REVIEW OF CEG'S SUBMISSION ON THE DEBT TENOR ANOMALY

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CONTENTS

EXECUTIVE SUMMARY

This paper has reviewed CEG's views on the Debt Tenor Anomaly, and my principal conclusions are as follows. Firstly, as argued by CEG, the Merton (1974) model does imply that debt beta rises with debt tenor, and therefore that a firm's equity beta falls with debt tenor, and this may lead to the Commission underestimating the WACC of New Zealand regulated businesses when its sets the debt tenor at five years but uses beta comparators that have an average debt tenor of 20 years. Secondly, the Merton model assumes that all of a firm's debt is zero coupon and matures at the same point in time. This is a poor representation of the real world situation in which firms stagger their debt maturity dates and this alone implies that the debt betas deduced from this model are not reliable and may not even increase with tenor. Thirdly, even if one does use the Merton model, the term parameter within it is the time to maturity of the bond rather than its tenor, and the values at both the beginning and end of the regulatory cycle are relevant, and correction for these two points substantially reduces the WACC error claimed by CEG. Replacing the term to maturity of the bonds by their duration, to reflect the existence of coupon payments, further reduces the WACC error, to 0.08%. Fourthly, these reductions in the WACC error undercut CEG's claim that the issue can be addressed through raising the allowed debt tenor for the New Zealand businesses from five to ten years, because doing so would then overcompensate the businesses. Fifthly, the small size of the error implied by the use of the Merton model and the fact that its assumptions are a very poor representation of the real world situation in which firms stagger their debt maturity dates suggest that no correction should be made. If there is an underestimate of WACC through doing so, it is mitigated and possibly more than compensated for by the Commission using the promised yield on debt to determine WACC.

1. Introduction

This paper reviews CEG's (2023b, section 2) views on the "Debt Tenor Anomaly" in its response to the Commerce Commission's IM Draft Decision on Cost of Capital.

2. CEG's Principal Argument

CEG (2023b, section 2) notes that the Commerce Commission estimates the equity beta for New Zealand energy businesses companies by using comparators that issue 20 year debt, whilst adopting a debt term of five years for these energy businesses. Implicit in this approach is the assumption that the equity beta of a business is invariant to the term of its debt. However, letting L denote leverage and β_V the beta of the firm's assets, the equity beta of a business (β_S) firm is inversely related to its debt beta (β_d) as follows

$$\beta_S = \frac{\beta_V - \beta_d L}{1 - L} \tag{1}$$

In addition, CEG argues that debt beta is positively related to debt tenor. It follows that equity beta is inversely related to debt tenor. Thus, the equity betas of businesses with 20 year debt will be lower than otherwise identical businesses with five year debt. Consequently, the Commission's use of equity beta estimates from firms with 20 year debt to estimate the cost of capital for businesses with five-year debt will underestimate the equity beta for the latter firms, and therefore underestimate its overall cost of capital.

In support of its claim that debt beta is positively related to debt tenor, CEG invokes the Merton (1974) model, which assumes that all of a firm's debt will mature in T years' time and that equity holders will default on the firm's debt at that time if the value of the assets at that point is below the promised payment to debt holders, i.e., they will 'put' the assets of the firm to its debt holders at that time if the value of the assets at that point is below the promised payment to debt holders. Consequently, letting β_v denote the asset beta of the firm, y the debt risk premium, σ_v the standard deviation of the return on the firm's assets, and $N(d_1)$ cumulative standard normal density up to d_1, the debt beta is[1]

[1] CEG do not provide a proof of this formula. Oxera (2020, page 17) also presents the formula and cites Berk and deMarzo (2014, page 768, equation 21.20), but the latter do not provide a proof. Appendix 1 here provides the proof.

$$\beta_d = \frac{1 - N(d_1)}{L} \beta_V \quad (2)$$

$$d_1 = \frac{-ln(L) - (y - 0.5\sigma_v^2)T}{\sigma_v \sqrt{T}}$$

CEG (2023b, Appendix A) differentiate β_d with respect to T and concludes that[2]

$$\frac{\partial \beta_d}{\partial T} = -\frac{N(d_1)}{L} \beta_V \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial T}$$

$$= -\frac{N(d_1)}{L} \beta_V \frac{\partial N(d_1)}{\partial d_1} \frac{[T(0.5\sigma_v^2 - y) + \ln(L)]}{2\sigma_v T \sqrt{T}} \quad (3)$$

Based upon estimates of the parameters in the term [ ] within equation (3), CEG concludes that the sign of [ ] is negative. Since all other terms on the RHS of equation (3) are positive, apart from the minus sign, it follows that $\partial \beta_d / \partial T$ is positive. It therefore follows from equation (1) that the equity beta β_S is negatively related to the debt tenor T.

CEG (2023b, section 2.3.3) then estimate the WACC understatement resulting from using comparator firms with a debt tenor of 20 years rather than the correct debt tenor of five years. In particular, they assume an asset beta of 0.40, leverage for the beta comparator firms of 0.41, leverage for the New Zealand regulated businesses of 0.41, a debt beta for firms issuing five-year debt of 0.02, and a debt beta for otherwise identical firms issuing 20-year debt of 0.12. Using equation (1), the comparator firms would have an equity beta of 0.595 whilst the New Zealand regulated businesses would have an equity beta of 0.664.[3] The error in using the estimate from the comparator firms would then be an underestimate of 0.069. Since the cost of equity is

$$k_S = R_f(1 - T) + \beta_S MRP$$

[2] The term $N(d_1)$ should not appear in the derivative, as this is the term that is being differentiated, but this does not affect CEG's conclusions.

[3] These results are shown in CEG (2023b, Table 2-2) whilst the preceding paragraphs on the same page of their paper report numbers of 0.59 (clearly rounded) and 0.68 (clearly wrong).

the impact of this beta underestimate on the cost of equity would then be the product of this beta error (.069) and the market risk premium (.07), which is an underestimate in the cost of equity of 0.00483. Since the WACC is

$$WACC = k_S(1 - L) + k_d(1 - T_c)L$$

the impact of this underestimate in the cost of equity of 0.00483 would be to underestimate the WACC by .000483(1 - 0.41) = 0.00285. The controversial part of this process is the estimates for the debt betas for firms with five and 20 year debt, of 0.02 and 0.12 respectively. The basis for these two estimates is debt beta estimates from Oxera (2020, Figure 2.4) for 10 and 12 year debt of 0.05 and 0.07 respectively. Using these two estimates, which are obviously rounded to the nearest 0.01, CEG extrapolate well beyond them to generate debt beta estimates for debt terms of five and 20 years. The presumed purpose of equations (2) and (3) is to provide theoretical support for the conclusion that debt beta is positively related to debt term, consistent with the Oxera estimates for 10 and 12 year debt.

CEG (2023b, paras 52 – 54) then compare their estimate of the WACC understatement from estimating the equity beta for the New Zealand businesses from the foreign comparators with regulatory use of the yield on ten rather than five year debt. CEG estimate the term credit spread differential at 0.1% per year. They also adopt an estimate for the risk-free rate differential for ten over five-year bonds of 0.14%, from Lally (2023a, page 6). The cost of ten-year debt is then estimated to be 0.64% higher than five-year debt, and the impact on the WACC would be 0.64%*L = 0.64%*0.41 = 0.26%. This is similar to adjusting the equity beta using the Merton (1974) model.

CEG's (2023b, section 2.5) preferred option for dealing with the WACC underestimate of 0.29% is to raise the debt term used in setting the allowed cost of debt, from five to ten years, because it would address the issue whilst aligning the benchmark debt with observed practice.

3. Analysis of CEG's Principal Argument

CEG's (2023b, section 2) principal argument, described in the previous section and whose results appear in the first row of Table 1 below, is subject to the following problems. Firstly, instead of using estimates from Oxera (2020, Figure 2.4) of the debt betas for 10 and 12 year debt to speculatively extrapolate to the betas of five and 20 year debt, CEG should instead have simply redone Oxera's calculations for the five and 20 year bonds. To do this requires the parameter values used by Oxera, apart from the debt term. Oxera (ibid, Figure 2.4) reports leverage of 0.4, a DRP of 0.01, equity volatility of 0.30 and an equity beta of 0.7. The latter two figures are the wrong parameters for the debt beta formula (2), which requires the asset volatility and asset beta. Oxera (ibid, Figure 2.3) recognizes this and corrects them, but fails to disclose the results and Oxera (ibid, Figure 2.4) erroneously repeats the very parameter values of 0.30 and 0.70 that it has replaced. Appendix 2 below deduces that their values are 0.18 for the asset volatility and 0.462 for the asset beta. With these values, equation (2) yields debt betas and the resulting WACC error as shown in the second row of Table 1. The results are very close to CEG's (which appear in the first row of Table 1).

The second problem with CEG's analysis is that the parameter values used in the above calculations are inconsistent with parameter values used elsewhere in CEG's calculations or favoured by them. In particular, CEG (2023b, Table 2-2) uses leverage of 0.41 rather than Oxera's 0.40, and CEG (Appendix A, Table 2) seems to favour an asset volatility of 0.22 (CEG, Appendix A, Table 2) rather than Oxera's 0.18. CEG (2023b, para 49) also deduces an asset beta of 0.40 from the estimated equity beta of 0.595 for the comparators, using equation (1) above and the estimated debt beta of 0.12 for these comparators. However, starting with the estimated equity beta of 0.595, it is necessary to simultaneously solve for the asset beta and the debt beta, as with equations (13) and (14) in Appendix 2 below. So, using equation (2) with $T = 20$, $y = 0.01$, $L = 0.41$ and $\sigma_v = 0.22$:

$$d_1 = \frac{-\ln(0.41) + \left(\frac{0.22^2}{2} - 0.01\right)20}{0.22\sqrt{20}} = 1.1948$$

and therefore $N(1.1948) = 0.8839$ and therefore:

$$\beta_d = \frac{(1 - 0.8839)}{0.41}\beta_V$$

In addition

$$\beta_V = 0.59\beta_S + 0.41\beta_d = 0.59(0.595) + 0.41\beta_d$$

Substituting the latter equation into its predecessor and solving yields β_d = 0.1125 and then β_v = 0.40.[4] Using equation (2) again, with β_v = 0.40 and T = 5 instead of 20, then yields β_v = 0.0240. These results are shown in the third row of Table 1 below, along with the resulting errors in β_S and *WACC*. The results are close to CEG's results as shown in the first row of the table.

Table 1: WACC Errors Arising from Debt Beta Errors

Bonds	Term	Averaged	Coupons	DRP	β_{d5}	β_{d20}	$\Delta\beta_e$	$\Delta WACC$
One	Tenor	No	No	0.01	.02	.12	.069	0.29%
One	Tenor	No	No	0.01	.0107	.1154	.073	0.30%
One	Tenor	No	No	0.01	.0240	.1125	.062	0.25%
One	TTM	No	No	0.01	.0036	.0631	.041	0.17%
One	TTM	Yes	No	0.01	.0035	.0439	.028	0.11%
One	Duration	Yes	Yes	0.01	.0027	.0317	.020	0.08%
Stagd	Duration	Yes	Yes	0.01	.0050	.0442	.027	0.11%
One	Tenor	No	No	Derived	.0197	.1137	.065	0.27%

The third problem with CEG's analysis is that the term parameter in Merton's (1974) model is the remaining term to maturity of the bond rather than its tenor. Thus, if a firm did borrow for T years and all of their debt matured at the same time (as assumed in the Merton model), the time to maturity for that debt when an analysis like this was conducted would be anything from zero to T years, with an average of half of it. Thus, for a five year tenor, equation (2) should use a term to maturity of 2.5 years. Likewise, for a 20 year tenor, equation (2) should use a term to maturity of 10 years. Following the same process as before, the results are shown in the fourth row of Table 1. The difference between the debt betas for 5 and 20 year tenors is much less than CEG's claim, which reduces the WACC error from 0.26% to 0.18%.

The fourth problem with CEG's analysis is that, even if a firm did borrow for T years and all of their debt matured at the same time (as assumed in the Merton model), equation (2)

[4] Coincidentally, the first of these values is close to CEG's value of 0.12, and therefore the latter matches CEG's value of 0.40.

generates a debt beta relevant only to the moment in time for which the parameter values apply, including the residual term to maturity of the bonds. However, CEG intends it to be used for a regulatory period of five years. Thus, for the five year bonds, CEG ought to have averaged the term to maturity of 2.5 years and five years later, which is also 2.5 years. For the 20 year bonds, they ought to have averaged the term to maturity of 10 years and five years later (when the term to maturity would be five years), yielding 7.5 years. Following the same process as before, the results shown in the fifth row of Table 1, and further reduce the WACC error to 0.11%.

The fifth problem with CEG's analysis is that, even if all of the firm's debt does mature at the same point in time (as assumed in the Merton model), debt typically pays coupons during the term of the bond and the duration (the value-weighted average term to the future payments on the bond) is less than the term to maturity. Oxera (2020, page 18) recognizes this point and seeks to address it by replacing the term of a bond by its duration, thereby reducing a debt tenor of 13.8 years to a duration of 10 years. Since CEG adopted Oxera's estimates, they presumably accept this substitution of duration for term to maturity. Assuming coupon and current rates of 6% (5% for the risk-free rate and a debt risk premium of 1%), and arbitrarily setting the face value on the bonds at $1 (which does not affect the result), the value of the bond with 2.5 years to maturity would be:[5]

$$B = \frac{\$0.06}{(1.06)^{0.5}} + \frac{\$0.06}{(1.06)^{1.5}} + \cdots \frac{\$1.06}{(1.06)^{2.5}} = \$1.029$$

and the duration of these bonds would be

$$D = (0.5)\frac{\left[\frac{\$0.06}{(1.06)^{0.5}}\right]}{\$1.029} + (1.5)\frac{\left[\frac{\$0.06}{(1.06)^{1.5}}\right]}{\$1.029} + (2.5)\frac{\left[\frac{\$1.06}{(1.06)^{2.5}}\right]}{\$1.029} = 2.33\ yrs$$

[5] The risk-free rate of 5% corresponds to the current (25.08.2023) value for five-year New Zealand government bonds: see Table B1 on the website of the Reserve Bank of New Zealand (https://www.rbnz.govt.nz/statistics/series/exchange-and-interest-rates/wholesale-interest-rates). The risk premium of 1% is that used by Oxera (2020, page 18) in calculations relied upon by CEG, and used for the calculations in Table 1 above.

Similarly, the duration for bonds with 7.5 years to maturity is 6.08 yrs. Following the same process as before, but using these durations rather than terms to maturity, the results are as shown in the sixth row of Table 1, and further reduce the WACC error to 0.08%.

The sixth problem with CEG's analysis is that firms generally stagger their debt maturities so that a firm with a debt tenor of 20 years would have 1/20th maturing each year, thereby granting it significant protection from rollover risk. Assuming interest is paid annually, and the coupon rates on this debt is 6% (as in the preceding paragraph) and arbitrarily denoting the total face value of its debt as \$100m, the promised payments on the firm's existing debt would be \$5m at the end of each year (the face value payments at the maturity of each bond) along with coupon payments of \$6m at the end of the first year, \$5.7m at the end of the second year (because the debt maturing at the end of the first year has dropped out), \$5.4m at the end of the third year, and so on. The duration of this existing debt is an average of the times to payments (1, 2, 3, etc years), weighted by the value of the payments at each of these times. Assuming the prevailing interest rate matches the coupon rate of 6% (as in the preceding paragraph), then the value of the aggregate payments would be:

$$B = \frac{\$11m}{1.06} + \frac{\$10.7m}{(1.06)^2} + \cdots \frac{\$5.3m}{(1.06)^{20}} = \$100m$$

The value weights for these payments would then be 0.104, 0.095, etc, and the duration would then be:

$$D = 1(0.104) + 2(0.095) + \cdots + 20(0.017) = 7.53\, yrs$$

Repeating the process for the debt of a firm with a five-year tenor, in which 1/5th would mature each year, the duration would be 2.78 yrs. Following the same process as before, but using these durations, the results are as shown in the seventh row of Table 1, the WACC error to 0.11%. With this approach, the debt betas in five years' time would not be any different, and therefore no averaging correction is required for this issue.

The seventh problem with CEG's analysis is that Oxera's (2020, Figure 2.4) debt beta estimates (which CEG use) assume a value of 0.01 for the debt risk premium (y), and also assume that y is invariant to the debt tenor T (as does CEG in deriving equation (3) above). By contrast, CEG (ibid, para 52) argues that y increases with T. So, CEG's beliefs about y

are inconsistent with those of Oxera despite relying upon their debt beta estimates. Furthermore, equation (2) is derived from the Merton (1974) model for the value of debt, and the primary purpose of that model (as evidenced in the title of the paper) is to estimate the debt risk premium (see Merton, 1974, equation (14)). Thus, one must use values for *y* within equation (2) that are consistent with the Merton model rather than arbitrarily selected, as Oxera does. The Merton (1974) formula for the value of a firm's zero-coupon debt which all matures in *T* years is as follows:[6]

$$B = V[1 - N(k_1)] + Fe^{-R_f^c T} N\left(k_1 - \sigma\sqrt{T}\right) \tag{4}$$

where

$$k_1 = \frac{\ln\left(\frac{V}{F}\right) + \left(R_f^c + 0.5\sigma^2\right)T}{\sigma\sqrt{T}}$$

Having determined *B*, the continuously compounded yield to maturity on the bonds is *k* such that

$$B = Fe^{-kT} \tag{5}$$

and the debt risk premium *y* is the excess of *k* over the risk-free rate. However, since leverage is fixed at 0.41, *B* = 0.41*V*. So, equation (4) must be solved iteratively. I illustrate this for *T* = 5, for which the prevailing discrete time risk-free rate is .05.[7] This implies a continuously compounded rate of *ln*(1.05) = .0488. Since the parameter of concern is *k*, it is sufficient to arbitrarily set the promised payment on the debt (*F*) at \$1. Starting with a guess at *y* of 0.01 and hence *k* = .0588, the value of debt from equation (5) would be *B* = \$0.7453, which implies *V* = \$0.7453/0.41 = \$1.818. Substituting this into equation (4) along with the other parameter values yields *B* = \$0.7729, which is more than the initial value. So, *V* = \$0.7729/0.41 = \$1.885, and substitution of this into equation (4) with the other parameter values yields *B* = \$0.7749, which is slightly more than the preceding value. So, *V* = \$0.7749/0.41 = \$1.890, and substitution of this into equation (4) with the other parameter values yields *B* = \$0.7749, which matches the preceding value. So, *B* = \$0.7749. Substitution into equation (5) and solving yields *k* = .0510, and therefore *y* = .0510 - .0488 =

[6] See Appendix 1 for a proof that is simpler than that in Merton (1974).

[7] This is the current (25.08.2023) value for five-year New Zealand government bonds: see Table B1 at the website of the Reserve Bank of New Zealand: (https://www.rbnz.govt.nz/statistics/series/exchange-and-interest-rates/wholesale-interest-rates).

.0022. This is considerably smaller than Oxera's estimate of 0.01. If this process is repeated for the 20 year bonds the result is 0.0103, which is very close to Oxera's estimate of 0.01. Replicating the analysis in the third row of Table 1, with these more appropriate values for *y*, the debt betas and resulting WACC errors are shown in the last row of Table 1. The debt betas and WACC error are very similar to the third row, despite Oxera's use of $y = 0.01$ for five-year debt being quite inaccurate. It follows that Oxera's use of a debt premium of 0.01 for all terms to maturity is sufficient for the current purposes.

The eighth problem with CEG's analysis is that the Merton (1974) model on which it relies, in assuming that the firm's debt (with a term to maturity of *T* years) is zero coupon and maturing at a single point in time (in *T* years), implies that default on the bonds could occur only at that bond maturity point. In addition, it implies that the excess of the bond promised payment over the firm's asset value in *T* years could be very large, because the asset's value could have fallen below the promised payment on the bonds many years earlier and continued to plunge. The losses to bondholders could then be very large. By contrast, in the typical real-world situation in which a firm has staggered maturity dates on its debt (some maturing each year) and interest payments, default on the bonds could occur at any of these points in time (and would do so if the value of the firm's assets at that time is less than the value of the bonds). Additionally, if default occurred with staggered debt maturities, the shortfall in asset value would in general be much smaller than if default could not occur for *T* years. The losses to the bondholders would then be smaller. This implies that default is more likely in the real-world situation in which firms stagger their maturity dates compared to the situation to which the Merton model applies, but the losses to bondholders should default occur are likely to be much smaller. Thus, the Merton (1974) model is a poor representation of the default risks faced by a firm in the typical real-world situation in which it staggers its debt maturities. Accordingly, the debt beta estimates arising from the Merton model may be poor, and may not even be increasing with debt tenor.

In summary, if the Merton model is used to estimate debt betas and the debt term used within it reflects the term to maturity of the bonds rather than their tenor, and terms to maturity for both the beginning and end of the regulatory period are used, and terms are further corrected for duration, the estimated WACC error from the Commission's approach falls from the 0.29% claimed by CEG to 0.08%. Accordingly, adopting CEG's preferred solution (of raising the debt term used by the Commission from five to ten years and thereby raising the

WACC by 0.26% in their view) would significantly overcompensate for it. CEG's less preferred option is to take account of debt betas for different debt terms in estimating the equity beta, using estimates of debt betas from the Merton approach, leading to a WACC increase of 0.29%. However, proper adoption of the Merton approach would lead to a considerably smaller WACC increase than 0.29%. Furthermore, the Merton model is a poor representation of the default risks faced by a firm in the typical real-world situation in which it staggers its debt maturities, and therefore the debt beta estimates arising from it may be poor and may not even increase with tenor. This suggests that the Merton model not be used. The third option would be to estimate debt betas by a more conventional approach, but such estimates are not very reliable. The fourth option would be to take no action, leading (even if the Merton model is adopted subject to the corrections noted above) to a small underestimate of WACC resulting from the difference between the debt tenors of the comparator firms. This underestimate may be more than compensated for by regulatory use of the promised yield on debt (as discussed in Lally, 2023b, Appendix 2).

Finally, I note that CEG favours raising the benchmark debt term from five to ten years to both address the WACC underestimate and to align the benchmark debt with observed practice. I offer no view here on the appropriate debt term benchmark. However, if it really is ten years as CEG claims, that fact alone justifies use of a ten-year cost of debt and use of an equity beta estimate derived from comparators with 20 year bonds would still leave a WACC underestimate arising from the difference between the terms of these 10 and 20 year bonds.

4. Analysis of CEG's Other Arguments

CEG (2023b, paras 21 – 24) notes that the Commission sets the benchmark leverage equal to the average amongst the beta comparators, to avoid WACC estimation error that would arise from any such difference coupled with the Commission's use of a beta gearing formula that does not include the debt beta and does so to avoid errors in estimating the debt beta ("leverage anomaly"). By analogy, CEG argues that the Commission should also set the benchmark debt tenor equal to the average amongst the beta comparators to avoid WACC estimation error from any such difference coupled with the Commission's use of a beta gearing formula that does not include the debt beta ("tenor anomaly"). However, there is a critical difference in the two situations. In the latter situation, the Commission considers that there is a clear difference between the appropriate debt tenor for the New Zealand businesses (five years) and the average debt tenor for the beta comparators (20 years), and using the latter would significantly raise the allowed cost of debt and hence the WACC. By contrast, in the former case, there is no indication that the average leverage of the beta comparators (0.41) is unsuitable for the New Zealand businesses. Thus, there is no drawback to using the average leverage of the beta comparators in order to address the "leverage anomaly".

CEG (2023b, para 34) asserts that the Miller-Modigliani theorem requires that WACC is invariant to capital structure choices. However, later in this same submission, CEG (2023b, para 75) states that the theorem holds "absent transaction costs". Furthermore, in their earlier submission, CEG (2023a, section 2.1) claims that this theorem holds only "if capital markets are efficient and there are no transaction costs". Thus, CEG make three mutually inconsistent claims about this theorem. The seminal paper in this area (Miller and Modigliani, 1958, pp. 272-276) also examined a classical tax world, in which interest is tax deductible and personal tax rates on debt and equity returns are equal, and concluded that WACC declined with leverage due to the tax deduction on interest.

CEG (2023b, para 38) states that, within a CAPM environment, all differences in expected return are driven by differences in beta risk, and this applies for all asset classes including debt. However, consistent with standard practice, the Commission invokes the CAPM only for estimating the cost of equity whilst the cost of debt is determined purely empirically. Furthermore, one component of the expected rate of return on debt is the liquidity premium within the DRP, and this is not explained by the CAPM. Furthermore, the cost of debt is the promised rate rather than the expected rate, and the former exceeds the latter, and this differential is not explained by the CAPM because the CAPM is concerned only with the expected rate of return.

CEG (2023b, para 46) asserts that longer tenor debt is more costly than shorter tenor debt, and therefore must have a higher beta. However, as explained in the previous paragraph, the cost of debt includes a liquidity premium and also includes the excess of the promised over the expected rate. Neither of these is determined by the debt beta, and they may increase with tenor, and this alone may explain why longer tenor debt (on average) has a higher cost than shorter tenor debt.

CEG (2023b, paras 59 – 63) quotes a paragraph from my earlier report (Lally, 2023b, section 3.1, first paragraph) and claims that it mistakenly used the phrase "asset beta" when it should have used the phrase "equity beta". In explaining their point, CEG note that an asset beta does not depend upon the debt beta and hence on the tenor of debt, and this is correct. However, an *estimated* asset beta will depend upon the debt beta and hence on the tenor of debt if the formula for converting an estimated equity beta to an estimated asset beta does not recognize the impact of the debt beta, and this is the case for the Commission's formula. The true relationship between the betas is

$$\beta_V = \beta_S \frac{S}{V} + \beta_d \frac{B}{V} \qquad (6)$$

As CEG correctly note, the asset beta β_v is invariant to the term of debt. If debt term rises, β_d will rise (as argued by CEG) and therefore β_S must fall. However, for the purposes of estimating the asset beta of the comparator firms from the estimated equity beta, the Commission treats the debt beta as zero and therefore the relationship between the estimated equity and asset betas used by them is:

$$\hat{\beta}_V = \hat{\beta}_S \frac{S}{V}$$

Thus, as debt term increases, the true equity beta falls, and therefore the estimated equity beta falls, and therefore the use of the last equation by the Commission causes the *estimated* asset beta to fall. Within the quotation presented by CEG (ibid, para 59), I refer to both the asset beta and the estimated asset beta (that allowed by the Commission). The latter use is correct but the former use is not.

CEG (2023b, paras 64 - 65) again quotes from my earlier report and claims the reference to "asset beta" in Lally (2023b, section 3.1, second paragraph) should have been to "equity beta". CEG are correct.

CEG (2023b, paras 66 – 69) returns to an argument raised in their earlier submission (CEG, 2023a, section 2.1), that the cost of debt rises with its tenor and therefore the adoption of longer term debt by firms must be because doing so reduces the cost of equity, and therefore reduces their equity beta. In response to this argument in CEG (2023a, section 2.1), I argued earlier that several alternative reasons for firms undertaking long-term rather than short-term borrowing have been presented in the finance literature, such as the fact that longer term debt (coupled with staggered maturity dates) ensures that a smaller proportion of the debt matures (and therefore requires rollover) within any short period, which reduces the refinancing risk to a firm (Lally, 2023b, section 3.1). In response to this, CEG (2023b, paras 66 – 69) argues that borrowing long term and thereby reducing exposure to this refinancing risk does reduce the firm's equity beta. I presume CEG are alluding to refinancing risk that arises from market-wide events (such as the GFC) that would also lower market returns, and therefore are a source of systematic risk. I accept that refinancing risk can arise from market-wide events, but it can also arise from events peculiar to a firm. If a firm experiences adverse events that are peculiar to it around the time of debt refinancing, it may be unable to refinance the debt, and therefore would prefer longer term debt (with staggered maturity dates) so as to minimise the amount of refinancing within any short period and therefore enable it to repay the maturing debt by selling liquid assets or cutting operating expenditure rather than having to default. Furthermore, market-wide events that would give rise to refinancing risks (such as the GFC) are rare, and possibly much rarer than adverse events peculiar to a firm. Thus, the reduction in the equity beta and hence WACC of a firm resulting from that firm adopting longer term debt may be less than the WACC impact from the increased cost of longer-term debt. Consequently, CEG's preference for raising the allowed debt tenor of the regulated New Zealand businesses to compensate for the reduced equity beta arising from using beta comparators with much longer debt tenors may lead to overcompensation, and the analysis in the previous section supports this conclusion.

Furthermore, there are additional reasons why firms might prefer longer term debt at a particular time. For example, firms might think currently that longer term debt will be cheaper than a succession of shorter term debts and therefore attempt to "time the market", and this is not inconsistent with the current term structure being upward sloping (see Titman, 2002, section IV, E). Doing this does not imply that the firm's equity beta would be lower.

CEG (2023b, paras 70-73) refers to a claim in my earlier paper (Lally, 2023b, section 3.1), that Copeland et al (2005, pp. 615-617) in surveying the merits to a firm of different debt tenors does not present CEG's argument that longer term debt reduces a firm's equity beta. CEG appear to accept that an earlier edition of this book with which they are familiar does not present any such argument, and seems to attribute this to the lack of any reference to debt beta in the book. The inference seems to be that Copeland et al (2005) also lacks any reference to debt betas. However, Copeland et al (2005, pp. 585-588) does examine debt betas and even reports equation (2).

CEG (2023b, paras 74-79) returns to an argument raised in their earlier submission (CEG, 2023a, section 2.1), that the Miller-Modigliani theorem states that under certain conditions WACC is invariant to financing choices including the tenor of debt. In offering this in support of their claim that longer term debt reduces a firm's equity beta, CEG imply that these conditions are met or at least to some degree sufficient to link the use of longer term debt with lower equity betas. However, CEG offer no discussion of these conditions and the degree to which they are met. The most they do is to quote the first paragraph from Titman (2002), which merely alludes to the possibility that WACC is invariant to debt tenor. Titman (ibid, section IV, E) goes on to examine the choice of debt tenor by firms but at no point does he conclude or even suggest that longer term debt reduces a firm's equity beta or cost of equity. Titman (2002, page 111) also appears to suggest that bond markets may be inefficient, which would be a violation of the Miller-Modigliani conditions. Titman is also co-author of a widely used textbook in corporate finance and a contemporaneous edition of it (Grinblatt and Titman, 2002, pp. 740-742) notes that the Modigliani-Miller Theorem can be applied to all aspects of the firm's financial strategy. However, even here, there is no claim that a firm's use of longer term debt lowers its equity beta.

CEG (2023b, para 80) concludes by stating that "*The only point that matters is whether debt betas are higher for long term debt than for short term debt*." I do not agree. CEG's argument is not simply that debt betas are higher for longer term debt, leading to an underestimate of WACC using the Commission's approach, but that the issue should be addressed by raising the benchmark debt term from 5 to 10 years. As indicated in the previous section, I think that would lead to excess compensation and the better approach would be to take no action here on the grounds that the resulting small WACC underestimate is likely to be more than compensated for by regulatory use of the promised yield on debt.

5. Conclusions

My principal conclusions are as follows. Firstly, as argued by CEG, the Merton (1974) model does imply that debt beta rises with debt tenor, and therefore that a firm's equity beta falls with debt tenor, and this may lead to the Commission underestimating the WACC of New Zealand regulated businesses when its sets the debt tenor at five years but uses beta comparators that have an average debt tenor of 20 years. Secondly, the Merton model assumes that all of a firm's debt is zero coupon and matures at the same point in time. This is a poor representation of the real world situation in which firms stagger their debt maturity dates and this alone implies that the debt betas deduced from this model are not reliable and may not even increase with tenor. Thirdly, even if one does use the Merton model, the term parameter within it is the time to maturity of the bond rather than its tenor, and the values at both the beginning and end of the regulatory cycle are relevant, and correction for these two points substantially reduces the WACC underestimate. Replacing the term to maturity of the bonds by their duration, to reflect the existence of coupon payments, further reduces the WACC error claimed by CEG, to 0.08%. Fourthly, these reductions in the WACC error undercut CEG's claim that the issue can be addressed through raising the allowed debt tenor for the New Zealand businesses from five to ten years, because doing so would then overcompensate the businesses. Fifthly, the small size of the error implied by the use of the Merton model and the fact that its assumptions are a very poor representation of the real world situation in which firms stagger their debt maturity dates suggest that no correction should be made. If there is an underestimate of WACC through doing so, it is mitigated and possibly more than compensated for by the Commission using the promised yield on debt to determine WACC.

APPENDIX 1: Proof of Equations (2) and (4)

Merton (1974) assumes that a firm's debt is zero coupon and all matures in *T* years. At that point, rational equity holders would default on the debt if and only if the value of the firm at that time is less than the promised payment to debt holders (*F*). Bondholders would then receive *F* if the contemporaneous value of the firm V_T is at least *F* and will receive V_T if V_T is less than *F*, because default means that the assets of the firm pass to bondholders. This payoff distribution is equal to a payoff of *F* in all states, less the payoff on an asset that pays nothing if V_T is at least *F* and pays ($F - V_T$) if V_T is less than *F*:

$$\text{Bond Payoff} = \begin{bmatrix} F & if\ V_T \geq F \\ V_T & if\ V_T < F \end{bmatrix} = \begin{bmatrix} F & if\ V_T \geq F \\ F & if\ V_T < F \end{bmatrix} - \begin{bmatrix} 0 & if\ V_T \geq F \\ F - V_T & if\ V_T < F \end{bmatrix}$$

The last payoff set [ ] is the payoff on a European put option over the assets of the firm, exercisable in *T* years and with exercise price *F*. So, the value of the bond is the value of a risk-free asset paying *F* in *T* years, less the value of the European put option just described and denoted *P*(*V*, *T*, *F*). Letting R_f^c denote the continuously compounded risk-free rate, the value of the bond is then:

$$B = Fe^{-R_f^c T} - P(V,T,F) \tag{7}$$

The put option can be valued using a European put formula, with life *T* and exercise price *F*. Assuming that the firm will pay no dividends before time *T*, the Black-Scholes (1973) formula can be used. Letting *V* denote the current value of the firm's assets, and σ_v the standard deviation of the instantaneous rate of return on the firm's assets, the value now of the put option is:

$$P = Fe^{-R_f^c T}\left[1 - N\left(k_1 - \sigma_v\sqrt{T}\right)\right] - V[1 - N(k_1)]$$

where

$$k_1 = \frac{\ln\left(\frac{V}{F}\right) + \left(R_f^c + 0.5\sigma^2\right)T}{\sigma\sqrt{T}}$$

and $N(k_1)$ is cumulative standard normal density up to k_1. Substitution of this formula for *P* into equation (7) yields

$$B = V[1 - N(k_1)] + Fe^{-R_f^c T} N\left(k_1 - \sigma_v\sqrt{T}\right) \tag{8}$$

This proves equation (4). Returning to equation (7), this shows that the bond value *B* is a function of the firm value *V*, and application of the Black-Scholes formula for valuing the put option *P* presumes that *V* follows Geometric Brownian Motion. So, Ito's Lemma applies to the change in *B* (*dB*) over an infinitesimally short period (*dt*):

$$dB = \frac{\partial B}{\partial V} dV + \frac{\partial B}{\partial t} dt + 0.5 \frac{\partial^2 B}{\partial V^2} dt$$

where *dV* is the change in *V* over an infinitesimally short period and the other terms are partial derivatives. This equation indicates that *dB* depends upon *dV* and also on *dt*, i.e., the bond value will change if the value of the firm's assets changes and, even if *dV* is zero over the period *dt*, the bond value still changes purely due to the passage of time *dt* (which reduces the first term on the RHS of equation (7) and also the life and hence the value of the option). Dividing through the last equation by *B* yields the rate of return on the bond over the period *dt*:

$$\frac{dB}{B} = \frac{\partial B}{\partial V} \frac{dV}{V} \left(\frac{V}{B}\right) + \frac{\partial B}{\partial t} \left(\frac{1}{B}\right) dt + 0.5 \left(\frac{1}{B}\right) \frac{\partial^2 B}{\partial V^2} dt$$

Letting *M* denote the value of the market portfolio and *dM* the change in its value over the period *dt*, so that *dM*/*M* is the rate of return on the market portfolio over the period *dt*, and noting that the terms involving *dt* in the last equation are not stochastic, it follows from the last equation that:

$$\frac{Cov\left(\frac{dB}{B}, \frac{dM}{M}\right)}{Var\left(\frac{dM}{M}\right)} = \frac{\frac{\partial B}{\partial V}\left(\frac{V}{B}\right) Cov\left(\frac{dV}{V}, \frac{dM}{M}\right)}{Var\left(\frac{dM}{M}\right)}$$

i.e.,

$$\beta_d = \frac{\partial B}{\partial V}\left(\frac{V}{B}\right)\beta_V \qquad (9)$$

This says that the beta of the bond is proportional to the beta of the firm's assets. Furthermore, using equation (8), the partial derivative of *B* with respect to *V* is[8]

[8] The terms $N(k_1)$ and $N(k_1 - \sigma\sqrt{T}\ )$ in equation (8) also depend on *V*, but their effects cancel out in the partial derivative in (10).

$$\frac{\partial B}{\partial V} = 1 - N(k_1) \tag{10}$$

Substituting (10) into (9) yields

$$\beta_d = [1 - N(k_1)]\frac{V}{B}\beta_V = \frac{1 - N(k_1)}{L}\beta_V \tag{11}$$

Referring to the definition of k_1 above, this can be expressed as

$$k_1 = \frac{ln\left(\frac{V}{F}\right) + ln\left(e^{R_f^c T}\right) + 0.5\sigma^2 T}{\sigma\sqrt{T}}$$

Letting y denote the continuously compounded debt risk premium, and k the continuously compounded cost of debt, so $k - y = R_f^c$, the preceding equation for k_1 can then be expressed as

$$k_1 = \frac{ln\left(\frac{V}{F}\right) + ln(e^{kT}) - ln(e^{yt}) + 0.5\sigma^2 T}{\sigma\sqrt{T}}$$

$$= \frac{ln\left(\frac{V}{Fe^{-kT}}\right) - yT + 0.5\sigma^2 T}{\sigma\sqrt{T}}$$

The term Fe^{-kT} is the promised payment on the debt F discounted at the prevailing cost of debt k for the period of T years, and therefore is the current value of the debt (B). With this substitution, the previous equation becomes:

$$k_1 = \frac{ln\left(\frac{V}{B}\right) - yT + 0.5\sigma^2 T}{\sigma\sqrt{T}}$$

$$= \frac{-ln\left(\frac{B}{V}\right) - yT + 0.5\sigma^2 T}{\sigma\sqrt{T}}$$

and this matches d_1, defined in equation (2). So, $k_1 = d_1$. Substitution of this into equation (11) yields

$$\beta_d = \frac{1 - N(d_1)}{L} \beta_V$$

This proves equation (2).

APPENDIX 2: Derivation of Oxera's Estimates for the Asset Beta and Asset Volatility

Oxera (2020, Figure 2.3) reports a debt beta estimate (from CEPA) of 0.16 using equation (2) and L = 0.4, y = 0.01, T = 10 yrs, β_S = 0.7 and σ_s = 0.3. This is confirmed as follows:

$$d_1 = \frac{-\ln(0.4) + \left(\frac{0.30^2}{2} - 0.01\right)10}{0.18\sqrt{10}} = 1.3346$$

and therefore $N(1.3346) = 0.9090$ and therefore from equation (2):

$$\beta_d = \frac{(1 - 0.9090)}{0.4}\beta_S = 0.2275(0.7) = 0.159 \qquad (12)$$

Oxera then (correctly) note that use of β_S in the last equation is incorrect and it should be β_v:

$$\beta_d = 0.2275\beta_V \qquad (13)$$

Oxera does not report the value for β_v that it uses but presumably it recognizes that β_v is a value-weighted average of the betas for equity and debt:

$$\beta_V = 0.6\beta_S + 0.4\beta_d = 0.6(0.7) + 0.4\beta_d \qquad (14)$$

Substituting (14) into (13) and solving yields β_d = 0.105, which is consistent with Oxera's (ibid, Figure 2.3) estimate of 0.11. Substituting β_d = 0.105 into (14) yields β_v = 0.462.

Oxera also correctly notes that use of σ_s above is incorrect and it should be σ_v. Presumably Oxera recognizes that the rate of return on the firm's assets R_v as a weighted average of the returns on equity R_S and debt R_d:

$$R_V = 0.6R_S + 0.4R_d$$

Assuming the volatility in R_d is small relative to R_S, it follows that

$$\sigma_v = 0.6\sigma_S = 0.6(0.3) = 0.18$$

Substituting σ_v = 0.18 and the other parameter values into d_1 above yields

$$d_1 = \frac{-\ln(0.4) + \left(\frac{0.18^2}{2} - 0.01\right)10}{0.18\sqrt{10}} = 1.7182$$

and therefore $N(1.7182) = 0.9571$ and therefore from equation (2):

$$\beta_d = \frac{(1 - 0.9571)}{0.4}(0.462) = 0.0495$$

which is consistent with Oxera's (ibid, Figure 2.3) estimate of 0.05. Using these parameter values of β_v = 0.462 and σ_v = 0.18 in equation (2) with T = 12 yields β_d = 0.065, which is also consistent with Oxera's (ibid, Figure 2.3) estimate of 0.07.

All of this suggests that the values for β_v and σ_v used by Oxera (ibid, Figure 2.3) are 0.462 and 0.18 respectively.

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