt, the annualised debt issue costs arising from  $T$  yearly debt issues (0.125% if  $T = 10$  years), and the transaction costs of the interest rate swap contracts (in the form of the spread between the “mid rate” and the price). In addition, the first term within the cost of equity is still the five year risk free rate. The fourth option would also only arise if the average debt term used by relevant comparator firms ( $T$  years) materially exceeded five years, and would then assume that regulated firms will borrow for  $T$  years but use neither interest rate swap contracts nor credit default swaps to convert the  $T$  year debt into five year debt. In this event, the total costs of debt that should be allowed every five years would be the  $T$  year risk free rate, the  $T$  year debt premium, and the annualised debt issue costs arising from  $T$  yearly debt issues (0.125% if  $T = 10$  years). In addition, the first term within the cost of equity is still the five year risk free rate. Finally, the fifth option differs from

the fourth option only in extending the use of the  $T$  year risk free rate to the first term within the cost of equity as well as the cost of debt.

The first option satisfies the  $NPV = 0$  test but treats the additional refinancing risk arising from the use of five year debt rather than any longer term as inconsequential. The second option also satisfies the  $NPV = 0$  test but may be subject to implementation difficulties in respect of credit default swaps. The third option violates the  $NPV = 0$  test but only trivially and not in any consistent direction. The fourth option also violates the  $NPV = 0$  test, and to a larger degree although again not in any consistent direction. Finally, the fifth option embodies the same violations of the  $NPV = 0$  test as the fourth option, in respect of the cost of debt, and also violates the  $NPV = 0$  test consistently positively in respect of the cost of equity, i.e., equity holders would be consistently over compensated by about 0.20% in the risk free rate if  $T = 10$  years. The fifth option can then be dismissed. The fourth option rests upon the very unrealistic assumption that firms borrowing for significantly more than five years would not engage in interest rate swaps in order to remove the interest rate risk arising from the mis-match between their borrowing term and the length of the regulatory cycle. A good example of the problem resulting from failure to hedge in this way would arise if a regulator set a price cap for five years in January 2004, using the prevailing ten year risk free rate of 5.70%, and reset it five years later in January 2009 using the then prevailing rate of 4.09%. In the absence of such hedging, the firm would experience a significant drop in its revenue in January 2009 whilst its costs remained at the higher level from earlier years. In view of the implausibility of the assumption that firms would *not* seek to hedge against this kind of risk, I think that option four should also be dismissed.

In relation to the remaining three options, I do not have sufficient information to choose between them but I can specify the conditions under which each should be chosen. The first option is favoured if the average debt term of relevant comparator businesses is not significantly larger than five years. If it is significantly larger than five years, then such firms will have suffered a higher cost of debt from adopting the longer debt term (because the maturity premium on the longer term debt will exceed the saving in annualized debt issue costs), and their willingness to do so would then indicate a concern with the incremental refinancing risks from the use of five

year debt. So, if the average debt term of relevant comparator businesses is significantly larger than five years, the use of the first option would be inappropriate because it assumes that these refinancing risks are trivial. This leaves the choice between the second and third options. The second option would be favoured if the relevant credit default swaps are available and their transaction costs are objectively determinable. If these conditions do not hold, then I favour the third option.

In respect of the appropriate choice of the risk free rate for the purposes of estimating the market risk premium, this depends upon the across-investor average period between successive portfolio reassessments. If this period is believed to be five years, then the CAPM would require use of the five year risk free rate within the first term of the model and the market risk premium, whilst the NPV = 0 requirement also mandates use of the five year risk free rate within the first term of the CAPM. No inconsistency then arises. Furthermore, despite the fact that the QCA bases its estimate of the market risk premium from studies that use ten rather than five year bonds, the QCA's (rounded) estimate of 6.0% would not be affected by the use of five year bonds. Alternatively, if the across-investor average period between successive portfolio reassessments is believed to be as little as one year, then the CAPM would require use of the one year risk free rate within the first term of the model and the market risk premium, whilst the NPV = 0 requirement would still mandate use of the five year risk free rate within the first term of the CAPM. The apparent conflict here is illusory because the two models are concerned with different periods, and is resolved by successive application of the one year CAPM to the five individual years for which a cost of equity is sought. This effectively leads to use of the five year risk free rate within the first term of the CAPM and the one year risk free rate within the market risk premium, and use of the latter would likely increase the QCA's estimate of the market risk premium by 0.5%. Finally, if the across-investor average period between successive portfolio reassessments is believed to be as much as ten years, then the CAPM would require use of the ten year risk free rate within both the first term of the model and the market risk premium, whilst the NPV = 0 requirement would still mandate use of the five year risk free rate within the first term of the CAPM. As before, this apparent conflict arises from the fact that the two models are concerned with different periods, but it cannot now be resolved in the same way. Thus, we face a choice between abandoning the CAPM and adapting it to the scenario in question, and the

lack of a credible alternative to the CAPM demands that it be adapted. Following the principle that one should minimize the modifications that are required to any model to adapt it to a particular scenario, the first term within the CAPM should be the five year risk free rate whilst the market risk premium should continue to be defined and therefore estimated relative to the ten year risk free rate. Since the QCA's estimate of the market risk premium reflects the use of this ten year risk free rate, then no alteration to the QCA's estimate of the market risk premium would be required.

Across these three scenarios, the first term within the CAPM is always the five year risk free rate, in conformity with the CAPM or the NPV = 0 requirement, whilst the risk free rate used within the market risk premium varies. However, unless the across-investor average period between successive portfolio reassessments is believed to be significantly less than five years, no change to the QCA's (rounded) estimate of the market risk premium would be likely to arise. The QCA's proposal is to use the five year risk free rate within the first term of the CAPM and estimate the market risk premium using the ten year risk free rate. Consistent with the analysis above, such a position is perfectly defensible if the QCA believes that the across-investor average period between successive portfolio reassessments is ten years. Furthermore, even if the QCA holds no view on this question, the lack of a sufficiently long time series of Australian risk free rate yields for any other bonds with a term of at least one year would complicate efforts to estimate the market risk premium using the Ibbotson methodology. Coupled with the fact that this average portfolio reassessment frequency would have to be appreciably less than five years in order to affect the (rounded) estimate of the market risk premium, this argues for the status quo.

This paper has also reviewed a number of submissions. The only credible arguments here relate to the possible need to allow for the cost of swap contracts required to effectively convert a firm's cost to debt to five year debt. If the first option described above is favoured, there is no need for this. If the second option is favoured, such hedging costs for both interest rate and credit default swaps should be allowed for. Finally, if the third option is favoured, such hedging costs on interest rate swaps should be allowed for and the debt premium should be defined relative to the average term for the debt of relevant comparator firms.

## APPENDIX 1: NPV VIOLATIONS

This Appendix seeks to assess the departures from the  $NPV = 0$  principle that arise from a regulator resetting the debt premium every five years using the premium applicable to ten year bonds. Consistent with recourse to the debt premium on ten year bonds, we assume that the firm initially borrows for ten years and rolls the residual debt over every ten years. The firm also undertakes a set of interest rate swaps so that the effective cost of debt incurred by it in any year is the five year risk free rate prevailing at the most recent regulatory reset plus the ten year debt premium determined at the last ten yearly roll-over point plus the transaction costs on the swap contracts. Consistent with the regulatory cycle being five years, we also assume that the firm's revenues are received every five years and operating costs (including company taxes) are incurred at the same point.<sup>21</sup>

Let the firm have a life of  $N$  years (where  $N$  is very large),  $S_{N-5}$  denote the market value of the firm's equity at the end of year  $N-5$ ,  $S_{N-5}^B$  the book value of equity at the same time,  $B_{N-5}$  the book value of debt at the same time,  $REV_N$  the revenues received at the end of year  $N$ ,  $OPEX_N$  the operating costs incurred at the end of year  $N$  (including unlevered company taxes),  $p_{N-10}$  the ten year debt premium plus the costs of the interest rate swaps set at the end of year  $N-10$  and payable by the firm on its debt over the following ten years,  $R_{jN-5}$  the five year risk free rate set at the end of year  $N-5$ , and  $k_{eN-5}$  the five year cost of equity set at the end of year  $N-5$  (with the last three rates expressed in five yearly rather than annualised terms). It follows that

$$S_{N-5} = \frac{E(REV_N) - E(OPEX_N) - (R_{jN-5} + p_{N-10})(1 - T_c)B_{N-5} - B_{N-5}}{1 + k_{eN-5}}$$

where the last term in the numerator is the debt repayment at the end of year  $N$  (being the book value of debt at the end of year  $N-5$ ). At the end of year  $N-5$ , the regulator sets the price cap for the next five years so that the total revenues received at the end of year  $N$  comprise the cost of capital allowance, operating costs and depreciation. Furthermore, the cost of debt allowed by the

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<sup>21</sup> This minimizes algebraic complexity and is identical in spirit to the usual practice in capital budgeting of assuming that cash flows arise annually.

regulator is the prevailing five year risk free rate plus the prevailing ten year debt premium plus the prevailing swap costs. Letting  $DEP_N$  denote the depreciation allowance for the end of year  $N$ , which must equal the book value of the firm's assets at the end of year  $N-5$ , and  $p_{N-5}$  the ten year debt premium and swap costs prevailing at the end of year  $N-5$ , it follows that

$$\begin{aligned} E(REV_N) &= S_{N-5}^B k_{eN-5} + B_{N-5}(R_{fN-5} + p_{N-5})(1 - T_c) + E(OPEX_N) + DEP_N \\ &= S_{N-5}^B k_{eN-5} + B_{N-5}(R_{fN-5} + p_{N-5})(1 - T_c) + E(OPEX_N) + S_{N-5}^B + B_{N-5} \end{aligned}$$

Substitution of this equation into the preceding equation yields the following:

$$\begin{aligned} S_{N-5} &= \frac{S_{N-5}^B(1 + k_{eN-5}) + B_{N-5}(p_{N-5} - p_{N-10})(1 - T_c)}{1 + k_{eN-5}} \\ &= S_{N-5}^B + \frac{B_{N-5}(p_{N-5} - p_{N-10})(1 - T_c)}{1 + k_{eN-5}} \end{aligned}$$

So, the market value of the firm's equity at the end of year  $N-5$  may diverge from its book value at that time because the prevailing ten year debt premium and swap costs used in setting the price cap for the next five year ( $p_{N-5}$ ) may differ from the premium and swap costs that will be incurred by the firm in that five year period (which were set five years earlier and denoted  $p_{N-10}$ ). Turning now to the end of year  $N-10$ , and following a similar process:

$$\begin{aligned} S_{N-10} &= S_{N-10}^B + \frac{B_{N-10}(p_{N-10} - p_{N-15})(1 - T_c)}{1 + k_{eN-10}} + \frac{E\left[\frac{B_{N-5}(p_{N-5} - p_{N-10})(1 - T_c)}{1 + k_{eN-5}}\right]}{1 + k_{eN-10}} \\ &= S_{N-10}^B + \frac{E\left[\frac{B_{N-5}(p_{N-5} - p_{N-10})(1 - T_c)}{1 + k_{eN-5}}\right]}{1 + k_{eN-10}} \end{aligned}$$

Continuing recursively back to time 0, the result is as follows:<sup>22</sup>

$$S_0 = S_0^B + \frac{E\left[\frac{B_5(p_5 - p_0)(1 - T_c)}{1 + k_{e5}}\right]}{1 + k_{e0}} + \frac{E\left[\frac{B_{15}(p_{15} - p_{10})(1 - T_c)}{(1 + k_{e5})(1 + k_{e10})(1 + k_{e15})}\right]}{1 + k_{e0}} + \dots$$

Since the book and market values of debt will be equal at time 0 (when the firm is established), then addition of the market value of debt to the left hand side of the last equation and the book value to the right hand side yields the following:

$$V_0 = V_0^B + \frac{E\left[\frac{B_5(p_5 - p_0)(1 - T_c)}{1 + k_{e5}}\right]}{1 + k_{e0}} + \frac{E\left[\frac{B_{15}(p_{15} - p_{10})(1 - T_c)}{(1 + k_{e5})(1 + k_{e10})(1 + k_{e15})}\right]}{1 + k_{e0}} + \dots$$

where  $V_0^B$  is the book value of the firm at time 0, which is the initial investment made into it. So, the NPV at time 0 of the firm is as follows:

$$NPV_0 = \frac{E\left[\frac{B_5(p_5 - p_0)(1 - T_c)}{1 + k_{e5}}\right]}{1 + k_{e0}} + \frac{E\left[\frac{B_{15}(p_{15} - p_{10})(1 - T_c)}{(1 + k_{e5})(1 + k_{e10})(1 + k_{e15})}\right]}{1 + k_{e0}} + \dots$$

The usual practice in discounted cash flow is to treat future costs of equity as both certain and equal to the current value, and this is not inconsistent with recognising that future debt premiums and swap costs may diverge from the current values. So, with this simplification, the last equation reduces to the following:

$$NPV_0 = \frac{B_5 E(p_5 - p_0)(1 - T_c)}{(1 + k_{e0})^2} + \dots + \frac{B_{15} E(p_{15} - p_{10})(1 - T_c)}{(1 + k_{e0})^4} + \dots$$

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<sup>22</sup> The terms for the first, third, fifth, etc, five year periods are not present in this series because they are zero, and this arises because the debt premiums and swap costs used by the regulator in these years correspond to the costs actually incurred by the firm in these periods.

So the NPV at time 0 of the firm will diverge from zero in so far as the expected future ten year debt premiums and swap costs used in setting the output prices differ from the premiums and swap costs actually incurred by the firm in the same year. Furthermore, because debt premiums are mean-reverting (unusually high values are expected to decline and unusually low values are expected to rise), such differences as shown in the last equation will arise whenever the current debt premium  $p_0$  is unusually high or low. For example, if  $p_0$  is unusually high, the expected values for  $p_5, p_{10}$ , etc will be lower until the long-run mean has been attained. In this case, the sequence of terms on the right hand side of the last equation will be initially negative and then zero, and therefore the NPV of the firm will be negative. Alternatively, if  $p_0$  is unusually low, the expected values for  $p_5, p_{10}$ , etc will be higher until the long-run mean has been attained and therefore the NPV of the firm will be positive. Convergence to the long-run mean is very likely to be attained within ten years. So, only the first term on the right hand side of the last equation is likely to depart from zero and therefore this equation reduces to the following.

$$NPV_0 = \frac{B_5 E(p_5 - p_0)(1 - T_c)}{(1 + k_{e0})^2} \quad (1)$$

Thus, departures from the NPV = 0 state will only occur if the current premium differs from that expected in five years, and this in turn requires that the current premium deviates from its long-run value. To assess the impact of such departures on the net present value of the firm's cash flows, we consider an extreme example. This involves a situation in which the one year debt premium is 2.5% and is expected to linearly converge to its long-run mean of 1% over the next five years, as shown in Table 2.<sup>23</sup> In addition the ten year debt premium at any point in time is the average of the expected one year premiums over the following ten years plus 0.50%. Thus the ten year debt premium is currently 2.0% (equivalent to 10.4% compounded over five years) and is expected to decline towards its long-run average of 1.5% (equivalent to 7.7% compounded over five years) over the next five years as shown in Table 2. In addition, the "current" cost of equity used is 10.0% (QCA, 2009, Table 1.3), equivalent to 61% over five years. Also, the corporate tax rate is .30. Finally, the debt book value  $B_5$  is 55% of the contemporaneous book

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<sup>23</sup> Swap costs are ignored on the grounds that the principal concern here relates to the debt premiums.

value of the firm (QCA, 2009, Table 1.3), and the latter is approximately equal to the initial book value of the firm  $V_0^B$ .

Table 2: Current and Expected Debt Premiums

Time	One yr Premium	Ten yr Premium
0	.025	.020
1	.022	.018
2	.019	.017
3	.016	.016
4	.013	.015
5	.01	.015

Substitution of these parameter values into equation (1) yields the following:

$$NPV_0 = \frac{.55V_0^B (.077 - .104)(1 - .30)}{(1.61)^2} = -.0040V_0^B$$

So, in this extreme example, the error is 0.40% of the initial book value of the firm. This is not a large sum. To put this in context, suppose an equivalent error of  $Y$  were made in assessing the allowed WACC, and applicable to each year in the future life of the firm. The appropriate discount rate on the WACC allowance would be the true WACC, for which a value of 9% is used (QCA, 2009, Table 1.3). So,  $Y$  satisfies the following equation:

$$Y(V_0^B) \left[ \frac{1}{1.09} + \frac{1}{(1.09)^2} + \dots \right] = -0.0040V_0^B$$

which reduces to

$$Y(V_0^B) \left[ \frac{1}{.09} \right] = -0.0040V_0^B$$

The result is  $Y = -0.00036$ , i.e., an understatement of WACC of 0.036% and this is very small. Had the one year debt premium been less than its long-run mean, then the error resulting from resetting the debt premium every five years using a ten year premium would have been equivalent to an overstatement in WACC.

In summary, the use of a ten year debt premium in the five yearly resetting of the prices for a regulated firm that undertakes ten yearly borrowing may induce departures from the  $NPV = 0$  principle, in either direction. However, the error in present value terms would be unlikely to exceed 0.40% of the initial book value of the firm, which is equivalent to an error in assessing WACC each year of about 0.04%.

## APPENDIX 2: FURTHER NPV VIOLATIONS

This Appendix seeks to assess the departures from the  $NPV = 0$  principle that arise from a regulator resetting the cost of debt every five years using the risk free rate and the premium applicable to ten year bonds. Consistent with recourse to the cost of ten year bonds, we assume that the firm initially borrows for ten years and rolls the residual debt over every ten years. Consistent with the regulatory cycle being five years, we also assume that the firm's revenues are received every five years and operating costs (including company taxes) are incurred at the same point.<sup>24</sup>

Let the firm have a life of  $N$  years (where  $N$  is very large),  $S_{N-5}$  denote the market value of the firm's equity at the end of year  $N-5$ ,  $S_{N-5}^B$  the book value of equity at the same time,  $B_{N-5}$  the book value of debt at the same time,  $REV_N$  the revenues received at the end of year  $N$ ,  $OPEX_N$  the operating costs incurred at the end of year  $N$  (including unlevered company taxes),  $R_{fN-10}^{10}$  and  $p_{N-10}^{10}$  the ten year risk free rate and the ten year debt premium respectively that prevail at the end of year  $N-10$  and payable by the firm on its debt over the following ten years, and  $k_{eN-5}$  the five year cost of equity prevailing at the end of year  $N-5$  (with the last three rates expressed in five yearly rather than annualised terms). It follows that

$$S_{N-5} = \frac{E(REV_N) - E(OPEX_N) - (R_{fN-10}^{10} + p_{N-10}^{10})(1 - T_c)B_{N-5} - B_{N-5}}{1 + k_{eN-5}}$$

where the last term in the numerator is the debt repayment at the end of year  $N$  (being the book value of debt at the end of year  $N-5$ ). At the end of year  $N-5$ , the regulator sets the price cap for the next five years so that the total revenues received at the end of year  $N$  comprise the cost of capital allowance, operating costs and depreciation. Furthermore, the cost of debt allowed by the regulator is the prevailing ten year risk free rate plus the prevailing ten year debt premium. Letting  $DEP_N$  denote the depreciation allowance for the end of year  $N$ , which must equal the

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<sup>24</sup> This minimizes algebraic complexity and is identical in spirit to the usual practice in capital budgeting of assuming that cash flows arise annually.

book value of the firm's assets at the end of year  $N-5$ , and  $R_{fN-5}^{10}$  and  $p_{N-5}^{10}$  the ten year risk free rate and the ten year debt premium respectively that prevail at the end of year  $N-5$ , it follows that

$$\begin{aligned} E(REV_N) &= S_{N-5}^B k_{eN-5} + B_{N-5} (R_{fN-5}^{10} + p_{N-5}^{10})(1 - T_c) + E(OPEX_N) + DEP_N \\ &= S_{N-5}^B k_{eN-5} + B_{N-5} (R_{fN-5}^{10} + p_{N-5}^{10})(1 - T_c) + E(OPEX_N) + S_{N-5}^B + B_{N-5} \end{aligned}$$

Substitution of this equation into the preceding equation yields the following:

$$\begin{aligned} S_{N-5} &= \frac{S_{N-5}^B (1 + k_{eN-5}) + B_{N-5} (R_{fN-5}^{10} + p_{N-5}^{10} - R_{fN-10}^{10} - p_{N-10}^{10})(1 - T_c)}{1 + k_{eN-5}} \\ &= S_{N-5}^B + \frac{B_{N-5} (R_{fN-5}^{10} + p_{N-5}^{10} - R_{fN-10}^{10} - p_{N-10}^{10})(1 - T_c)}{1 + k_{eN-5}} \end{aligned}$$

So, the market value of the firm's equity at the end of year  $N-5$  may diverge from its book value at that time because the prevailing ten year risk free rate and ten year debt premium used in setting the price cap for the next five year may differ from the ten year risk free rate and ten year premium that will be incurred by the firm in that five year period (and which were set five years earlier). Turning now to the end of year  $N-10$ , and following a similar process:

$$S_{N-10} = S_{N-10}^B + \frac{E \left[ \frac{B_{N-5} (R_{fN-5}^{10} + p_{N-5}^{10} - R_{fN-10}^{10} - p_{N-10}^{10})(1 - T_c)}{1 + k_{eN-5}} \right]}{1 + k_{eN-10}}$$

Continuing recursively back to time 0, the result is as follows:<sup>25</sup>

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<sup>25</sup> The terms for the first, third, fifth, etc, five year periods are not present in this series because they are zero, and this arises because the risk free rates and debt premiums used by the regulator in these years correspond to the costs actually incurred by the firm in these periods.

$$S_0 = S_0^B + \frac{E \left[ \frac{B_5 (R_{f5}^{10} + p_5^{10} - R_{f0}^{10} - p_0^{10})(1 - T_c)}{1 + k_{e5}} \right]}{1 + k_{e0}} + \frac{E \left[ \frac{B_{15} (R_{f15}^{10} + p_{15}^{10} - R_{f10}^{10} - p_{10}^{10})(1 - T_c)}{(1 + k_{e5})(1 + k_{e10})(1 + k_{e15})} \right]}{1 + k_{e0}} + \dots$$

Since the book and market values of debt will be equal at time 0 (when the firm is established), then addition of the market value of debt to the left hand side of the last equation and the book value to the right hand side yields the following:

$$V_0 = V_0^B + \frac{E \left[ \frac{B_5 (R_{f5}^{10} + p_5^{10} - R_{f0}^{10} - p_0^{10})(1 - T_c)}{1 + k_{e5}} \right]}{1 + k_{e0}} + \frac{E \left[ \frac{B_{15} (R_{f15}^{10} + p_{15}^{10} - R_{f10}^{10} - p_{10}^{10})(1 - T_c)}{(1 + k_{e5})(1 + k_{e10})(1 + k_{e15})} \right]}{1 + k_{e0}} + \dots$$

where  $V_0^B$  is the book value of the firm at time 0, which is the initial investment made into it. So, the NPV at time 0 of the firm is as follows:

$$NPV_0 = \frac{E \left[ \frac{B_5 (R_{f5}^{10} + p_5^{10} - R_{f0}^{10} - p_0^{10})(1 - T_c)}{1 + k_{e5}} \right]}{1 + k_{e0}} + \frac{E \left[ \frac{B_{15} (R_{f15}^{10} + p_{15}^{10} - R_{f10}^{10} - p_{10}^{10})(1 - T_c)}{(1 + k_{e5})(1 + k_{e10})(1 + k_{e15})} \right]}{1 + k_{e0}} + \dots$$

The usual practice in discounting cash flows is to treat future costs of equity as both certain and equal to the current value, and this is not inconsistent with recognising that future risk free rates and debt premiums may diverge from the current values. So, with this simplification, the last equation reduces to the following:

$$NPV_0 = \frac{B_5 E (R_{f5}^{10} + p_5^{10} - R_{f0}^{10} - p_0^{10})(1 - T_c)}{(1 + k_{e0})^2} + \dots + \frac{B_{15} E (R_{f15}^{10} + p_{15}^{10} - R_{f10}^{10} - p_{10}^{10})(1 - T_c)}{(1 + k_{e0})^4} + \dots$$

So the NPV at time 0 of the firm will diverge from zero in so far as the expected future ten year risk free rates and ten year debt used in setting the output prices differ from the rates actually incurred by the firm in the same year. Furthermore, because both risk free rates and debt

premiums are mean-reverting (unusually high values are expected to decline and unusually low values are expected to rise), such differences as shown in the last equation will arise whenever the current ten year risk free rate  $R_{f0}^{10}$  and the current ten year debt premium  $p_0^{10}$  are unusually high or low. For example, if the current values are unusually high, the expected values for years 5, 10 etc will be lower until the long-run mean has been attained. In this case, the sequence of terms on the right hand side of the last equation will be initially negative and then zero, and therefore the NPV of the firm will be negative. Alternatively, if the current values are unusually low, the expected values for years 5, 10 etc will be higher until the long-run mean has been attained and therefore the NPV of the firm will be positive. Convergence to the long-run mean is very likely to be attained within ten years. So, only the first term on the right hand side of the last equation is likely to depart from zero and therefore the last equation reduces to the following.

$$NPV_0 = \frac{B_5 E(R_{f5}^{10} + p_5^{10} - R_{f0}^{10} - p_0^{10})(1 - T_c)}{(1 + k_{e0})^2} \quad (2)$$

Thus, departures from the NPV = 0 state will only occur if the current ten year risk free rate and ten year debt premium differs from that expected in five years, and this in turn requires that the current values deviate from their long-run values. To assess the impact of such departures on the net present value of the firm's cash flows, we consider an extreme example. In relation to the debt premium, the situation matches that in the previous Appendix. In relation to the risk free rate, suppose the one year rate is 8.0% and is expected to linearly converge to its long-run mean of 5% over the next five years, as shown in Table 3. In addition the ten year risk free rate at any point in time is the average of the expected one year rates over the following ten years plus 1.00%. Thus the ten year risk free rate is currently 6.9% (equivalent to 39.6% compounded over five years) and is expected to decline towards its long-run average of 6.0% (equivalent to 33.8% compounded over five years) over the next five years as shown in Table 3. In addition, the "current" cost of equity used is 10.0% (QCA, 2009, Table 1.3), equivalent to 61% over five years. Also, the corporate tax rate is .30. Finally, the debt book value  $B_5$  is 55% of the contemporaneous book value of the firm (QCA, 2009, Table 1.3), and the latter is approximately equal to the initial book value of the firm  $V_0^B$ .

Table 3: Current and Expected Risk Free Rates

Time	One yr Rate	Ten yr Rate
0	.080	.069
1	.074	.066
2	.068	.064
3	.062	.062
4	.056	.061
5	.050	.060

Substitution of these parameter values into equation (2) yields the following:

$$NPV_0 = \frac{.55V_0^B (.338 - .396)(1 - .30)}{(1.61)^2} = -.0086V_0^B$$

So, in this extreme example, the error is 0.86% of the initial book value of the firm. This is not a large sum. To put this in context, suppose an equivalent error of  $Y$  were made in assessing the allowed WACC, and applicable to each year in the future life of the firm. The appropriate discount rate on the WACC allowance would be the true WACC, for which a value of 9% is used (QCA, 2009, Table 1.3). So,  $Y$  satisfies the following equation:

$$Y(V_0^B) \left[ \frac{1}{1.09} + \frac{1}{(1.09)^2} + \dots \right] = -0.0086V_0^B$$

which reduces to

$$Y(V_0^B) \left[ \frac{1}{.09} \right] = -0.0086V_0^B$$

The result is  $Y = -0.00078$ , i.e., an understatement of WACC of 0.078% and this is very small. Had the one year risk free rate been less than its long-run mean, then the error resulting from

resetting the ten year risk free rate every five years would have been equivalent to an overstatement in WACC.

In summary, the use of a ten year risk free rate in the five yearly resetting of the prices for a regulated firm that undertakes ten yearly borrowing may induce departures from the NPV = 0 test, in either direction. However, the error in present value terms would be unlikely to exceed 0.90% of the initial book value of the firm, which is equivalent to an error in assessing WACC each year of about 0.08%. To this can be added the error from five yearly use of the ten year debt premium, which is unlikely to exceed 0.40% of the initial book value of the firm (equivalent to an error in assessing WACC each year of about 0.04% as discussed in the previous Appendix). Thus the aggregate error is very unlikely to exceed 1.3% of the initial book value of the firm, which is equivalent to an error in assessing WACC each year of about 0.12%.

### APPENDIX 3: SUCCESSIVE APPLICATIONS OF THE CAPM

This Appendix explores the implications of successively invoking the CAPM to value a cash flow arising in more than one year's time, assuming that the CAPM is defined over a one year period. Consider the following example. A project will deliver cash flow  $X_2$  in two years time. Invoking the one-year CAPM, the value now of this project is

$$V_0 = \frac{E_0(V_1)}{1 + R_{f01} + \phi_1\beta} \quad (3)$$

where  $R_{f01}$  is the current one year risk free rate,  $\phi_1$  is the current market risk premium defined with respect to the one year risk free rate,  $\beta$  is the project beta, and  $E_0(V_1)$  is the expectation now of the project value in one year. In one year, the CAPM is applied again with a one year risk free rate then of  $R_{f12}$ . Assuming that investors act as if the market risk premium defined with respect to the one year risk free rate does not change over time<sup>26</sup>, then the project value in one year will be as follows

$$V_1 = \frac{E_1(X_2)}{1 + R_{f12} + \phi_1\beta}$$

where  $E_1(X_2)$  is the expectation in one year of the project cash flow in two years. Consistent with successive application of the CAPM, one must assume that future risk free rates are certain now (Fama, 1977) or at least that investors act on that basis.<sup>27</sup> Clearly, future risk free rates are uncertain and therefore one must assume that investors simply disregard this fact. In this case, they must act as if  $R_{f12}$  will equal the current expectation of it, being  $E_0(R_{f12})$ . Accordingly, the expectation now of  $V_1$  is

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<sup>26</sup> This implies that the market risk premium is invariant to changes in the one year risk free rate, and this assumption is implicit in the historical averaging approach to estimating the market risk premium, as in Ibbotson (2004) and Dimson et al (2010).

<sup>27</sup> Otherwise, investors will price assets to reflect their ability to hedge against changes in future risk free rates (and in changes in investment opportunities in general). If this occurs and investors can revise portfolios at any time, then the appropriate CAPM will be that of Merton (1973) or Breeden (1979).

$$E_0(V_1) = \frac{E_0(X_2)}{1 + E_0(R_{f12}) + \phi_1\beta}$$

Substitution of the last equation into equation (3) then yields

$$V_0 = \frac{E_0(X_2)}{[1 + R_{f01} + \phi_1\beta][1 + E_0(R_{f12}) + \phi_1\beta]}$$

By extension, a cash flow arising in five years time will have the following value.

$$V_0 = \frac{E_0(X_5)}{[1 + R_{f01} + \phi_1\beta][1 + E_0(R_{f12}) + \phi_1\beta] \dots [1 + E_0(R_{f45}) + \phi_1\beta]}$$

Defining  $\bar{R}_f$  as the average over the five risk free rates here, this is approximately equal to

$$V_0 = \frac{E_0(X_5)}{[1 + \bar{R}_f + \phi_1\beta]^5} \quad (4)$$

Consistent with acting as if future risk free rates are certain, the expectations hypothesis should characterise the term structure of interest rates. In this event,  $\bar{R}_f$  should be equal to the current five year spot risk free rate  $R_{f05}$ . Substitution of this into equation (4) then yields the following result.

$$V_0 = \frac{E_0(X_5)}{[1 + R_{f05} + \phi_1\beta]^5}$$

This formula invokes the five year risk free rate as the first term in the CAPM whilst simultaneously defining the market risk premium relative to the one year rate. Thus, “consistency” seems to be violated within the model, but this is simply a consequence of successive application of the CAPM defined over a one year period to a five year period.

## REFERENCES

- Breeden, D. 1979, 'An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities', *Journal of Financial Economics*, vol.7, pp.265-96.
- CEG, 2010, *Estimating the Risk Free Rate and Debt Risk Premium*, submission to the QCA.
- Commerce Commission, 2009, *Final TSO Cost Calculation Determination for TSO Instrument for Local Residential Telephone Service for the period between 1 July 2006 and 30 June 2007* ([www.comcom.govt.nz](http://www.comcom.govt.nz)).
- Cornell, B. 1999, *The Equity Risk Premium*, John Wiley and Sons, New York.
- Dimson, E., Marsh, P. And Staunton, M., 2010, *Credit Suisse Global Investment Returns Sourcebook 2010*, Credit Suisse.
- Fama, E. 1977, 'Risk-Adjusted Discount Rates and Capital Budgeting under Uncertainty', *Journal of Financial Economics*, vol. 5, pp. 3-24.
- Fernandez, P., 2009, 'Market Risk Premiums used in 2008 by Professors: A Survey with 1400 Answers', working paper, IESE Business School.
- Froot, K., Perold, A. and Stein, J. 1992, 'Shareholder Trading Practices and Corporate Investment Horizons', *Journal of Applied Corporate Finance*, vol. 5 (2), pp. 42-58.
- Ibbotson Associates, 2004. *Stocks, Bonds, Bills, and Inflation: 2004 Yearbook*, Ibbotson Associates (Chicago).
- Lally, M., 2002, *Regulation and the Choice of the Risk Free Rate*, paper prepared for the Australian Competition and Consumer Commission ([www.accc.gov.au](http://www.accc.gov.au)).
- \_\_\_\_\_ 2004, Regulation and the Choice of the Risk Free Rate, *Accounting Research Journal*, vol. 17 (1), pp. 18-23.
- \_\_\_\_\_ 2007. 'Regulation and the Term of the Risk Free Rate: Implications of Corporate Debt', *Accounting Research Journal*, vol. 20 (2), pp. 73-80.
- Marshall, W., Yawitz, J. and Greenberg, E. (1981), 'Optimal Regulation Under Uncertainty', *The Journal of Finance*, vol. 36, pp. 909-22.
- Merton, R. 1973, 'An Intertemporal Capital Asset Pricing Model', *Econometrica*, vol.41, pp.867-87.
- Miller, M. and Modigliani, F., 1958, 'The Cost of Capital, Corporation Finance and the Theory of Investment', *American Economic Review*, vol. 48, pp. 261-297.

Officer, R. 1989, 'Rates of Return to Equities, Bond Yields and Inflation Rates: An Historical Perspective', in Ball, R., Finn, F., Brown, P. and Officer, R. editors, *Share Markets and Portfolio Theory*, 2<sup>nd</sup> edition, University of Queensland Press.

\_\_\_\_\_ 1994, 'The Cost of Capital of a Company under an Imputation Tax System', *Accounting and Finance*, vol. 34, pp. 1-17.

Queensland Competition Authority, 2009, *Draft Decision QR 2009 DAU*.

Queensland Government, 2010, *Queensland Government Submission to the QCA Draft Decision on Queensland Rail Network's 2009 Draft Access Undertaking (UT3)*, submission to the QCA.

Queensland Treasury Corporation, 2010, *Queensland Treasury Corporation Submission to the QCA Draft Decision on Queensland Rail Network's 2009 Draft Access Undertaking (UT3)*, submission to the QCA.

QR Network, 2010, *QR Network's Access Undertaking: Response to QCA Draft Decision*, submission to the QCA.

Schmalensee, R. (1989), 'An Expository Note on Depreciation and Profitability Under Rate-of-Return Regulation', *Journal of Regulatory Economics*, vol. 1, pp. 293-298.

Siegel, J. 1992, 'The Equity Premium: Stock and Bond Returns since 1802', *Financial Analysts Journal*, Jan-Feb, pp. 28-38.