THE APPROPRIATE TERM FOR THE ALLOWED COST OF CAPITAL

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EXECUTIVE SUMMARY

The AER currently uses an allowed cost of capital in which the cost of equity is forward-looking for the next ten years whilst the cost of debt is an annually-adjusted equally-weighted ten-year trailing average of historic costs. This paper has sought to assess the appropriate term for each of these costs of capital, and some ancillary issues. The principal conclusions are as follows.

Firstly, in respect of the appropriate term for the cost of equity, the NPV = 0 principle implies that this term must match the regulatory cycle (of five years). Thus, the risk-free rate must match the regulatory cycle. Exact satisfaction of the NPV = 0 principle requires use of the yield on a five-year government bond whose duration matches that of the regulatory payoffs, but a very close approximation is achieved with the available bonds. In accordance with the NPV = 0 principle, the appropriate term for expected inflation should also be the regulatory cycle of five years. So, the terms match but they are separable consequences of the NPV = 0 principle.

Secondly, firms that are regulated are similar to unregulated firms in the sense of delivering payoffs over an indefinite future period, and the latter are typically valued using the ten-year government bond rate, suggesting that the same rate should apply to regulated businesses. However the valuation problem for a regulator is like that for an unregulated business terminating in five years' time, or a floating rate bond whose coupon rate is reset every five years. In each of the latter cases, the correct discount rate to use for the payoffs over the next five years is the current five-year rate, just as it is for the regulatory situation.

Thirdly, in respect of the cost of debt, satisfying the NPV = 0 principle requires that the allowed cost of debt match that incurred by the benchmark efficient firm. In principle, this can be achieved by using an *N*-year trailing average for the entire cost of debt (TA approach), or an *N*-year trailing average for the DRP component coupled with the risk-free rate at the commencement of each regulatory cycle for the (five-year) term matching the regulatory cycle (Hybrid Approach), with *N* being the borrowing term for the benchmark efficient firm, and the trailing average weights reflecting the circumstances of the regulated firm. Implementing either approach with unequal weights across past years would be cumbersome, and use of the (usual) equally-weighted trailing average will therefore in general induce departures from the NPV = 0 test. In view of these departures, the on-the-day (OTD) approach should also be considered (in which the allowed cost of debt for a regulatory cycle is that prevailing at the beginning of the regulatory cycle, with the base rate being for a term matching the regulatory cycle and the DRP term being N years). For existing firms with moderate capex, the OTD approach yields greater departures from the NPV = 0 test than the TA and Hybrid approaches, and this favours the latter two approaches. However, other considerations are relevant. These comprise the natural hedge that exists between estimation errors for the MRP and the contemporaneous value for the DRP, which favours the OTD approach; the difficulties in estimating the term for which the benchmark efficient entity borrows (N), which favours the OTD and hybrid approaches; the desirability of low average prices for consumers, which favours the OTD and hybrid approaches over the TA approach; and the desirability of low volatility over time in prices for consumers, which favours the TA approach over the hybrid and the OTD approach. So, despite ranking lowest in respect of the NPV = 0 test and in respect of price volatility, the OTD approach ranks best in other respects. I offer no view on the relative importance of these criteria, and therefore offer no view on the best approach (for existing regulated businesses with moderate capex).

Fourthly, if the TA approach were adopted, the appropriate term for the allowed cost of debt would be historical and equal to the term for which the benchmark efficient entity borrows. If the hybrid approach were adopted, the appropriate term for the allowed DRP would be historical and equal to the term for which the benchmark efficient entity borrows, whilst the appropriate term for the allowed risk-free rate within the cost of debt would be the future term of the regulatory cycle (five years). Finally, if the OTD approach were adopted, the appropriate term for the allowed DRP would be the future term for which the benchmark efficient entity borrows, whilst the appropriate term for the allowed risk-free rate within the cost of debt would be the future term of the regulatory cycle (five years). Regardless of which approach is adopted, the NPV = 0 principle implies that the appropriate term for expected inflation is the regulatory cycle, and quite separately also implies that the appropriate term for the cost of equity is also the regulatory cycle.

Fifthly, in the event that the AER elects to switch from the TA approach to the OTD approach, a transitional process will be required. Since the current transitional process used by the AER arises from its 2013 decision to switch from the OTD to the TA approach, the natural choice of a transitional process arising from reversing that decision would be to reverse its current transitional process over the same period of time that it has operated. Alternatively, if the AER elects to instead switch from the TA to the hybrid approach, this would involve a change only in the risk-free rate component of the cost of debt. The natural choice for transitioning this component would be the same transitioning method applied to the entire cost of debt, as described in the previous sentence.

Sixthly, if the firm being regulated has just entered the regulated sector, it can therefore be presumed to have undertaken all of its borrowing at this time and to have staggered the maturity dates to mitigate its refinancing risk. Unlike an existing regulated business, the new entrant will therefore initially pay the OTD rate and transition to a TA or Hybrid payment pattern over *N* years. So, unless the regulator at least commences with the OTD approach, the resulting departures from the NPV = 0 test will be unacceptably large whenever the current DRP or cost of debt is significantly different from its trailing average. After *N* years, the new entrant is in the same position as an existing regulated business with moderate capex, and therefore the optimal choice of regulatory policy at this point is the same as for an existing regulated business with moderate capex. This implies the following regulatory policy for new entrants. First, choose the optimal policy for existing regulated businesses with moderate capex (STEP 1). If the STEP 1 policy choice is OTD, apply it immediately to new entrants and maintain this. If the STEP 1 policy choice is the hybrid approach, which involves a trailing average DRP, assess whether this trailing average is substantially different to the prevailing rate at the time the new entrant appears; if not, apply the hybrid approach immediately to the new entrant and maintain this, and otherwise apply the OTD now and transition to the hybrid approach over *N* years. Finally, if the STEP 1 policy choice is the TA approach, which involves a trailing average for the entire cost of debt, assess whether this trailing average is substantially different to the prevailing rate at the time of new entry; if not, apply the TA approach immediately to the new entrant and maintain this, and otherwise apply the OTD now and transition to the TA approach over *N* years.

Seventhly, for existing regulated businesses that are about to undertake substantial capex (relative to RAB), such businesses constitute a portfolio comprising an existing regulated business without the temporarily high capex plus a new entrant whose investment is the temporarily high capex. In respect of the temporarily high capex, this situation is in principle the same as that of a new entrant. So, the policy applied to a new entrant, as just described, is also applied to the borrowing induced by this new capex. The policy applied to the rest of the firm's debt is the optimal choice for an existing regulated business with moderate capex.

Eighthly, in respect of submissions received in response to the AER reducing the term for its estimate of expected inflation from ten years to five years, these submissions do not suggest any error in the AER's new approach.

Ninthly, in respect of the AER's newly developed index of the DRP costs of regulated energy network businesses (the EICSI), the AER's proposal to use this data to modify its current DRP estimate using ten-year data from other sources involves ascribing the entire difference between the EICSI estimate and the allowance under the current process to the credit rating, and this is not appropriate because differences could also be due to differences in the debt term and other factors. A better approach would be for the AER to decompose this total difference into the part due to credit rating, the part due to debt term, and the residue (which is due to factors other than debt term and credit rating).

1. Introduction

The AER currently uses an allowed cost of capital in which the cost of equity is forward-looking for the next ten years whilst the cost of debt is an annually-adjusted ten-year trailing average of historic costs. This paper seeks to assess the appropriate term for each of these costs of capital. Section 2 examines the appropriate term for the cost of equity. Section 3 examines the appropriate term for the cost of debt. The remaining sections examine some ancillary issues.

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 ODRC 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 undepreciated 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 undepreciated 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 V_1, discounted at the one-year cost of equity prevailing at time 0 (ke_{01}):

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

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

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

and equation (2) becomes

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

So the NPV = 0 test is satisfied. By contrast, for example, 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 accordance with the CAPM, the one-year cost of equity is the risk-free rate plus the product of the market risk premium and the beta, all defined over the one-year period in question.

In response to this kind of reasoning in Lally (2012), the AER (2018, page 130) asserts that this reasoning assumes recovery of the asset book value in cash at the end of the first regulatory period. No such assumption appears in equation (4); to the contrary, the equation explicitly recognizes that the payoff at the end of the first regulatory period is the market value then of the business and that this would equal the contemporaneous regulatory book value of its assets of ($A - DEP_1$). The AER (ibid) also appears to suggest that the above proof assumes that the value of the regulated assets at the end of the current regulatory period is known now for certainty, and asserts that this is not true because regulated businesses may over or under perform their allowed rate of return. However the above analysis is performed in terms of *expected* revenues, which is entirely consistent with the possibility of actual revenues being higher or lower than this (as would occur under a price cap coupled with output being higher or lower than expected). For example, suppose the expected revenues in equation (1) are set at \$100m to cover depreciation and the cost of capital, and output is expected to be 100m units, leading to the regulator setting the price cap at \$1 per unit. If output is 100m units, the firm will receive revenues of \$100m, matching the expectation. However, if output is 110m units, the firm will receive revenues of \$110m. So, equation (1) is entirely consistent with the possibility of the business under or over performing its expected revenues, and therefore under or over performing its allowed rate of return.

The AER (2018, page 130) also suggests that the above proof assumes that the value of the regulated assets at the end of the current regulatory period is known now for certain, and asserts that this is not true because of volatility in the stock market. However nothing in the above proof precludes the fact that the values of *other* assets are volatile. Nevertheless, it is possible that the value of the regulatory assets at the end of the first regulatory cycle (V_1) may not be equal to the contemporaneous regulatory book value of the assets, because the regulator may err at time 1 in setting the revenues for the second regulatory cycle, and this possibility has not been recognized in equation (3) in the above analysis. 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., any such errors at time 1 are as likely to be too high as too low. So, the expected value of V_1 will be equal to the contemporaneous regulatory book value of assets, but the actual value for V_1 may diverge from this asset book value. Furthermore, such regulatory errors may 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). However, nothing here warrants *additionally* using a longer term risk-free rate than the rate whose term matches the regulatory cycle (of one year). If the term structure of risk-free rates at time 0 were upward sloping, using the longer term (higher) rate would be not only allowing for this uncertainty about the value of the business at time 1 (V_1) via the risk premium but also seeking to allow for it through a higher risk-free rate. This would be double counting. Alternatively, if the term structure of risk-free rates at time 0 were downward sloping, using the longer term (lower) rate would undercut the risk premium that had been allowed. So, the risk in question here is allowed for automatically through the beta estimate and cannot be addressed through consistently using a longer term risk-free rate than that matching the regulatory cycle.

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 $100, which is depreciated at $50 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 $50 + $100*.02 = $52 for the first cycle and $50 + $50*.04 = $52 for the second cycle. Since these are certain, the first year's revenues are valued now using the current one-year risk-free rate of 2% and the second year's revenues are valued back to the beginning of that year using the one-year risk-free rate for the second year of 4% (to yield $50) followed by being valued back to now using the current one-year risk-free rate of 2%, yielding a total value now of $100:[1]

$$V_0 = \frac{\$52}{1.02} + \frac{\left[\frac{\$52}{1.04}\right]}{1.02} = \frac{\$52}{1.02} + \frac{\$50}{1.02} = \$100$$

This matches the current RAB of $100, and therefore satisfies the NPV = 0 principle. However, if the allowed risk-free rate for the first year is 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 $53 rather than $52. 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 $52 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 using 4% for the second year and then 2% for the first year. The result is a total value now of $101:

[1] 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 $100.

$$V_0 = \frac{\$53}{1.02} + \frac{\left[\frac{\$52}{1.04}\right]}{1.02} = \frac{\$53}{1.02} + \frac{\$50}{1.02} = \$101$$

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 $50(1 + R_{12}), and their value at the beginning of that year will be $50(1 + R_{12})/(1 + R_{12}) = $50. So, the value of the business in one year will still be $50 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 $50 + $100*.02 = $52 as before and therefore the value now of the business will still be $100 as follows:

$$V_0 = \frac{\$52}{1.02} + \frac{\$50}{1.02} = \$100$$

Again, this matches the current RAB of $100, and therefore satisfies the NPV = 0 principle. However, if the allowed risk-free rate 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 $53.30 rather than $52. The correct discount rate is still 2%, so the value now of the business will then be thus:

$$V_0 = \frac{\$53.30}{1.02} + \frac{\$50}{1.02} = \$101.30$$

Again, this does not satisfy the NPV = 0 principle. I now introduce additional risk, in the form of uncertainty about the revenues to be received in both years and possibly also 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). It should not and cannot be additionally addressed by using a different term for the allowed risk-free rate. 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 \$50(1 + R_{12} +.015), and their value at the beginning of that year will be expected to be \$50(1 + R_{12} + .015)/(1 + R_{12} + .015) = \$50, 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 \$50 + \$100*(.02 + .015) = \$53.50. So, the value now of the business will still be \$100 as follows:

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

Again, this matches the current RAB of \$100, and therefore satisfies the NPV = 0 principle. However, if the allowed risk-free rate 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 \$50 + \$100*(.033 + .015) = \$54.80. The value now of the business will then be \$101.3 as follows:

$$V_0 = \frac{\$54.8}{1.035} + \frac{\$50}{1.035} = \$101.30$$

Again this does not satisfy the NPV = 0 principle. So, risk is and must be dealt with through a premium in the discount rates and hence the allowed rates of return rather than 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 current 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 more or 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.[2] 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.[3] In addition, suppose the coupon interest rate

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

[3] These numbers approximate the current situation (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%.[4] 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.[5] Using this risk-free rate to set the allowed rate of return for the firm, the resulting revenues for the next year would be:

$$REV_1 = OPEX_1 + DEP_1 + B_0 R_f = \$10m + \$2m + \$100m(.00483) = \$12.483m$$

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%:

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[4] 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.

[5] 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)[6], 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.

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

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

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%).

The AER's current practice is to set the allowed rate of return 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) = \$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

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[6] 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.

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 current (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%.[7] 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%.[8] 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 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% - 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

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

[8] 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.[9]

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%

The AER have requested that the following criteria be used to evaluate the appropriate term for the cost of equity: Reliability (reflects economic principles and empirical evidence), relevance to the Australian benchmark, suitability for use in the regulated environment, simplicity, and materiality. The choices considered here have been the regulatory cycle (five years) or the AER's current choice (ten years). The two options only differ on the first and last of these criteria. The first (reliability) translates into conformity with the NPV = 0 principle, which requires use of a five-year term. The last (materiality) reinforces this conclusion, because the difference in the risk-free rates for five and ten years is currently very material (0.48% versus 1.32%), and it is generally material.

2.3 Comparison with Unregulated Firms and Other Assets

In conducting valuations of unregulated businesses, the set of future cash flows extends out to infinity. Typical practice in Australia is to use one cost of capital, rather than a cost of capital for each of these future cash flows. Denoting this singular cost of capital as k and the cash flows to be discounted as C_1 in the first year, C_2 in the second year etc, the value now (V_0) of the business is the expected cash flows discounted using k as follows:

[9] 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.

$$V_0 = \frac{E(C_1)}{1+k} + \frac{E(C_2)}{(1+k)^2} + \cdots \quad (5)$$

The valuer's task is to choose the single discount rate k, from which the value V_0 then follows. The usual choice for that single discount rate typically embodies the ten-year risk-free rate because the cash flows extend to infinity and the ten-year risk-free rate is the longest available term in Australia.

Since regulated businesses also deliver cash flows out to infinity, it might be thought that the appropriate term for their cost of capital would also be ten years, and therefore the regulator should also use it in setting the allowed revenues. The AER (2018, page 127) appears to invoke this argument. However, regulators do *not* conduct an exercise like equation (5), in which the cash flows that are to be valued at the present time extend to infinity. Instead, regulators are only concerned with the cash flows over the next regulatory cycle (five years), and the regulatory asset book value in five years (A_5), which is known now. In addition, and unlike equation (5), the regulator sets the expected revenues for each of the next five years, and hence the expected cash flows for the next five years, so that the value now of these future payoffs is equal to the current regulatory asset book value (A_0). Letting k denote the discount rate chosen by them, their valuation problem now is then to choose k, from which the expected cash flows follow in order to satisfy the following equation:

$$V_0 = A_0 = \frac{E(C_1)}{1+k} + \frac{E(C_2)}{(1+k)^2} + \cdots + \frac{E(C_5) + A_5}{(1+k)^5} \quad (6)$$

Because this valuation involves future benefits that extends only five years into the future, and the payoff in five years is the principal one, the appropriate discount rate here (k) is the five-year rate. As shown in the previous section, it follows that the allowed cost of capital within the expected revenues in the numerator is also the five-year rate. Valuation practices that are relevant to equation (5), to which the AER (2018, page 127) refers, are not relevant to equation (6), because equation (6) is entirely different to equation (5).

The only kind of unregulated business for which the valuation problem is similar to that for a regulated business is an unregulated business whose cash flows terminate at the end of the fifth year, and the cash flow in the fifth year is the principal one. The appropriate discount rate would then be the five-year cost of capital, just as it is for the regulatory situation:

$$V_0 = \frac{E(C_1)}{1+k_5} + \frac{E(C_2)}{(1+k_5)^2} + \cdots + \frac{E(C_5)}{(1+k_5)^5} \quad (7)$$

The regulatory valuation problem is also similar to that for a floating-rate government 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:

$$V_5 = \frac{R_{f5,10}}{1+k} + \frac{R_{f5,10}}{(1+k)^2} + \cdots + \frac{R_{f5,10} + \$1}{(1+k)^5} \quad (8)$$

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 (8) 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:

$$V_0 = \frac{R_{f5}}{1+d} + \frac{R_{f5}}{(1+d)^2} + \cdots + \frac{R_{f5} + \$1}{(1+d)^5} \quad (9)$$

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 (9) 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.

In summary, the valuation problem confronting a regulator with a five-year regulatory cycle, as shown in equation (6), does not resemble that for an unregulated business, as shown in equation (5). Instead, the valuation problem for a regulator is like that for an unregulated business terminating in five years' time, or a floating rate bond whose coupon rate is reset every five years. In each of the latter cases, the correct discount rate to use for the payoffs over the next five years is the current five year rate, just as it is for the regulatory situation. Nothing in this conclusion bears directly on the appropriate term for expected inflation. In accordance with the NPV = 0 principle, the appropriate term for expected inflation should be the regulatory cycle of five years (see Lally, 2020). In accordance with the same NPV = 0 principle, the appropriate term for the cost of equity should be the regulatory cycle as proved. The conclusions match, but they are separable consequences of the NPV = 0 principle.

3. The Appropriate Term for the Allowed Cost of Debt

3.1 The Generic Case

By definition the cost of equity is forward looking. If equity finance is raised at time 0, the cost at that time is the set of expected rates of return, one for each of the time spans from time 0 to the realization of future cash flows that the firm will receive. If the business is regulated, with a cycle of five years, the relevant set of expectations are those for each of the next five years, which can be compressed into a single expectation within which the risk-free rate component is that on a bond with a five-year term to maturity and a coupon rate matching the ratio of regulatory cash flows per year to the current regulatory asset base. As time moves forward, the set of expected rates of return changes, as each is now defined from the new current time until the realization of future cash flows. So, in five years' time, the relevant expectations are from then until the end of that regulatory cycle.

The cost of debt is fundamentally different. At any given point in time, there are a set of market borrowing rates, each for a defined future period. Unlike the costs of equity, these are not expectations but promised rates. In addition, every borrowing by a firm gives rise to a set of future cash flow obligations that are locked in at the time of borrowing. Suppose proportion L of the regulatory asset base is financed by debt. So, at time 1 when this regulatory asset base is $(A – DEP_1)$, the amount of debt must be $(A – DEP_1)L$, which will be (notionally) repaid at time 2.[10] This will give rise to payment at time 2 of interest at some rate known at time 1 of k_1^p, and repayment at time 2 of the outstanding debt. In addition, the allowed cost of capital set by the regulator at time 1 for this subsequent year will now be rate k_{e12} on the time 1 equity book value of $(A – DEP_1)(1 – L)$ as per section 2, and some allowed rate k_1^a on the time 1 debt of $(A – DEP_1)L$. So, following equation (1), the equity value at time 1 of this business will be the expectation at time 1 of the net cash flows at time 2, being the allowed cost of capital on both equity and debt plus depreciation less the payments of interest and principal to the debtholders at time 2, all discounted at the one-year cost of equity prevailing at time 1 (ke_{12}): [11]

$$V_1 = \frac{(A-D)(1-L)k_{e12} + (A-D)Lk_1^a + (A-D) - (A-D)Lk_1^p - (A-D)L}{1 + k_{e12}} \quad (10)$$

A similar equation holds at time 0: the equity value at time 0 of this business will be the expectation at time 0 of the net cash flows at time 1, being the allowed cost of equity at rate k_{e01} on the time 0 equity book value of $A(1 – L)$ plus the allowed cost of debt at some rate k_0^a known at time 0 on the time 0 debt of AL plus year 1 depreciation of DEP_1 less the payment of interest at some rate known at time 0 of k_0^p less the repayment of principal to the debtholders of DEP_1L, plus the expectation at time 0 of V_1, all discounted at the one-year cost of equity prevailing at time 0 (ke_{12}):

[10] Since the assets would be replaced at time 2 no actual repayment of debt would occur.

[11] To save space, I abbreviate the year 1 depreciation from DEP_1 to simply D within equation (10).

$$V_0 = \frac{A(1-L)k_{e01} + ALk_0^a + DEP_1 - ALk_0^p - DEP_1L + E(V_1)}{1 + k_{e01}} \qquad (11)$$

The NPV = 0 principle requires that $V_0 = A(1 - L)$, i.e., the value of the future cash flows to equity holders equals their initial investment.[12] This can only occur if the interest rate on debt incurred by the (benchmark efficient) firm matches that allowed by the regulator in the numerator of equation (10), and the interest rate on debt incurred by the (benchmark efficient) firm matches that allowed by the regulator in the numerator of equation (12).

I now consider how this matching of the allowed and incurred interest rates on debt (for the benchmark efficient firm) could be achieved. For the purposes of this analysis, it is convenient to think of the regulated assets as having been purchased at some point prior to time 0, so that the amount *A* represents the undepreciated book value at time 0 rather than the purchase price. One possibility might be for the regulator to set the cost of debt allowance in accordance with the market rate at the commencement of each regulatory cycle for a term equal to that of the regulatory cycle (the on-the-day or OTD approach), and for the firm to then match its borrowing policy to that. So, with a regulatory cycle of one year, the firm would have to borrow for a one year term at the beginning of each regulatory cycle, and roll it over at maturity for the same term (except the part that is repaid at that time). In this case $k_0^p = k_0^a$ and $k_1^p = k_1^a$, whereupon $V_1 = (A - D)(1 - L)$ in equation (5), and therefore $V_0 = A(1 - L)$ in equation (11), so the NPV = 0 requirement would be met. In the more typical case of a five-year regulatory cycle, the firm would have to borrow for a five-year term at the beginning of each regulatory cycle, and roll it over at maturity for the same term. However, as noted by the AER (2009, pp. 151-154), this is not a viable debt policy for a (private-sector) firm because rollover of all of its debt at the same point in time would significantly expose it to opportunistic pricing by lenders and aberrations in the debt market at this time (debt markets freezing up or rates being freakishly high); all of this is called “refinancing risk”.[13] By contrast, if a firm spreads its maturity dates (say) equally over ten years, it could address

[12] Debt holders always achieve a value on their investment equal to the amount invested at the time of investing, by appropriate choice of the interest rate charged.

[13] A viable debt policy means feasible and not so inefficient that firms would avoid it. The same issue does not afflict businesses in the public sector because they are owned by governments with debts well in excess of those of one of their businesses, and it is only their aggregate debts that are subject to refinancing risk. Consistent with this, these businesses seem to be unconcerned with significantly staggering their debt maturity dates (see Lally, 2015a, page 61).

the scenario just described by repaying the debt in question rather than rolling it over, through some mixture of asset sales and use of its cash holdings, and this would be feasible because the amount of debt requiring repayment would be only 10% of the firm's debt rather than 100%. However this spread in maturity dates would imply that its cost of debt was some average of current and historical rates, which would not match the regulator's OTD allowance, and therefore the NPV = 0 test would not be satisfied.

A second possibility would involve the regulator adopting the same OTD approach as described in the previous paragraph and the firm borrowing for *N* years, staggering the maturity dates to mitigate refinancing risk, entering interest rate swap contracts to match the base rate component of its cost of debt to the OTD regulatory allowance, and entering credit default swap contracts to match the DRP component of its cost of debt to the OTD regulatory allowance.[14] The evidence is that private-sector firms did act in these ways when the AER adopted an OTD approach, except that they did not use credit default swap contracts (AER, 2009, pp. 151-154). The failure to do the latter appears to have been because these contracts were not available on the desired bonds or in sufficient quantities for many of the regulated businesses in question.[15] So, in toto, this is not a viable debt policy for a firm.

A third possibility involves the regulator adopting a variant on the OTD policy described above, in which the regulator sets the base rate component of the cost of debt allowance equal to the market rate at the beginning of the regulatory cycle for the term of the regulatory cycle and sets the DRP component of the cost of debt allowance equal to the market rate at the beginning of the regulatory cycle for the term for which the benchmark efficient firm borrows (*N* years). The firm borrows for *N* years, with staggering of the maturity dates to mitigate refinancing risk, and enters interest rate swap contracts to match the base rate component of

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[14] In respect of the interest rate swap contracts, this involves borrowing at the fixed rate, immediately swapping this into floating rate debt, and then (at the beginning of each regulatory cycle) swapping the floating rate debt into fixed rate debt that aligns with the regulatory cycle. Equivalently, one would borrow at a floating rate and then undertake the second set of swap contracts just noted. These contracts do not perfectly convert the firm's *N*-year base rate incurred into the five-year base rate allowed by the AER because the base rate used by the AER is Australian government bonds whilst the swap contracts involve the swap rate. However Lally (2015a, Appendix 2) demonstrates that this mismatch has only a slight effect. In addition, when using the OTD approach, the AER sets the allowed base rate using a one-month window whilst the firms might have to spread the swap contracts over a wider window. Again, Lally (2015a, Appendix 2) shows that the effect of this difference in the windows is trivial. Consistent with this, private-sector businesses subject to the OTD regime by the AER prior to 2014 did engage in these interest rate swap contracts (AER, pp. 152-154; Jemena, 2013, page 19; Citipower et al, 2013, page 7), and did so despite not receiving compensation from the AER.

[15] See Chairmont (2013a, page 5) and Pwc (2013, page 8). In addition, the mechanics of credit default swap contracts are elaborated on in Lally (2015b, pp. 18-20).

its cost of debt to the OTD regulatory allowance. So, in respect of the base rate component of the cost of debt, the rate allowed matches that paid but there is no matching for the DRP component, with the firm paying the trailing average DRP for *N* years whilst the allowance for a regulatory cycle is the *N*-year DRP at the beginning of the cycle. On average these two DRPs match, but not otherwise.

A fourth possible means of matching the allowed and incurred interest rates on debt would be for the regulator to set the allowance for the entire cost of debt in accordance with an annually-adjusted trailing average cost over *N* years (TA approach), and for firms to align their borrowing with this by borrowing for *N* years and staggering the maturity dates. For example, if the TA allowance were equally weighted over the last ten years, the firm would borrow so that 10% of its debt matured each year. Since it is viable for firms to act in this way, and firms generally do so (AER, 2009, pp. 151-154), this would satisfy the NPV = 0 test. Of course, firms could choose not to do this but the NPV = 0 test would be satisfied because it would be entirely feasible for them to align their borrowing with the regulatory allowance.

A fifth possible means of matching the allowed and incurred interest rates on debt would be for the regulator to set the base rate component of the cost of debt in accordance with the market rate at the commencement of each regulatory cycle, and to set the allowance for the DRP component of the cost of debt in accordance with a trailing average cost over *N* years, with annual updating of the latter. Firms would then align the terms of their borrowing with this, and also use interest rate swap contracts to align the base rate component of their cost of debt with the regulatory allowance. Since it is viable for firms to act in this way, this would satisfy the NPV = 0 test. Of course, firms could choose not to do this but the NPV = 0 test would be satisfied because it would be viable for them to align their borrowing arrangements with the regulatory allowance. Table 2 summarises these approaches, with the regulatory cycle assumed to be for five years, and with *N* being the borrowing term chosen by the regulator by reference to the behavior of what it judges to be the benchmark efficient firm.

The only regulatory approaches that are in principle consistent with the NPV = 0 test are the last two. One of these involves an *N*-year TA for the entire cost of debt. The other involves an *N*-year TA for the DRP component coupled with the five-year market rate at the commencement of each regulatory cycle for the base rate component. By contrast, until 2014 the AER adopted the OTD strategy shown in the first two sections of the table, and with firms borrowing for *N* years with staggering and using interest rate swap contracts; this created a mismatch between the *N*-year TA DRP paid by firms and the five-year DRP allowed at the beginning of each regulatory cycle. It therefore switched to the fourth strategy, with *N* = 10 yrs, and a ten-year transitional period that is not yet complete.

Table 2: Possible Means of Matching the Allowed and Incurred Costs of Debt

	Regulatory Policy	Matching Firm Strategy	Viable?	NPV = 0?
1	OTD Base: 5 yrs	Borrow for 5 yrs, unstaggered	No	
	OTD DRP: 5 yrs			
2	OTD Base: 5 yrs	Borrow for *N* yrs, staggered	Yes	
	OTD DRP: 5 yrs	+ Interest Rate Swaps	Yes	
		+ Credit Default Swaps	No	
3	OTD Base: 5 yrs	Borrow for *N* yrs, staggered	Yes	No
	OTD DRP: *N* yrs	+ Interest Rate Swaps	Yes	
4	TA Base: *N* yrs	Borrow for *N* yrs, staggered	Yes	Yes
	TA DRP: *N* yrs	+ Interest Rate Swaps	Yes	
5	OTD Base: 5 yrs	Borrow for *N* yrs, staggered	Yes	Yes
	TA DRP: *N* yrs	+ Interest Rate Swaps	Yes	

3.2 Types of Trailing Averages

The previous section shows that the only regulatory approaches that are in principle consistent with the NPV = 0 test is to allow an *N*-year TA for the entire cost of debt, or an *N*-year TA for the DRP component coupled with the five-year market rate at the commencement of each regulatory cycle for the base rate component of the cost of debt. The value for *N* would be determined by examination of benchmark efficient firms. However, the weights in these trailing averages would have to reflect the particular circumstances of the regulated business. For example, a firm borrowing for (say) ten years with its borrowing growing over time in line with the expansion of the business would incur a cost of debt with higher weights on the most recent five years of debt costs and lower weights on the previous five years. By contrast, regulatory trailing averages are usually equally weighted, as is the AER's (2018) current approach, and this will constitute the actual borrowing costs of the firm in only one very special case (the "ideal" scenario). This involves a business that makes only one investment (of debt and equity), the debt terms are staggered so that $1/N$th of it matures in each of the next N years, and each tranche on maturity is rolled over for N years. In addition, further capex matches the regulatory allowance for depreciation, so that no additional borrowing or repayments of principal are required. After N years, the business's cost of debt in every year will be an equally-weighted trailing average for N years. So, apart from this special case, a regulatory allowance for the cost of debt set at an equally-weighted annually-adjusted average over N years will not correspond to the actual borrowing costs of a regulated business.

One response to this problem would be to vary the weights within the trailing average to reflect the circumstances of each regulated business. This will be cumbersome, as noted by the AER (2013, section 7.3.5), leading to their use of equal weighting. An alternative approach would be to investigate whether variations from the "ideal" scenario described above produce significant differences between the regulatory allowance and the actual costs incurred by the business. This will depend upon the extent to which borrowing rates vary over time, and therefore actual data from a long historical series should be used.

Consistent with the "ideal" scenario that I consider here, I consider a firm whose existing borrowing (at the commencement of regulation) is (arbitrarily) set at $1000, on which it pays the ten-year TA cost of debt in all future years (because 10% of it matures every year). The firm immediately borrows an additional $30 to undertake new capex (i.e., capex in addition to replacement of existing assets), which is equal to 3% of its existing assets. One year later, it expects to borrow a further $31.37 for new capex at that time, being 4.55% larger than in the preceding year (to reflect expected inflation of 2.5% and expected real growth of 2%). This new capex growth and the resulting new borrowing continues indefinitely. Each of these borrowings are rolled over indefinitely, to reflect the indefinite life of the firm and replacement of the assets when they expire (replacement at a higher cost does not incur further borrowing because the regulatory depreciation allowance deals with the increased cost of the replacement asset). The analysis is undertaken for 30 years.[16]

I draw upon the same data as Lally (2016, section 2.1): monthly long-term corporate bond yields (on BBB bonds) from the US over the period 1953-2014 (because Australian data is only available back to 2005). This data is used to estimate the time-series model underlying it (a mean-reverting model), which is then used to predict future values.[17] Regressing monthly costs of debt (in percentage terms) on the preceding month's value yields the following result:

$$k_1 = .02562\% + .99695 k_0$$

This is equivalent to the following mean-reverting model:

$$k_1 = k_0 + .00305(8.4\% - k_0)$$

So, given an existing value for the cost of debt (k_0), this model predicts the cost in one month (k_1), which is fed back into the model to predict the cost one month later, and so on. Furthermore, the notion that interest rates are mean-reverting processes is mainstream in the academic literature (Hull, 1989, page 259; Jarrow and Turnbull, 1996, page 490).

To commence the analysis, the cost of debt corresponding to the 95th percentile of the historical data (described above) is treated as the current value, in order to consider an extreme scenario. This rate is 13.95% and occurred in February 1983. The mean-reverting model above is then used to predict the monthly values for the next 30 years. Thus, the predicted rate in one month is 13.93%, the rate one month later 13.92%, and so on. These predicted rates gradually converge on 8.4%. In respect of the existing debt of $1000, the firm pays the TA, which is the average of the actual monthly rates in the historical data over the ten years leading up to and including February 1983 (11.41% and therefore a payment of $114.07). In addition the firm borrows a further $30 to partly finance the new capex, and does so by borrowing for ten years at the current ten year rate of 13.95% (and rolled over

[16] This approach differs from that in Lally (2016, section 2.1), who considers a newly established firm, which must borrow at that time at the prevailing rate and transition towards a TA payment.

[17] The data is from http://research.stlouisfed.org/fred2/. Using the same data permits direct comparison of the results from the current paper with those in Lally (2016, section 2.1).

every ten years at the prevailing ten-year rate).[18] The resulting interest payment is $4.19, leading to total interest payments of $118.26 (which is paid in one year). In one year the firm will still have the borrowing on existing assets of $1000, on which it will pay the prevailing TA rate of 11.96% (being the average over the nine years of historical rates leading up to February 1983 plus the first year's future predicted rates), plus the borrowing of $30 on the first years' capex (at the current rate of 13.95%), plus the expected borrowing of $31.37 on the next year's capex (at the predicted rate prevailing in one year of 13.75%), yielding a total payment of $128.07 (which is paid in two years' time).

Turning now to the regulatory allowance, involving a trailing average (TA) approach, I assume (consistent with the AER's practice) that the regulatory allowance is reset each year. At the beginning of the first year, the TA rate at that point is 11.41% (as noted above). Application of this rate to the regulatory debt level of $1030 at that point yields a regulatory allowance of $117.49, which will be received in one year.[19] This is less than the amount paid at that point of $118.25 (as explained above), yielding a discrepancy of -$0.76, which is converted to post-tax terms and discounted at the prevailing cost of debt of 13.95% to yield a present value (PV) difference of -$0.47. In one year's time, application of the TA rate at that time of 11.96% to the borrowing on all assets of $1061.36 at that point yields a regulatory allowance of $126.91, which will be received in two years. This is less than the amount paid at that point of $128.07, yielding a discrepancy of -$1.18, which is converted to post-tax terms and discounted at a cost of debt of 13.95% for two years to yield a PV difference of -$0.64. Proceeding in this way, and adding up over the first 30 years yields a present value (PV) on the difference in the costs of debt of $0.15 as follows:

$$PV = \frac{(\$1030 * .1141 - \$118.25)(1-.3)}{1.1395} + \frac{(\$1061.36 * .1196 - \$128.07)(1-.3)}{(1.1395)^2} + \cdots$$
$$= \$0.15$$

18 Unlike the analysis in Lally (2016, section 2.1), this borrowing is not transitioned to a TA because the succession of new borrowings for the new capex each year will over time automatically produce something close to a TA. For example, in nine years' time, the rates paid on all borrowing for new capex will comprise the rate in nine years on the borrowing in the ninth year, the rate in eight years on the borrowing in the eighth year, the rate in seven years on the borrowing in the seventh year, and so on.

19 In order to focus upon the merits of different regulatory approaches to the allowed interest rate, the actual and regulatory debt levels are assumed to be equal. Inter alia, this implies that the firm adopts the same leverage level as the regulator.

The PV of the total debt is $1336, comprising the $1000 associated with the existing assets plus the PV of the borrowing associated with the succession of new capex expenditures discounted at the prevailing cost of debt of 13.95%. As a proportion of this PV of current debt, the PV difference of $0.15 is essentially zero.

For comparison, I also consider the on-the-day (OTD) approach, in which the regulatory allowance (set at the beginning of each five-year period) is the cost of debt prevailing at that time. This is currently 13.95% and it is expected to be 13.02% in five years' time, and so on. Use of these rates in substitution for the TA regulatory rates in the preceding equation yields a PV on the difference in the costs of debt of $8.70 as follows:

$$PV = \frac{(\$1030 * .1395 - \$118.25)(1-.3)}{1.1395} + \frac{(\$1061.36 * .1395 - \$128.07)(1-.3)}{(1.1395)^2} + \cdots$$
$$= \$26.98$$

As a proportion of the PV of the current debt of $1336, this is 2.0%. Thus, use of the OTD approach to setting the regulatory costs of debt produces a bigger departure from the NPV = 0 requirement than use of the TA approach. These results are shown in Table 3.

These results reflect use of the 95th percentile value from the historical cost of debt data as the current cost of debt. If the 7th percentile (of 4.51%) had been used instead, the PV differences would have been zero for the TA approach and -1.3% for the OTD approach.[20] These numbers are shown in the second column of numbers in Table 3. Again, the TA approach yields smaller divergences.

These results also reflect the assumption that new capex is initially equal to 3% of existing assets. Table 3 shows the results from varying this assumption (using 1% and 5%); the TA approach yields smaller divergences and almost perfectly satisfies the NPV = 0 test. However, there may be cases in which a business's capex and hence debt is expected to temporarily grow much more rapidly. So, I consider cases in which there is a new borrowing in the first year of $500 (half the current level) or $1000 (equal to the current debt level),

[20] The 5th percentile (of 3.85%) could not be used because it occurs so early in the historical data series that there is not ten years of earlier data to use to form the ten-year TA. It is not until the 7th percentile is reached that this problem is overcome, and therefore the 7th percentile is used.

coupled with $30 in the following year after which it grows at 4.55% per year. I continue to assume that all debt financing for new capex is initially for ten years and rolled over at maturity for the same term. The results are shown in the remaining columns of Table 3. Unsurprisingly, the PV divergences for the TA approach worsen, and those of the OTD improve, to the point where the OTD approach is comparable with the TA.

Table 3: PV Divergences for the Cost of Debt (%)

	7th Percentile Cost of Debt					95th Percentile Cost of Debt				
Capex	1%	3%	5%	500	1000	1%	3%	5%	500	1000
TA	0	0	0	1.3	2.2	0	0	0	-1.2	-2.0
OTD	-2.3	-1.3	-0.8	-0.6	0	2.6	2.0	1.6	1.2	0.6

Confronted with a regulator adopting an OTD approach to the entire cost of debt, firms could be expected to use swap contracts to eliminate the base rate differences between the cost allowed and the cost incurred, and the private sector firms did so when the AER used an OTD approach to the entire cost of debt (AER, 2009, pp. 151-154). So, the second row in Table 3 would not arise. I therefore repeat the analysis focusing instead on the DRP rather than the entire cost of debt, with the DRP being the cost of debt less the contemporaneous ten-year US government bond rate.[21] This constitutes a comparison of results from the regulator using a TA or OTD approach to the DRP, i.e., a hybrid or an OTD approach, because they differ only in respect of the DRP allowances. The present valuing is performed using a cost of debt of 6% in all cases. The results are shown in Table 4, and are similar to Table 3.

Table 4: PV Divergences for the DRP (%)

	5th Percentile Cost of Debt					95th Percentile Cost of Debt				
Capex	1%	3%	5%	500	1000	1%	3%	5%	500	1000
Hybrid	0	-0.1	-0.1	0.4	0.8	-0.1	-0.2	-0.2	-1.5	-2.4
OTD	0.1	0.2	0.2	0.6	1.0	2.9	2.0	1.5	1.2	0.5

[21] The latter data is the GS10 series, from http://research.stlouisfed.org/fred2/.

In summary, for an existing business with moderate capex and growing over time at a moderate rate, regulatory use of a TA cost of debt (with annual updating and equal weights over years) will yield very small divergences from the NPV = 0 test. If the regulator adopts the OTD approach, the divergences will be much larger, inducing the firm to use swap contracts to deal with the base rate differences. The resulting DRP divergences would be very small for regulatory use of a TA approach and larger from an OTD approach. However, if capex were temporarily high, the divergences from regulatory use of the TA approach would significantly worsen, whilst those from the OTD approach would lessen. This might induce a firm to transition its borrowing in respect of these extreme events towards a trailing average over the course of *N* years, and/or the regulator might initially grant an OTD allowance and then transition to the TA approach over the *N*-year term for which firms borrow. These possibilities will be examined further in the next two sections.

3.3 Approaches to the Cost of Debt: Existing Firms with Moderate Capex

I now assess the relative merits of the three possible regulatory approaches to the cost of debt allowance for which there is a viable matching strategy for a firm (as shown in Table 2): the OTD approach with a five-year base rate and an *N*-year DRP, an *N*-year TA approach to the entire cost of debt, and the hybrid approach involving a five-year OTD rate for the base rate component of the cost of debt and an *N*-year TA for the DRP. Numerous criteria are relevant to this choice, including but not only the extent to which the NPV = 0 test is satisfied. As will be seen, these criteria do not clearly favour one of these three methods over the others. I start by examining the typical situation involving existing regulated businesses with moderate capex.

The first criterion is the extent to which the NPV = 0 test is satisfied. As shown in the preceding section, for existing regulated businesses with moderate capex levels, the TA and the hybrid approaches give rise to very small departures from the NPV = 0 test, and in this respect are each superior to the OTD approach. Despite this, one might suspect that there was still an incentive problem in respect of capex under the TA or hybrid approaches, as follows. At the time of undertaking new borrowing to finance any capex, the firm will pay the prevailing rate. So, if the TA cost of debt is well below the current cost of debt, regulatory use of the TA for the cost of debt will likely fail the NPV = 0 test in respect of that capex even if the test is satisfied in respect of the entire firm's activities, and it might then seem that regulated firms in this situation would be unwilling to undertake the capex. However, a firm could be expected to consider the entirety of its regulated activities rather than focus upon a capex event in isolation. As shown in Table 3, in the presence of moderate capex, a TA cost of debt allowance will approximately satisfy the NPV = 0 test across the entire regulated activities of the firm, which includes activities in place at the time regulation commenced, capex events preceding the current one, and capex events to come. The same issue applies to the DRP. As shown in Table 4, in the presence of moderate capex, a TA allowance for the DRP will approximately satisfy the NPV = 0 test across the entire regulated activities of the firm, which include activities in place at the time regulation commenced, capex events preceding the current one, and capex events to come. So, this capex issue is embodied within the earlier conclusion that the TA and hybrid approaches are superior to the OTD approach in satisfying the NPV = 0 test if capex is moderate.

The second criterion concerns estimation errors in the MRP. Since the MRP estimated by the AER is very stable over time (because high weight is placed on the long-term historical averaging methodology), and the true value is likely to fluctuate much more than this (with high values during unfavourable economic conditions and low values during favourable economic conditions), the MRP is likely to be overestimated during favourable economic conditions and underestimated during unfavourable conditions. The DRP fluctuates in the same way as the MRP, and is therefore above its ten-year TA when economic conditions are unfavourable and below its TA when economic conditions are favourable. For example, in the US DRP series invoked in section 3.2, the highest margins for the prevailing DRP over its ten-year TA occurred in 2008-09 (3.54%), 1974-75 (1.85%), 2001-2002 (1.71%), 1970-71 (1.67%), and 1980-81 (1.18%); these periods correspond to the set of US recessions since 1970. Consequently, use of the OTD approach to the DRP yields errors that are favourable to firms at the times that the MRP allowance is unfavourable, and vice versa, which at least partly offsets the MRP estimation errors. This “natural hedge” is an advantage to the OTD approach to the DRP, and therefore favours the OTD approach over the TA and hybrid approaches.[22]

[22] This argument does not imply that the AER’s MRP estimates should be more variable over time, because it is impossible to reliable estimate short-term variations in this parameter even if one can be confident that a stable estimate will be too low (by an unknown amount) during unfavourable economic conditions and too high (by an unknown amount) in favourable economic conditions.

The third criterion concerns the difficulties in determining the term for the DRP within the TA and hybrid approaches (*N*). This involves observing the behavior of benchmark efficient firms and mirroring that behavior in the regulatory regime. Such benchmark firms would have to be efficient, and similar to the regulated businesses in question, but such firms do not seem likely to exist. The very fact of being similar implies that they would be monopolistic providers of basic services and therefore would be unlikely to be efficient and likely to be regulated. If they were regulated under the TA approach, their choice of debt term might be affected by the regulator's choice of debt term, and the regulator seeks to determine the former, which constitutes a circularity problem. If the firms were regulated under the OTD approach, their efficient choice of debt term there would not necessarily be their efficient choice in the TA regulatory situation, because their choice could change with the regulatory regime. If they were unregulated, the same problem would apply, as well as the difficulty of finding unregulated Australian businesses that were monopolistic providers of basic services. In addition to these conceptual issues, there are difficulties arising from determining which sample of firms to use, which point(s) in time to observe them, how to weight the sample data, how to treat callable bonds, and the effect of firms' unregulated activities. As indicated in Table 2, all three approaches considered here require an estimate of *N*, but it is much more important for the TA approach because it is required for the risk-free rate as well as the DRP and in addition the term structure for the former is much more pronounced than for the latter; so, errors in estimating *N* are much more important for the TA approach (especially at the present time).[23] This favours the OTD and hybrid approaches over the TA approach.

The fourth criterion concerns the impact on consumers, in terms of the average output price and its volatility over time. Since the cost of debt is more variable over time than its trailing average, output price variations over time could be expected to be greatest from the OTD approach and least from the TA approach, with the hybrid approach between them. This is an advantage to the TA approach over the other two, and an advantage to the hybrid approach over the OTD approach. In addition, both the OTD and hybrid approaches substitute the five-year for the ten-year risk-free rate within the allowed cost of debt, and therefore could be expected to generate lower average output prices for consumers, but with no disadvantage to the regulated businesses because the allowed rate matches their costs in both cases (a TA ten-

[23] At the present time (February 2021 average), the ten-year government bond yield exceeds the five-year yield by 0.84% whilst the spread for ten versus five year DRPs for BBB corporate bonds (spread to AGS) is only 0.20%: see tables F2 and F3 on the RBA's website: https://www.rba.gov.au/statistics/tables/#interest-rates.

year rate when the regulator uses a TA approach, and an OTD five-year rate when the regulator uses the OTD or hybrid approaches coupled with the use of interest rate swap contracts). To investigate this issue, let S denote the book value of equity, B the book value of debt, k_e the allowed cost of equity, k_d the allowed cost of debt, and Y denote all other revenue components. The allowed revenues of the business for a regulatory cycle are then as follows:

$$REV = Sk_e + Bk_d + Y$$

Under the TA regime, the allowed cost of equity is the sum of the five-year risk free rate prevailing at the beginning of the regulatory cycle (R_{f5}^{c}) and an allowed MRP (MRP) whilst the allowed cost of debt is the sum of the ten-year TA risk-free rate prevailing at the beginning of each year within the regulatory cycle (R_{f10}^{TA}) and the ten-year TA DRP at the same point (DRP^{TA}). So, the last equation becomes:

$$REV = S\left(R_{f5}^{C} + MRP\right) + B\left(R_{f10}^{TA} + DRP^{TA}\right) \quad (12)$$

To limit the scope of the analysis, the additional revenues Y are deleted from the analysis. In addition, the MRP allowed by the AER has been 6.5%.[24] In addition, the typical regulatory leverage ratio is 60%. So, per \$100 of asset book value, the last equation becomes

$$REV = \$40\left(R_{f5}^{C} + .06\right) + \$60\left(R_{f10}^{TA} + DRP^{TA}\right) \quad (13)$$

I examine values for this annual revenue from January 2005 onwards, since Australian DRP values for ten-year BBB corporate bonds are available since then.[25] I assume regulatory cycles commence in January. I start with businesses whose (five-year) regulatory cycles commence in January 2005. For the 2005 year, R_{f5}^{c} is the January 2005 average five-year government bond rate (5.26%), R_{f10}^{TA} is the ten-year TA DRP at the same point (6.46%), and DRP^{TA} is the ten-year TA DRP at the same point (1.18%). For the 2006…2009 years of this

[24] This was adopted in 2013 (AER, 2013, page 93) for the years 2013-2018, and I adopt this for the entire analysis. Recognising variations over time equally affects results for all three methods for setting the cost of debt allowance, and therefore does not affect the conclusions here.

[25] See column AL (spread to AGS for ten-year BBB corporate bonds) in Table F3 on the website of the RBA: https://www.rba.gov.au/statistics/tables/#interest-rates. For values prior to this, which are required for the TA, I assume the January 2005 value prevailed for the previous ten years.

regulatory cycle, R^c_{f5} is still 5.26% whilst R^{TA}_{f10} and DRP^{TA} are annually updated in accordance with the TA method. So, using equation (13), the revenues for that regulatory cycle are then as follows:

$$REV(2005) = \$40(.0526 + .065) + \$60(.0646 + .0118) = \$9.28$$
$$\ldots\ldots\ldots\ldots\ldots\ldots$$
$$REV(2009) = \$40(.0526 + .065) + \$60(.0575 + .0151) = \$9.05$$

At the beginning of the next regulatory cycle, in January 2010, the value for R^c_{f5} is updated to that of January 2010 whilst the values for R^{TA}_{f10} and DRP^{TA} continue to be annually updated as before. This pattern continues, leading to a revenue outcome for each year from 2005 to 2021. The average of these annual revenues is \$8.38 and their standard deviation is \$1.05. This is shown in the first column of numbers in the first section of Table 5. The process is then repeated for businesses whose regulatory cycles commence in 2006, with the results shown in the second column of numbers in the first section of the table, and businesses whose regulatory cycles commence in 2007, with the results shown in the third column of the first section of the table, etc. Across these five types of businesses, the median outcomes for average revenue and the standard deviation of annual revenues are <u>\$8.38</u> and \$1.01 respectively, as shown in the last column of the first section of the table.

Table 5: Average Revenues and their Standard Deviations

	2005	2006	2007	2008	2009	Median
TA: Average Rev	\$8.38	\$8.41	\$8.37	\$8.42	\$8.06	\$8.38
TA: Standard Deviation	\$1.05	\$1.05	\$0.93	\$1.01	\$0.73	\$1.01
Hybrid: Average Revenue	\$7.72	\$7.88	\$7.83	\$7.99	\$7.14	\$7.83
Hybrid: Stnd Deviation	\$1.54	\$1.55	\$1.36	\$1.57	\$0.67	\$1.54
OTD: Average Revenue	\$7.59	\$7.79	\$7.97	\$7.99	\$8.34	\$7.97
OTD: Stnd Deviation	\$1.88	\$1.58	\$1.48	\$1.89	\$1.89	\$1.88

Note: The Average Rev shown in a column headed 200X is for all years from 200X to 2021.

I next consider the hybrid regime. This differs from the TA only in that the risk-free rate within the cost of debt allowance for the regulatory cycle is the rate prevailing at the beginning of the regulatory cycle (R_f^c). Modifying equation (13), the revenue equation is then

$$REV = \$40\left(R_{f5}^C + .065\right) + \$60\left(R_{f5}^C + DRP^{TA}\right) \tag{14}$$

Using this equation, the process is repeated. For example, for businesses with regulatory cycles commencing in January 2005, and for the 2005 year, R_{f5}^c is the January 2005 average five-year government bond rate (5.26%), and DRP^{TA} is the ten-year TA DRP at the same point (1.18%), yielding revenues of $8.56. Across all years from 2005 to 2021, for businesses with regulatory cycles commencing in January 2005, the average of these annual revenues is $7.72 and their standard deviation is $1.54, as shown in the first column of numbers in the middle section of Table 5.

Finally, I consider the OTD regime. This differs from the hybrid regime only in that the ten-year DRP within the cost of debt allowance for the regulatory cycle is the rate prevailing at the beginning of the regulatory cycle (DRP^C). Modifying equation (14), the revenue equation is then

$$REV = \$40\left(R_{f5}^C + .065\right) + \$60\left(R_{5f}^c + DRP^C\right) \tag{15}$$

Using this equation, the process is repeated. For example, for businesses with regulatory cycles commencing in January 2005, and for the 2005 year, R_{f5}^c is the January 2005 average five-year government bond rate (5.26%), and DRP^C is the ten-year DRP at the same point (1.18%), yielding 2005 revenues of $8.56. Across all years from 2005 to 2021, for businesses with regulatory cycles commencing in January 2005, the average of these annual revenues is $7.59 and their standard deviation is $1.88, as shown in the first column of numbers in the last section of Table 5.[26]

[26] The analysis for the TA and hybrid approaches does not incorporate any regulatory allowance for the transactions costs of the pair of interest rate swap contracts required to convert the ten-year base rate into the five-year base rate. This is because the AER did not provide such compensation when it used the OTD method before 2014. Even if it had, the allowance would have been very small. Jemena (2013, page 22) estimated the total cost at 0.09% based upon quotes from its banks, Chairmont (2013b, page 31) provides the even lower estimate of 0.03% - 0.10%, and UBS (2015, page 13) estimates it as 0.10%. Using the median figure of 0.07%, this would add 0.0007*$60 = $0.04 to the average revenues for the firms, for the Hybrid and OTD approaches. This is very small relative to the difference between the average revenues of the TA and Hybrid/OTD methods.

The principal results are in the last column of Table 5, and represent the median result across the preceding five columns. In respect of volatility (i.e., standard deviation) over time, the TA approach is the best, followed by the hybrid approach, and then the OTD approach, consistent with the fact that ten-year trailing averages are less volatile than monthly rates. This favours the TA approach over the hybrid, and the hybrid over the OTD approach. In respect of the average revenue, the OTD and hybrid approach have similar average revenues, and both are about 5% less than the TA approach, consistent with the latter two approaches substituting the five-year for the ten-year risk-free rate within the allowed cost of debt. This favours the hybrid and OTD approaches over the TA approach.

The fifth criterion is the business's exposure to bankruptcy risk arising from businesses receiving an allowance for the cost of debt that is less than that paid. This can only occur when the DRP allowance is set by the OTD regime whilst the firm instead pays the TA rate.[27] However, in assessing the resulting bankruptcy risk, it is necessary to consider the other cash flows of the firm, because they provide a cushion against this. In respect of these other cash flows, I limit the analysis to the allowed cost of equity. The revenues from the allowances for the cost of equity and debt are given by equation (15). Subtracting the interest payments incurred by the firm, comprising the risk-free rate at the beginning of the regulatory cycle (because the firm would use interest rate swap contracts in this case) and the annually adjusted TA DRP yields net net cash flows as follows:

$$NCF = \$40\left(R_{f5}^{C} + .065\right) + \$60(DRP^{C} - DRP^{TA})$$

The bankruptcy issue could only arise if the DRP value were less than its TA and sufficiently so to outweigh the cost of equity allowance in this equation. I use the same data underlying Table 5 above. The maximum shortfall between the DRP and its ten-year TA occurs in February 2018, when the DRP is 1.5% and the ten-year TA is 2.9%. At this point, the five-year risk-free rate is 2.4%. So the net cash flow is

[27] The issue does not arise when the TA approach is adopted for setting the cost of debt allowance because the allowance then matches the payments. The issue also does not arise when the hybrid approach is adopted for setting the cost of debt allowance because this involves allowing the risk-free rate at the beginning of the regulatory cycle, which will match the firm's payments when it uses interest rate swap contracts, and allowing the TA DRP, which will match the firm's payments.

$$NCF = \$40(.024 + .065) + \$60(.015 - .029) = \$3.56 - \$0.84 = \$2.72$$

So, the worst-case cash flow shortfall arising from the cost of debt allowance being less than that paid ($0.84 per $100 of asset book value) is only 24% of the cash flow cushion provided by the cost of equity allowance, and other cash flow terms will increase this cushion. So, bankruptcy risk arising the OTD approach to setting the cost of debt allowance is trivial.

I now summarise these points. The bankruptcy problem does not arise, even for the OTD method. This leaves five issues: departures from the NPV = 0 test, estimation errors for the MRP that are partly hedged using the contemporaneous DRP, problems in identifying the debt term of the benchmark efficient firm, the average output price, and volatility in the average output price. Table 6 ranks each of the three methods for setting the cost of debt allowance, with 1 = best, 2 = middle, 3 = worst, and with sharing of ranking numbers in the event of a tie, with the shared number chosen so that the ranks add to 6. The last row in the table gives the median rank for each method.

Table 6: Ranking of Methods for Setting the Allowed Cost of Debt

	TA	Hybrid	OTD
NPV = 0	1.5	1.5	3
MRP/DRP Natural Hedge	2.5	2.5	1
Debt Term Identification Problem	3	1.5	1.5
Output Price Average	3	1.5	1.5
Output Price Volatility	1	2	3
Median	2.5	1.5	1.5

Note: When the first ranking is shared, each policy receives a ranking of 1.5 each rather than 1 and 2 for first and second. Similarly, when the second ranked is shared, each receives 2.5.

So, if equal weight were given to each of these five factors, the OTD and hybrid approaches would be the best, followed by the TA approach. However, if output price volatility and satisfying the NPV = 0 test were considered the most important criteria, the TA method would be the best. Since the decision depends upon the weight given to these five factors, I do not express a view. If the TA approach were adopted, the appropriate term for the allowed cost of debt would be historical and equal to the term for which the benchmark efficient entity borrows (*N* years). If the hybrid approach were adopted, the appropriate term for the allowed DRP would be historical and equal to the term for which the benchmark efficient entity borrows, whilst the appropriate term for the allowed risk-free rate within the cost of debt would be the future term of the regulatory cycle (five years). Finally, if the OTD approach were adopted, the appropriate term for the allowed DRP would be the future term for which the benchmark efficient entity borrows, whilst the appropriate term for the allowed risk-free rate within the cost of debt would be the future term of the regulatory cycle (five years). Regardless of which approach is adopted, the NPV = 0 principle implies that the appropriate term for expected inflation is the regulatory cycle of five years (Lally, 2020), and quite separately also implies that the appropriate term for the cost of equity is also the regulatory cycle.

A further consideration is as follows. In 2013 the AER switched from the OTD to the TA method, with a ten-year transitional period that has not yet been completed. The inevitable problems in changing any methodology may provide further grounds for continued use of the TA method, and therefore might be treated as an additional factor. Again, I express no view on the weight to be given to this factor.

In the event that the AER elects to switch from the TA approach to the OTD approach, a transitional process will be required. Since the current transitional process used by the AER arises from its 2013 decision to switch from the OTD to the TA approach, the natural choice of a transitional process arising from reversing that decision would be to reverse its current transitional process over the same period of time that it has operated. If the AER elects to instead switch from the TA to the hybrid approach, this involves a change only in the risk-free rate component of the cost of debt. The natural choice for transitioning this component would be the same transitioning method applied to the entire cost of debt, as described in the previous sentence.

The AER have requested that the following criteria be used to evaluate the appropriate term for the cost of debt: Reliability (reflects economic principles and empirical evidence), relevance to the Australian benchmark, suitability for use in the regulated environment (transparency), simplicity, and materiality (of the differences in the revenues). The choices examined here are the OTD approach (five years), the TA approach (*N* years) and the hybrid approach (five years for the risk-free rate and *N* years for the DRP). The three options differ only on reliability, simplicity, and materiality. Reliability (conformity with the NPV = 0 test) favours the TA and hybrid approaches, simplicity (difficulty of estimating the debt term for the benchmark efficient entity) favours the OTD and hybrid approaches, and materiality (of revenue differences) favours the OTD and hybrid approaches in respect of average revenues and the TA approach in respect of revenue volatility. However these criteria do not include consideration of the MRP/DRP natural hedge, which favours the OTD approach.

3.4 Approaches to the Cost of Debt: New Entrants and Large Capex

I now consider the case of a new entrant to the regulated sector, who can be presumed to undertake all of its borrowing at this time and stagger it so as to mitigate its refinancing risk. Unlike an existing regulated business, the new entrant will therefore initially pay the OTD rate, and transition to a TA or Hybrid payment pattern over *N* years. Thus, if a regulator adopts and maintains a TA (or Hybrid) allowance, it will initially allow far too much or far too little if the current cost of debt (or the DRP) is well below or well above the TA cost of debt (or the TA for the DRP). Alternatively, if a regulator adopts and maintains an OTD approach, it will initially provide the correct allowance but, after *N* years, will be providing too much or too little if the cost of debt (or DRP) at that time (which it continues to provide) is above or below the TA (which the firm will now be paying).

To investigate the size of these divergences, I consider a new entrant that initially borrows for ten years but engages in no further borrowing (other than rollovers). I also consider the same extreme cases considered in the previous section; the 7^{th} and 95^{th} percentiles of the historical cost of debt distribution, and the 5^{th} and 95^{th} percentiles of the historical DRP distribution. At the 7^{th} percentile of the cost of debt, if the firm staggers its debt and thereby transitions to a ten-year TA cost of debt over the course of ten years and the regulator allows an equally-weighted ten-year TA for the cost of debt with annual resetting, the PV of the divergences from the NPV = 0 test is 5.5% of the debt level and is shown in the top left corner of Table 7.

The rest of the first row of Table 7 shows the result of the regulator instead adopting and maintaining an OTD approach with five-yearly resetting, the regulator initially adopting OTD with transition to a TA for the cost of debt over ten years, and the corresponding results for the 95^{th} percentile. For completeness, the second row shows the results if the firm does not stagger its debt, i.e., it borrows for ten years with rollover at each maturity date for the same term.

Table 7: PV of k_D Divergences from Combinations of Firm Policy and Regulatory Policy

Firm Policy	7th Percentile & Reg Policy			95th Percentile & Reg Policy		
	TA	OTD	Trans	TA	OTD	Trans
Stagger	5.5*	2.2	0**	-3.9*	-0.9	0**
No Staggering	6.0	2.6	0.5	-4.4	-1.4	-0.5

Table 8 repeats the analysis for the DRP, which arising from the regulator adopting an OTD approach to the base rate at all times and the firm reacting by using interest rate swap contracts to match the base rate; the choices shown there for the firm and the regulator therefore relate solely to the DRP.

Table 8: PV of DRP Divergences from Combinations of Firm Policy and Regulatory Policy

Firm Policy	5th Percentile & Reg Policy			95th Percentile & Reg Policy		
	TA	OTD	Trans	TA	OTD	Trans
Stagger	0.9*	1.0**	0**	-4.6*	-1.0**	0**
No Staggering	2.1	2.2	1.2	-5.8	-2.2	-1.2

A new entrant could be expected to stagger its debt, and therefore to transition to a TA on the cost of debt or the DRP, regardless of the regulator's approach, so as to mitigate its refinancing risk. Therefore the last row in each of these two tables can be dismissed. Furthermore, if the regulator adopts an OTD approach to the entire cost of debt, the firm will likely use interest rate swap contracts to annul base rate differences, the results of this appear in the OTD columns of Table 8, and therefore the OTD results in Table 7 can be dismissed. This leaves only the asterisked results in Table 7 and 8 (* and **). Amongst these, the results from regulatory use of the TA approach to the entire cost of debt (Table 7) or the DRP (Table 8) are highly adverse, and therefore these approaches should be dismissed. For the regulator, this leaves only the transitional approach from OTD to TA for the entire cost of debt (first row of Table 7 with Trans column), the OTD approach to the entire cost of debt at all times (first row of Table 8 with OTD column), and the transitional approach from OTD to the hybrid approach (first row of Table 8 with Trans column); these results are double asterisked (**) in the tables. In all three such cases, the regulator commences with the OTD approach for the entire cost of debt and the choice is simply whether it continues with that approach for the entire cost of debt, or transitions to a TA approach to the entire cost of debt, or transitions to the hybrid approach. The latter two cases yield no divergences from the NPV = 0 test whilst the former yields moderate divergences.

This ranking of the three possible regulatory policies in respect of divergences from the NPV = 0 test matches the rankings for an existing regulated business with moderate capex, as shown in the first row of Table 6, and the rankings on the other factors listed in Table 6 are also identical to those for an existing regulated business with moderate capex as shown in Table 6. So, apart from starting with the OTD approach for the entire cost of debt, the best choice of long-term policy for a new entrant is exactly the same as for existing regulated businesses with moderate capex. For example, if the regulator favours the hybrid approach for existing regulated businesses with moderate capex (OTD for the base rate and an *N*-year TA for the DRP), it should apply OTD initially to new entrants, maintain OTD for the base rate, and transition to an *N*-year TA for the DRP over *N* years. Alternatively, if the regulator favours the TA approach for existing regulated businesses with moderate capex, it should apply OTD initially to new entrants, and transition to an *N*-year TA for the cost of debt over *N* years.

These conclusions are all premised on the current value for the cost of debt or the DRP being significantly different to its *N*-year trailing average (with only the 5^{th}, 7^{th} and 95^{th} percentiles examined). If the relevant phenomenon is not significantly different to its *N*-year trailing average, the regulator should immediately adopt (rather than transition towards) whatever policy it favours for existing regulated businesses with moderate capex. So, the decision making sequence for a new entrant should be as follows:

STEP 1: Choose the optimal policy for an existing regulated business with moderate capex, as per the previous section.

STEP 2: If the STEP 1 policy choice is OTD, apply it immediately to new entrants and maintain this.

If the STEP 1 policy choice is the hybrid approach, which involves a trailing average DRP, assess whether this trailing average is substantially different to the prevailing rate at the time of new entry; if not, apply the hybrid approach immediately to the new entrant and maintain this, and otherwise apply the OTD now and transition to the hybrid approach over *N* years.

If the STEP 1 policy choice is the TA approach, which involves a trailing average for the entire cost of debt, assess whether this trailing average is substantially different to the prevailing rate at the time of new entry; if not, apply the TA approach immediately to the new entrant and maintain this, and otherwise apply the OTD now and transition to the TA approach over *N* years.

The last situation to consider is that of existing regulated businesses that are about to undertake substantial capex (relative to RAB). Such firms can be treated as a portfolio comprising an existing regulated business without the temporarily high capex plus a new entrant whose investment is the temporarily high capex. In respect of the temporarily high capex, this situation is in principle the same as that of a new entrant. So, the policy applied to a new entrant, as just described, should be applied to the borrowing induced by this new capex. The policy applied to the rest of the firm's debt is that determined in the previous section. For example, suppose the regulator has chosen to apply a TA approach (over *N* years) to existing regulated businesses with moderate capex, and an existing regulated business is about to engage in significant capex. Suppose further that the current cost of debt is significantly different to its *N*-year trailing average. The regulator should then initially apply the OTD approach to the borrowing induced by the new capex and transition towards an *N*-year TA policy over *N* years, whilst continuing to apply the *N*-year TA approach to the rest of the firm's debt.

4. Review of Submissions on the AER's 2020 Inflation Review

Lally (2020) argued that the term for the estimate of expected inflation must match that for the regulatory cycle (five years), regardless of the term for the allowed cost of capital, in order to satisfy the NPV = 0 test. In response, the AER (2020a) reduced the term for its estimate of expected inflation from ten years to five years.

The CRG (2020, pp. 11-13) argues that making this change without also changing the term of the risk-free rate within the WACC is "disjointed". Implicit in this view is the CRG's view that use of a five-year term for expected inflation necessarily requires use of a five-year risk-free rate throughout the WACC calculation. As indicated in the previous sections, the risk-free rate within the cost of equity (but not necessarily the cost of debt) should match the term of the regulatory cycle (five years), but this is driven by satisfying the NPV = 0 test rather than conformity with the term for expected inflation.

The CRG (2020, page 12) seems unclear as to the AER's rationale for switching from a ten-year term for estimating expected inflation to a five-year term. The correct rationale for making the change is to satisfy the NPV = 0 test, as explained in Lally (2020, section 2), and the AER (2020, page 40) accepted that advice.

The APGA (2020, page 14) believes that the terms for the WACC and the estimate for expected inflation are unrelated, with the former determined by the regulatory period (over which the RAB is inflated) and the latter determined by efficient financing practices, which involve long-term debt and equity. However, each of choices should be determined so as to satisfy the NPV = 0 condition. As shown in Lally (2020), this leads to estimates of expected inflation for each of the years covering the regulatory cycle (of five years). In addition, as shown in section 2 above, this also leads to use of a five-year cost of equity. In addition, as shown in section 3 above, this may lead to a term for the cost of debt equal to the efficient borrowing term, or a term for the DRP equal to the efficient borrowing term coupled with a term for the risk-free rate equal to the term of the regulatory cycle.

The ENA (2020a, section 4.3) presents evidence that the inflation swap rate is a better forecaster of actual inflation for one and two year forecast periods than the RBA's short-term forecasts, over the period since 2010. However, the swap rate data used by them are not disclosed or otherwise accessible, and therefore the ENA's analysis cannot be replicated. Furthermore, the test is conducted over a shorter period than that for which publicly-available swap rate data is available. As shown in Lally (2020, Table 2 and Table 3), use of the longer such series for swap rates from the RBA (from 2006, for seven-year swaps) shows that the swap rate is far inferior to the RBA target for a seven-year forecast period, whilst the RBA target is inferior to the RBA's short-term forecasts over one and two-year forecast periods.

The ENA (2020a, page 33) appears to favour using data over only the last ten years because it reflects "current market conditions". However, the only data that reflects current market conditions is current data, and this is insufficient to conduct statistical tests. At least some historical data must then be used, and using all reliable historical data rather than the last ten years of data (or any other subset) avoids the suspicion that the historical period has been chosen so as to favour the conclusions that are preferred. Similar issues arise in estimating the MRP using historical data, and the same principle applies there.

CEG (2020, Appendix A) presents evidence that, amongst the break-even inflation rate, the inflation swap rate and the AER's forecasting method (the RBA short-term forecasts coupled with the RBA target), the former is the best forecaster of inflation over two and five-year periods, from 2010. However, the break-even and swap rate data used by them are not disclosed or otherwise accessible, and therefore CEG's analysis cannot be replicated. Furthermore, the test is conducted over a shorter period than that for which publicly-available data is available. As shown in Lally (2020, Table 2 and Table 3), use of the longer such series for break-even and swap rates from the RBA (1986 and 2006 respectively) shows that the two market-based measures are far inferior to the RBA target, which in turn is inferior to the RBA target coupled with the RBA's short-term forecasts. Furthermore CEG does not explain why it uses only a subset of the available data. If it has done so for the same reason as the ENA, the same critique applies: using all reliable historical data rather than the last ten years of data (or any other subset) avoids the suspicion that the historical period has been chosen so as to favour the conclusions that are preferred.

5. Review of the ENA's Submission on Debt Data

The AER (2020b) has developed a new index of the DRP of regulated energy network businesses (the EICSI), in the form of a twelve month moving average of the average DRP costs of the included bonds. Using this twelve-month moving-average of data from 2014, the average DRP of these bonds is always below the cost allowed under the AER's current approach, which involves weights of 2/3 and 1/3 on the ten-year BBB and ten-year A indexes for corporate bond DRPs, and the average term of these bonds is almost always less than the ten-year benchmark currently used by the AER (AER, 202b, Figure 1, Figure 2). The AER proposes to use this EICSI data over an observation window (the 2018-2022 period) to alter the weights on the currently employed ten-year BBB and ten-year A indexes for corporate bond DRPs (currently 2/3 and 1/3 respectively) so that the resulting weighted average over these two DRPs matches the average DRP in the EICSI data over the observation window, and then to apply these new weights in its existing process for determining the ten-year trailing average DRP.

In response, the ENA (2020b, paras 4-8) argues that the difference between the average DRP observed in the EICSI data and that in the currently employed data is attributable purely to the regulated businesses having an average term on their debt of less than ten years and therefore the appropriate course of action by the AER would (at most) be to reduce its benchmark debt term within the context of its current process. I agree, providing the difference referred to by the ENA is purely due to debt term and the evidence in ENA (2020b, Figure 2-3) is consistent with that.

The ENA (2020b, paras 9-11) also argues that the AER's proposal would involve effectively changing the benchmark credit rating to reflect evidence that instead related to the debt term, thereby producing a new benchmark credit rating that differed from the observed ratings of energy network businesses. I agree. To illustrate this point, suppose the EISCI data over the observation window (2018-2022) revealed an average DRP of 4.0%. Suppose also that, using the RBA, Bloomberg and Thomson Reuters data over the same period, the DRP of ten-year BBB debt were 5% and that of ten-year A debt were 4%, yielding an allowed DRP for the regulated businesses under the AER's current process of (2/3)*5% + (1/3)*4% = 4.67%. Under the AER's proposal, it would then raise the weight on the ten-year A bonds to 100% and reduce that on the ten-year BBB bonds to zero, thereby effectively producing a new benchmark credit rating for the businesses of A rather than BBB+. However, if the difference between the 4.0% incurred by the businesses and the 4.67% allowed under the current approach were due entirely to the businesses having debt with an average term of 8 years rather than ten years, the AER's approach would mistake a change in debt term for a change in credit rating. The more appropriate course of action for the AER would be to change the benchmark debt term it uses rather than the credit rating weights that it uses, but this possibility is precluded by its proposed approach.

These above two points raised by the ENA give rise to a more general issue. If the AER is going to use the DRP estimate from the EICSI data to modify its current estimate based on use of the RBA, Bloomberg and Thomson Reuters data, it is not appropriate to *automatically* ascribe the entire difference between the DRP estimate from the EICSI data and the DRP allowed under the current process to the credit rating (which is implicit in the AER adjusting only its benchmark credit rating). A better approach would be for the AER to decompose this difference into the part due to credit rating, the part due to debt term, and the residue (which is due to factors other than debt term and credit rating), as follows:

(a) Use the EISCI data over the observation window (2018-2022) to determine the average debt term and the average credit rating of the regulated businesses. Call these T years and R respectively.

(b) Reset the weights on the BBB and A bonds to be consistent with this average credit rating R. Call these new weights w and $(1 - w)$. For example, if R is BBB+, the current weights of 2/3 on the BBB bonds and 1/3 on the A bonds would still be correct. By contrast, if R is instead A-, then the weights should instead be 1/3 on the BBB bonds and 2/3 on the A bonds.

(c) Re-determine the average DRP allowance over the 2018-2022 period under the current process but using a debt term of T years and the revised weights w, $1 - w$. Call this average new allowance Q_A.

(d) Compare this average new allowance Q_A with the average DRP in the EISCI data over the 2018-2022 period (Q). Define $D = Q_A - Q$ to be the excess of the allowed rate under the current process over the rate arising from the EICSI data.

Having performed this decomposition, the better way (compared to the AER's proposal) in which this information could be used to modify the AER's current use of the RBA, Bloomberg and Thomson Reuters data would be for the AER to determine the trailing average allowed DRP for the regulated businesses using the RBA, Bloomberg and Thomson Reuters data, but with a debt term of T years, and weights of w and $1 - w$ on the BBB and A bonds respectively, followed by subtracting the amount D.

For example, using the 2018-2022 period, suppose the EICSI data yields an average DRP of Q = 4.2%, an average debt term of eight years and an average credit rating of R = midway from BBB+ to A-. In addition, using the same 2018-2022 period, suppose the average DRP allowed under the current process with a debt term of ten years and weights on the BBB and A bonds of 2/3 and 1/3 respectively is 4.8%. Since R is midway between BBB+ and A-, the weights on the BBB and A bonds should be reset at $w = 0.5$ and $1 - w = 0.5$. Using these new weights and a debt term of eight years, suppose the average cost of debt using the RBA, Bloomberg and Thomson Reuters data over the 2018-2022 period is Q_A = 4.4%. Accordingly, $D = Q_A - Q = 0.2\%$. So, to determine the trailing average DRP, using the RBA, Bloomberg and Thomson Reuters data, the AER should use a debt term of eight years, weights on the BBB and A bonds of 0.5 each, and then subtract 0.2% from the result.

Even this use of the EICSI data is problematic, because it involves extrapolating values for T, R and D obtained from the 2018-2022 period to the six preceding years, in the course of modifying the ten-year trailing-average DRP calculation under the current process. The value for T has changed over time (AER, 2020b, Figure 1), and values for R and D are therefore likely to have also done so. This would be like obtaining better data on market returns in the last ten 20 years, leading to the average value declining by 0.5%, and then extrapolating this reduction to all earlier years in the course of estimating the MRP using this historical data.

There is also the further question of whether the EICSI data set is sufficiently large to warrant its use. This involves the classic trade-off in statistics: using the EICSI data rather than the existing data reduces the sample size, and therefore yields a higher standard error on the estimate, but it also eliminates the potential bias arising from the existing data (because it comprises mostly unregulated firms). Unlike betas, which are estimated with considerable error, the errors here are likely to be quite small. The bias in using the existing data is the parameter D as estimated above. If this is zero, the existing data should be favoured as the sample is then larger. If D is not zero, there is the trade-off just described. If D is not trivial, the EICSI data is favoured because the estimation errors here are small.

The ENA (2020b, paras 15-21) argues that the AER proposes to maintain a ten-year benchmark term and hence a ten-year trailing average allowance, but to reduce compensation below that because the average debt term of the NSPs is less than ten years. Accordingly, the AER would be determining a ten-year trailing-average DRP allowance each year, but using (say) the eight-year DRP rather than the ten-year DRP. Firms could not replicate this strategy. This is simply a different way of expressing the ENA's earlier point that the AER's proposal would involve effectively changing the benchmark credit rating to reflect evidence that instead related to the debt term, thereby producing a new benchmark credit rating that differed from the observed ratings of energy network businesses. As discussed above, I agree with the ENA's point and have therefore proposed a different way for the AER to utilize the EICSI data.

The ENA (2020b, para 23) argues against a shortening of the benchmark debt term below ten years, despite recognizing that the average term is currently less than ten years, on the grounds that the current ten-year benchmark is efficient, low risk, and that customers benefit from this low risk through less volatile prices. However, minimizing risk has never been the criterion for selecting the benchmark debt term and, if it had, it would have led to the longest possible debt term rather than ten years. Furthermore, "efficiency" as a criterion has always been measured by the average behavior of the relevant businesses. So, it is contradictory for the ENA to argue for efficiency whilst also recognizing that the average debt term is currently less than ten years.

Additional considerations are as follows. Firstly, it might be suspected that recent EICSI evidence on the average debt term being less than the current ten-year benchmark is purely temporary and that the longer term evidence supports retention of the ten-year benchmark term. This appears to have been the position taken by the AER in its 2018 Guidelines (AER, 2018, page 299). If this view is maintained, then recent EICSI data on the DRP should not be used to modify any feature of the current process, because that EICSI data reflects an average debt term less than ten years. Secondly, the AER is currently transitioning from an OTD ten-year cost of debt to a ten-year trailing average cost of debt. Using the EISCI data on the DRP, to the extent it reflects an average debt term less than ten years, would be inconsistent with this transitional process. Using the EICSI data to instead modify the benchmark credit rating (via the weights on the BBB and A bonds) would avoid this inconsistency but only at the price of ascribing the difference between the EICSI estimate for the DRP and that allowed under the current methodology to a credit rating difference when it is instead attributable (at least partly) to other features.

The ENA (2020b, para 28) argues that the average DRP in the EICSI series should be value-weighted. If the EICSI data were being used to directly set the allowed DRP for the regulated businesses, I would agree, otherwise use of the average cost in the EICSI series to generate the allowed DRP for regulated businesses would fail to match the costs of these businesses in aggregate. For example, suppose the energy infrastructure sector comprised only two firms (A and B), with firm A's debt comprising one bond with a value of $100m and a DRP of 4%, and firm B's debt comprising one bond with a value of $10m and a DRP of 5%. The overall DRP of the sector would then be $4.5m/$110m = 4.1%. So, if the EICSI index were a simple average, it would be 4.5% and application of this allowance to both firms would then produce an allowance that was too high at the sector level purely due to the use of simple rather than value-weighted averaging. However the EICSI data is being used merely to modify the AER's use of the RBA, Bloomberg and Thomson Reuters indexes. Accordingly, the technical features of the indexes need to match, to avoid differences in the DRP estimates that arise purely from differences in such features (which would wrongly be ascribed some real significance). So, the EICSI data should be value or not value-weighted according to whether the RBA etc indexes are or are not. The RBA index is certainly value-weighted (Arsov et al, 2013, page 20), the Bloomberg index is partly value-weighted through excluding low value bonds (directly and via the minimum BVAL score requirement: see ACCC, 2014, page 8), and the situation regarding the Thomson Reuters index is unclear. So, it is unclear whether the EICSI index should be value-weighted or not.

The ENA (2020b, para 28) argues that the average DRP in the EICSI data should include subordinated debt because it includes the senior debt that the excluded subordinated debt supports. If the EICSI data were being used to directly set the allowed DRP for the regulated businesses, I would agree, otherwise use of the average DRP in the EICSI data to generate the allowed DRP for regulated businesses would fail to match the costs of these businesses in aggregate. For example, suppose the energy infrastructure sector comprised only two firms (A and B), with firm A's debt comprising one bond with a value of $100m and a DRP of debt of 4.5%, and firm B's debt comprising one senior bond with a value of $50m and a DRP of debt of 4% and a subordinated bond with a value of $50m and a cost of debt of 5%. The two firms then have the same overall DRP of debt (of 4.5%). So, if the subordinated bond were excluded from the EISCI index, the value-weighted average DRP in the EICSI data would be 4.37% and application of this allowance to both firms would then produce an allowance that was too low at the sector level, purely due to the EICSI excluding subordinated bonds. However the EICSI data is being used merely to modify the AER's use of the RBA, Bloomberg and Thomson Reuters indexes. Accordingly, the technical features of the indexes need to match, to avoid differences in estimates of the DRP that arise purely from differences in such features (which would wrongly be ascribed some real significance). So, the EICSI should include or exclude subordinated bonds according to whether the RBA etc indexes do or don't. I understand that both the RBA and Bloomberg indexes exclude subordinated bonds (ACCC, 2014, page 8). This will impart a downward bias to the result. The EICSI data should therefore do likewise.

The ENA (2020b, para 28) asserts that there are incentive problems in the AER's proposal. I presume this means that regulated businesses might alter their behavior purely in order to affect the EICSI to their advantage. However, as argued by the AER (2020b, section 5.4.2), any firm acting in this way would bear a cost in doing so (from acting differently to what it otherwise judged to be optimal) whilst the gain from doing so would be much less because the EICSI uses data from many regulated businesses. Thus, there would be no incentive for regulated businesses to act in this way.

6. Conclusions

The AER currently uses an allowed cost of capital in which the cost of equity is forward-looking for the next ten years whilst the cost of debt is an annually-adjusted equally-weighted ten-year trailing average of historic costs. This paper has sought to assess the appropriate term for each of these costs of capital, and some ancillary issues. The principal conclusions are as follows.

Firstly, in respect of the appropriate term for the cost of equity, the NPV = 0 principle implies that this term must match the regulatory cycle (of five years). Thus, the risk-free rate must match the regulatory cycle. Exact satisfaction of the NPV = 0 principle requires use of the yield on a five-year government bond whose duration matches that of the regulatory payoffs, but a very close approximation is achieved with the available bonds. In accordance with the NPV = 0 principle, the appropriate term for expected inflation should also be the regulatory cycle of five years. So, the terms match but they are separable consequences of the NPV = 0 principle.

Secondly, firms that are regulated are similar to unregulated firms in the sense of delivering payoffs over an indefinite future period, and the latter are typically valued using the ten-year government bond rate, suggesting that the same rate should apply to regulated businesses. However the valuation problem for a regulator is like that for an unregulated business terminating in five years' time, or a floating rate bond whose coupon rate is reset every five years. In each of the latter cases, the correct discount rate to use for the payoffs over the next five years is the current five-year rate, just as it is for the regulatory situation.

Thirdly, in respect of the cost of debt, satisfying the NPV = 0 principle requires that the allowed cost of debt match that incurred by the benchmark efficient firm. In principle, this can be achieved by using an *N*-year trailing average for the entire cost of debt (TA approach), or an *N*-year trailing average for the DRP component coupled with the risk-free rate at the commencement of each regulatory cycle for the (five-year) term matching the regulatory cycle (Hybrid Approach), with *N* being the borrowing term for the benchmark efficient firm, and the trailing average weights reflecting the circumstances of the regulated firm. Implementing either approach with unequal weights across past years would be cumbersome, and use of the (usual) equally-weighted trailing average will therefore in general induce departures from the NPV = 0 test. In view of these departures, the on-the-day (OTD) approach should also be considered (in which the allowed cost of debt for a regulatory cycle is that prevailing at the beginning of the regulatory cycle, with the base rate being for a term matching the regulatory cycle and the DRP term being *N* years). For existing firms with moderate capex, the OTD approach yields greater departures from the NPV = 0 test than the TA and Hybrid approaches, and this favours the latter two approaches. However, other considerations are relevant. These comprise the natural hedge that exists between estimation errors for the MRP and the contemporaneous value for the DRP, which favours the OTD approach; the difficulties in estimating the term for which the benchmark efficient entity borrows (*N*), which favours the OTD and hybrid approaches; the desirability of low average prices for consumers, which favours the OTD and hybrid approaches over the TA approach; and the desirability of low volatility over time in prices for consumers, which favours the TA approach over the hybrid and the OTD approach. So, despite ranking lowest in respect of the NPV = 0 test and in respect of price volatility, the OTD approach ranks best in other respects. I offer no view on the relative importance of these criteria, and therefore offer no view on the best approach (for existing regulated businesses with moderate capex).

Fourthly, if the TA approach were adopted, the appropriate term for the allowed cost of debt would be historical and equal to the term for which the benchmark efficient entity borrows. If the hybrid approach were adopted, the appropriate term for the allowed DRP would be historical and equal to the term for which the benchmark efficient entity borrows, whilst the appropriate term for the allowed risk-free rate within the cost of debt would be the future term of the regulatory cycle (five years). Finally, if the OTD approach were adopted, the appropriate term for the allowed DRP would be the future term for which the benchmark efficient entity borrows, whilst the appropriate term for the allowed risk-free rate within the cost of debt would be the future term of the regulatory cycle (five years). Regardless of which approach is adopted, the NPV = 0 principle implies that the appropriate term for expected inflation is the regulatory cycle, and quite separately also implies that the appropriate term for the cost of equity is also the regulatory cycle.

Fifthly, in the event that the AER elects to switch from the TA approach to the OTD approach, a transitional process will be required. Since the current transitional process used by the AER arises from its 2013 decision to switch from the OTD to the TA approach, the natural choice of a transitional process arising from reversing that decision would be to reverse its current transitional process over the same period of time that it has operated. Alternatively, if the AER elects to instead switch from the TA to the hybrid approach, this would involve a change only in the risk-free rate component of the cost of debt. The natural choice for transitioning this component would be the same transitioning method applied to the entire cost of debt, as described in the previous sentence.

Sixthly, if the firm being regulated has just entered the regulated sector, it can therefore be presumed to have undertaken all of its borrowing at this time and to have staggered the maturity dates to mitigate its refinancing risk. Unlike an existing regulated business, the new entrant will therefore initially pay the OTD rate and transition to a TA or Hybrid payment pattern over *N* years. So, unless the regulator at least commences with the OTD approach, the resulting departures from the NPV = 0 test will be unacceptably large whenever the current DRP or cost of debt is significantly different from its trailing average. After *N* years, the new entrant is in the same position as an existing regulated business with moderate capex, and therefore the optimal choice of regulatory policy at this point is the same as for an existing regulated business with moderate capex. This implies the following regulatory policy for new entrants. First, choose the optimal policy for existing regulated businesses with moderate capex (STEP 1). If the STEP 1 policy choice is OTD, apply it immediately to new entrants and maintain this. If the STEP 1 policy choice is the hybrid approach, which involves a trailing average DRP, assess whether this trailing average is substantially different to the prevailing rate at the time the new entrant appears; if not, apply the hybrid approach immediately to the new entrant and maintain this, and otherwise apply the OTD now and transition to the hybrid approach over *N* years. Finally, if the STEP 1 policy choice is the TA approach, which involves a trailing average for the entire cost of debt, assess whether this trailing average is substantially different to the prevailing rate at the time of new entry; if not, apply the TA approach immediately to the new entrant and maintain this, and otherwise apply the OTD now and transition to the TA approach over *N* years.

Seventhly, for existing regulated businesses that are about to undertake substantial capex (relative to RAB), such businesses constitute a portfolio comprising an existing regulated business without the temporarily high capex plus a new entrant whose investment is the temporarily high capex. In respect of the temporarily high capex, this situation is in principle the same as that of a new entrant. So, the policy applied to a new entrant, as just described, is also applied to the borrowing induced by this new capex. The policy applied to the rest of the firm's debt is the optimal choice for an existing regulated business with moderate capex.

Eighthly, in respect of submissions received in response to the AER reducing the term for its estimate of expected inflation from ten years to five years, these submissions do not suggest any error in the AER's new approach.

Ninthly, in respect of the AER's newly developed index of the DRP costs of regulated energy network businesses (the EICSI), the AER's proposal to use this data to modify its current DRP estimate using ten-year data from other sources involves ascribing the entire difference between the EICSI estimate and the allowance under the current process to the credit rating, and this is not appropriate because differences could also be due to differences in the debt term and other factors. A better approach would be for the AER to decompose this total difference into the part due to credit rating, the part due to debt term, and the residue (which is due to factors other than debt term and credit rating).

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