REVIEW OF SUBMISSIONS ON THE RISK-FREE RATE AND THE COST OF DEBT

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EXECUTIVE SUMMARY

This paper has reviewed submissions from Oxera and CEG to the Commerce Commission on the risk-free rate within the CAPM and various aspects of the cost of debt. With two partial exceptions, I consider that these submissions are conceptually or empirically flawed and therefore do not agree with them. The first exception is Oxera's submission that the trailing average DRP allowance be reset annually rather than five yearly, so as to provide a better match to the costs incurred by the regulated firms. My empirical analysis supports this claim, but the gain is very small and annual updating incurs additional administrative costs. Accordingly, there are advantages and disadvantages to annual versus five-yearly updating, and I do not express a view on which is on balance the better method.

The second exception is CEG's claim that use of a trailing average cost of debt is preferable to the hybrid method used by the Commerce Commission (involving a trailing average DRP coupled with an on-the-day risk-free rate) because it is simpler to hedge to (which benefits businesses) and is more stable (which benefits customers). I agree with both claims, but CEG neglects to mention two additional points, which favours the Commerce Commission's hybrid approach over a TA cost of debt. Firstly, whenever the Commission recognizes that a regulated firm's debt tenor is greater than five years, the hybrid approach will be expected to generate a lower average allowed cost of debt and therefore lower average output prices for consumers, but with no disadvantage to these regulated businesses because the risk-free rate component of its allowed cost of debt matches its debt costs in both cases (a TA rate in excess of five years when the regulator uses a TA approach, and an on-the-day five-year rate when the regulator uses the hybrid approach coupled with the firm's use of interest rate swap contracts). Secondly, the appropriate debt tenor for a firm or group of firms is not obvious and any estimate of it is likely to be too high or too low, leading to an allowed cost of capital that is too high or low, with adverse implications for consumers and firms respectively. This problem in estimating the appropriate debt tenor afflicts both the TA cost of debt approach favoured by CEG and the hybrid approach favoured by the Commerce Commission, but is more severe for the former than the latter because errors in estimating the correct tenor for the TA approach to the cost of debt afflict the entire cost of debt rather than just the DRP. Accordingly, there are advantages and disadvantages to the hybrid method over the TA cost of debt, and I do not express a view on which is on balance the better method.

1. Introduction

This paper reviews submissions from Oxera and CEG to the Commerce Commission, resulting from the Commission's review of its 2016 Input Methodologies decisions.

2. Oxera

2.1 The Term of the Risk-Free Rate[1]

Oxera (2023, section 2.3) asserts that there is "*no clear precedent academic or otherwise on the term that should be used to compute the risk-free rate*." In view of this, Oxera proposes that "*the NZCC could consider a range of evidence on yields for government bonds with maturities between five and 20 years*." The only "academic" evidence that Oxera refers to is work for the AER by myself (Lally, 2021, section 2), which relates to the proposition that the term of the risk-free rate allowed by the regulator must match the regulatory cycle in order to satisfy the NPV = 0 principle (at the time a firm invests in regulated activities, the present value of its future cash flows must be equal to its initial investment). Oxera claims that Lally (2021) interprets earlier work by Schmalensee (1989) to provide a proof of this proposition, and Oxera further claims that Schmalensee (2022) denies that his work is relevant to the term issue.

My principal views on this are as follows. Firstly, Schmalensee (2022) does deny that Schmalensee (1989) proves the proposition in question. For example, Schmalensee (2022, page 8) states that: "*Schmalensee (1989) certainly does not show that the term of the allowed return must match the term of the regulatory cycle*." However, Lally (2022, section 2) does not rely upon Schmalensee (1989) for the proof of this proposition. Lally (2021, section 2.1) himself supplies the proof, which is reproduced in Appendix 1 below, and merely cites Schmalensee (1989) to acknowledge him as the first presenter of such a proof. So, if Schmalensee (2022) is correct in his denial, then the only error in Lally (2021) would be in attributing credit to Schmalensee (1989) that was not warranted. This would not undercut the analysis in Lally (2021), which stands or falls on its own merits, and Oxera have provided no

[1] At the commencement of their discussion of the risk-free rate in their section 2, Oxera imply that this discussion applies equally to the parameter in the CAPM and to the cost of debt. However, in the course of doing so, they refer to Appendix A1.1, which commences by referring only to the role of the risk-free rate within the CAPM. So, I assess Oxera's arguments in their section 2 as if they applied only to the CAPM. I separately address their comments on the Cost of Debt (in their section 5) and, at that point, assess their arguments on the risk-free rate to the extent they are relevant to the cost of debt.

critique of it. The question of whether Schmalensee (1989) proved it earlier is of no consequence to its merits.

Secondly, despite Schmalensee (2022) denying credit for this proposition, I consider that credit to him is warranted. In proving that any depreciation schedule will satisfy the NPV = 0 principle, subject to the standard requirement that the depreciation allowances aggregate to the initial investment, Schmalensee (1989, page 294) considers a scenario in which the regulated assets have a life that may cover multiple periods, with the regulator setting the allowed revenues at the beginning of each such period, and the revenues are received at the end of the period. So, each period is a regulatory cycle. These allowed revenues comprise the allowed depreciation plus the allowed rate of return applied to the depreciated book value of the regulated assets. Implicitly, there are no operating costs or taxes, and revenues are certain. The allowed rate of return for period *t*, set at the beginning of the period, is designated r_t. Schmalensee (1989, page 294) shows that NPV = 0 for any choice of depreciation schedule so long as $\varepsilon_t = 0$, with ε_t defined as $r_t - \rho_t$, and ρ_t defined as the cost of capital in period *t*, i.e., NPV = 0 if the allowed rate of return r_t is equal to the cost of capital ρ_t. In respect of the term to which the cost of capital ρ_t relates, Schmalensee states that "*Under certainty, ρ_t is just the one-period interest rate in period t*." By certainty, he means certainty over everything except future interest rates, and the one-period interest rate he refers to is the (risk-free) rate that corresponds to the length of period *t*, which in turn is the length of the regulatory cycle. So, if the regulatory period in question were one year, the one-year cost of capital would be the one-year risk-free rate observed at the beginning of the year._Thus, under certainty over everything except future interest rates, Schmalensee (1989) proves that NPV = 0 for any choice of depreciation schedule if the allowed rate of return set at the beginning of a regulatory cycle has a term equal to the regulatory cycle.

Thirdly, despite Schmalensee (2022) denying that Schmalensee (1989) has proved the proposition in question, he in fact asserts that he has, in stating (Schmalensee, 1989, page 296): "*The Invariance Proposition (that any depreciation schedule satisfies NPV = 0) rests on the assumption that the regulated firm's actual rate of return on the book value of its assets is adjusted each period to equal the current one-period interest rate*." Clearly, Schmalensee's (1989) focus was upon the depreciation schedule when he showed that the NPV = 0 result held for any depreciation schedule so long as the allowed rate was for a term matching the regulatory period. He therefore viewed the requirement for the allowed rate of return to match the regulatory cycle as a mere ancillary assumption to his Invariance Proposition. This was entirely legitimate, but it still remains true that he has proved a second proposition without him intending to do so: NPV = 0 if the term for the allowed cost of capital matches the regulatory cycle.

2.2 The Choice of Proxy for the Risk-Free Rate

Oxera (2023, section 2.3) proposes that the risk-free rate within the CAPM be proxied by the yield on AAA corporate bonds rather than government bonds, because the demand for government bonds (and hence the yield on these bonds) is determined by reasons that "*go beyond the rate of return expected on these instruments*." In support of this Oxera (2023, Appendix A1.1) cite various papers.[2]

To assess these claims, it is firstly necessary to consider the context within which the risk free rate is being sought. This context is that of the Capital Asset Pricing Model (CAPM), which requires a risk free asset but it does not designate any particular asset of this type. In choosing an asset to provide the risk free rate, the only explicit requirement within the CAPM is that the rate of return on that asset be free of risk. There is also an implicit requirement relating to liquidity, i.e., a very illiquid asset would be unsuitable because illiquidity is (inter alia) a manifestation of high transaction costs and the CAPM assumes that there are no transactions costs. In addition, there is an implicit requirement that investors are not attracted to or repelled from any asset for reasons other than the probability distribution on its return, because the model assumes that investors choose portfolios solely according to their return distributions. Furthermore, within the CAPM, the risk-free rate is determined exogenously, i.e., given the quantities of the risk-free and risky assets, the risk-free rate, and the probability distributions for the future payoffs on all assets, the equilibrium prices are found for the risky assets (and hence their expected rates of return) and the equilibrium portfolios chosen by each investor, which could involve borrowing at the risk-free rate (see Mossin, 1966, pp. 769-775; Hirshleifer, 1970, Chapter 10). Thus, any factors that affect the risk-free asset are irrelevant to the model, but any factors other than the probability distribution for payoffs that affect investors' decisions conflict with the model's assumption that investor decisions are based only on the probability distribution for payoffs.

[2] This discussion about the appropriate proxy asset for the risk-free rate relates only to the risk-free rate within the CAPM. It has no implications for the cost of debt because any change in the risk-free rate would alter the debt risk premium by an offsetting amount.

Turning now to the papers cited by Oxera (2023, Appendix A1.1), the first of these is Krishnamurthy and Vissing-Jorgensen (2012, page 235), who assert that "*Cost of capital computations using the capital asset pricing model should use a higher riskless rate than the Treasury rate; a company with a beta of zero cannot raise funds at the Treasury rate*." They go on to say that "*In order to recover the true riskless rate from the data, one has to estimate the "convenience yield" and adjust Treasury rates by this convenience yield*." (ibid, pp, 260-261) They estimate this convenience yield at 73 basis points from the average Baa to Treasury spread over the 1926-2008 period (ibid, page 258), and note that it comprises the Baa to Aaa spread (which is a premium for the lower default risk of Aaa bonds) and the Aaa to Treasury spread (which is a premium for the lower liquidity of Aaa bonds).[3] However, Krishnamurthy and Vissing-Jorgensen are recommending the use of the Treasury rate plus the Baa to Treasury spread, which is the Baa yield, whereas Oxera are recommending the Aaa bond yield. So, Oxera cite authors in support of their proposal who are instead advocating something different. Furthermore, the primary requirement in choosing the risk-free asset is that it's rate of return is certain and, whilst no asset meets that test, the government bond rate is closer to it than BBB bonds because the latter are subject to materially higher default risk, which Krishnamurthy and Vissing-Jorgensen estimate to be at least 27 basis points (ibid, page 258). Furthermore, the CAPM implicitly assumes that all assets have very high liquidity, because illiquidity would raise the transaction costs of buying and selling assets, and the CAPM assumes that there are no transactions costs. Thus, if government bonds have much higher liquidity than corporate bonds, this would be grounds for preferring government bonds rather than AAA or BBB corporate bonds as a proxy for the risk-free asset. Furthermore, even if one did use corporate bond yields to estimate the current risk-free rate, one would also need to estimate the MRP using corporate bond yields as risk-free rate proxies, this would require corporate bond yields back to 1900 to estimate the MRP using historical averaging approaches (such as the Ibbotson approach), and New Zealand corporate bond yield data of this vintage does not exist.

Oxera (ibid) also cite Berk and DeMarzo (2014, page 404), who claim that "*In mid-2012, for example, even the highest credit quality borrowers had to pay almost 0.30% over U.S. Treasury rates on short-term loans. Even if a loan is essentially risk-free, this premium compensates lenders for the difference in liquidity compared with an investment in Treasuries. As a result,*

[3] These bond grades are Moody's, with Aaa and Baa corresponding to S&P's AAA and BBB respectively.

practitioners sometimes use [risk-free] rates from the highest quality corporate bonds in place of Treasury rates." However, Berk and DeMarzo also state that "*We generally determine the risk-free savings rate using the yields on U.S. Treasury securities.*" (ibid, page 404) Thus, these authors do not themselves support Oxera's substitution of AAA corporate bond yields for government bond yields within the CAPM. So, again, Oxera cite authors in support of their proposal who are instead advocating something different. Furthermore, despite asserting that practitioners sometimes do use AAA corporate bond yields for this purpose, Berk and DeMarzo (2014, page 406) cite a paper by Bruner et al (1998) that surveys the behavior of practitioners, and this paper reveals that *all* respondents who provide the relevant details use government bonds of some term rather than corporate bonds (ibid, Exhibit 2). Thus, Berk and DeMarzo's preferred survey evidence does not support their own claims about practitioners. Furthermore, the explanation that Berk and DeMarzo offer for the difference in yields on government and AAA corporate bonds is the higher liquidity of the government bonds and, as noted in the previous paragraph, this makes Treasury rates *more* rather than less suitable as a risk-free rate proxy.

Oxera (ibid) also cite Feldhutter and Lando (2008), who note a number of factors that differentiate Treasury rates from true risk-free rates, which they collectively designate as the "convenience yield" (ibid, page 378). These include the extremely high liquidity of Treasury bonds and the regulatory requirement for some financial institutions to purchase them. However, Feldhutter and Lando conclude that swap rates are better estimates of risk-free rates than AAA bond yields or Treasury rates at all maturities (ibid, pages 395 and 398), whereas Oxera are recommending the AAA bond yield. So, again, Oxera cite authors in support of their proposal who are instead advocating something different. Furthermore, one of the factors included in Felhutter and Lando's convenience yield (which differentiates Treasury rates from a true risk-free rate) is the extremely high liquidity of Treasury bonds and, as noted in the penultimate paragraph, this makes Treasury rates *more* rather than less suitable as a risk-free rate proxy. Furthermore, even if one did use the swap rate to estimate the current risk-free rate, one would also need to estimate the MRP using swap rates as risk-free rate proxies, this would require swap rates back to 1900 to estimate the MRP using historical averaging approaches (such as the Ibbotson approach), and swap rate data of this vintage does not exist (even for the US). Furthermore, the risk-free rate within the CAPM is a rate of return on an asset and swap rates are not of this kind. Finally, since the risk-free rate is a parameter determined outside the CAPM, the fact that some financial institutions are required to purchase Treasury bonds, thereby lowering Treasury rates, is not grounds for disqualifying Treasury bonds as the risk-free asset. The most that could be said is that this purchasing requirement conflicts with the CAPM's assumption that investor decisions are based only on the probability distribution for payoffs, and this is simply one of many (inevitable) examples of unrealistic assumptions underlying a model like the CAPM. Even here, the issue appears devoid of practical significance because reconstruction of the CAPM with this assumption *not* applied to government bonds would produce the same model.

Oxera (ibid) also cite van Binsbergen et al (2022), and note that they estimate the convenience yield at about 40 basis points. However, van Binsbergen et al (2022, section 2.2) estimate the risk-free rate from the contemporaneous prices on put and call options with the same strike price on the S&P 500 index, whereas Oxera are recommending the AAA bond yield.[4] So, again, Oxera cite authors in support of their proposal who are instead advocating something different. Furthermore, van Binsbergen et al (2022, Table 1) estimate the risk-free rate for six, 12 and 18 months (from options with those terms to maturity) rather than the period of five years required by the Commerce Commission. Furthermore, there seem to be too few trades on options maturing in approximately five years to estimate the risk-free rate for five years using this methodology.[5] So, the methodology may not be capable of application to a five year term, even in the US to which this data relates. Furthermore, the data situation in New Zealand would be even less satisfactory than in the US. Furthermore, even if this data were sufficient to estimate the current risk-free rate, one would also need to estimate the MRP using this option data as risk-free rate proxies, this would require such option data back to 1900 to estimate the MRP using historical averaging approaches (such as the Ibbotson approach), and option data of this vintage does not exist (even for the US).

Oxera (ibid) also cite Koijen and Yogo (2020), and allege that these authors conclude that the special status of the US dollar (it being the most important reserve currency) induces demand

[4] Van Binsbergen et al (2022, section 2.2) use the put call parity theorem shown in their equation (2), which involves discounting the strike price on the options from maturity until the moment in time corresponding to the observed value of the options.

[5] See S&P 500 Index Options Prices - Barchart.com. On 24 February 2023, the total number of trades for options maturing in 6, 12, 18 months was 2,300, 800, and 900 respectively. By contrast, for the longest dated options (maturing in almost five years), there were only four trades, one on calls and three on puts but not with the same strike price, so no estimate of the risk-free rate is available for five years at that time. The same problem applies for a four year term, and it is not until the term shortens to three years that there are trades (on 24 February 2023) for both put and call options with the same strike price.

from foreigners that reduces the yield on long-term US Treasury bonds by 2.15%. Koijen and Yogo (2020, page 3) do make this claim, and claim to carry out this work in section V of their paper (ibid, page 5) but an examination of section V of their paper reveals that the figure of 2.15% is instead drawn from Jiang et al (2018). Koijen and Yogo do not identify where in Jiang et al (2018) that this figure of 2.15% comes from, and the latter paper does not report any such figure. Instead, Jiang et al (2018, page 36) estimates the effect at 2.51%. So, Koijen and Yogo (2018, page 3) seem to have incorrectly transcribed the figure of 2.51% as 2.15%, and Oxera has repeated this error. These minor issues aside, there are three fundamental problems with the application of this paper to the best choice of the risk-free asset in New Zealand. Firstly, the figure of 2.51% arises from the US dollar being the world's most important reserve currency, and this has no relevance to New Zealand.[6] Secondly, even in respect of the best choice of the risk-free asset in the US, the paper does not propose a better proxy for the risk-free asset than government bonds; identifying factors that influence the yield on government bonds does not involve nominating an alternative asset, and the idea that one should simply add some margin to the observed yield on government bonds to obtain a 'more suitable rate' is incompatible with the fact that the CAPM is concerned with expected rates of return on existing rather than hypothetical assets. Thirdly, since the risk-free rate is a parameter determined outside the CAPM, the fact that some investors choose Treasury bonds for reasons other than it returns, thereby lowering Treasury rates, is not grounds for disqualifying Treasury bonds as the risk-free asset. The most that could be said is that these reasons for purchasing Treasury bonds conflict with the CAPM's assumption that investor decisions are based only on the probability distribution for payoffs, and this is simply one of many (inevitable) examples of unrealistic assumptions underlying a model like the CAPM.

Oxera (ibid) also cite Longstaff (2004), who compares the yields on US Treasury bonds with those of REFCORP (a US government agency whose bonds are guaranteed by the US Treasury) from 1991-2001, and finds that yields on the REFCORP bonds are higher, which Longstaff attributes to the higher liquidity of US Treasury bonds. Oxera (ibid) repeats this analysis for the period 2010-2022, and finds a similar result, with an average premium of 50 basis points. However, this work suggests (at most) that the yield on these REFCORP bonds

[6] This work yields a much higher estimate of the convenience yield on US Treasury bonds than Feldhutter and Lando (2008), Krishnamurthy and Vissing-Jorgensen (2012), and van Binsbergen et al (2022) because the assets examined in these latter papers are also affected by the foreign demand for US dollar assets induced by the reserve currency status of the US dollar.

be used as the risk-free rate, whereas Oxera are instead recommending the AAA bond yield. So, again, Oxera cite authors in support of their proposal whose work would (at most) support a quite different proposal, and not even Longstaff proposes that REFCORP bond yields displace Treasury bond yields as a proxy for the risk-free rate. Furthermore, REFCORP bonds do not exist in New Zealand, so Longstaff's (2004) work has no apparent relevance to New Zealand. Furthermore, as noted previously, the superior liquidity of Treasury bonds makes Treasury bonds *more* rather than less suitable as the risk-free rate proxy.

Oxera (ibid) also notes that some regulators use yields on AAA corporate bonds to proxy for the risk-free rate in the CAPM. However, proposals must be defended on their merits, and these regulatory decisions contribute nothing here that is not presented in the papers cited above.

In summary, none of the academic papers cited by Oxera support Oxera's preference for AAA bonds as a proxy for the risk-free rate within the CAPM. Furthermore, there are practical and conceptual problems with these various proposals to use corporate bond yields, swap rates, risk-free rate estimates from option data, and REFCORP rates. Even if these problems did not exist, the impact on WACC may not be large. In particular, if AAA bonds were used, the increment to the government bond rate implied by Krishnamurthy and Vissing-Jorgensen (2012, page 235) would be up to 46 basis points. If swap rates were used, the increment to the government bond rate implied by Feldhutter and Lando (2008, Figures 9 and 10) would be about 50 basis points. If option price data were used, the increment to the government bond rate implied by van Binsbergen et al (2022, Table 1) would be about 35 basis points. If REFCORP bond yields were used, the increment to the government bond rate implied by Oxera's (2023, Figure A1.1) analysis would be about 50 basis points. Collectively, this evidence suggests an increment of about 40 basis points. However, within the simplified Brennan-Lally version of the CAPM adopted by the Commerce Commission, this increment would need to be scaled by the tax correction to the risk-free rate (28%: see Commerce Commission, 2016, para 576), reducing 40 basis points 29 basis points. This increase of 29 basis points would also reduce *some* of the MRP estimates by a similar amount and therefore raise the MRP estimate by up to that amount. With an equity beta of 0.65 (the midpoint of the values of 0.60 for the EDBs and Transpower, and 0.69 for the GPBs: see Commerce Commission, 2016, para 264), the net effect on the cost of equity would be an increase of 35% - 100% of 29 basis points, which is 10 – 29 basis points. With leverage of 42% (Commerce

Commission, 2016, para 546), it would then raise WACC by 58% of this, which is 6 – 17 basis points.

The lower figure of 6 basis points is quite small and any figure from the 6 – 17 basis points range may be offset by other simplifications in the regulatory process that are beneficial rather than adverse for the regulated businesses. For example, regulators use the promised yield on corporate bonds, which comprises the expected return to bondholders plus an allowance for expected default losses, and the latter comprises an allowance for expected bankruptcy costs plus an allowance for the value of the default option possessed by equity holders, and the inclusion of the last allowance in the cost of debt is unwarranted (because it is a mere transfer between debt holders and equity holders and therefore does not affect the WACC). Consequently, regulatory use of the promised yield on debt gives rise to an overstatement in the cost of debt and hence the WACC.[7]

2.3 Annual Updating of the Risk-Free Rate

Oxera (2023, section 2.3) proposes that the risk-free rate, which the Commerce Commission (2016, paras 534-536) sets every five years for a five year term, be reset annually so as to reduce exposure to interest rate risk. This appears to be a reference to the risk-free rate used in estimating the cost of debt rather than the cost of equity, and is therefore addressed in the next section.

2.4 Annual Updating of the Risk-Free Rate within the Cost of Debt

Oxera (2023, section 5.1.1) proposes that the Commerce Commission annually update the risk-free rate used in setting the allowed cost of debt so as to reduce exposure to interest rate risk. However, since the Commerce Commission's current approach to the cost of debt is to reset the rate every five years as the sum of the prevailing five-year risk-free rate plus the estimated Debt Risk Premium, with the latter based on a trailing average rate, it is implicit in this that regulated firms will (at the commencement of each five-year regulatory cycle) convert the base rate component of their cost of debt to five-year debt, and it would be rational for them to do so in order to avoid interest rate risk. Furthermore, the Commerce Commission (2016, paras 207-208) allows for the transaction costs of these swap contracts. In this event, firms would *not* face any interest rate risk in respect of the base rate component of their cost of debt, and

[7] See Appendix 2 for an illustration of this point.

therefore the rationale for Oxera's proposal is spurious. The fact that Oxera even presents its proposal suggests that it is not aware that the regulated firms are engaging in these interest rate swap contracts.

2.5 Averaging Periods for the Risk-Free Rate and DRP Components of the Cost of Debt

Oxera (2023, section 5.3) notes that the averaging periods for the risk-free rate and the DRP within the cost of debt are three months and five years respectively, and asserts that this is a mismatch that requires correction. However the purposes of these averaging periods are entirely different; three months for the risk-free rate component to provide a sufficiently wide window for regulated businesses to undertake interest rate swap contracts, and five years for the DRP in order to replicate the DRP costs incurred by regulated firms that borrow for five-year terms with staggered maturity dates. Thus, there is no need for these averaging periods to be matched, and Oxera's proposal to do so suggests (as in the previous section) that it is not aware that the regulated firms are engaging in these interest rate swap contracts.

It is possible that, with recognition of this misunderstanding, Oxera might still favour the same historical averaging period for both components of the cost of debt, matched to the term of borrowing for these firms. This would constitute a trailing average applied to the entire cost of debt rather than just the DRP, as does the AER and Ofgem. There are numerous pros and cons for these alternative approaches to the cost of debt. However, since the only point raised by Oxera on this matter involves a misunderstanding about the purpose of three-month averaging for the risk-free rate component of the cost of debt, I presume Oxera is ambivalent on the question of a trailing average for the entire cost of debt rather than merely the DRP. In any event, CEG (2023) clearly favours the trailing average cost of debt, and its arguments are assessed in section 3.2 below.

2.6 The Assumed Tenor of Debt

Oxera (2023, section 5.3) proposes that the assumed term of borrowing by the regulated businesses be raised from five years. Having not seen data on the terms for which these New Zealand regulated businesses are borrowing, I offer no view on this matter.

2.7 Annual Updating of the Trailing Average DRP

Oxera (2023, section 5.3) proposes that the trailing average DRP be annually updated rather than reset only every five years, to provide a better match to the costs incurred by the regulated firms. Oxera does not supply any empirical evidence on the results from annual versus five-yearly updating.

Oxera's belief that the fit will be improved by annual rather than five-yearly resetting is correct. To illustrate this, suppose a firm has a constant debt level with a debt term of five years, and maturity dates staggered so that 20% of the debt is rolled over on the last day of each year in the regulatory cycle. Suppose the DRPs prevailing at the end of each year in the last regulatory cycle are as shown in the first row of the main body of Table 1 for years 1 – 5, and the DRP prevailing at the end of the next year (year 6) is 3%, as shown in the same row of the table. The firm's DRPs incurred in years 6 and 7 are then 1.8% and 2.2%, as shown in the next row of the table. If the regulator sets the DRP allowance at the beginning of each year using the average of the values prevailing at the ends of the previous five years (annual resting), the DRP allowances for years 6 and 7 will be 1.8% and 2.2% respectively, as shown in the next row of the table. So, the DRP allowed matches the DRP incurred. By contrast, if the regulator sets the DRP allowance only at the beginning of each regulatory cycle (using the average of the values prevailing at the ends of the previous five years), and does not change it until the beginning of the next cycle, the DRP allowances for years 6 and 7 will be 1.8% for both years, as shown in the last row of the table. So, the DRP allowed does not match that incurred in year 7.

Table 1: Incurred and Allowed DRPs

Year	1	2	3	4	5	6	7
DRP at Year End	1%	2%	2%	2%	2%	3%	
DRP Incurred						1.8%	2.2%
Allowed DRP under Annual Reset						1.8%	2.2%
Allowed DRP with Five-Yearly Reset						1.8%	1.8%

This example merely illustrates Oxera's point that better matching occurs with annual resetting, but it does not determine the extent of the disparity, and it is important to do so because annual resetting is administratively more tedious and would only be warranted if the disparity was material. So, it is necessary to estimate the extent of the disparity. This requires a long time series of DRP values on BBB bonds, and this requires US data. Lally (2016, section 2.1) examines this issue using monthly data of this type (on ten-year BBB bonds for the period 1953-2014) and focuses upon extreme values for the DRP at the imagined current moment in time, corresponding to the 5^{th} and 95^{th} percentiles of the historical distribution of DRP values. The firm is assumed to commence operations at the current moment in time, and therefore to commence borrowing at that point, whilst the Trailing Average (TA) for the allowed DRP, whether updated annually or five-yearly, is immediately set in accordance with the historical TA rather than transitioned to that. Focusing on the 95^{th} percentile situation, Lally (ibid, Table 1) finds that both annual and five-yearly resetting produce very substantial divergences between the allowed and incurred DRPs, when present valued over all future years, and that the divergence is larger for five-yearly resetting. However, this scenario is unsatisfactory in the sense that a typical regulatory situation involves applying regulation to an existing rather than a newly established firm and, if the firm were newly established, any application of a TA allowance would presumably commence with the current value and transition to a TA.

In view of this, I instead assume that regulation is applied to an existing firm whose currently outstanding debt has a term of ten years with 10% maturing (and requiring rollover) in each year.[8] To facilitate comparison with the results just referred to, I use the same data set. Consider a firm whose existing borrowing (at the commencement of regulation) is (arbitrarily) set at \$1000, on which it pays the ten-year trailing average DRP in all future years (because 10% of it matures every year). The firm also 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 2.0% and expected real growth of 2.5%). 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.

[8] The assumption of ten-year debt is required by the use of ten-year DRP data. This conflicts with the Commerce Commission's assumption that firms borrow for five years but the data limitation precludes acting otherwise. The results from using five-year bonds (if such data were available) should be broadly similar to those from ten-year bonds.

The DRP data is used to estimate the time-series model underlying it (a mean-reverting model), which is then used to predict future values.[9] Regressing monthly DRPs (in percentage terms) on the preceding month's value yields the following result:

$$DRP_1 = .0451\% + .9765DRP_0$$

This is equivalent to the following mean-reverting model:

$$DRP_1 = DRP_0 + .0235(1.92\% - DRP_0)$$

So, given an existing value for the DRP (DRP_0), this model predicts the value in one month (DRP_1), which is fed back into the model to predict the value one month later, and so on.

To commence the analysis, the DRP 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 3.2% and occurred in December 1974. 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 3.17%, the rate one month later is 3.14%, and so on. These predicted rates gradually converge on 1.92%. 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 December 1974 (this average is 1.436%, which implies a payment of $14.36 in one year). 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 DRP of 3.2% (and then rolled over every ten years at the prevailing ten-year rate).[10] The resulting payment is $0.96 in one year, leading to total DRP payments of $15.32 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 1.679% (being the average over the nine years of historical rates leading up to December 1974 plus the first year's

[9] The data is from http://research.stlouisfed.org/fred2/. The idea that interest rates are mean-reverting processes is mainstream in the academic literature (Hull, 1989, page 259; Jarrow and Turnbull, 1996, page 490).

[10] 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.

future predicted monthly rates), plus the borrowing of $30 on the first years' capex (on which the current rate of 3.2% is paid), plus the expected borrowing of $31.37 on the next year's capex (on which the predicted rate prevailing in one year of 2.88% is paid) yielding a total DRP payment of $18.66 in two years' time.

I turn now to the regulatory allowance, involving a trailing average (TA) approach with the allowance reset every five years. At the beginning of the first year, the TA rate at that point is 1.436% (as noted above). Application of this rate to the regulatory debt level of $1030 at that point yields a regulatory allowance of $14.79, which will be received in one year.[11] This is less than the amount paid at that point of $15.32 (as explained above), yielding a discrepancy of -$0.53, which is converted to post-tax terms and discounted at a cost of debt of 6% to yield a present value (PV) difference of -$0.36.[12] In one year's time, application of the same allowed rate of 1.436% to the borrowing on all assets of $1061.36 at that point yields a regulatory allowance of $15.24, which will be received in two years. This is less than the amount paid at that point of $18.66, yielding a discrepancy of -$3.42, which is converted to post-tax terms and discounted at a cost of debt of 6% for two years to yield a PV difference of -$2.19. Proceeding in this way, and adding up over the first 30 years, yields a present value (PV) on the difference in the DRP values of -$11.31 as follows:

$$PV = \frac{(\$1030 * 0.01436 - \$15.32)(1 - .28)}{1.06} + \frac{(\$1061.36 * 0.01436 - \$18.66)(1 - .28)}{(1.06)^2} + \cdots = -\$11.31$$

The PV of the total debt is $1742, 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 assumed cost of debt of 6%. As a proportion of this PV of current debt of $1742, the PV difference of -$11.31 is -0.6%. If the 5th percentile (of 0.66%) had been used instead of the 95th percentile, the PV differences would have been -0.7%. These two numbers of -0.6% and -0.7% are shown in the first row of results in Table 2, in the two columns labelled "3%".

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[11] 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.

[12] The discount rate of 6% is arbitrary, but plausible variations in it do not change the conclusions reached here.

These results also reflect the assumption that new capex is initially equal to 3% of existing assets. The first row of Table 2 shows the results from varying this assumption (using new capex of 1% and 5% as well as 3%). In addition, there may be cases in which a firm's capex and hence its debt is expected to temporarily grow much more rapidly. So, I consider cases in which there is also new borrowing in the first year of $500 (half the current level) or $1000 (equal to the current debt level), coupled with $30 in the following year after which borrowing grows at 4.55% per year from $30. 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 last two columns of Table 2. All of these results assume that the DRP allowance is rest only five-yearly, at the beginning of each five-year regulatory cycle. The last row of Table 2 shows results with annual resetting of the DRP allowances.

Table 2: 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
Five Yearly	-0.7	-0.7	-0.7	-0.2	0.1	-0.8	-0.6	-0.6	-2.2	-3.1
Annual	0	-0.1	-0.1	0.4	0.8	-0.1	-0.2	-0.2	-1.5	-2.5

Table 2 shows that, for an existing business with moderate capex and growing over time at a moderate rate, regulatory use of a trailing average DRP (with annual updating and equal weights over years) will yield very small divergences between the allowed and incurred DRP costs in PV terms, even when using extreme DRP values. If the regulator updates the DRP allowances only at the beginning of each five-year regulatory cycle, the divergences will be larger but still low in absolute terms. By contrast, if capex were temporarily high, the divergences would in general significantly worsen.

The conclusions are twofold. Firstly, for an existing business with moderate capex and growing over time at a moderate rate, annual updating is slightly superior to five yearly updating, in terms of the resulting correspondence between allowed and incurred DRP costs. This is consistent with Oxera's claim. Secondly, in the case of temporarily high capex, the correspondence is much poorer for both annual and five-yearly updating, and it is less clear that annual updating is superior. However, in this case and in respect of the temporarily high borrowing, the regulator might then switch from a trailing average to an initial on-the-day allowance and transition to a trailing average over the term for which firms borrow; this would necessarily produce a perfect match of the allowed DRP to that incurred in the case of annual updating, and almost a perfect match with five-yearly updating.

3. CEG

3.1 Inconsistent Asset Beta Estimate and Debt Tenor

CEG (2023, section 2.1) note that the Commerce Commission adopts a five-year debt tenor (subject to some exceptions), that its asset beta estimate is drawn from (mostly foreign) firms with an average debt tenor of 20 years, and argue that this inconsistency leads to a downward bias in WACC. This downward bias allegedly arises because the five-year debt tenor gives rise to both a lower cost of debt and a higher asset beta than the use of 20 year debt, and the regulated businesses receive the lower allowed cost of debt associated with a five-year debt tenor but do not receive the higher asset beta associated with such five-year debt because the asset beta allowed for them by the Commission arises from firms with 20-year debt.

This argument rests on the proposition that a firm's use of longer term debt reduces its cost of equity by at least a compensating amount, and this occurs because its asset beta declines as its debt term increases. In support of this proposition, CEG offers three arguments. Firstly, they note that longer dated debt is "*typically associated with a higher cost of debt*" (ibid, para 16), which is uncontroversial, and assert that "*There is only one reason why the equity owners of a firm would choose to issue higher cost long term debt rather than lower cost short term debt. This must be because doing so reduces the cost of equity. Moreover, in the CAPM used by the NZCC to estimate the cost of equity, this must manifest through a lower beta.*" (ibid, paras 16-17). However, several alternative reasons for firms undertaking long-term rather than short-term borrowing have been presented in the finance literature. For example, longer term debt (coupled with staggered maturity dates) ensures that a smaller proportion of the debt matures (and requires rollover) within any short period, which reduces the refinancing risk to a firm (Diamond, 1991). CEG (2015, para 59) makes the same point in arguing that very short-term debt (say three monthly) would minimize a firm's debt costs in most situations but this would require refinancing 100% of its debt every three months, which would expose it to possible disruptions in financial markets that would make it impossible to refinance its debt, leading to default and therefore costly constraints on the firm's ability to operate. Accordingly, the expected cost of short-term debt might be higher than longer-term debt. At no point does CEG (2015) mention any effects of short-term debt on the firm's asset beta. Furthermore, in surveying arguments for and against longer term debt, Copeland et al (2005, pp. 615-617) do not present any argument of the type presented by CEG (2023).

Secondly, CEG (2023, section 2.1) cite the Miller-Modigliani (1958) theorem, which CEG characterizes as stating that, under certain conditions, a firm's WACC is invariant to its capital structure. However, this theorem relates to the leverage of the firm (the proportion of its financing that is in the form of debt) rather than to the term of its debt. So, it is irrelevant to CEG's claim. Thirdly, CEG notes that the Commerce Commission (2016, paras 546-562) adopts the average leverage of the firms used to estimate the asset beta, so as to mitigate errors arising from failure to recognize debt betas, and CEG then asserts that the same internal consistency principle must apply to the debt tenor and asset beta issue. However, the two issues are quite distinct and the merits of the leverage/asset beta argument have no apparent relevance to the debt tenor/asset beta issue. CEG would need to demonstrate that asset betas are related to debt tenor, by developing a formula akin to those relating equity betas to leverage, such as Hamada (1972) and Conine (1980). CEG have not done so.

3.2 The Trailing Average Cost of Debt

CEG (2023, section 2.1.1) recommend regulatory use of a trailing average cost of debt, rather than the hybrid method used by the Commerce Commission (involving a trailing average DRP coupled with an on-the-day risk-free rate). In support of this recommendation, CEG claims that the former is "*simpler to hedge to and is more stable (which benefits both EDBs and customers)*." I agree with the hedging claim, because the use of a trailing average cost of debt obviates the need for firms to undertake interest rate swap contracts to match the base rate component of their cost of debt to the on-the-day allowance by the Commission. In respect of CEG's stability claim, the TA approach to the allowed cost of debt differs from the hybrid approach only in substituting the TA for the on-the-day value for the risk-free rate component of the cost of debt, and the Law of Large Numbers implies that averages (of all types) are more stable than the individual data points.[13] Thus, in respect of the risk-free rate component of the allowed cost of debt, the TA approach will yield more stable results. However, CEG's reference to stability presumably relates (and should relate) to the allowed regulatory revenues

[13] See https://en.wikipedia.org/wiki/Law_of_large_numbers.

rather than one component of them, and negative correlation between the risk-free rate component of the cost of debt and the other components of revenues might induce more stability in revenues arising from the hybrid rather than the TA approach to the cost of debt. CEG offer no empirical evidence on this, and there is no readily available New Zealand time series of BBB bond yields to test it. However, using Australian data from 2005-2021, Lally (2021, pp. 34-38 and Table 5) estimates revenue volatility under different regulatory approaches to the cost of debt and finds that the TA approach to the cost of debt yields significantly lower volatility than the hybrid approach, consistent with CEG's claims. Thus, I also agree with CEG's claim concerning the stability of revenues, and that this is beneficial to consumers. By contrast, the impact on the stability of business' revenues is not important, as businesses would be concerned instead with the stability of net cash flows rather than revenues.

However, CEG neglect to mention two additional points, which favours the Commerce Commission's hybrid approach over a TA cost of debt. Firstly, within the cost of debt, the hybrid approach always uses the five-year risk-free rate whilst the TA cost of debt uses a longer term risk-free rate whenever the Commission recognizes that the firm's debt tenor is greater than five years. As noted by CEG (2015, para 16), longer-term interest rates are generally higher than shorter term rates. So, for these businesses, the hybrid approach will be expected to generate a lower average allowed cost of debt and therefore lower average output prices for consumers, but with no disadvantage to these regulated businesses because the risk-free rate component of its allowed cost of debt matches its debt costs in both cases (a TA rate in excess of five years when the regulator uses a TA approach, and an on-the-day five-year rate when the regulator uses the hybrid approach coupled with the firm's use of interest rate swap contracts).

To illustrate this, suppose a business has ten-year debt, it is treated as having a ten-year debt tenor by the Commission, the average ten-year risk-free rate is 5% and the average five-year risk-free rate is 4.5%. For this business, its allowed prices will be lower on average under the hybrid method (being based upon an average allowed risk-free rate of 4.5%) than under the TA cost of debt (being based upon an average allowed risk-free rate of 5%). In addition, under the hybrid approach, the firm's allowed risk-free rate averages 4.5%, and this matches its costs because it uses interest rate swap contracts to convert the base rate component of its ten-year debt into five-year debt. In addition, under the TA cost of debt approach, the firm's allowed risk-free rate averages 5% and this matches its costs from borrowing ten-year debt.

The second point that CEG does not mention is that the appropriate debt tenor for a firm or group of firms is not obvious, any estimate of it is likely to be too high or too low, leading to an allowed cost of capital that is too high or low, with adverse implications for consumers and firms respectively. Estimation problems include 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. In respect of the choice of firms, the use of regulated firms is subject to the problem that their choice of debt tenor might be affected by the nature of the regulation they were subject to, which constitutes a circularity problem. Alternatively, if unregulated firms were chosen, they would need to be efficient, and similar to the regulated businesses in question, but such firms are unlikely to exist; the 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. This problem in estimating the appropriate debt tenor afflicts both the TA cost of debt approach favoured by CEG and the hybrid approach favoured by the Commerce Commission, but is more severe for the former than the latter because errors in estimating the correct tenor for the TA approach to the cost of debt afflict the entire cost of debt rather than just the DRP.

To illustrate this point, suppose the TA risk-free rates for terms of 8, 10 and 12 years are 4.2%, 4.3% and 4.4% respectively, each averaged over the same term, and the corresponding TA rates for the DRP are 2.2%, 2.3% and 2.4%. Suppose further that the appropriate debt tenor is ten years, but is erroneously judged to be 8 years. So, using the TA approach to the cost of debt, the allowed cost of debt would be 4.2% + 2.2% = 6.4% whereas it should have been 4.3% + 2.3% = 6.6%. The resulting estimation error would then be 0.2%, to the disadvantage of the regulated businesses. By contrast, using the hybrid approach, the allowed DRP would be 2.2% whereas it should have been 2.3%, yielding an underestimate of 0.1% to the disadvantage of the regulated businesses. So, the effect of the error in estimating the debt tenor is more severe for the TA than the hybrid approach to the cost of debt.

4. Conclusions

This paper has reviewed submissions from Oxera and CEG to the Commerce Commission on the risk-free rate within the CAPM and various aspects of the cost of debt. With two partial exceptions, I consider that these submissions are conceptually or empirically flawed and therefore do not agree with them. The first exception is Oxera's submission that the trailing average DRP allowance be reset annually rather than five yearly, so as to provide a better match to the costs incurred by the regulated firms. My empirical analysis supports this claim, but the gain is very small and annual updating incurs additional administrative costs. Accordingly, there are advantages and disadvantages to annual versus five-yearly updating, and I do not express a view on which is on balance the better method.

The second exception is CEG's claim that use of a trailing average cost of debt is preferable to the hybrid method used by the Commerce Commission (involving a trailing average DRP coupled with an on-the-day risk-free rate) because it is simpler to hedge to (which benefits businesses) and is more stable (which benefits customers). I agree with both claims, but CEG neglects to mention two additional points, which favours the Commerce Commission's hybrid approach over a TA cost of debt. Firstly, whenever the Commission recognizes that a regulated firm's debt tenor is greater than five years, the hybrid approach will be expected to generate a lower average allowed cost of debt and therefore lower average output prices for consumers, but with no disadvantage to these regulated businesses because the risk-free rate component of its allowed cost of debt matches its debt costs in both cases (a TA rate in excess of five years when the regulator uses a TA approach, and an on-the-day five-year rate when the regulator uses the hybrid approach coupled with the firm's use of interest rate swap contracts). Secondly, the appropriate debt tenor for a firm or group of firms is not obvious and any estimate of it is likely to be too high or too low, leading to an allowed cost of capital that is too high or low, with adverse implications for consumers and firms respectively. This problem in estimating the appropriate debt tenor afflicts both the TA cost of debt approach favoured by CEG and the hybrid approach favoured by the Commerce Commission, but is more severe for the former than the latter because errors in estimating the correct tenor for the TA approach to the cost of debt afflict the entire cost of debt rather than just the DRP. Accordingly, there are advantages and disadvantages to the hybrid method over the TA cost of debt, and I do not express a view on which is on balance the better method.

APPENDIX 1: Proof that the Risk-Free Rate Term Must Match 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 residual 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}):

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

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

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

and equation (2) becomes

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

So the NPV = 0 test is satisfied. By contrast, if the allowed cost of equity in the numerator of equation (4) were larger or smaller than the discount rate in that equation, the present value of the future cash flows of the business (V_0) would not match the initial investment of A. In 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.

It is sometimes asserted 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 (3); 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 ($A – DEP_1$).

It is also sometimes asserted 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 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.

It is also sometimes asserted 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 this is not true because 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 due to the regulator erring 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 lead to 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:[14]

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

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:

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

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

[14] 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.

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, at the current point in 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:

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

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).

APPENDIX 2: The Implications of Regulatory Use of the Promised Yield on Debt

The promised yield on corporate bonds comprises the expected return to bondholders plus an allowance for expected default losses, and the latter comprises an allowance for expected bankruptcy costs plus an allowance for the value of the default option possessed by equity holders, and the inclusion of the last allowance in the allowed cost of debt is unwarranted (because it is a mere transfer between debt holders and equity holders and therefore does not affect the WACC). Consequently, regulatory use of the promised yield on debt gives rise to an overstatement in the cost of debt and hence the WACC.

To illustrate this point, suppose that an unlevered firm will deliver a payoff of $155m or $55m in one year with equal probability, investors are risk neutral, the risk free rate is 5%, and there are no taxes (personal or corporate).[15] The expected payoff on the firm is then $105m, which is discounted at the unlevered cost of equity of 5%, to yield a value now for the firm of $100m, which equals the purchase price of the assets. This satisfies the NPV = 0 principle. Suppose now that the firm acquires some debt finance, promises a payment of $60m to debt holders (principal plus interest), and there are no bankruptcy costs, i.e., even in the presence of debt, the possible payoffs from the firm in one year to its capital suppliers are still $155m or $55m with equal probability. So, the value of the firm is still $100m and the WACC now involves a weighted average of the costs of debt and equity, which is still 5%. However, given the default option possessed by equity holders (the option to default when the value of the firm in one year is under $60m), the payoff on the debt will be $60m in the good state and only $55m in the bad state, and therefore the value now of the debt will be

$$B = \frac{.5(\$55m) + .5(\$60m)}{1.05} = \$54.76m$$

So, a promise of $60m will allow the firm to borrow $54.76m, and the promised yield on debt will then be 9.57% comprising the risk free rate of 5% and compensation of 4.57% to debt holders for expected default losses, which arise purely from the default option possessed by

[15] The example is intended only to illustrate the principle and not also the scale of the effect. So, these simplifying assumptions are acceptable.

equity holders rather than also from bankruptcy costs. Since the debt comprises 54.76% of firm value then the WACC defined using the promised yield on debt as the cost of debt will be

$$WACC = .4524ke + .5476kd = .5(5\%) + .5(9.57\%) = 7.50\%$$

The WACC is now too high, being 7.50% rather than 5%, because the cost of debt is wrongly defined as the promised yield. If the regulator allowed 7.50% on the firm's asset base of \$100m, the regulator would then set a price or revenue cap so that the firms' expected payoffs in one year would be \$100m(1.075) = \$107.5m. The resulting value now of the firm would be as follows:

$$V_0 = \frac{\$107.5m}{1.05} = \$102.4m$$

By contrast, the purchase price of the assets is only \$100m. This violates the NPV = 0 principle, and shareholders would have been gifted \$2.4m through the regulator defining the cost of debt as the promised yield. Of course, it is not feasible for regulators to do otherwise, as this would require deducting from the promised yield on debt the allowance for the default option possessed by equity holders. However, the result is that equity holders would be over compensated by the regulator.

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