THE APPROPRIATE TERM FOR THE ALLOWED COST OF EQUITY

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EXECUTIVE SUMMARY

The ERA currently uses an allowed cost of equity whose term matches the regulatory cycle of five years. Contrary submissions have been received from a number of parties. This paper has reviewed these submissions and the principal conclusions are as follows.

Firstly, I concur with the ERA's choice of term, because it ensures that the NPV = 0 principle is satisfied (the present value of future cash flows of the regulated business equals its current regulatory asset base) and this is the primary consideration in choosing the term for the cost of equity.

Secondly, none of the contrary submissions (all of which argue for a cost of equity for a ten-year term or higher) have undercut the formal proof that the five-year cost of equity satisfies the NPV = 0 principle.

Thirdly, none of the contrary submissions has presented a proof that the NPV = 0 principle is satisfied with a ten-year or higher term for the cost of equity.

Fourthly, none of the contrary submissions has advanced any criteria that dominates this NPV = 0 principle, and also supports a ten-year or longer cost of equity.

1. Introduction

The ERA (2021, page 47) currently favours an allowed cost of equity capital whose term matches the regulatory cycle of five years. The CRG (2022, page 6) concurs with this. Contrary submissions have been received from a number of parties. This paper seeks to review these submissions. I commence with my own views, in section 2.

2. The Appropriate Term for the Allowed Cost of Equity

2.1 Revenues Received only at the end of the Regulatory Cycle

A fundamental requirement of regulation is the NPV = 0 principle, i.e., at the time a firm invests in regulated activities, the present value of its future cash flows must be equal to its initial investment. Schmalensee (1989) shows that satisfying this principle requires that, at the commencement of each regulatory cycle (when the allowed cost of capital is set), the term to which the allowed cost of capital relates matches the term of the regulatory cycle. Lally (2004) extends this to the situation in which cost and volume risks are present, and revaluation risks arising from the use of DORC methodology; the conclusion is the same.

To illustrate this principle, suppose that regulated assets are purchased now for A, with a life of two years, the regulatory cycle is one year, prices are set at the beginning of each year, and the resulting revenues are received at the end of each year. In addition, there is no opex, capex, or taxes. Let the regulatory depreciation of the asset base for the first year be denoted DEP_1, in which case that for the second year is the residue of $A - DEP_1$. Consider first the position at the end of the first year (time 1), at which point a price or revenue cap will be set to yield revenues at time 2 (REV_2). These expected revenues are set equal to depreciation of ($A - DEP_1$) plus the allowed cost of capital (at some rate k_1 observable at time 1) applied to the regulatory book value of the assets at time 1 of ($A - DEP_1$). The value at time 1 (V_1) of this business will be the expectation at time 1 of these future revenues, discounted at the one-year cost of equity prevailing at time 1 (ke_{12}):

$$V_1 = \frac{E(REV_2)}{1 + k_{e12}} = \frac{(A - DEP_1)k_1 + (A - DEP_1)}{1 + k_{e12}} \qquad (1)$$

At the current time (time 0), the price or revenue cap will be set to yield revenues at time 1 (REV_1). These expected revenues are set equal to depreciation of DEP_1 plus the allowed cost of capital (at some rate k_0 observable at time 0) applied to the regulatory book value of the assets at time 0 (A). The value at time 0 (V_0) of this business will be the expectation now of REV_1 plus the expectation now of V_1, discounted at the one-year cost of equity prevailing at time 0 (ke_{01}):

$$V_0 = \frac{E(REV_1) + E(V_1)}{1 + k_{e01}} = \frac{[Ak_0 + DEP_1] + E(V_1)}{1 + ke_{01}} \qquad (2)$$

The NPV = 0 principle requires that $V_0 = A$. This can only occur if the allowed cost of capital k_1 in the numerator of equation (1) matches the discount rate k_{e12} in that equation (which is the one-year cost of equity prevailing at time 1) and the allowed cost of capital k_0 in the numerator of equation (2) matches the discount rate k_{e01} in that equation (which is the one-year cost of equity prevailing at time 0). In this case, equation (1) becomes

$$V_1 = \frac{(A - DEP_1)k_{e12} + (A - DEP_1)}{1 + k_{e12}} = A - DEP_1 \qquad (3)$$

and substitution of this into equation (2) yields

$$V_0 = \frac{[Ak_{e01} + DEP_1] + (A - DEP_1)}{1 + ke_{01}} = A \qquad (4)$$

So the NPV = 0 test is satisfied. By contrast, if the allowed cost of equity in the numerator of equation (4) were larger or smaller than the discount rate in that equation, the present value of the future cash flows of the business (V_0) would not match the initial investment of A. In using the CAPM to determine the one-year cost of equity, the risk-free rate, the market risk premium, and the beta are all defined over the one-year period in question.

The following intuitive explanation for why the allowed cost of equity cannot be for a term other than the regulatory cycle may be helpful. Suppose the regulatory assets have a life of two years, there is no risk in the regulatory business (so the allowed return on equity is the risk-free rate), the regulatory cycle is one year, the current one-year risk-free rate is 3%, the one-year rate in one year will be 7% for certain due to increased inflation in the second year, and therefore arbitrage implies that the current two-year rate is 5% per year. If the regulator allows the two-year rate for the first year, the rate will be 5% rather than 3%. In one year, with the assets having a remaining life of one year, the regulator will presumably allow the one-year rate of 7%. So, the investors in the regulated business will receive an allowed rate in both years that reflects increased inflation in the second year. This duplicates compensation for circumstances peculiar to the second year. By contrast, matching the term of the allowed rate to the length of the regulatory cycle, and therefore allowing 3% in the first year and 7% in the second year, avoids this duplicate compensation.

The analysis in equations (1) to (4) above assumes that the regulator does their job perfectly in the sense that their decisions at time 1 give rise to a value of the regulatory assets at that time (V_1) that is equal to the contemporaneous regulatory asset base (RAB_1). Of course, no regulatory process is so perfect, and regulatory errors may lead to V_1 diverging from RAB_1. However, at the commencement of the first regulatory cycle (time 0), there is no reason to expect bias in the regulator's revenue setting at time 1, i.e., in equation (3), $V_1 = A – DEP_1 + e_1$ where e_1 is the regulatory error with $E(e_1) = 0$. So, $E(V_1) = A - DEP_1$. With substitution of this into equation (2), equation (4) still holds, and therefore the NPV = 0 test is still satisfied. The only significance of such regulatory errors is that they might be systematic, in which case the risk premium within the first year's discount rate k_{e01} will automatically allow for it (through the usual empirical process for estimating beta).[1] Additionally using a longer term risk-free rate than the rate whose term matches the regulatory cycle (of one year) would then be a form of duplicate compensation, and it would be highly imperfect duplication because the allowance for risk is (appropriately) particular to a firm or project whereas risk-free rates are not. An extreme case of this imperfection would arise when the term structure of risk-free rates was downward sloping, in which case using the longer term rate rather than the five-year rate would undercut the compensation for risk within the empirically determined beta estimate.

In addition to regulatory errors, investors may expect regulated businesses to outperform regulatory benchmarks because there are incentives for them to do so, and therefore the

[1] To illustrate how errors might be systematic, suppose a regulator puts primary weight on historical average excess returns for estimating the MRP. This estimation process reacts slowly to changes in the true MRP. In a recession, the true MRP will rise whilst historical average excess returns will initially fall, leading to the true MRP exceeding the allowance, i.e., the allowance will be too low. So, allowed revenues will be too low, and therefore V_1 will be less than the RAB. In an economic expansion, the opposite happens. So, for these regulatory errors, investors in regulated businesses experience adverse shocks in a recession and favourable shocks in an economic expansion. This is systematic risk.

expected value of the business at any point in time may exceed the contemporaneous RAB. However the values appearing in equations (1) to (4) purposely do not account for this, otherwise regulators would be anticipating (and thereby neutralizing) the opportunity for firms to be rewarded for this outperformance.

To illustrate these points, consider the scenario underlying the above equations with a current one-year risk-free rate of 2%, and a current RAB of $100m, which is depreciated at $50m per year over the two years. I start by assuming that there is no risk anywhere. So, the one-year risk-free rate in one year must be known now. Suppose it will be 4%. Accordingly, arbitrage requires that the two-year rate now be 3% per year. If the allowed risk-free rate is matched to the regulatory cycle, the allowed rate for the first cycle (i.e., the first year) will be 2% and that for the second cycle (the second year) will be 4%, leading to allowed revenues (inclusive of depreciation) of $50m + $100m*.02 = $52m for the first cycle and $50m + $50m*.04 = $52m for the second cycle. Since these are certain, the first year's revenues should be valued now using the current one-year risk-free rate of 2% and the second year's revenues should be valued back to the beginning of that year using the one-year risk-free rate for the second year of 4% (to yield $50m) followed by being valued back to now using the current one-year risk-free rate of 2%, yielding a total value now of $100m:[2]

$$V_0 = \frac{\$52m}{1.02} + \frac{\left[\frac{\$52m}{1.04}\right]}{1.02} = \frac{\$52m}{1.02} + \frac{\$50m}{1.02} = \$100m \qquad (5)$$

This matches the current RAB of $100m, and therefore satisfies the NPV = 0 principle. However, if the risk-free rate allowed for the first year were instead the current two-year rate of 3% rather than the current one-year rate of 2%, the allowed revenues for the first year will be $53m rather than $52m. To focus on this first year, I assume that a proponent of this approach would still use the one-year risk-free rate to set the allowed revenues in the last year of the project's life, which is 4%, yielding allowed revenues for the second year of $52m as before. Since both revenues are certain, they are valued in the same way as above: the first year's revenue using the current one-year risk-free rate of 2% and the second year's revenue

[2] Alternatively, the first year's revenues are valued using the current one-year risk-free rate of 2% and the second year's revenues (which are known now) can be valued now using the current two-year risk-free rate of 3% per year. The result is again $100m.

using 4% for the second year and then 2% for the first year. The result is a total value now of $101m:

$$V_0 = \frac{\$53m}{1.02} + \frac{\left[\frac{\$52m}{1.04}\right]}{1.02} = \frac{\$53m}{1.02} + \frac{\$50m}{1.02} = \$101m \qquad (6)$$

This does not satisfy the NPV = 0 principle, because the allowed revenues for the first year have been set using the two-year rate rather than the one-year rate. So, with no risk anywhere, the allowed risk-free rate must match the term of the regulatory cycle.

I now introduce risk, purely in the form of uncertainty about the one-year risk-free rate prevailing in one year (R_{12}). The current two-year risk-free rate will rise to reflect this uncertainty, in accordance with the Liquidity Premium hypothesis about the term structure of interest rates; suppose this rate is 3.3% rather than 3%. The one-year rate in one year (R_{12}) represents the discount rate used in the second year, and also the allowed rate of return used to set the second year's revenues. So, in one year's time, the allowed revenues arising at the end of that second year will be $50m(1 + R_{12}), and their value at the beginning of that year will be $50m(1 + R_{12})/(1 + R_{12}) = $50m. So, the value of the business in one year will still be $50m for certain as before, regardless of the one-year risk-free rate prevailing in one year, and therefore will still warrant discounting over the first year by the current one-year risk-free rate of 2%. So, if the allowed rate of return for the first year is matched to the regulatory cycle, the revenues for the first year will be $50m + $100*.02 = $52m as before and therefore the value now of the business will still be $100 as follows:

$$V_0 = \frac{\$52m}{1.02} + \frac{\$50m}{1.02} = \$100m \qquad (7)$$

Again, this matches the current RAB of $100m, and therefore satisfies the NPV = 0 principle. However, if the risk-free rate allowed for the first year is instead the current two-year rate of 3.3%, rather than the current one-year rate of 2%, the allowed revenues for the first year will be $50m + $100m*.033 = $53.3m rather than $52m. The correct discount rate is still 2%, so the value now of the business will then be $101.3m as follows, which does not satisfy the NPV = 0 principle:

$$V_0 = \frac{\$53.3m}{1.02} + \frac{\$50m}{1.02} = \$101.3m \qquad (8)$$

I now introduce additional risk, in the form of uncertainty about the revenues to be received in both years and uncertainty about the value of the business in one year due to the possibility of the regulator erring. This is dealt with through adding a premium to the allowed risk-free rate (as per the CAPM or some other model). Suppose this premium is 1.5% for each year. Both discount rates then rise by 1.5% and therefore so too must the allowed rates of return. So, in one year's time, the revenues arising at the end of that second year will be *expected* to be \$50m(1 + R_{12} +.015), and their value at the beginning of that year will be *expected* to be \$50m(1 + R_{12} + .015)/(1 + R_{12} + .015) = \$50m with some uncertainty around this due to the possibility of regulatory error. The first year's discount rate on this expected value and also on the expected revenues at the end of the first year is now 3.5% rather than the 2%. Furthermore, if the allowed rate of return for the first year embodies a risk-free rate matched to the regulatory cycle, of 2%, the *expected* revenues for the first year will be \$50m + \$100m*(.02 + .015) = \$53.5m. So, the value now of the business will still be \$100m as follows:

$$V_0 = \frac{\$53.5m}{1.035} + \frac{\$50m}{1.03.5} = \$100m \tag{9}$$

Again, this matches the current RAB of \$100m, and therefore satisfies the NPV = 0 principle. However, if the allowed risk-free rate for the first year were instead the current two-year rate of 3.3%, rather than the current one-year rate of 2%, the allowed revenues for the first year would be \$50m + \$100m*(.033 + .015) = \$54.8m. The value now of the business would then be \$101.3m as follows:

$$V_0 = \frac{\$54.8m}{1.035} + \frac{\$50m}{1.035} = \$101.3m \tag{10}$$

Again this does not satisfy the NPV = 0 principle. So, risk must be dealt with only through a premium in the discount rates, and hence also in the allowed rates of return, rather than by also using a longer term risk-free rate.

An important property of this NPV = 0 scenario is that the regulator need only concern themselves with the next regulatory period, i.e., choose the allowed cost of capital at time 0 in the numerator of equation (4) so that the present value of the net cash flows over the next regulatory cycle plus the present value of the regulatory book value at the end of this cycle is equal to the current book value of the regulated assets, as shown in equation (4). At the end of that cycle, at time 1, it then chooses the allowed cost of capital in the numerator of equation (3) so that the present value of the net cash flows over the next regulatory cycle plus the present value of the regulatory book value at the end of this cycle is equal to the contemporaneous book value of the regulated assets, as shown in equation (3).

2.2 Revenues Received Throughout the Regulatory Cycle

The preceding analysis assumes that revenues are received only at the end of the regulatory cycle. When the regulatory cycle is one year, revenues are then assumed to be received at the end of each year, which accords with general practice in DCF analysis. However, when the regulatory cycle is the more typical period of five years, this assumption is too unrealistic. So, suppose the revenues (and other cash flows) still arise at the end of each year, but the regulatory cycle is five years. It might then seem that the appropriate risk free rate would be the current yield to maturity on a bond maturing in five years. However the duration of this bond (which will be something less than five years) might differ from the duration of the regulatory payoffs (something less than five years). To illustrate this point, consider the following example.

Suppose the regulatory asset book value is currently \$100m, the output price is reset every five years from now, depreciation is \$2m per year, capex is \$2m per year, operating costs are \$10m per year and incurred at year end, and revenues are certain and received annually at the end of each year.[3] In five years' time, and following the analysis in the previous section, the output price will be reset to ensure that the value at that time of the subsequent payoffs on the regulatory assets equals the regulatory asset book value prevailing at that time (of \$100m, because capex matches depreciation over the next five years). In addition, suppose the current spot interest rates for the next five years are 0.1% for year 1, 0.1% for year 2, 0.1% for year 3, 0.3% for year 4 and 0.5% for year 5.[4] In addition, suppose the coupon interest rate

[3] Uncertainty about revenues or opex leads to a risk premium being added to the discount rate, but this does not otherwise affect the analysis.

[4] These numbers approximate the situation in February 2021 (data from February 2021 in Table F2 on the website of the RBA: https://www.rba.gov.au/statistics/tables/#interest-rates) and are also typical in the sense of being upward sloping.

on the five-year bond used to derive the five-year yield to maturity is 2.75%.[5] Denoting the face value of this bond by F, the market value of this bond would be as follows:

$$B_0 = \frac{.0275F}{1.001} + \frac{.0275F}{(1.001)^2} + \frac{.0275F}{(1.001)^3} + \frac{.0275F}{(1.003)^4} + \frac{1.0275F}{(1.005)^5} = 1.1117F$$

The yield to maturity (YTM) on this bond (denoted y) would then satisfy the following equation.

$$1.1117F = \frac{.0275F}{1+y} + \frac{.0275F}{(1+y)^2} + \frac{.0275F}{(1+y)^3} + \frac{.0275F}{(1+y)^4} + \frac{1.0275F}{(1+y)^5}$$

Accordingly, y = .00483. This matches the February 2021 average YTM on a five-year Australian government bond.[6] Using this risk-free rate to set the allowed rate of return for the firm, the resulting revenues for the next year would be:

$$REV_1 = OPEX_1 + DEP_1 + B_0R_f = \$10m + \$2m + \$100m(.00483) = \$12.483m$$

The net cash flow for this year would be this revenue less the opex and capex, yielding \$0.483m, and the same figure would apply for each of the following four years because the regulatory asset book value does not change. Using the spot interest rates given above, the present value of these net cash flows along with the value in five years of all subsequent payoffs on the regulatory assets (which equals the regulatory asset book value in five years, of \$100m) would then be as follows.

$$V_0 = \frac{\$0.483m}{1.001} + \frac{\$0.483m}{(1.001)^2} + \frac{\$0.483m}{(1.001)^3} + \frac{\$0.483m}{(1.003)^4} + \frac{\$100.483m}{(1.005)^5} = \$99.93m$$

This present value of \$99.93m is marginally below the current regulatory book value of the assets, of \$100m. Setting the allowed rate of return so that V_0 is exactly \$100m requires raising the allowed rate of return from 0.483% to 0.497%:

[5] This is the median coupon rate for the nine bonds shown on Table F16 of the website of the RBA (https://www.rba.gov.au/statistics/tables/#interest-rates), with terms to maturity up to five years away as at February 2021.

[6] See Table F2 on the website of the RBA: https://www.rba.gov.au/statistics/tables/#interest-rates.

$$V_0 = \frac{\$0.497m}{1.001} + \frac{\$0.497m}{(1.001)^2} + \frac{\$0.497m}{(1.001)^3} + \frac{\$0.497m}{(1.003)^4} + \frac{\$100.497m}{(1.005)^5} = \$100m$$

So, setting the allowed rate using the YTM on a five-year government bond is too low by only .016%. The trivial extent of this error reflects the fact that the duration for the five-year bond and that of the regulatory payoffs are very similar. In particular, and using Macaulay's second measure of duration (Elton et al, 2003, pp. 548-550)[7], which is a value-weighted average of the terms to maturity of the various cash flows, the duration on the bond (D_B) is 4.75 years and that for the regulatory cash flows (D_R) is 4.95 years as follows.[8]

$$D_B = \left[\frac{\frac{.0275}{1.001}}{1.1117}\right](1) + \left[\frac{\frac{.0275}{(1.001)^2}}{1.1117}\right](2) + \cdots + \left[\frac{\frac{1.0275}{(1.005)^5}}{1.1117}\right](5) = 4.75 \text{ yrs}$$

$$D_R = \left[\frac{\frac{\$0.483\text{m}}{1.001}}{\$99.93\text{m}}\right](1) + \left[\frac{\frac{\$0.483\text{m}}{(1.001)^2}}{\$99.93\text{m}}\right](2) + \cdots + \left[\frac{\frac{\$100.483\text{m}}{(1.005)^5}}{\$99.93\text{m}}\right](5) = 4.95 \text{ yrs}$$

This close correspondence in durations has occurred because depreciation matches capex, and therefore the regulatory asset book value is unchanged over the regulatory period. To achieve a perfect match, the coupon rate on the bond would have to be such that the duration on the bond matched that of the payoffs on the regulatory assets (and this would occur with a coupon rate on the bond of 0.483% rather than the actual rate of 2.75%).

Now suppose that the allowed rate of return is set using a risk-free rate equal to the YTM on a ten-year government bond. Doing so, using the February 2021 average for the YTM on a ten-year Australian government bond (1.32%), the annual revenues net of opex and capex in the preceding example would rise from \$100m(0.00483) = \$0.483m to \$100m(.0132) =

[7] Macaulay's second rather than first measure of duration is required because the term structure of (spot) interest rates is not flat in this example.

[8] The duration calculations for the regulated business uses only its cash flows for the first five years and the known value of the business in five years because the regulatory resetting process implies that the value in five years of subsequent cash flows is invariant to an interest rate shock now, and duration by definition (as opposed to the computational process here) is the sensitivity of current value to an interest rate shock now (see Elton et al, 2003, pp. 548-550).

$1.32m. Using the spot rates above, the present value of these net cash flows over the regulatory cycle along with the value in five years of all subsequent payoffs on the regulatory assets (which equals the regulatory asset book value in five years, of $100m) would then be as follows.

$$V_0 = \frac{\$1.32m}{1.001} + \frac{\$1.32m}{(1.001)^2} + \frac{\$1.32m}{(1.001)^3} + \frac{\$1.32m}{(1.003)^4} + \frac{\$101.32m}{(1.005)^5} = \$104.1m$$

This present value is well in excess of the current regulatory asset value of $100m, and the allowed rate of 1.32% exceeds the rate satisfying the NPV = 0 principle (0.497%) by 0.82%. These results are shown in the first row of Table 1. The last column in the table shows the risk-free rate used in setting the allowed rate of return that satisfies the NPV = 0 principle, the third column shows the present value of the regulatory cash flows arising from using the five-year YTM on a government bond to set the allowed rate of return, and the fifth column shows the present value of the regulatory cash flows arising from using the ten-year YTM on a government bond to set the allowed rate of return.

This analysis assumes that capex ($2m) exactly matches depreciation ($2m), so that the regulatory asset book value does not change. I therefore consider a more realistic case in which capex is $4m and therefore exceeds depreciation by $2m per year (to reflect both inflation and real growth in the network). Using the current five-year risk-free rate of 0.483% to set the allowed rate of return, the revenues in the first year are still $12.483m as before but net of opex of $10m and capex of $4m yields a net cash flow of -$1.517m. The revenues for the following four years are -$1.507m, -$1.497m, -$1.488m and -$1.478m respectively. The present value of these net cash flows along with the value in five years of all subsequent payoffs on the regulatory assets (which equals the regulatory asset book value in five years, of $110m) would then be as follows.

$$V_0 = \frac{-\$1.517m}{1.001} + \frac{-\$1.507m}{(1.001)^2} + \frac{-\$1.497m}{(1.001)^3} + \frac{-\$1.488m}{(1.003)^4} + \frac{\$108.522m}{(1.005)^5} = \$99.87m$$

Again, this is very close to the $100m current regulatory book value of the assets, of $100m. In addition, the allowed rate of return that yields a present value of $100m (thereby exactly satisfying the NPV = 0 principle) is 0.509%. This is very close to the YTM on a five-year government bond (0.483%). By contrast, setting the allowed rate using a risk-free rate equal to the YTM on a ten-year government bond (1.32%), the present value of the resulting net cash flows plus the regulatory asset book value of $110m in five years would be

$$V_0 = \frac{-\$0.68m}{1.001} + \frac{-\$0.654m}{(1.001)^2} + \frac{-\$0.627m}{(1.001)^3} + \frac{-\$0.601m}{(1.003)^4} + \frac{\$109.426m}{(1.005)^5} = \$104.2m$$

Again, this is well in excess of the current regulatory asset book value of $100m, and the allowed rate of 1.32% exceeds the rate satisfying the NPV = 0 principle (of 0.509%) by 0.81%. These results are shown in the second row of Table 1. The third row of the table shows the results with capex of $8m, and therefore capex exceeds depreciation by $6m. Even here, the allowed rate of return that perfectly satisfies the NPV = 0 principle (0.531%) is very close to the YTM on a five-year government bond, and well below the YTM on a ten-year government bond.

This analysis reflects the typical situation, in which the term structure of interest rates is upward sloping. The contrary case is therefore considered. Since 2000, the most pronounced such case was in November 2007, when the five-year YTM on government bonds averaged 6.36% whilst that on ten-year bonds averaged 6.03%.[9] In addition, the median coupon rate on government bonds with residual terms to maturity of up to five years as at November 2007 was 5.75%.[10] A set of spot rates over the first five years that is compatible with this coupon rate of 5.75% and the five-year YTM of 6.36% is 6.8%, 6.7%, 6.6%, 6.5% and 6.33% for years 1…5 respectively. Using these spot rates, the analysis in the first section of Table 1 is reproduced and shown in the second section of the table.

Across the six cases shown in Table 1, relative to the risk-free rate satisfying the NPV = 0 principle (see last column of the table), setting the allowed rate equal to the YTM on a five-year government bond (see second column) yields an error of no more than 0.05% whilst setting the allowed rate equal to the YTM on a ten-year government bond (see fourth column) yields an error of 0.30% to 0.82%. So, using the five-year rate YTM is approximately correct and using the ten-year YTM is not, regardless of whether the term structure of interest rates is

[9] See Table F2 on the website of the RBA: https://www.rba.gov.au/statistics/tables/#interest-rates.

[10] See Table F16 of the website of the RBA (https://www.rba.gov.au/statistics/tables/#interest-rates).

upward or downward sloping and regardless of whether capex is equal to or much larger than the regulatory depreciation allowance.[11]

Table 1: Allowed Rates of Return

Capex - Dep	5-Yr YTM	PV	10-Yr YTM	PV	Correct
0	0.483%	$99.93m	1.32%	$104.1m	0.497%
$2m	0.483%	$99.87m	1.32%	$104.2m	0.509%
$6m	0.483%	$99.74m	1.32%	$104.4m	0.531%
0	6.36%	$99.99m	6.03%	$98.62m	6.363%
$2m	6.36%	$100.03m	6.03%	$98.61m	6.353%
$6m	6.36%	$100.12m	6.03%	$98.59m	6.334%

In summary, when revenues are received annually and the regulatory cycle is five years, use of the YTM on a five-year government bond as the risk-free rate is approximately correct and using the ten-year YTM is not, regardless of whether the term structure of interest rates is upward or downward sloping and regardless of whether capex is equal to or much larger than the regulatory depreciation allowance.

2.3 Comparison with Other Assets

The regulatory valuation problem is similar to that for a floating-rate government (default-free) bond with (say) a ten-year life, in which the coupon rate is initially set to match the prevailing five-year government bond rate, and reset in five years to that rate prevailing at that time. Thus, the bond delivers cash flows over the course of ten years but it is not valued now by reference to cash flows over the next ten years. Instead, the valuation is recursive, as follows. In five years' time, per $1 of face value, the value of the bond at that time (V_5) will arise from the coupon payments over the following five years (which each equal the five-year government bond rate prevailing in five years' time for the following five years, denote $R_{f5,10}$) plus repayment of the face value of $1 at the end of that five year period. The value of the bond in five years' time using the appropriate discount rate k is then:

[11] The smaller size of the errors in the second section of Table 1 is due to the coupon rate on the five-year bonds being much closer to the spot rates.

$$V_5 = \frac{R_{f5,10}}{1+k} + \frac{R_{f5,10}}{(1+k)^2} + \cdots + \frac{R_{f5,10} + \$1}{(1+k)^5} \tag{11}$$

At this point in five years' time, this bond will be a government bond with five-years to maturity, and therefore the appropriate discount rate (k) then will be the five-year government bond rate prevailing in five years' time ($R_{f5,10}$). Substitution of this discount rate into equation (11) yields a value for the bond in five years' time of \$1. This remains true no matter what the five-year government bond rate will be in five years' time, because the discount rate used at the beginning of that five year period equals the coupon rate paid over the last five years of the bond's life.

Turning now to the current moment in time, the bond will deliver a set of coupon payments over the next five years each equal to the current five-year government bond rate (R_{f5}) and additionally (as just proven) a value of \$1 in five years' time. The value now of the bond using the appropriate discount rate d will then be as follows:

$$V_0 = \frac{R_{f5}}{1+d} + \frac{R_{f5}}{(1+d)^2} + \cdots + \frac{R_{f5} + \$1}{(1+d)^5} \tag{12}$$

This bond has exactly the same payoffs as a government bond with five years to maturity, despite the fact that the \$1 payoff in five years is a market value rather than a repayment of principal, and therefore the appropriate discount rate on this bond (d) is the current five-year government bond rate (R_{f5}). Substitution of this discount rate into equation (12) yields a value now for the bond of \$1. So, despite delivering cash flows over the next ten years, this bond is valued now using only the cash flows over the first five years plus the value in five years' time of \$1, and the discount rate used in this valuation exercise should be the current five-year government bond rate rather than the current ten-year government bond rate. This is the same process that a regulator uses, in the case of a five-year regulatory cycle.

3. Review of Submissions

3.1 Frontier Economics

Frontier (2021) argues for use of the ten-year risk-free rate within the cost of equity, rather than the five-year rate matching the regulatory cycle and the ERA's current approach. In support of the ten-year rate, Frontier advances a number of arguments. Frontier (2021, sections 2.3 and 2.4) argues that all other Australian regulators use the ten-year rate. This is true but omits an important detail: the AER (2018, section 6.2.1) currently uses the ten-year rate but is contemplating using a rate matching the regulatory period (AER, 2021b, section 3.2). Frontier is perfectly aware of this because it devotes section 2.8 of its paper to critiquing these recent views of the AER. More importantly, it is not the practices of other regulators that are important but the merits of the arguments offered in support of those practices. These arguments are presented more comprehensively by Frontier in subsequent sections of their paper, and addressed below.

Frontier (2021, section 2.5) also argues that valuation practitioners use a ten-year risk free rate in performing DCF valuations of regulated businesses. In support of this claim, two surveys and a number of valuation exercises for individual companies are cited. The surveys are more useful (because they span many valuers) and the Incenta (2013) survey is the better one because it deals with the valuation of regulated businesses. In this 2013 survey of the valuation practices of 14 investment analysts, Incenta (page 26) posed four questions to these analysts, of which the first two were as follows:

(a) what risk free rate term is used in valuing a regulated businesses subject to five-year regulatory cycle?

(b) is a different rate applied to an unregulated business?

Incenta (ibid, pp. 27-29) claimed that all interviewees used the ten-year rate in valuing a regulated business, and that they would all apply the same rate to an unregulated business but use a different beta. Incenta therefore concluded that regulators should use the ten-year rate so as to achieve consistency with the practice of valuation professionals (ibid, page 43).

There are numerous difficulties with this line of argument. Firstly, simply replicating the actions of practitioners without an assessment of their reasons is an abnegation of a regulator's responsibility. A government bond maturing in five years' time would seem to warrant discounting at the five-year rather than the ten-year rate. If a survey of practitioners revealed that they used the ten-year rate, it would be essential to understand why they did this (and assess their arguments) rather than simply accept their view. The same principle applies to regulatory situations.

Secondly, since Incenta refers to regulatory debates over the choice of the five or ten year rate, and these regulatory rates are the prevailing rates (those at the commencement of the regulatory cycle), and Incenta recommends regulatory use of the ten-year rate, it follows that Incenta is recommending regulatory use of the *prevailing* ten-year rate. However, the rates used by its interviewees averaged 5% (Incenta, Table 2) whilst the prevailing ten-year rates averaged 3.2%.[12] Thus, most of the interviewees were *not* using the prevailing ten-year rate; in fact only one of the interviewees (who used a rate of 3.5%) could have been using the prevailing ten-year rate. Furthermore, one of the interviewees (Mr Edwards of Lonergan Edwards) stated that the term structure was significantly upward sloping and therefore a rate in excess of the prevailing ten-year rate was warranted for valuing the infinite-life cash flows of these businesses (ibid, page 45). Since most of the other interviewees stressed the long-term nature of the cash flows and the need for a matching discount rate (ibid, pp. 45-46), Mr Edwards's explanation may also characterise some or all of these other interviewees. Other interviewees described their risk free rate as being "through the cycle" (ibid, pp. 45-46) and therefore they may be using a ten-year rate averaged over some historical period in order to estimate some kind of long-term average rate. Thus, despite Incenta recommending the regulatory use of the prevailing ten-year rate on the basis that it accords with market practice, their survey of market practice reveals that market practice does *not* involve using prevailing rates. If market practice is not relevant to regulators in this respect, it would be perverse for regulators to defer to it in other respects.

Thirdly, the valuers that Incenta surveys are forecasting the cash flows from the regulated businesses. Since the cash flows beyond five years depend upon the allowed rates of return by regulators in 5, 10, 15 etc years', this requires forecasting future interest rates, which is difficult and full of opportunity for error. However, if regulators are doing their job, the present value of the future cash flows for the regulated assets will be equal to the current Regulatory Asset Base (RAB), subject only to the possibility that the regulated business in question is expected to outperform the regulatory allowances. If the expected degree of outperformance is 10% on average per regulatory cycle, the regulated business would be worth 10% more than RAB. This approach requires no forecasting of future cash flows in

[12] The dates of the interviews are not given but the report is dated June 2013 and I therefore examine the ten-year rates over the preceding year (June 2012-May 2013). The monthly averages range from 2.86% to 3.5% over this period and average 3.2% over the full year (data from the table F2 on the Reserve Bank website: www.rba.gov.au).

dollar terms and therefore no need for a discount rate.[13] So, the fact that the valuers are forecasting future cash flows implies that they do not have any confidence in regulators to set prices in accordance with the NPV = 0 principle. If so, it would be perverse of regulators to defer to any significant aspect of their valuation practices.

Fourthly, the valuers are valuing cash flows extending beyond five years into the future. Suppose these future cash flows arise every five years, in 5, 10, 15 etc years' time, and each is expected to be $1m. Suppose further that the current discount rates for these cash flows are 5.0% for those arising in five years, 5.5% for those arising in ten years, and 5.6% for the rest. The correct practice would be to value these cash flows using these discount rates, as follows:

$$V = \frac{\$1m}{(1.05)^5} + \frac{\$1m}{(1.055)^{10}} + \frac{\$1m}{(1.056)^{15}} + \cdots = \$3.22m \tag{13}$$

However, a reasonable approximation may be achieved by applying the ten-year discount rate of 5.5% to all cash flows, yielding a value of $3.26m:

$$V = \frac{\$1m}{(1.055)^5} + \frac{\$1m}{(1.055)^{10}} + \frac{\$1m}{(1.055)^{15}} + \cdots = \$3.26m \tag{14}$$

The valuers use this approximation because the slight error (only 1%) resulting from this may not affect the price ultimately paid for the asset, because the valuation is merely one input into a negotiation exercise. However this reasoning does *not* imply that a regulator should use the ten-year rate in a five-year regulatory cycle. At the beginning of a cycle, the regulator is only concerned with the next five years. Suppose the revenues it sets at the beginning of a cycle are realised only in five years' time, these revenues allow only for the cost of capital (because there is no opex, depreciation, capex or taxes), the RAB is currently $20m, and is expected to be likewise in five years. Letting k denote the discount rate, the allowed rate of return on the current RAB of $20m is then R such that

$$\$20m = \frac{R\$20m + \$20m}{1+k} \tag{15}$$

[13] The regulated business might also have additional value arising from the future possibility of entering into unregulated activities with positive NPV. If so, this would be valued as a separate exercise, and using discount rates that would have no relevance to the rate that the regulator should allow on the regulated activities.

The payoffs in five years warrant discounting at the five year discount rate k of 5%, and therefore the allowed rate of return R must be likewise in order to satisfy the above NPV = 0 test. The fact that the valuers use of the ten-year rate of 5.5% rate in equation (14), which approximately averages over the five, ten and later year rates, does not imply that a regulator should use 5.5% because the time periods for the two exercises are completely different. Furthermore, the regulator's use of the 5% rate in equation (15) is consistent with the valuers use of 5.5% in equation (14) because equation (14) is simply an approximation of equation (13), in which different rates are used for different terms including a rate of 5% for cash flows arising in five years. Furthermore, the computational exercises carried out by regulators flow directly through to the prices paid by customers and the revenues received by the regulated businesses, even down to a one basis point variation in the allowed rate. By contrast, a one basis point variation in the cost of capital estimated by a valuer would be unlikely to affect the transaction price, or perhaps even a 50 basis point variation in the estimated cost of capital. So, precision in the regulatory exercise is far more important than in the exercises carried out by valuers, which allows the approximation shown above to be used by valuers. This greater precision amongst regulators is reflected in the reports that regulators write on the cost of capital, being vastly more complex than the parallel exercises by valuers.

Frontier (2021, section 2.6) also argues that the ten-year risk-free rate is appropriate, consistent with general regulatory practice in Australia and elsewhere. However, as argued above, it is not the practices of other regulators that are important but the merits of the arguments offered in support of those practices. The arguments offered are as follows. Firstly, these regulators argue that the appropriate cost of debt is the ten-year rate, reflecting the term for which regulated businesses borrow. This has no relevance to the appropriate term for the cost of equity as the terms can be different (as argued in Lally, 2021). Secondly, these regulators argue that other regulators are adopting the ten-year rate. This is not a merits-based argument. Thirdly, these regulators cite the general practice of valuation practitioners. This argument has been addressed above, around equations (13) to (15). Fourthly, these regulators cite the long lives of regulated assets. However, regulators only set prices for a fraction of that time (the regulatory cycle), and reset them at the end of the cycle. Thus, at each price-setting point, regulators are not concerned with the life of the assets (except to the extent of setting the allowed depreciation for the current regulatory cycle).

Frontier (2021, section 2.7) also argues that the mathematical proof in support of matching the term of the cost of equity to the regulatory cycle, as presented in equations (1) to (4) above, is wrong because it assumes the value of the regulated business at the end of the first regulatory cycle (V_1) is known at the beginning of the cycle, and this assumption is false, and it is critical to the result (ibid, para 58). However, Frontier then notes Lally's (2021) point that it is sufficient for the expected value of the regulated business at the end of the cycle to equal the contemporaneous RAB, and Frontier then goes on to critique the new assumption. So, I focus upon Frontier's (2021, para 74) critique of the new assumption.

Firstly, Frontier argues that the RAB at the end of a cycle (RAB_1) is not known at the beginning of the cycle, due to capex yet to be determined. This is true but would not seem to be a significant issue. A similar issue would arise if future depreciation allowances were uncertain, and I focus upon this because the analysis in section 2.1 incorporates depreciation but not capex. If depreciation during the first regulatory cycle (DEP_1) were uncertain, then DEP_1 in equation (2) would be replaced by its expectation at the beginning of the cycle, denoted $E(DEP_1)$, and the expectation of V_1 in equation (3) would be $A - E(DEP_1)$, and substitution of this into equation (2) would still yield equation (4) as before, i.e., the NPV = 0 test would still be satisfied. So, the assumption that RAB_1 is known now is not necessary for the result, and is therefore innocuous. Furthermore, any systematic risk arising from uncertainty about DEP_1 would be reflected in the empirically determined beta estimate, and this would compensate for the risk. The presence of this risk would not then be grounds for varying the term of the cost of equity, with the term instead reflecting the *timing* of the payoffs that are discounted.

Secondly, Frontier (2021, para 74) argues that investors expect regulated businesses to outperform regulatory benchmarks because there are incentives for them to do so, and therefore the expected value of the business at any point in time exceeds the contemporaneous RAB. However, as argued in section 2.1, the values appearing in equations (1) to (4) purposely do not account for this, otherwise regulators would be anticipating (and thereby neutralizing) the opportunity for firms to be rewarded for this outperformance. Expressed equivalently, regulators set prices to satisfy the NPV = 0 test using benchmark expectations that purposely ignore the possibility that firms will outperform these benchmarks, so as to allow firms to be rewarded for such outperformance (at least for one regulatory cycle).

To illustrate this, suppose a regulated firm's RAB is currently $100m, with a remaining life of one year, the one-year cost of equity is 7%, there are no taxes, and the annual opex of an efficient firm is judged to be $20m. The allowed revenues (comprising depreciation, cost of capital and opex) would then be $100m + $100m*0.07 + $20m = $127m. The business may be expected to outperform this benchmark in the sense of incurring lower opex (of $15m), but the regulator does not reduce the revenues by $5m because this would annul the reward for the firm outperforming the benchmark. So, the NPV analysis performed by the regulator uses expected opex of $20m and therefore the value now of the business is assessed by the regulator as $100m, matching the current RAB:

$$V_0 = \frac{E(REV) - E(opex)}{1.07} = \frac{\$127m - \$20m}{1.07} = \$100m$$

Thirdly, Frontier (2021, para 74) argues that the analogy between a floating-rate bond and a regulated business (as in section 2.3 above) is not valid when the end of cycle value of a regulated business may differ from the contemporaneous RAB. However, an analogy is not a proof and its value lies in merely offering intuition for the proof. Thus, identifying features of an analogy that are not perfectly analogous might undercut the value of the analogy but it does not undercut the proof (which appears in section 2.1).

Fourthly, Frontier (2021, para 74) argues that, even if a regulated business is like a perpetual floating rate bond with a five yearly reset, the reset rate on the bond would be in excess of the prevailing "five year spot rate" and the same would be true of a regulated business. However, Frontier provides no further details in support of its claim about the reset rate. If the resetting process references the prevailing rate on another bond with lower default risk (the reference bond), a margin over this rate must be provided so as to compensate for the higher default risk on the first bond. Similarly, the cost of equity allowed by the regulator is the prevailing CGS rate for five years plus a margin for risk. These are both margins for risk, and do not imply that the term of the reset rate is longer than five years.

Fifthly, Frontier (2021, para 74) argues that investors do not value regulated firms in the same way as that assumed in equations (1) to (4), i.e., investors do not value the expected cash flows over the rest of the current cycle plus the RAB at the end of the cycle. Instead, Frontier claims that they value cash flows out to infinity, as with an unregulated business. The principal evidence offered for this is Incenta (2013). However, the Incenta (2013) evidence cited by Frontier involves valuation practitioners rather than investors and therefore Frontier must be assuming that the thinking of these two groups is identical. If so, then all of the problems identified above with the behavior of the valuation professionals applies equally to investors. If not, then the Incenta (2013) evidence presented concerning valuation practitioners has no relevance to investors.

Sixthly, Frontier (2021, para 74) notes Lally's (2021) argument that uncertainty over the end of cycle RAB is addressed through the risk premium in the cost of equity rather than the term of the risk-free rate, and questions how that risk would be quantified if the regulatory cycle length were four rather than five years. Any systematic risk arising from uncertainty over the end of cycle RAB will contribute to beta, which is empirically estimated in the usual way. The resulting premium, which allows for all sources of systematic risk, is for a period of one year because the MRP is estimated for that period and then scaled by beta, which is estimated using monthly or weekly data and assumed to apply equally to an annual period. Thus, if the regulatory cycle were reduced from five to four years, the annual risk premium would be unaffected and simply applied to four years rather than five. Frontier's implicit point would seem to be that, if a risk cannot be addressed through the beta, it must be addressed through substituting the ten-year for the five-year risk-free rate. However, as argued in section 2.1 above, risk cannot be compensated for in this way (because risk is firm or project specific and risk-free rates are not) and even if it could would duplicate the allowance for it through the empirically estimated beta.

Frontier (2021, section 2.8) attempts to rebut a number of arguments advanced by the AER (2021a, pp. 38-43) in support of matching the term for the cost of equity to the length of the regulatory cycle. Firstly, Frontier notes the AER's claim that term matching satisfies the NPV = 0 principle, and then repeats various counter arguments that have been addressed above, such as claims relating to investor valuation practices. Secondly, Frontier attributes to the AER the claim that term matching is warranted because the term structure is upward sloping. This is not correct; the AER make no such claim. Instead the AER claim (rightly) that using a ten-year risk-free rate (which typically exceeds the five-year rate) will therefore typically lead to over compensating investors. This is not an additional argument but merely a consequence of the argument that term matching satisfies the NPV = 0 principle and therefore provides appropriate compensation to investors. Thirdly, Frontier notes the AER's references to the analogy of a floating rate bond, and then points out various features of such bonds that are not analogous with regulatory situations. Again, this repeats an argument that has been addressed above. Fourthly, Frontier notes that the AER points to support for its position from the NZCC, and then repeats its counterargument that many other foreign regulators favour use of the ten-year rate. As noted earlier, it is not the practices of other regulators that are important but the merits of the arguments offered in support of those practices, and these have been addressed above. Fifthly, Frontier notes the AER's argument that the behavior of valuation practitioners is not relevant to regulators because the nature of the exercises is different, and repeats counterarguments that have been addressed above. Finally, Frontier notes the AER's reference to judicial decisions in support of term matching, and offers the counter argument that other judicial decisions support use of the ten-year rate. As with regulators' decisions, the important point is the merits of the arguments offered in support of those decisions, and these have been addressed above.

Most of Frontier's submission is devoted to critiquing the analysis in section 2.1, which shows that matching the term of the cost of equity to the length of the regulatory cycle satisfies the NPV = 0 test. Frontier instead favours use of the ten-year risk-free rate within the cost of equity, but the case for using the ten-year risk-free rate does not arise simply by critiquing the analysis in section 2.1. It is also necessary to prove that use of the ten-year rate satisfies the NPV = 0 principle, in the mathematically formal fashion of section 2.1, and Frontier have not done this. The nearest Frontier comes to doing so is to state that "The NPV principle requires that the regulatory allowance is set to match the return that investors require – which is based on a ten-year risk-free rate" (ibid, para 99). This single sentence does not constitute a proof. Furthermore, as shown by the proof in section 2.1, the NPV = 0 principle requires that the regulatory allowed rate of return on equity match the return that investors require over the next five years rather than ten years. Thus, evidence about ten-year required returns is not relevant to a regulator dealing with a five-year regulatory cycle.

3.2 AGIG Submissions

AGIG (2022, section 4.2) favours use of the ten-year rather than the five-year risk-free rate within the cost of equity, and its arguments are as follows. Firstly, it argues that the fundamental proposition (that regulatory use of the five-year cost of equity will satisfy the NPV = 0 test) assumes that future RAB values are certain, and this is not the case due to the possibility that the ERA does not allow full recovery of the RAB. This matches a claim by Frontier (2021) discussed in the previous section, and is addressed there: the presence of risks relating to the RAB must and is addressed through the estimate of beta (which is firm or project specific) rather than through substituting the ten-year for the five-year risk-free rate (which is not firm or project specific).

Secondly, AGIG argues that the fundamental proposition (that regulatory use of the five-year cost of equity will satisfy the NPV = 0 test) derives from Lally (presumably Lally 2004), it is not supported by mainstream financial literature, and it should be independently assessed. However, AGIG's view that the fundamental proposition derives from Lally (2004) is not correct; the proposition derives from Schmalensee (1989), who shows that satisfying the NPV = 0 test requires that the aggregate depreciation allowed matches the initial investment and the allowed rate for each regulatory cycle equals the cost of capital for the same period. To quote from Schmalensee (1989, page 296): "The Invariance Proposition rests on the assumption that the regulated firm's actual rate of return on the book value of its assets is adjusted each period to equal the current one-period interest rate". Rather than being the source of this proposition, Lally (2004) merely extended Schmalensee's analysis, which admits uncertainty only over future interest rates, to cost and demand risks, as stated in Lally (2004, page 18). AGIG (2021, footnote 9) appears to hold Schmalensee (1989) in high regard, and therefore the genesis for the fundamental proposition is in a paper that AGIG holds in high regard. Furthermore, regardless of the level of support for any proposition, it must stand or fall on its merits rather than by the counting of votes. Furthermore, the independent assessment that the AGIG seeks is being performed by the ERA, and it is independent because the ERA (unlike regulated businesses or consumer groups) has no vested interest in the outcome.

Thirdly, AGIG argues that the fundamental proposition (that regulatory use of the five-year cost of equity will satisfy the NPV = 0 test) requires that the term structure of risk-free rates is not flat and this is inconsistent with the single-period version of CAPM adopted by the ERA (the Officer, 1994, model). In support of its claim concerning the term structure, AGIG quotes from Lally (2004, page 20): "The implications of using a risk-free rate whose term is other than that of the regulatory cycle depends upon the slope of the term structure. In particular, if the term structure is upward sloping, then the use of a risk-free rate for a term longer (shorter) than the review cycle produces a present value on the future cash flows that is greater (less) than the initial investment. If the term structure is downward sloping, then the conclusions are revered." AGIG appears to be interpreting the quote as *requiring* that the term structure be upward sloping or downward sloping, i.e., it cannot be flat. This interpretation is incorrect; the case of a flat term structure was not mentioned by Lally (2004) simply because it was less interesting rather than because it was precluded. The quoted words could have been augmented as follows: "If the term structure is flat, the choice of the risk-free rate term has no effect on the present value of the future cash flows." So, AGIG has attached significance to something that has none. Consistent with this, the seminal paper by Schmalensee (1989) does not mention this term structure issue. Furthermore, AGIG's belief that there is an inconsistency between a world in which term structures are (sometimes) not flat and the single-period CAPM is not correct. Because it is a single-period model, the single-period CAPM has nothing to say about expected rates of return for periods other than the single period to which it relates. It cannot then be inconsistent with phenomena that it has nothing to say about.

Fourthly, AGIG argues that most regulators favour use of the ten-year rather than the five-year risk-free rate. This repeats an argument raised by Frontier (2021), and discussed in the previous section. Arguments must stand or fall on their merits rather than by the counting of votes.

Aside from the counting of votes, AGIG's arguments in support of using the ten-year risk-free rate consist entirely of critiquing the analysis in section 2.1 relating to use of the five-year rate. However, one cannot prove that the use of the ten-year rate is correct merely by critiquing the proof for using the five-year rate. It is necessary to prove that use of the ten-year rate satisfies the NPV = 0 principle, and AGIG have not done this.

3.3 ATCO Submissions

ATCO (2022, section 3.1) favours use of the ten-year rather than the five-year risk-free rate within the cost of equity, and its arguments are as follows. Firstly, it argues that the NPV = 0 test applies over the life of the assets rather than the regulatory period, investors in regulated assets require a return that reflects the life of the assets rather than the regulatory cycle (because they are investing for the life of the assets), and therefore the regulator should use the ten-year rate. However, ATCO supplies no proof that the first two claims lead to its conclusion. The analysis in section 2.1 above is a mathematical proof, akin to that underlying versions of the CAPM. ATCO must do likewise, and has not done so. Furthermore, ATCO's first claim (that the NPV = 0 test applies over the entire life of the assets) implies that this is not the case in section 2.1, and this is not correct. Equations (1) and (2) collectively value cash flows over the entire life of the asset. Furthermore ATCO's second claim (that investors require a return that reflects the life of the assets) is inconsistent with the price resetting process at the beginning of each regulatory cycle, in which the regulator allows a return on equity for the next cycle (of five years) rather than the life of the assets, and then resets that allowed return five years later. The analysis in section 2.1 shows that the term of this allowed return must match the length of the regulatory cycle, in order to satisfy the NPV = 0 test.

Secondly, ATCO asserts that the fundamental proposition (that regulatory use of the five-year cost of equity will satisfy the NPV = 0 test) assumes that value of the regulated business at the end of the current cycle is certain, and this is not the case, thereby undercutting the proof of that proposition. However, as shown in section 2.1, this assumption is not necessary. Furthermore, any risk here is automatically allowed for through the empirically determined estimate of beta and must be addressed through beta (because the required allowance is firm or project specific) rather than through substituting the ten-year for the five-year risk-free rate (which is not firm or project specific).

Thirdly, ATCO claims that the version of the CAPM used by the ERA (the Officer, 1994, model) is a single-period model, which assumes that investors invest for some period common to all investors and then consume the proceeds, and therefore the term of the risk-free rate within the CAPM should be this common investment horizon. However, as noted by Partington (2022, page 4) who is quoted by ATCO, the investment horizon varies across investors and therefore matching the term of the risk-free rate to this "common" investment horizon is impossible. Partington (ibid) instead claims that the investors in regulated businesses tend to have long investment horizons and therefore a long-term risk-free rate should be adopted in applying the CAPM to such investments. However, once one admits that the CAPM assumption of a common investment horizon does not hold, as Partington does, aligning the term of the risk-free rate to the claimed investment horizon of its alleged principal investors cannot be justified by reference to the CAPM. Furthermore, Partington clearly implies that the investment horizons of investors in other businesses might differ from those in regulated businesses, which is incompatible with the CAPM assumption of a common investment horizon for *all* investors, not just those in regulated businesses.

Furthermore, doing so involves treating all other considerations as secondary. In regulatory decisions, the primary consideration should be that the NPV = 0 test be satisfied, or else regulated businesses are over or under compensated. As shown in section 2.1, this requires matching the term of the regulatory allowance for the cost of equity to the term of the discount rate, and the term of the discount rate must match the term of the payoffs being discounted (five years) by definition of a discount rate. One must then choose a model to estimate the discount rate. Since the common investment horizon assumed in the CAPM does not exist, one can either find another model (but no better alternative is available) or pragmatically adapt it to the particular problem in question, which is the estimation of a five-year discount rate. Pragmatism suggests treating the model as applying to a five year term, and therefore the relevant risk-free rate is then for five years. Using a ten-year term in order to align with the alleged investment horizon of the alleged principal investors in a regulated businesses would at best achieve approximate conformity with an assumption of the CAPM, but the result would be to violate the NPV = 0 test. The latter is the more important requirement.

Fourthly, ATCO argues that the fundamental proposition (that regulatory use of the five-year cost of equity will satisfy the NPV = 0 test) requires that the term structure of risk-free rates is not flat and this is inconsistent with the single-period version of CAPM adopted by the ERA. This repeats an argument raised by AGIG (2022, section 4.2), and is addressed in the previous section.

Fifthly, ATCO claims that it is standard practice in the academic literature and amongst market practitioners to value equities using long-term risk-free rates. Even if this were true, the discussion in section 3.1 around equations (13) to (15) shows that this does not imply that a regulator should do likewise.

Sixthly, ATCO claims that standard practice amongst regulators is to use a ten-year or longer risk-free rate. However, an argument must stand or fall on its merits rather than by counting votes.

3.4 ENA Submissions

In its submissions to the ERA, the ENA (2022, page 3) references earlier submissions to the AER (ENA, 2021) and I therefore focus on them but only to the extent they are relevant to the ERA.[14] The ENA (2021, section 4) favours use of the ten-year rather than the five-year risk-free rate within the cost of equity, and its arguments are as follows. Firstly, the ENA (2021, section 4.4) argues that it is standard practice amongst market practitioners to value equities using long-term risk-free rates. These arguments, and even the exact wording of them, match those in Frontier (2022, section 2.5) and these have been addressed in section 3.1 above.

Secondly, the ENA (2021, section 4.5) argues that standard practice amongst regulators is to use a ten-year or longer risk-free rate. However, an argument must stand or fall on its merits rather than by counting votes.

Thirdly, the ENA (2021, section 4.6) argues that trading volumes in the five year commonwealth government securities (CGS) market are much lower than the three and ten-year CGS markets, which undercuts the value of the five-year CGS as a suitable proxy for the risk-free rate. However, lower trading volumes are only significant here to the extent that they result in markedly more volatility over time in the yields on five-year bonds than ten-year bonds. As shown in ENA (2021, Figure 2), this is not the case; the yields on five-year bonds exhibit very similar fluctuations over time.

Fourthly, the ENA (2021, section 4.6) argues that bid-ask spreads are higher for five-year CGS than ten-year CGS, leading to more variability in the yields on five-year bonds. As shown in the ENA (2021, Figure 4), with the exception of the period around March 2020, the spread is about one basis point for five-year bonds and about half of this for ten-year bonds. So, the ENA's claim concerning the difference in spreads is correct in relative terms but the

[14] For example the ENA (2021, section 4.1) argues that it would not be an appropriate time for the AER to switch from using the ten-year to the five-year risk-free rate. This argument has no relevance to the ERA as it is not proposing to change its practice but to maintain it.

difference in the absolute level of these spreads is so low that one would not expect any discernable difference in the volatility of the yields and this is consistent with the evidence in ENA (2021, Figure 2).

Fifthly, the ENA (2021, section 4.7) claims that the fundamental proposition (that regulatory use of the five-year cost of equity will satisfy the NPV = 0 test) derives from Lally (2004), and Lally's (2004) claim that it derives from Schmalensee (1989) is not correct. However, as shown in section 3.2, the proposition does derive from Schmalensee (1989).

Sixthly, and in respect of the assumption in section 2.1 above that the expected value of the regulated business at the end of a regulatory cycle will match the contemporaneous RAB, the ENA (2021, section 4.7) raises a number of contrary arguments. These arguments, and even much of the wording of them, match those in Frontier (2022, section 2.7) and these have been addressed in section 3.1 above.

Seventhly, the ENA (2021, section 4.8) attempts to rebut a number of arguments advanced by the AER (2021a, pp. 38-43) in support of matching the cost of equity to the term of the regulatory cycle. These arguments, and even much of the wording of them, match those in Frontier (2022, section 2.8) and these have been addressed in section 3.1 above.

Aside from the counting of votes, the ENA's arguments in support of using the ten-year rather than the five-year risk-free rate consist entirely of critiquing the use of the five-year rate. However, one cannot prove that the use of the ten-year rate is correct merely by critiquing the use of the five-year rate. It is also necessary to prove that use of the ten-year rate satisfies the NPV = 0 principle, as has been done in section 2.1 above for the five-year rate, and the ENA have not done this.

3.5 GGT Submissions

GGT (2022, pp. 4-10) favours use of the ten-year or longer risk-free rate rather than the five-year risk-free rate within the cost of equity, and its argument is as follows. The version of the CAPM used by the ERA (Officer, 1994) is a single-period model, which assumes that investors invest for some period common to all investors, and therefore the term of the risk-free rate within the CAPM should be this common period. Investors desire wealth to finance consumption over their lives, and therefore the appropriate choice for this common period is long-term, and therefore the appropriate choice of the risk-free asset in the single-period CAPM is a long-term government bond (at least ten years). However, as noted by Partington (2022, page 4) and quoted by ATCO (2022, section 3.1), the assumed common period in question here (the investment horizon of investors) varies across investors and therefore matching the term of the risk-free rate to this "common" investment horizon is impossible. Even if it were true that most investors had a horizon of at least ten years, the consequence of choosing to apply the CAPM with a ten-year risk-free rate to a particular valuation problem would be to elevate this issue above all considerations relating to the specific valuation problem being examined.

In respect of the regulatory problem to which the CAPM is applied, the primary consideration is that the NPV = 0 test be satisfied, or else regulated businesses are over or under compensated. As shown in section 2.1 above, this requires matching the term of the regulatory allowance for the cost of equity to the term of the discount rate, and the term of the discount rate must match the term of the payoffs being discounted (five years) by definition of a discount rate. One must then choose a model to estimate the discount rate. Since the common investment horizon assumed in the CAPM does not exist, one has a choice of not using this model (for which no better alternative is available) or pragmatically adapting it to the particular valuation problem in question, which is the estimation of a five-year discount rate. Pragmatism suggests treating the model as applying to a five year term, and therefore the relevant risk-free rate is then for five years. Using a ten-year or higher term in order to align with the alleged investment horizon of typical investors as GGT does might achieve approximate conformity with an assumption of the CAPM, but the result would be to violate the NPV = 0 test. The latter is the more important requirement.

The issue here is not peculiar to a regulatory problem. Suppose one were trying to value an asset whose risky payoff arises solely in one year. The right discount rate would be the one-year risk-free rate plus some risk premium. Using the CAPM with a 10 or 20 year risk-free rate, especially if it differed significantly from the one-year rate, plus a risk premium would give rise to a valuation error. For example, suppose the one-year risk-free rate is 2% and the 10 year rate is 6% because inflation is expected to significantly rise after the first year. The result of valuing this asset's sole payoff in one year using the CAPM with a ten-year risk-free rate plus a risk premium would be to undervalue it by reflecting in the discount rate an inflation issue that is irrelevant to this project. Thus, if one is going to use the CAPM (whose assumed common investment horizon does not exist) for a particular valuation problem, one should adopt a risk-free rate that is consistent with the particular valuation problem. In short, the tool should be adapted to the problem rather than the problem adapted to the tool.

4. Conclusions

The ERA currently uses an allowed cost of equity whose term matches the regulatory cycle of five years. Contrary submissions have been received from a number of parties. This paper has reviewed these submissions and the principal conclusions are as follows.

Firstly, I concur with the ERA's choice of term, because it ensures that the NPV = 0 principle is satisfied (the present value of future cash flows of the regulated business equals its current regulatory asset base) and this is the primary consideration in choosing the term for the cost of equity.

Secondly, none of the contrary submissions (all of which argue for a cost of equity for a ten-year term or higher) have undercut the formal proof that the five-year cost of equity satisfies the NPV = 0 principle.

Thirdly, none of the contrary submissions has presented a proof that the NPV = 0 principle is satisfied with a ten-year or higher term for the cost of equity.

Fourthly, none of the contrary submissions has advanced any criteria that dominates this NPV = 0 principle, and also supports a ten-year or longer cost of equity.

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