DETERMINING THE RISK FREE RATE FOR REGULATED COMPANIES

Prepared for

THE AUSTRALIAN COMPETITION AND CONSUMER COMMISSION

by

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August 2002

EXECUTIVE SUMMARY

This paper seeks to review a number of issues relating to the risk free rate, in the context of determining the cost of capital for regulated entities in Australia. The principal questions are as follows. First, what is the appropriate term to use in choosing a risk free rate? Second, what is the appropriate method to use for forecasting inflation, for the purpose of setting the allowed output price in the first year? Third, over what period should the risk free rate be averaged in determined the rate to be used? Fourth, should a forward rate be deduced from the observed term structure of rates, so as to match the period to which the allowed output price relates? Finally, is it appropriate to confidentially advise the regulated firms in advance of the period over which the interest rate will be averaged?

The conclusions are as follows. First, the appropriate term to use for the risk free rate is that matching the regulatory period, of five years. Of the two primary arguments offered for the ten year rate, the first is to reflect the age of the assets but is irrelevant because regulatory price resetting using the five year rate eliminates the firm's exposure to long-term interest rate risk. In addition, the claim that the use of the ten year rate in estimating the market risk premium implies consistent use of that rate throughout the valuation process is not correct.

Second, the process for supposedly forecasting inflation from the geometric difference in the real and nominal five year bond rates is not correct as an inflation forecast. However the process is not actually intended to generate an inflation forecast and is in fact sound for the actual purpose involved. To describe it as an inflation forecast is simply shorthand, although it risks some confusion. On account of the last point I do not favour the use of this term.

Third, the principle of averaging the observed rates over a short period of time is sound, although no definite answer can be offered on the issue of the optimal period. A five day period would seem to be the minimum to serve the smoothing purpose. In respect of the particular averaging technique, I favour arithmetic averaging. This provides a good match between the revenues allowed and the borrowing costs actually incurred by the firm.

Fourth, the principle of deriving a forward interest rate to match the period for which revenues will arise is sound. It allows firms to match their borrowing costs to the revenues allowed to them.

Finally, the principle of providing prior confidential notification to the regulated firm of the period over which the interest rate will be averaged is sound, although a period of some months notification seems excessive.

1. Introduction

This paper seeks to review a number of issues relating to the risk free rate, in the context of determining the cost of capital for regulated entities in Australia. The principal questions are as follows. First, what is the appropriate term to use in choosing a risk free rate? Second, what is the appropriate method to use for forecasting inflation, for the purpose of setting the allowed output price in the first year? Third, over what period should the risk free rate be averaged in determined the rate to be used? Fourth, should a forward rate be deduced from the observed term structure of rates, so as to match the period to which the allowed output price relates? Finally, is it appropriate to confidentially advise the regulated firms in advance of the period over which the interest rate will be averaged?

In addressing these questions, references will be made to arguments raised by affected parties and of the analysis of those arguments by the ACCC.

2. The Appropriate Term for the Risk Free Rate

At the present time, the ACCC resets output prices every five years, taking into account the interest rates and inflation forecasts prevailing at that time (ACCC, 1999). As a result of this, the risk free rate chosen by the Commission is the yield on five year Commonwealth bonds. Some regulated entities have argued instead for the yield on ten year bonds (ElectraNetSA, 2002; Ergas, 2002; GasNet, 2002; Officer, 2002a, 2002b; SPI PowerNet 2002). A number of arguments are presented in support of this claim. The ACCC (2002) analyses these arguments and I agree with the points made there. Nevertheless, some elaboration on this analysis is warranted, as follows.

2.1 Matching the Term of the Risk Free Rate to the Asset Life

The most prominent argument in favour of the ten year rate is the argument that the interest rate term selected should match the life of the assets. This issue only arises if the term structure of spot interest rates is not flat, and there are two possible explanations for a non-flat term structure. The first is the presence of a liquidity premium to compensate holders of long-term bonds for uncertainty about future short term rates (van Horne, 1984, Ch. 5). To analyse this situation, a simplified scenario will be examined in which the only source of uncertainty is in future real interest rates[1]. In this scenario, an asset has a life of two years, an initial expenditure of $100m and operating costs at the end of years 1 and 2 of $30m each (there is no inflation risk)[2]. The output will be 10m units per year. The output price is reset annually. So, the allowed price for the first year is set now (and received in one year) while the allowed price for the second year is set in one year (and received one year later). The allowed depreciation is straight line, i.e., $50m per year. The spot interest rate for the first year is .06, while that for the second year is equally likely to be .04 or .08. In recognition of this uncertainty about future spot rates, and the existence of a liquidity premium in compensation, the two year spot rate now is .07.

We start by analyzing the result from adopting the ACCC's current policy of setting the price on the basis of the prevailing spot rate for the period until the price is reset, i.e., on the basis of the one year spot rate. Using the "building block" approach, the revenue allowed for the first year will be the sum of operating costs, depreciation and the allowed rate of return on the current asset base of $100m, i.e.,

$$REV_1 = \$30m + \$50m + \$100m(.06) = \$86m$$

With output of 10m units per year, this implies a price of $8.60. In one year the allowed revenue set for the second year will be the same except that the asset base will be only $50m and the allowed rate on this will be either .08 or .04, i.e.,

$$REV_2 = \$30m + \$50m + \$50m(.08) = \$84m$$

or

$$REV_2 = \$30m + \$50m + \$50m(.04) = \$82m$$

These revenues imply output prices of $8.40 or $8.20. We now determine the present value of the future cash flows. The revenue received in one year, net of the operating cost then, is known now, and is therefore valued using the current one year spot rate (.06). The revenue received in two years, net of the operating cost then, is uncertain

[1] The analysis here is based on Lally (2002a).

(it is equally likely to be \$54m or \$52m) and therefore cannot be valued now using the current two year spot rate. However, in one year, the value of REV_2 net of the operating cost can be determined using the one year spot rate at that time (R_{12}), i.e.,

$$V_1 = \frac{REV_2 - \$30m}{1 + R_{12}} = \frac{\$50m + \$50m(R_{12})}{1 + R_{12}} = \$50m$$

So, regardless of what the one year spot rate is in one year, the value of the project in one year will be \$50m (because the allowed return on assets is reset to match the one year spot rate prevailing at that time). Since V_1 is known now then it can be valued now using the current one year spot rate. So, the value now of the future cash flows is

$$V_0 = \frac{REV_1 - \$30m}{1.06} + \frac{V_1}{1.06} = \frac{\$86m - \$30m}{1.06} + \frac{\$50m}{1.06} = \$100m$$

This figure of \$100m exactly matches the initial expenditure of \$100m. Consequently, the ACCC's current policy for setting the allowed output price is correct.

We turn now to the alternative suggestion that, at each point at which the price is set, the allowed rate of return should reflect the prevailing spot rate whose term matches the residual life of the project rather than the term until the next price setting. This implies use of the two year spot rate to set the price for year one, followed in one year by using the then one year spot rate. The allowed revenue for the first year will then be

$$REV_1 = \$30m + \$50m + \$100m(.07) = \$87m \quad (1)$$

This implies an output price of \$8.70. In one year the allowed revenue will be the same as indicated earlier for the ACCC's current policy, i.e., either

$$REV_2 = \$30m + \$50m + \$50m(.08) = \$84m \quad (2)$$

or

[2] The use of two periods is just sufficient to illustrate the difference in the two arguments. Use of more than two periods would be more realistic but give rise to a much more complex example.

$$REV_2 = \$30m + \$50m + \$50m(.04) = \$82m \tag{3}$$

We now determine the present value of these future cash flows. As indicated above for the ACCC's current policy, the value in one year of the cash flows in two years is \$50m and can therefore be valued now using the one year spot rate of .06. So, the value now of the future cash flows is

$$V_0 = \frac{REV_1 - \$30m}{1.06} + \frac{V_1}{1.06} = \frac{\$87m - \$30m}{1.06} + \frac{\$50m}{1.06} = \$101m \tag{4}$$

This figure of \$101m exceeds the initial expenditure of \$100m. Consequently, this scheme for setting the allowed price is incorrect, i.e., it leads to excessive revenues. The reason is simple. In setting the price for the first year, this scheme invokes a spot rate applicable to a term longer than the term until the revenues are reset. In the presence of a liquidity premium in the term structure of interest rates, the allowed price is greater than it would otherwise be. This increased allowance is inappropriate because the regulated firm is being compensated for bearing interest rate risk for a period beyond the review term, when it does not face that risk due to the resetting of the output price to reflect interest rate changes.

The other possible explanation for a term structure that is not flat is the expectations hypothesis, i.e., the differential between the current one and two year spot rates reflects a prediction about the future one year spot rate (van Horne, 1984, Ch. 5). In this case, the use of the longer-term interest rates for price setting is still undesirable because it will overcompensate in some cases and undercompensate in others. To illustrate this, we invoke the earlier example but assume no liquidity premium in the term structure and that the two year spot rate completely anticipates the future one year spot rate. So, if the one year spot rate in one year will be .08, then the two year spot rate now will be .07. Equations (1) and (2) above then describe the revenue setting now and in one year. Equation (4) then applies to the project value now, in which case overcompensation has occurred.

By contrast, if the one year spot rate in one year will be .04, then the two year spot rate now will be .05. The allowed revenue for the first year will then be

$$REV_1 = \$30m + \$50m + \$100m(.05) = \$85m \qquad (5)$$

The allowed revenue for the second year, set in one year's time, is given by equation (3). The value of this (net of operating cost) at the end of the first year will be \$50m, as explained earlier. Both this \$50m and REV_1 in equation (5) above (net of the year one operating cost) are valued using the current one year spot rate of .06. The result is a value now of

$$V_0 = \frac{REV_1 - \$30m}{1.06} + \frac{V_1}{1.06} = \frac{\$85m - \$30m}{1.06} + \frac{\$50m}{1.06} = \$99m$$

This is less than the initial expenditure of \$100m. So, the use of the two year spot rate for setting REV_1 leads to inadequate revenues ex ante. In fact, in this situation, rational investors would refuse to invest.

To summarise, the use of an interest rate of longer term than the regulatory period for setting output prices leads to two problems in a presence of a non-flat term structure. If the non-flat term structure is due to a liquidity premium, and therefore unpredictability in future spot rates, the use of the long-term spot rate for setting prices will lead to the revenues being too large ex ante, i.e., their present value will exceed the initial investment. In addition, if the non-flat term structure is due to predictable change over time in the short term spot rate, then the use of the longer term interest rate for setting prices will lead to revenues that are sometimes too large and sometimes too small, ex ante. The only policy that leads to future cash flows whose present value matches the initial investment is the setting of prices using an interest rate whose term matches the regulatory period. This is a basic test that any formula for setting output prices of regulated firms should satisfy. To draw an analogy mentioned by Davis (1998, p 15), the resetting of prices in accordance with the current five year interest rate removes interest rate risk at the end of the regulatory period in the same way that a long-term bond subject to a floating interest rate for five years is thereby freed of interest rate risk in five years time.

2.2 Consistency with Measurement of the MRP

A second argument raised in support of the ten year bond rate is the claim that the market risk premium in the CAPM is estimated using the ten year bond rate, and consistency must be observed (GasNet, 2002; SPI PowerNet 2002). This argument implies use of the ten-year risk free rate on all projects, and therefore is inconsistent with the argument raised in the previous section that the risk free rate used must accord with the life of the project. Despite this inconsistency, both arguments are raised by GasNet (2002) and SPI PowerNet (2002). Nevertheless the argument can be assessed on its own merits, and it fails.

To illustrate the point, suppose that the market risk premium is defined relative to the one year risk free rate, because investors are assumed to have a common investment horizon of one year[3]. In addition we seek to value a cash flow arising in two years. Suppose that this cash flow is expected to be \$1m, the market risk premium is estimated at .065, the beta of the investment is .50, the one year risk free spot rate is .06 and the two year rate is .07. The "consistency" argument then implies that the value now of the cash flow is as follows.

$$V_0 = \frac{\$1m}{[1+.06+.065(.50)]^2} \tag{6}$$

So, despite the fact that the cash flow arises in two years, it is valued using the one year spot rate of .06. This result must be false, because it produces an incorrect result as the risk of the cash flow goes to zero, i.e., as risk goes to zero the beta must also go to zero and equation (6) then becomes

$$V_0 = \frac{\$1m}{[1+.06]^2}$$

[3] The CAPM is a one-period model in that it assumes a common investment horizon across all investors. However this common horizon is not specified and any attempt to empirically establish it is confounded by the obvious variation in investment horizons across investors.

This is incorrect because a risk free cash flow arising in two years must be valued using the current two year spot rate rather than the current one year spot rate[4]. Nevertheless, the fact that the common investor horizon is one year suggests use of the one year spot rate.

The resolution of this paradox is as follows. The CAPM is a one period model, i.e., if the investor horizon is one year then the model can only directly value a cash flow arising in one year. To employ it to value a cash flow arising subsequently requires further assumptions. In particular, it is necessary to assume that the set of possible investments that confronts investors at the end of the year (and all subsequent years) is non-stochastic. In this event the single-period CAPM can be applied to a succession of future periods (see Fama, 1977). Of course the assumption made here does not hold. In particular the risk free rate changes stochastically. So, to justify application of the CAPM to a succession of future one year periods, it is necessary to act as if any changes to the set of possible investments that confront investors are entirely predictable. An extreme case of this is to act as if they will never change. For the risk free rate, this assumption is clearly untenable because the term structure of prevailing spot interest rates offers information about future one year spot rates. Thus predictable changes in the one year risk free rate should be admitted.

We turn now to the earlier example. The current one and two year spot rates (of .06 and .07 respectively) imply a one year "forward" rate for year two of .08. If the expectations hypothesis about the term structure of spot rates is correct then this forward rate is an unbiased predictor of the one year spot rate for the second year (van Horne, 1984, Ch. 5). Furthermore the assumption that future investment opportunities confronting investors are certain compels us to adopt the expectations hypothesis[5]. Thus, to apply the CAPM to future periods, we must act as if the one year spot rate in one year will be .08. We now turn to the project. Invoking the one-period CAPM, the value now of this project is

[4] This result presumes that the cash flow arising in two years is certain. If the cash flow is reset in one year, to reflect the one-year spot rate at that time, then it will not be appropriate to value this cash flow now using the two year spot rate. This issue was discussed in the previous section.
[5] The operation of arbitrage would ensure this.

$$V_0 = \frac{E_0(V_1)}{1 + .06 + (.065)(.50)} \qquad (7)$$

where $E_0(V_1)$ is the expectation now of the project value in one year. In one year, the CAPM can be applied again with a one year spot rate of .08 (the market risk premium will be unaffected as any rise in the one year spot rate should also lead to a rise in the expected return on the market[6]). So, the project value in one year will be

$$V_1 = \frac{E_1(X_2)}{1 + .08 + (.065)(.50)}$$

where $E_1(X_2)$ is the expectation in one year of the project cash flow in two years. The expectation now of this is

$$E_0(V_1) = \frac{E_0(X_2)}{1 + .08 + (.065)(.50)} = \frac{\$1m}{1 + .08 + (.065).50)}$$

Substitution of the last equation into equation (7) yields

$$V_0 = \frac{\$1m}{[1 + .06 + (.065)(.50)][1 + .08 + (.065)(.50)]}$$

To a close approximation this matches the result of replacing the spot rate in year one and the forward rate in year two by the two year spot rate in both cases, i.e.,

$$V_0 = \frac{\$1m}{[1 + .07 + (.065)(.50)]^2}$$

We now have the "standard" result, i.e., to value a cash flow due in two years when the CAPM horizon is one year, we employ both the one year spot rate and the two year spot rate. The one year spot rate is used to determine the market risk premium, because it accords with the perceived investor horizon, and the two year spot rate is

[6] This is implicit in the historical averaging approach to estimating the market risk premium, as in Ibbotson (2000) and Officer (1989).

used elsewhere in the valuation formula to reflect the point at which the cash flow arrives. Thus the claim that the risk free rate used to determine the market risk premium must be consistently applied throughout the CAPM valuation formula is false.

Consistency aside, it is also worth noting that the choice of risk free rate for determining the market risk premium is unlikely to change the currently employed estimate of .06. This is because the range of plausible values is sufficiently wide that one cannot hope for more precision than the second decimal point (i.e., .05, .06, .07 etc) and the differences arising from the choice of risk free rate tend to be subsumed within this level of precision. Lally (2002b) surveys estimates of the market risk premium relative to ten year bonds. The range of estimates is from .04 with a forward-looking approach to .07 from historical averaging of the Ibbotson (2000) type. Had five year bonds been used instead then, in so far as recalculation is possible, the results would have been raised by only about .20%[7].

2.3 Other Arguments

We now examine a number of further arguments for the use of the ten year rate. Ergas (2002) notes that the appropriate rate of return for a regulated firm is the opportunity cost from not investing elsewhere, and asserts that this return available elsewhere is unrelated to the regulatory period in question here. The opportunity cost is the expected return available in an alternative investment with *equal* risk. So, if the regulatory period matters, it must be matched in the alternative investment.

Ergas (2002) also claims that the allowed rate of return must be such that past investment is expected to be recouped, and then adds that use of the five year risk free rate fails to do so. The requirement presented here is equivalent to stating that the present value of the future cash flows matches the initial investment. Section 2.1 shows that the use of the ten year interest rate fails this ex-ante test and that the five year rate satisfies it.

[7] This is not only the current differential on five and ten year bonds but it also equals the average over the period since 1983 (ElectraNet SA, 2002, p. 4-11).

Ergas (2002) also notes that the allowed rate of return must signal new investment, and then claims that this requires the use of the ten year bond rate. Clearly the allowed rate of return must be sufficient to encourage new investment. This implies that the present value of the future cash flows must be at least the initial investment. The analysis in section 2.1 shows that use of the five year rate achieves this. The use of the ten year rate may overcompensate ex ante or under-compensate ex ante. In the latter case, rational investors would refuse to invest. So, contrary to Ergas' claim, it is the use of the ten year rate that may lead to the under-investment problem.

Officer (2002a) asserts that the ten year rate must be used because investors are still committed to the asset at the time of the price resetting. This "commitment" is embodied in the analysis of section 2.1. Nevertheless it is shown there that use of a risk free rate whose term matches the regulatory cycle yields cash flows whose present values matches the initial investment. The use of a longer term rate fails this basic test.

Officer (2002b) also argues for the ten year rather than the five year rate because the future interest rates are not known at the time of the initial investment. As the examples in section 2.1 show, this leads to uncertainty at the end of the first regulatory period about future cash flows, but this uncertainty is offset by the discount rate used to value those future cash flows at the end of the first regulatory period. The result is a business value at the end of the first regulatory period that is free of interest rate risk, and this in turn supports the use of the five year rate for setting revenues.

Finally, Officer (2002b) argues for the ten rather than the five year rate because the regulated firm cannot walk away if compensation is inadequate. Clearly, if the ACCC fails to adjust allowed prices in light of prevailing interest rates, then the argument for the five year interest rate evaporates. However Officer presents no evidence to support this. In the absence of contrary evidence I think one is bound to assume that the ACCC will observe its announced policy. As demonstrated in section 2.1, it follows that the interest rate used should match the regulatory period, i.e., the five year rate should be used.

GasNet (2002) argues for the ten year rate rather than the five year rate because the ten year rate is less volatile. They add that the volatility in the five year rate induces a "…lottery divorced from the long-term nature of the investment…" (ibid, p 53). Clearly, longer term interest rates are less volatile. Nevertheless, as shown in section 2.1, their use leads to cash flows whose present value at the initiation of a project will deviate from the initial investment. Accordingly they fail the basic test in a price setting process. By contrast the five year rate satisfies this basic test, because variations in the five year rate remove interest rate risk that the investment would otherwise be subject to. In the same way, a long-term bond that is subject to a floating rate of interest is thereby freed from interest rate risk. So, far from inducing a "lottery", the revising of prices in accordance with current five year rates is risk reducing rather than risk increasing.

GasNet (2002) also argues for the ten year rate because it is more "market-reflective". This point is difficult to understand. Both the five and ten year rates are market yields. However the latter is inappropriate for price setting with a five year cycle because it generates cash flows whose present value at the initiation of a project will deviate from the initial investment.

ElectraNet SA (2002) argues for the ten year rate because the transactions costs of reissuing five year debt would be too high. No evidence to support this cost claim is offered. In fact Macquarie Bank (2002, p 22) indicates that the average term is about five years. Nevertheless, even if some incremental transaction cost were incurred by borrowers, this cost would be dominated by the arguments presented in section 2.1 for the use of the five year rate.

ElectraNet SA (2002) also argue for the ten year rate because 75% of the value of a regulated firm lies in the cash flows arising from regulatory periods beyond the first. The statement about the distribution of cash flows over time may be true. Nevertheless, as section 2.1 shows, use of the ten year interest rate for resetting prices leads to cash flows whose present value fails to match the initial investment. By contrast, the use of the five year interest rate satisfies this basic test.

Finally, ElectraNet SA (2002) argues for the ten year rate because other regulators are doing so. With thinking like this, the wheel might never have been invented.

3. Forecasting Inflation

The ACCC's current process for setting the allowed output price involves choosing the initial price so that (with escalation in accordance with expected CPI inflation) the present value of the future cash flows matches the initial expenditure. Having established the initial price in this way, it is subsequently revised in accordance with actual CPI inflation. Thus a forecast of inflation would seem to be required to establish the initial output price. The ACCC's approach to this is to forecast inflation from the geometric difference in the five year nominal and real commonwealth bond yields. It is noted that the differential comprises not merely inflation but also an inflation risk premium on the nominal bonds and a liquidity premium on the real bonds. The liquidity premium is argued to be close to zero. In respect of the inflation risk premium, evidence is presented for a figure of about .01 (OXERA, 2000; Remolona et al, 1998; Shen, 1998). However it is suggested that the inflation forecast need not be corrected for this figure of .01 because the regulated output price is subject to adjustment in accordance with actual inflation.

The justification offered for ignoring the inflation risk premium is somewhat unclear, and can be explained as follows. To simplify the demonstration, assume that the only source of uncertainty is in future inflation rates. Since the output price is inflation adjusted, and assuming that operating costs behave in the same way, the cost and revenue streams are fixed in real terms[8]. An appropriate discount rate on these cash flows is then the real risk free rate of r. Furthermore, following the arguments in section 2.1, the appropriate term for this rate is five years[9]. The initial output price P is chosen to equate the present value of the future cash flows over the n years of the project life to the initial investment of I. Denoting expected output in year t by Q_t, and expected real operating costs in year t by C_t, this implies that

[8] The operating costs are not in fact fixed in real terms although their expectations could be presumed to. However, under the assumption that the only uncertainty is that arising from inflation, these operating costs would have to be treated as fixed in real rather than nominal terms.

$$I = \frac{Q_1 P - C_1}{1+r} + ... + \frac{Q_n P - C_n}{(1+r)^n} \qquad (8)$$

Letting *R* denote the five year nominal bond rate, the last equation is equivalent to

$$I = \frac{Q_1 P\left[\frac{1+R}{1+r}\right] - C_1\left[\frac{1+R}{1+r}\right]}{1+R} + ... + \frac{Q_n P\left[\frac{1+R}{1+r}\right] - C_n\left[\frac{1+R}{1+r}\right]}{(1+R)^n} \qquad (9)$$

i.e., the real cash flows are "inflated up" by the term [ ] and the resulting cash flows are then discounted using the nominal bond rate *R*. Of course [ ] is not a good inflation forecast because it ignores the inflation risk premium. However, it is not actually an inflation forecast. This is simply a convenient name for it. It is simply the geometric excess of the nominal bond rate over the real bond rate. So long as equation (8) is valid then (9) follows. Whether we call the term [ ] the "inflation forecast" or not is merely semantic. However the use of the term "inflation forecast" does risk some confusion. On account of the last point I do not favour the use of this term.

By the same reasoning, the omission of an allowance for inferior liquidity in the real bonds when estimating "inflation" is also warranted. However the ACCC (2002, footnote 14) argues that this liquidity allowance is zero, and thereby implies that a non-zero value would have affected the "inflation" estimate. In summary then, equation (9) is valid. Whether the difference between the real and nominal bond yields reflect factors other than expected inflation is irrelevant.

4. The Use of a Five Day Average

In seeking to measure the interest rate to be used for resetting the output price, the ACCC averages the observed yields over a short period. This is presented as a trade-off between two competing forces: the desire for the relevant rate leads one to choose

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[9] In the absence of an observed yield corresponding to this five year term, interpolation is employed by the ACCC, and this seems reasonable.

the last observation before the commencement of the relevant period, whilst the desire to minimize exposure to the rates on an aberrant day leads to choosing an average over a long period. Averaging over time also allows the regulated firm to spread its new borrowing or hedging activities over time, and this protects it from rate spike due to a high volume of activity within a short period. The average that is undertaken is geometric rather than arithmetic because the former is claimed to be "more consistent with the holding period return" (ACCC, 2002, p 16).

Officer (2002b) argues for use of the last observed rate solely on the grounds that earlier data is less relevant. This point is valid but is encompassed within the ACCC's trade-off argument. Implicitly Officer places no weight upon the other considerations in this trade-off debate.

My view is that averaging is justified, principally because it smooths output prices for consumers. It also allows firms to match borrowing costs to output prices without exposure to adverse volume effects on the interest rate paid by them. The latter reason is less significant because it only addresses issues relating to debt capital rather than capital in aggregate. Having said this, it is not apparent what the optimal length of the period should be. The use of a five day period would seem to be the bare minimum consistent with the purpose of smoothing output prices for consumers.

In respect of the method of averaging, the choice here depends upon the purpose of the averaging. Two purposes are advanced, the first of which is to gain protection from an aberrant rate. In this event the best averaging method would seem to be the median rather than the geometric mean. For example, if the rates used in averaging are .06, .07 and .15, then the last figure is aberrant and should not affect the average. It will not affect the median but it will drive both the arithmetic and geometric averages upwards.

The second rationale for averaging is to match the borrowing costs incurred by the regulated firms, because their borrowings are spread over time. In this event the use of the median will discard outliers that still affect the firm's borrowing cost, and is therefore inappropriate. In respect of arithmetic or geometric means, both will understate the firm's incurred cost but the geometric mean will do so to a greater degree, and is therefore inferior to the arithmetic mean. Nevertheless, the differences are trivial. To see this, assume for simplicity that these firms can borrow at the government stock rate and let X dollars be borrowed at each of the rates R_1, R_2……R_n for repayment with interest in T years. Revenues are also received only in T years. Letting AM[ ] denote the arithmetic average, the total repayment cost in T years is then

$$X(1+R_1)^T + ... + X(1+R_n)^T = nX\left[AM\left\{(1+R)^T\right\}\right] \quad (10)$$

If arithmetic averaging over R_1, R_2……R_n is used to determine the interest rate used for setting the output price, then the revenue received by the firm in T years will be

$$nX\left[1+AM(R)\right]^T \quad (11)$$

If geometric averaging (GM) is used instead to determine the interest rate used for setting the output price, then the revenue received by the firm in T years will be

$$nX\left[1+GM(R)\right]^T \quad (12)$$

Because of the power function, (10) will exceed (11). In addition, because an arithmetic mean always exceeds a geometric one in the presence of variation, then (11) exceeds (12).

To illustrate this, assume $100m is borrowed at .065 and the same at .068, each for 20 years. Following equation (10), the compounded sum is $725.12m. However, if we used the arithmetic mean of the interest rates to set the firm's revenue, then following equation (11) we would allow revenue of $724.85m. Finally, if we used the geometric mean of the interest rates to set the firm's revenue, then following equation (12) we would allow revenue of $724.83m. The revenues will then be less than the actual borrowing costs, but these differences are inconsequential.

To summarise on this question of which averaging technique is best, the median is preferred for the purpose of protecting consumers against a freak interest rate in the period examined whilst arithmetic averaging is preferred for matching a firm's revenues to their borrowing costs. My view is that the latter protection is the more significant issue. Accordingly I favour arithmetic averaging, although the results from geometric averaging would not differ by much.

5. The Use of a Forward Rate

The risk free rate to be used by the ACCC for resetting the output price over the next cycle (times 1 to 2) is determined a few weeks prior to the beginning of that cycle (time 0), to enable the affected firms to advise their customers of a price change. So, the output price is determined in advance of the period for which it generates revenues. Consequently the ACCC proposes to set the interest rate at time 0 equal to the forward rate then prevailing for the period from time 1 to 2 rather than setting it equal to the spot rate at time 0 for the period from time 0 to time 2.

This approach to setting the interest rate seems sensible, although the effect from not doing so may be small. Since the interest rate underlying the determination of the firm's revenues is set in advance of their receipt, a desire for hedging on the part of the firm would then lead them to fix their borrowing costs at time 0 for the period from time 1 to time 2. This can be achieved through a short futures contract, undertaken at time 0, maturing at time 1 and involving a bond maturing at time 2. The resulting interest rate fixed at time 0, for the period from time 1 to 2, would be the forward rate for the latter period (Kolb, 1988, Ch. 6). This matches the forward rate chosen by the ACCC. Consequently the regulated firm is better able to match its borrowing costs to its revenues. This matching process operates regardless of whether forward rates are unbiased predictors of future spot rates. However the ACCC (2002, Appendix) appears to suggest otherwise.

6. Prior Notification of the Measurement Period for the Risk Free Rate

The final issue is that of prior notification to regulated firms of the period over which the risk free rate will be averaged. This would enable firms to undertake appropriate hedging actions as described in the previous section. Such notification would be confidential so as to ensure that these firms were not placed at a disadvantage when they negotiated hedging arrangements. Prior notification by a number of months is suggested.

This proposed approach seems sensible, with the exception of the period of prior notification. A period of months seems unnecessarily long for the purpose of engaging in a standard hedging action.

7. Conclusions

This paper has surveyed a number of issues relating to the risk free rate in the context of regulating output prices in Australia, and the conclusions are as follows. First, the appropriate term to use for the risk free rate is that matching the regulatory period, of five years. Second, the process for supposedly forecasting inflation from the geometric difference in the real and nominal five year bond rates is not correct as an inflation forecast. However the process is not actually intended to generate an inflation forecast and is sound for the actual purpose involved. Third, the principle of averaging the observed rates over a short period of time is sound, although no definite answer can be offered on the issue of the optimal period. However a period of five days would seem to be the bare minimum consistent with the purpose of smoothing. In respect of the particular averaging technique, I favour arithmetic averaging. Fourth, the principle of deriving a forward interest rate to match the period for which revenues will arise in sound. Finally, the concept of prior confidential notification to the regulated firm of the period over which the interest rate will be averaged is sound, although a period of some months notification seems excessive.

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