COMPETITION ECONOMISTS GROUP

Response to 2023 IM draft decision on cost of capital

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COMPETITION ECONOMISTS GROUP

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1 Executive summary

1. This report addresses a number of issues related to estimating the WACC under the IMs and proposes a number of reforms to the 2016 IMs. These can be summarised below.

1.1 The debt tenor anomaly

2. We demonstrate that Dr Lally and the NZCC incorrectly interpreted our evidence. We show, using evidence from UK regulatory proceedings that, the NZCC's current method results in a downward bias in WACC of around 29 bppa.

1.2 Term Credit Spread Differential (TCSD)

3. We correct errors in the NZCC modelling that raise the estimated TCSD from 7.4 bppa to 8.4 bppa holding all other aspects on the NZCC methodology constant. We also explain why our preferred estimate is 8.9 bppa.

1.3 RAB indexation and CPI forecasting

4. We commend the draft decision to target a nominal return on debt. However, we suggest ways to do this that will result in less price volatility than the NZCC's suggested approach.

1.4 Amortisation of issuance costs

5. We rebut the NZCC logic for not amortising issuance costs. We demonstrate the with a rising RAB (even just in nominal terms rising for inflation) the NZCC method will not provide adequate compensation even for prospective debt raising costs (let alone historical costs of raising existing debt).

1.5 Percentile

6. We explain that the NZCC has not correctly reported CEG's estimates of the optimal percentile. We explain that the only reasonable estimate is that the optimal percentile has increased since 2014 and that, in this context, the NZCC's decision to reduce the percentile is problematic.

1.6 Equity raising costs

7. We are critical of the NZCC calling for more submissions on how to accurately model equity raising costs in the fact of potentially high RAB growth due to electrification.

8. We gave the NZCC a fully functioning model of how we thought equity raising costs should be estimated. The draft decision was the correct time for the NZCC to explain why it did not agree with any aspects of that model and to propose an alternative. It is most unhelpful for the NZCC draft decision to state:

> *However, we are aware that capex associated with electrification of the economy may lead to equity raising costs being incurred in the future. We welcome any further evidence on the likelihood that equity raising costs will be incurred and the materiality of these costs.*

9. We gave the NZCC our submission on this and the NZCC's response is to "welcome further evidence" instead of to clearly state its own position. This makes it impossible to actually consult on the NZCC decision unless a new separate consultation process is opened prior to the final decision.

2 The debt tenor anomaly

10. The NZCC estimates an equity beta for energy companies that issue 20 year debt and has implicitly assumed that the same equity beta would apply (for the same gearing) if the companies issued 5 year debt (which is the NZCC's assumption for New Zealand energy companies).

11. The problem with this approach is that equity beta does not just depend on the amount of debt issued but also the type of debt issued. Long term debt shifts more risk from equity holders to debt holders and, therefore, lowers the equity beta for a company (relative to the equity beta that they would have if they issued short term debt).

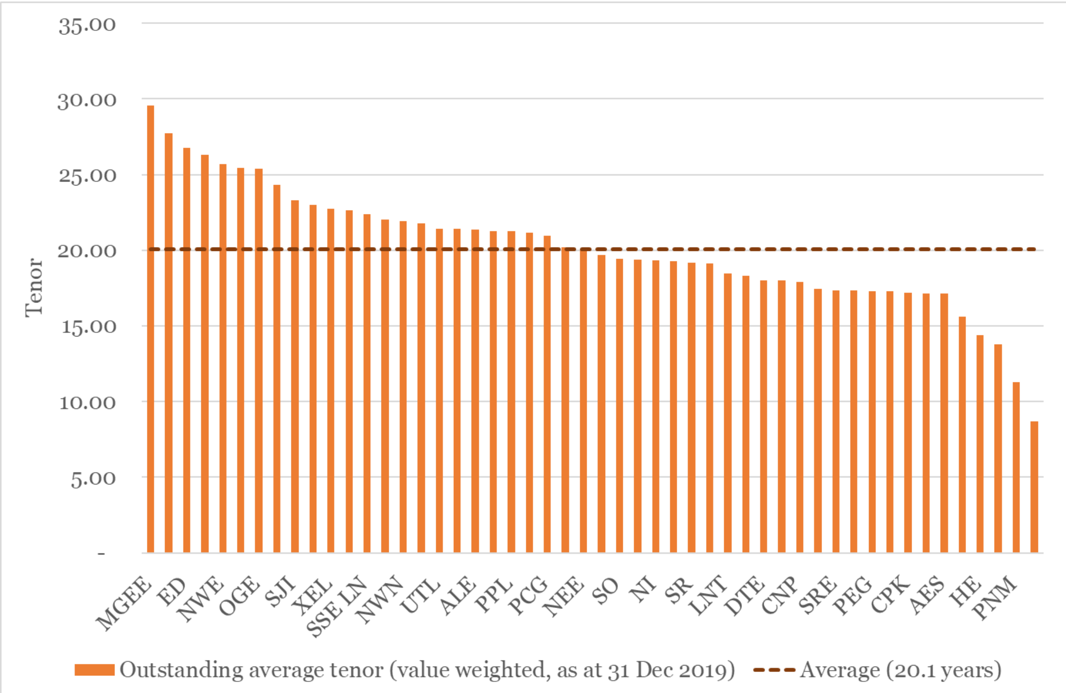
12. In technical terms, long term debt has a higher debt beta (risk) than short term debt. The NZCC's leverage formula ignores this difference and assumes the same debt beta applies to long and short term debt (zero). This is not a reasonable assumption. We estimate that this error biases down the ultimate WACC estimate by around 29bp.

2.1 Our previous submission

13. The NZCC currently sets a cost of debt based on the baseline assumption that the EDB maintains a staggered portfolio of 5-year debt. Large EDBs that issue longer tenor debt receive compensation of the higher debt risk premium (DRP) on that debt via the TCSD.

14. Our previous submission noted that the NZCC sets the asset beta for all EDBs based on benchmarking against businesses that universally have a longer average tenor of debt. In fact, in the updated NZCC asset beta sample from 2016, the value weighted average tenor of all bonds issues is over 20 years.

Figure 2-1: Average tenor of bonds issued for firms in asset beta sample



Source: Bloomberg and CEG analysis. 31 December 2019 is chosen to reflect pre Covid impacts. There is significant evidence that during the Covid period long term corporate debt was difficult to finance [Ref] and the subsequent rapid inflation escalation has also tended to the available of long term nominal debt funding.[1]

15. We noted that the difference between the actual practice of the firms in the asset beta sample (20 years) and the NZCC's assumption (5 years) is highly material. In this context it is critical to understand why firms choose to issue longer dated debt even though this is typically associated with a higher cost of debt and, in particularly, a higher DRP.

16. We explained 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. That is, any higher interest costs must be associated with an at least offsetting lower cost of equity – otherwise it would be irrational to incur the higher costs associated with issuing long term debt.

17. We also explained that, in the capital asset pricing model (CAPM), used by the NZCC to estimate the cost of equity, this must manifest through a lower beta. That is, a firm specific decision to issue longer term debt can only reduce the cost of equity if it reduces the equity beta for any given gearing level (given that the market risk premium and risk free rate are market wide parameters).

18. We stated:

[1] Ropele, Gorodnichenko and Coibion, Inflation expectations and corporate borrowing decisions: new causal evidence, NBER working paper series, Working Paper 30537, October 2022.

Longer term debt reduces the equity beta precisely because longer term debt absorbs some of "equity like" risk. Equity is infinitely lived (or, at least, as long lived as the firm) while debt funding is made for discrete periods of time. The longer debt funding is provided for the more like equity funding it is. The longer a debt instrument is the more exposed is the lender to the long-term viability of the firm. That is exposure raises the "debt beta" for the debt instrument and, in doing so, the equity beta is reduced.

19. We also stated that this is formalised in the following commonly used relationship between asset beta, equity beta and debt beta – where asset beta is the weighted average of equity and debt beta.[2]

$$\beta_a = \beta_e \times (1 - \mathrm{L}) + \beta_d \times \mathrm{L}$$

$$\Rightarrow \beta_e = \frac{\beta_a - L \times \beta_d}{1 - L}$$

Where:
β_e is the equity beta
β_a is the asset beta
β_d is the debt beta
L is the leverage/gearing

20. We explained that this is consistent with:

the well-known Modigliani Miller theorem that the WACC should be more or less invariant to the level of debt leverage.[3] This is also sometimes described as the "conservation of risk" theorem (drawing a parallel from the law of the conservation of energy in physics). It states that the fundamental risk of a firm cannot be changed by the funding strategy of the firm – it can only be allocated in different ways between funders. In this context, this means issuing low cost short term debt rather than high cost long term debt cannot lower the WACC for a firm. All that is happening when a firm issues low cost short term debt is that it is retaining more of the risk for equity holders that it would otherwise have passed onto long term debt funders.

2 We note that there was a typographical error in our previous report where we reported $\beta_e = \frac{\beta_a - \beta_d}{1-L}$ rather than the correct formula $\beta_e = \frac{\beta_a - L \times \beta_d}{1-L}$

3 The Modigliani Miller theorem is a cornerstone of modern finance theory. It states that if financial markets are efficient and there are no transaction costs, then a firm's WACC is not affected by its capital structure. Modigliani, F.; Miller, M. (1958). "The Cost of Capital, Corporation Finance and the Theory of Investment". American Economic Review. 48 (3): 261–297.

21. Such a relationship between debt beta and equity beta is well understood and accepted by the NZCC. Indeed, the NZCC carefully explains why the existence of positive debt betas means internal consistency requires it to use the same benchmark gearing as the sample average gearing from the asset beta sample of firms. Otherwise, using a debt beta of zero and a value for benchmark gearing above the sample average would tend to overestimate the equity beta and create "the leverage anomaly" whereby WACC increases with gearing when the Modigliani Miller Theorem argues that WACC should be independent of gearing (within reasonable ranges).

22. To this end we quoted from the NZCC where it states:[4]

> *562. We continue to consider that using the average leverage of the asset beta comparator samples is the best way of dealing with the anomaly. As we have estimated a notional leverage in line with the companies in our asset beta comparator samples, the resulting WACC will be the same for those services regardless of the value assumed for the debt beta.*

23. We explained that the same principle of internal consistency applies in the context where the NZCC uses the asset beta for firms with long term debt and applies it to a benchmark where it assumes short term debt is being used. Other things equal this will create precisely the same sort of bias that the NZCC is concerned about with the leverage anomaly.

24. That is, the "leverage anomaly" is a direct corollary of the "tenor anomaly". Choosing a different leverage to the sample average should not affect the WACC but, without accounting for debt beta it does. Similarly, choosing a different tenor to the sample average should not affect the WACC but, without accounting for debt beta it does. The NZCC has addressed the leverage anomaly but the same logic means it should also address the tenor anomaly.

[4] NZCC, Input methodologies review decisions, Topic paper 4: Cost of capital issues, December 2016, p. 144.

Table 2-1: Leverage anomaly vs tenor anomaly

	Leverage anomaly	Tenor anomaly
Problem	The sample average equity beta reflects the sample average **leverage** and its effect on the (unknown) sample average debt beta. Debt beta is important. Therefore, setting the **benchmark gearing** different to the sample average **gearing** would require an accurate estimate of the value of the debt beta (and how it changes with **leverage**) but this is not available.	The sample average equity beta reflects the sample average **debt tenor** and its effect on the (unknown) sample average debt beta. Therefore, setting the **benchmark debt tenor** different to the sample average **debt tenor** would require an accurate estimate of the value of the debt beta (and how it changes with **debt tenor**) but this is not available.
Solution	Set the **benchmark leverage** equal to the **sample average leverage** to avoid any adjustments that require an estimate of debt beta.	Set the **benchmark debt tenor** having regard to the **sample average debt tenor** to avoid any adjustments that require an estimate of debt beta.

2.2 NZCC draft decision response

25. The draft decision responded as follows to our submission (emphasis added).

> *3.88 We sought advice from Dr Lally on this issue. Lally (2023) notes that the issues on asset beta and debt tenor are quite distinct in regard to notional leverage, and the merits of the leverage/asset beta argument have no apparent relevance to the debt tenor/asset beta issue.*[84]
>
> *[84] Lally "Review of submissions on the risk-free rate and the cost of debt" (report to the Commerce Commission, 17 March 2023), pp. 19-20.*
>
> *3.99 We agree with Dr Lally that CEG has not established the equivalence between the 'leverage anomaly' and the 'debt tenor anomaly'.* ***There is a mathematical proof of the 'leverage anomaly' which is the basis of our use of notional leverage, whereas the relationship between the debt tenor and debt beta is an empirical question and CEG has not provided evidence to support their claim that issuing longer term debt reduces*** **(sic)** ***debt beta****.*
>
> *3.100 Without the link between the 'leverage anomaly' and 'debt tenor anomaly' claimed by CEG, the choice of comparator firms for the estimation of a benchmark asset beta for EDBs and the choice of a benchmark efficient debt tenor are distinct matters. We provide detailed reasoning for our draft decisions on these two matters in other sections.*

26. I assume that the "mathematical proof" of the leverage anomaly referred to above is the following:

<u>Leverage anomaly</u>

$$\text{WACC}= (r_f + \beta_e \times MRP) \times (1 - L) + r_d \times L$$

Substituting the leverage formula for β_e from above

WACC=$(r_f + \frac{\beta_a - L \times \beta_d}{1-L} \times MRP) \times (1-L) + r_d \times L$

Assuming that $\boldsymbol{\beta_d}$ is independent of leverage (L), then taking the derivative of WACC with respect to leverage (L) gives:

$$\frac{\partial WACC}{\partial L} = -r_f + r_d = DRP$$

27. That is, assuming that debt beta is independent of leverage, higher leverage will lead to a higher WACC (i.e., a one percentage point increase in leverage (say, from 40% to 41%) will increase WACC by 0.01×DRP).

28. This is the "leverage anomaly" because we know, as a result of the Modigliani Miller theorem, that the WACC should be more or less invariant to the financial structure of a firm (over most of the range of "normal" structures). The NZCC has recognised that this "anomaly" exists due to the simplifying assumption that the debt beta is zero and invariant to leverage.

29. In reality, higher leverage raises the risk transferred to debt holders per unit of debt (raises β_d). The NZCC's simplifying assumption fails to pick this up and, consequently, the estimated return on equity increases "too fast" with leverage and the overall WACC rises when it should, according to the Modigliani Miller theorem, stay constant.

30. I now apply the same "mathematical proof" to the tenor anomaly.

Tenor anomaly

WACC=$(r_f + \frac{\beta_a - L \times \beta_d}{1-L} \times MRP) \times (1-L) + r_d \times L$

Assuming that $\boldsymbol{\beta_d}$ is independent of tenor, then taking the derivative of WACC with respect to tenor (T) gives:

$$\frac{\partial WACC}{\partial T} = \frac{\partial r_d}{\partial T} \times L$$

31. That is, assuming that debt beta is independent of debt tenor, higher debt tenor will lead to a higher WACC in proportion to the impact on the cost of debt multiplied by the leverage.

32. This is the "tenor anomaly" because we know, as a result of the Modigliani Miller theorem, that the WACC should be more or less invariant to the financial structure of a firm (over most of the range of "normal" structures). The NZCC has recognised that this "anomaly" exists in relation to leverage due to the simplifying assumption that the debt beta is zero and invariant to leverage.

33. Equivalently, higher tenor raises the risk transferred to debt holders per unit of debt (raises β_d). The NZCC's simplifying assumption fails to pick this up and, consequently, the estimated return on equity fails to decrease as tenor is increased and the overall WACC rises when it should, according to the Modigliani Miller theorem, stay constant.

34. It is my hope that this demonstrates to the NZCC that the "mathematical proof" of the leverage anomaly is, in fact, identical in structure to the "mathematical proof" of the "tenor anomaly". Both "anomalies" exist because the estimated WACC increases with changes in capital structure (debt leverage and debt tenor) when this is inconsistent with the Modigliani Miller.

35. The explanation for both anomalies is due to the failure of the simple formula (with zero and constant debt beta) to accurately capture the fact that the changes in capital structure, by passing on more risk to debt holders, reduce the amount of risk that resides with equity holders. This is why the WACC appears to rise when, in reality, it should be largely invariant to changes in capital structure.[5]

2.3 Literature on longer term debt to higher debt beta

2.3.1 Does long term debt have higher risk and risk premium?

36. The answer to this question is, as appears to be agreed by all, "yes".

- The NZCC TCSD estimates embody an explicit estimate of the higher risk premium associated with longer term corporate debt.
- Similarly, Martin Lally states this it is "uncontroversial" that the cost of debt rises with tenor.[6]

37. The higher cost of long term debt must reflect higher perceptions of risk attached to lending at a long versus a short tenor. Equivalently, if debt holders are bearing higher risk when lending long-term to a firm then this must be because more of the fundamental risk of the firm (as embodied in the asset beta) has been transferred to debt holders.

2.3.2 Does higher risk debt have higher debt beta?

38. Operating within a CAPM framework this is a peculiar question to even ask. All differences in expected returns are driven by differences in beta risk – and this applies for all asset classes (including debt).

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5 Unless one models specific transaction costs such as differential tax rates of equity and debt etc.

6 Dr Martin Lally, Review of submissions on the risk-free rate and the cost of debt, 17 March 2023, p.19.

39. In any event, it is generally recognised that one of the primary drivers of debt beta is the tenor of the debt issued. For example, Oxera, in a report entitled "estimating debt beta for regulated entities,[7] estimates that that the debt beta of 10 year debt is 0.05 but that this rises to 0.07 if the debt tenor rises to 12 years. [8]

40. This estimate was derived using a model of the allocation of fundamental risk between debt and equity holders develop by CEPA[9] for UK regulators. CEPA include a section 2.2.2 entitled "Debt maturity profiles". CEPA does not include an estimate of the sensitivity of debt beta to maturity but does advise the UK regulators in that section that differences in the debt tenor for the comparable companies relative to the benchmark assumption may well mean that different debt betas should be used to de-lever and re-lever equity betas.[10]

> *We suggest that one of the implications of this is that UK regulators should not assume that the same debt beta assumption should necessarily be used in both the de-levering and re-levering stages of their equity beta calculations for UK regulated business.*

41. However, Oxera does use the CEPA model of debt beta to derive a sensitivity of debt beta to tenor. The CEPA model was derived using standard option pricing theory. Oxera states: [11]

> *CEPA also discusses structural methods. The structural methods rely on the theoretical option pricing models derived by Merton (1974) and Black and Cox (1976). These models can be used to calculate a debt beta based on assumptions about parameters such as gearing, equity volatility and equity beta.*

42. Oxera note that the: [12]

> *structural methods developed by Merton (1974) and Black and Cox (1976) and others view debt as a put option on a firm's assets while equity—a call option. The main difference between the Black–Cox model and the Merton*

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7 Oxera, Estimating debt beta for regulated entities Prepared for Energy Networks Association8 June 2020.

8 Oxera, Estimating debt beta for regulated entities Prepared for Energy Networks Association8 June 2020, p. 18, Figure 2.4.

9 CEPA (2019), 'Considerations for UK regulators setting the value of debt beta', 2 December.

10 CEPA (2019), 'Considerations for UK regulators setting the value of debt beta', 2 December, page 17.

11 Oxera, Estimating debt beta for regulated entities Prepared for Energy Networks Association8 June 2020, p.15

12 Oxera, Estimating debt beta for regulated entities Prepared for Energy Networks Association8 June 2020, p.15

> *model is that the Black-Cox model allows for the possibility of default before the debt matures.*

43. Moreover, it is clear from Box 2.3 the debt beta is a function of $\boldsymbol{T}$ time to maturity of the bond as well as gearing; asset beta; asset variance; and credit spread.

Figure 2-2: Reproduction of Box 2.3 from Oxera report

Box 2.3 Structural model methodology

The Merton model can be arranged to obtain debt beta:

$$\beta_d = \frac{(1 - N(d_1))}{g} \cdot \beta_a$$

Where:

$$d_1 = \frac{-\ln(g) - \left(y - \frac{\sigma_a^2}{2}\right) \cdot T}{\sigma_a \cdot \sqrt{T}}$$

$\boldsymbol{g}$ gearing; $\boldsymbol{\beta_d}$ debt beta; $\boldsymbol{\beta_a}$ asset beta; $\boldsymbol{N}$ is the cumulative normal distribution; $\boldsymbol{\sigma_a^2}$ asset variance, $\boldsymbol{T}$ time to maturity of the bond; $\boldsymbol{y}$ credit spread

Asset variance needs to be estimated as it is not directly observable. Schaefer and Strebulaev (2008) have presented ways to estimate the volatility and variance of assets.[1]

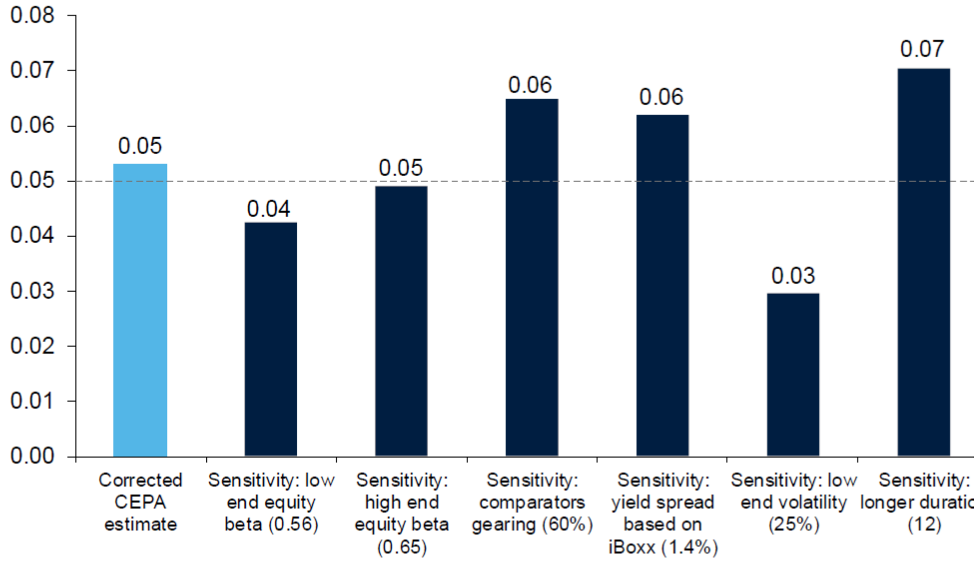
44. Appendix A demonstrates that for plausible values of these parameters the derivative of debt beta with respect to T must be positive and will be highest the lower is T (that is, debt beta will increase more between T=5 and T=10 than between T=10 and T=15).

45. In fact, Oxera modelling (using the CEPA/UK regulator model) shows that debt beta is only really sensitive to time to maturity of the debt and the underlying asset volatility. This can be seen in Figure 2.4 (reproduced below) of the Oxera report and also the following quote:[13]

> *It can be seen that the debt beta estimate is relatively insensitive to most of the sensitivities we have considered, apart from the equity volatility and time horizon. CEPA has not reported their assumed time horizon, but we were able to replicate their results using an assumption of 10 years.*

13 Oxera, Estimating debt beta for regulated entities Prepared for Energy Networks Association8 June 2020, p. 18.

Figure 2.4 Sensitivity analysis of structural debt beta



2.3.3 Quantifying the impact

46. There can be no reasonably expressed doubt that longer tenor debt is more costly (has higher debt beta) then shorter tenor debt.

47. It follows that the equity beta observed for firms that issue long term debt will be lower than the equity beta that would be observed for an identical firm that issued only short term debt.

48. How much lower is simple to calculate using the standard leverage formula

$$\beta_e = \frac{\beta_a - \mathrm{L} \times \beta_d}{1 - L}$$

49. Assuming that:

- the underlying asset beta in this formula is 0.40;
- the leverage is 41% (as estimated for EDBs in the draft decision);
- the average debt beta for:
  - firms in the NZCC sample is 0.12 (a conservative estimate given the Oxera estimate of 0.05 for firms issuing 10 year debt plus 0.01 for every year above 10 years);[14]
  - firms that issue 5 year debt is 0.02; then

14 Noting that Oxera estimated a 0.02 increase in debt beta when tenor increased from 10 to 12 years.

- the observed equity beta would be 0.59 (= $\frac{0.40-41\%\times0.12}{1-41\%}$);
  - note that this 0.59 is the NZCC estimate of asset beta because the illustration has been calibrated to this result; and
- the asset beta derived from a 0.59 equity beta assuming a zero debt beta (as the NZCC does) would be 0.35 (which is consistent with the NZCC draft decision for EDBs);
  - critically, this is below the assumed asset beta in the first dot point (0.41) because the NZCC has de-levered the observed equity beta (which has embodied in it the effects of a debt beta of 0.12 associated with issuing 20 year debt) but has assumed a zero debt beta.
- the NZCC estimate for the equity beta will be 0.59 (re-levering the underestimated asset beta assuming a zero debt beta); but
- the correct estimate of the equity beta will be 0.68 (= $\frac{0.40-41\%\times0.02}{1-41\%}$) based on the correct asset beta and the correct debt beta (for firms issuing 5 year debt);
- This 0.07 underestimate in equity beta will result in 0.49% underestimate in the cost of equity assuming a 7.0% TAMRP (=0.07×7.0%); and
- A 0.29% underestimate in the WACC (=0.49% × (1.0 - 41%)).

50. These calculations are summarised in Table 2-2 below.

Table 2-2: Quantification of the impact of failing to account for higher debt beta on long term debt

	NZCC sample that issues long term debt	**NZCC sample if the firms issued 5 year debt**
Actual asset beta (β_a)	0.40	0.40
Leverage (L)	41.0%	41.0%
Actual debt beta (β_d)	0.12	0.02
Observed equity beta ($\beta_e = \frac{\beta_a - L\times\beta_d}{1-L}$)	0.595	0.664
Estimated asset beta derived assuming $\beta_d = 0$	0.35	0.39
Cost of equity underestimate (=0.069×7.0%)	**0.49%**	
WACC underestimate(=0.069×7.0%×(1.00-0.41))	**0.29%**	

51. Naturally, one might reasonably disagree about precisely what the impact of long term debt on the debt beta is, but one cannot reasonably argue that there is no impact. Even if it was assumed that the debt beta for 20 year debt was the same as Oxera's estimate for 12 year debt (0.07) and the debt beta for 5 year debt was zero then the WACC underestimate would be 0.20%.

Table 2-3: Lower bound quantification of the impact of failing to account for higher debt beta on long term debt

	NZCC sample that issues long term debt	NZCC sample if the firms issued 5 year debt
Actual asset beta (β_a)	0.40	0.40
Leverage (L)	41.0%	41.0%
Actual debt beta (β_d)	0.07	0.00
Observed equity beta ($\beta_e = \frac{\beta_a - \mathrm{L}\times\beta_d}{1-L}$)	0.629	0.678
Estimated asset beta derived assuming $\beta_d = 0$	0.37	0.40
Cost of equity underestimate (=0.049×7.0%)	**0.34%**	
WACC underestimate (=0.049×7.0%×(1.00-0.41))	**0.20%**	

52. It is a useful cross-check to compare this with the impact on the WACC if assuming a 10-year cost of debt rather than a 5-year cost of debt. As described in section 3, we estimate that the best estimate of the TCSD is around 10b bppa (after correcting errors in the NZCC 2016 and 2023 draft decision calculations).

53. This means that a 10 year tenor debt is estimated to have 0.50% (=5×0.10%) higher debt premium. Assuming an additional 0.14%[15] term premium for the average difference between 5 and 10 year "risk free"[16] rates, this implies a roughly 0.64% higher cost of debt and a 0.26% (=0.64%×41%) higher WACC.

54. This 0.26% estimate is broadly similar to the 0.29% WACC impact derived in Table 2-2.

55. This is a good illustration of the Modigliani Miller theorem. Whether a firm structures itself with 5 or 10+ year debt there should be no difference in WACC. The above calculations show that if the NZCC were to correctly account for the higher debt beta on long term debt there would be little difference between the WACC estimated:

- Using 5 year debt and a 41% gearing which lowers debt costs relative to 10 year debt issuance by around 0.64% (0.26% negative impact on WACC at 41% gearing); but
- Raises equity costs by around 0.34+% (0.20+% positive impact on WACC at 41% gearing);

15 This is Lally's estimate of the New Zealand average from 1985 to 2022 found on page 6 of, Lally, Estimation of the TAMRP, 10 April 2023 (p.6). "..the average differential for the New Zealand five and ten year rates from 1985-2022 inclusive has been 0.14%."

16 The term "risk free" is in quotation marks here because even default risk free bonds are subject to interest rate risk, and this is why long-term default free bonds typically have higher interest rates than short term default free bonds. (Interest rate risk refers to the risk a lender takes that interest rates will change in unexpected ways over the term of the loan).

- Leaving the WACC largely unaffected (<0.06% estimated impact);

56. By contrast, the NZCC draft decision failure to accept a higher debt beta on long term debt implies a direct contravention of the Modigliani Miller theorem. It implies adopting a 10 year debt tenor would raise the WACC by around 0.26% (due to higher interest costs) with no offsetting reduction in the cost of equity.

57. This is not reasonable. Not only is it a contradiction of the Modigliani Miller theorem, but it is also a direct contravention of standard practice by regulated utilities. The NZCC decision implies that these businesses are irrationally borrowing at more costly longer maturities than 5 years without receiving any benefit for doing so in the form of lower risk equity.

2.4 Dr Lally's advice to the NZCC

58. Dr Lally provides the NZCC with three paragraphs of advice that the NZCC then relied on to reject any need to address the "debt tenor anomaly" as termed by me (but, in fact, the bias resulting from taking an equity beta from firms issuing 20 year debt and applying it to a benchmark firm assumed to issue five year debt).

59. In an attempt to be methodical and to avoid any further confusion, I repeat each of Dr Lally's paragraphs and provide my response below.

2.4.1 Dr Lally's first paragraph

> *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.*

60. This paragraph is not correct. It would be accurate if the term "asset beta" was replaced by "equity beta". In the CAPM the asset beta is a measure of fundamental risk. This means that it cannot be changed as a result of changes in financial structure (e.g., issuing short term or long term debt, having low or high gearing, issuing callable or non-callable debt etc.).

61. Only the equity beta is affected by differences in financial structure. Therefore, it is only the equity beta that can be affected by the decision to issue long term versus short term debt.

62. For the absence of doubt, it is our contention that the observed *equity beta* for the firms in the NZCC sample (who issue debt with average tenors around 20 years) is lower than it would be if they issued debt with a 5 year tenor. This is because 20 year debt has higher debt beta. That is, issuing 20 year debt passes more of the fundamental risk to debt investors (and thereby lowers the residual left with equity investors) than would be the case if the debt was 5 years.

63. This is how we previously defined the "tenor anomaly" – note the reference to equity beta in this definition.[17]

> *Longer term debt* ***reduces the equity beta*** *precisely because longer term debt absorbs some of "equity like" risk. Equity is infinitely lived (or, at least, as long lived as the firm) while debt funding is made for discrete periods of time. The longer debt funding is provided for the more like equity funding it is. The longer a debt instrument is the more exposed is the lender to the long-term viability of the firm. That is exposure raises the "debt beta" for the debt instrument and, in doing so, the equity beta is reduced.*

And

> *The* ***sample average equity beta*** *reflects the sample average* ***debt tenor*** *and its effect on the (unknown) sample average debt beta. Therefore, setting the* ***benchmark debt tenor*** *different to the sample average* ***debt tenor*** *would require an accurate estimate of the value of the debt beta (and how it changes with* ***debt tenor****) but this is not available*

2.4.2 Dr Lally's second paragraph

64. The first sentence of this paragraph is (emphasis added):

> *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.***

65. This is not correct. The reduction in the cost of equity (relative to issuance of short term debt) is because equity beta is lower (relative to the level it would be if the firm issued only short term debt). Once more, this is because debt beta is higher for long term debt.

66. The second to the fourth sentences of this paragraph are:

> *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*

[17] CEG, Estimating the WACC under the IMs, January 2023, paragraph 19 and Table 2-1

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).

67. These are accurate quotations from my report. The next four sentences are:

> *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.*

68. I interpret the last sentence above as meaning "the *expected WACC associated* with issuing short term debt might be similar, or, at least, not lower than the *expected WACC associated* with issuing longer-term debt because the benefits of lower interest costs are offset by higher costs of equity" (i.e., not that short term debt itself has higher interest costs than long term debt).

69. This passage is, in my view, entirely accurate. However, Dr Lally appears to believe that it in some way this contradicts my central claim. The opposite is true. If issuing short term debt exposes a firm to greater risk from shocks hitting financial markets ("disruptions in financial markets") then this, by definition, is a source of higher equity beta risk for a firm issuing short term debt.[18] This is precisely my point – lower interest rates on short term debt come at the expenses of a higher cost of equity (because short term debt has lower debt beta than long term debt).

70. The final two sentences of this paragraph are:

> *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*

[18] Indeed, this is a good example for why long-term debt has higher debt beta than short term debt. Short term lenders can access their funds at shorter horizons when needed most (e.g., during financial market disruptions). They therefore take on lower risk (lower debt beta) for the loan and leave more risk (refinance risk) with equity investors.

> *longer term debt, Copeland et al (2005, pp. 615-617) do not present any argument of the type presented by CEG (2023).*

71. Once more, in the first sentence above, Dr Lally refers to an effect on asset beta where none is claimed. In any event, the point being made in CEG (2015) is perfectly aligned with the point being made in the current context. Short term debt lowers debt costs but raises residual risks (including refinance risks) left with equity holders. CEG (2015) provides only support for the propositions I have put in the current context.

72. In relation to the second sentence, I do not have a copy of Copeland et al (2005 pp. 615-617)) and so cannot confirm or deny the accuracy of Dr Lally's claim that this textbook does not discuss differences in debt beta associated with short and long-term debt.

73. I do have access to a 1981 version of the same textbook and I can confirm that there is no reference to the term "debt beta" anywhere in that textbook let alone a discussion of the relationship between debt tenor and debt beta. However, I do not take the absence of this specific undergraduate textbook mentioning debt beta to imply that the concept does not have any validity. That, in my opinion, would be absurd – especially given the literature outside this textbook, including from Nobel laureates and as surveyed above, that does deal with this relationship.

Dr Lally's third (and final) paragraph

74. The first passage of this paragraph is as follows:

> *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.

75. The first sentence is correct in its statement that the Modigliani Miller theorem states that (absent transaction costs) "a firm's WACC is invariant to its capital structure". The second sentence is incorrect in its assertion that "capital structure" relates only to leverage – and not to other forms of capital structure (such as debt tenor).

76. It is correct that the original 1958 paper focused on leverage only and assumed the existence of only a generic concept of "debt" without dealing with the different attributes that debt can take. However, the Modigliani Miller theorem has since been

understood to apply to all aspects of capital structure. For example, Titman (2002) states:[19]

> *As we all know, the first step in understanding corporate finance theory is the Modigliani and Miller (1958) theorem, which specifies conditions under which various corporate financing decisions are irrelevant. When the theorem was first stated, most of us thought of it as a proposition about a firm's debt-equity mix.* ***However, applications of the theorem have since been expanded to discussions of debt maturity****, risk management, and even mergers and spinoffs, which, according to the logic of M&M, neither create, nor destroy value in the absence of positive or negative synergies. By clearly stating the conditions under which these decisions have no relevance, the theorem provides a basis for examining how these choices can create and destroy value for a corporation.*

77. The assertion that the Modigliani Miller theorem, as understood by modern finance experts, relates only to debt leverage and is "irrelevant" to other aspects of capital structure is a serious error in Dr Lally's advice to the NZCC.

78. Dr Lally's third paragraph goes onto state:

> *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.*

79. In response I note:

- The Conine (1980) formula is precisely the formula that I use in this report and my previous report to relate equity, asset and debt betas. This is also the formula that the NZCC has used in past decisions to explain the leverage anomaly.
- Once more, asset betas are independent of debt tenor and debt leverage. For Dr Lally's statement to make sense it must be rewarded as follows.

  > *CEG would need to demonstrate that ~~asset~~ equity 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.*

19 Sheridan Titman, The Modigliani and Miller Theorem and the Integration of Financial Markets, Financial Management, Vol. 31, No. 1 (Spring, 2002), pp. 101-115 (15 pages).

- So long as debt betas are related to debt tenor then it mathematically follows that equity beta is related to debt tenor as is evident in the Conine (1980) formula that I have used to generate the values in Table 2-2 and Table 2-3 above.

80. The final dot point is the key point. Dr Lally's advice to the NZCC is, in my view, unnecessarily circuitous. The only point that matters is whether debt betas are higher for long term debt (around 20 years) than for short term debt (around 5 years). This is the key point that Dr Lally should have advised the NZCC on and it is the key point that the NZCC needs to determine.

2.5 Conclusion

81. If the NZCC determines that the debt beta is higher for 20 year than 5 year debt then it must accept the existence of a bias in its analysis – a bias that can be quantified using the approach set out in Table 2-2 and Table 2-3.

82. In my view, there can be no reasonable conclusion that debt beta does not increase with the tenor of corporate debt. Longer term debt clearly shifts risks from equity holders to debt investors and, in return for this, debt investors demand higher returns.

83. The fundamental model deployed by CEPA for UK regulators and which has been used by Oxera as reported above by me, relies on established option pricing theory developed by Merton (1974) and Black and Cox (1976) and others to estimate how much of the asset risk is transferred to debt holders. That model shows mathematically that the longer is the tenor of the debt issued the more asset risk that is transferred to debt holders (higher debt beta).

84. Moreover, Oxera's modelling showed that the debt beta was **most sensitive** to the debt tenor and less sensitive to other factors.

85. To argue against, or to obfuscate, the proposition that longer term debt has higher (debt beta) risk is, in my view, unreasonable.

86. One might reasonably argue about magnitudes. My best estimate of the bias in the WACC is around 0.29% based on Table 2-2. However, one cannot, in my view, reasonably argue that the magnitude is zero.

87. Certainly, it is incorrect to dismiss, as Dr Lally does, the issues raised as "*irrelevant*" or "*have no apparent relevance*".

2.5.1 If the NZCC accepts that long term debt has higher risk (debt beta) than short term debt

88. If the NZCC accepts that long term debt has higher debt beta than short term debt then there are two obvious options for it to address the current bias:

a. Adopt a longer benchmark tenor assumption (e.g., 10 years) to reduce the magnitude of the bias;

b. Retain a 5 year benchmark tenor but apply a separate adjustment such as:

   i. De-levering its equity beta estimates (based on firms that issue long term debt) using a positive debt beta (e.g., around 0.12 as per Table 2-2); but

   ii. Re-levering its equity beta estimates (based on firms that issue 5 year debt) using a positive debt beta (e.g., around 0.02 as per Table 2-2).;

c. Make some other adjustment (e.g., to the WACC standard error and/or the percentile) that would offset this bias.

89. In my view the first option would be preferable because it would ameliorate the bias while also aligning the benchmark debt with observed business practice. The second option would be the next best. This option would be consistent with the advice of CEPA to UK regulators that, when there are large differences between comparables tenor and benchmark tenor, then: [20]

> *…UK regulators should not assume that the same debt beta assumption should necessarily be used in both the de-levering and re-levering stages of their equity beta calculations for UK regulated business.*

90. The third option is, in my view, the next best option.

2.5.2 If the NZCC rejects the proposition that long term debt has higher risk (debt beta) than short term debt

91. If the NZCC rejects the proposition that long term debt has higher debt beta than short term debt then no adjustment to its method is required.

92. However, if the NZCC does reach this conclusion it would be useful to understand:

a. Why the NZCC believes that long term debt has a higher cost than short term debt? That is, why do lenders demand higher returns on long term debt if long term debt is not riskier than short term debt?

b. Why the NZCC believes that businesses rationally borrow at long term rates if the equity holders receive no benefit, in the form of lower equity risks, to offset the higher cost of long term debt?

c. Why the CEPA model that relates debt beta to tenor, and Oxera's estimate of a 0.02 increase in debt beta for a 2 year increase in tenor, is not informative.

[20] CEPA (2019), 'Considerations for UK regulators setting the value of debt beta', 2 December, page 17.

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3 Term Credit Spread Differential

93. Term Credit Spread Differential (TCSD) refers to the increase in Debt Risk Premium (DRP) as the tenor of the bond increases. This parameter is used by the NZCC to capture the additional cost of network operators of holding bonds with tenor greater than 5 years.

3.1 Overview of CEG's prior submission

94. In the 2016 IM final decision the NZCC reported an estimate of the TCSD of 4.5-6.0 bps using its own methodology. However, the NZCC also relied on CEG's estimate of 9.5-11.0 bps. The final decision chose a value in the middle of 7.5 bps.

95. The differences in our methods, as we understand them based on the NZCC's description, were relatively small. The most material difference is that we proposed to estimate the TCSD every month of the relevant historical period and then take an average of the monthly estimates. The NZCC determined that it would break the data up into 6 monthly periods rather than monthly periods. Otherwise, we understood that our methods were very similar.

3.1.1 Inability to replicate NZCC 2016 final decision.

96. In the process of preparing our previous report CEG attempted to replicate the NZCC's TCSD estimate of "4,5 to 6 bps" [21] from its final decision and are unable to do so. Subsequently, the ENA requested the data underlying Figure 31 from the NZCC final decision and was supplied with the NZCC's TCSD estimate for each of the NZCC's 6 monthly estimation windows (but not the underlying data/calculations for how that estimate was arrived at). [22]

97. We were unable to replicate those estimates. For example, following the methodology that the NZCC set out in its 2016 Topic Paper 4, we estimate an TCSD of 11 bps for second half of 2015, and NZCC estimate is only 4 bps. [23] While there is some uncertainty in the NZCC method, all the interpretations we that appear consistent with the NZCC description result in us estimating a TCSD of around 10bp.

21 See Paragraph 909 in NZCC Input Methodologies Review Decisions – Topic paper 4 – Cost of Capital Issues, 20 December 2016

22 ENA_CEG_TCSD_Query (4502834.1).xlsx in email from Geoff Brooke to Keith Hutchinson 27 September 2022

23 ENA_CEG_TCSD_Query (4502834.1).xlsx in email from Geoff Brooke to Keith Hutchinson 27 September 2022

98. We note that the NZCC did estimate a 6bp TCSD in their draft decision which we can replicate. However, the methodological changes agreed in the final decision[24] imply a materially higher TCSD.

3.1.2 Updated estimates

99. We reported updated estimates to 2022 (using the NZCC description of its method and an updated sample of bonds) are very similar to our estimates in 2016 and our attempted replication of the NZCC method in 2016.

Table 3-1: Updated TCSD estimates*

	Excel software	R Software
Jan 2013 to June 2016	0.10%	0.11%
Jan 2013 to June 2022	0.09%	0.10%
Jan 2016 to June 2022	0.09%	0.10%
Jan 2018 to June 2022	0.10%	0.11%

* The use of NSS curve fitting applies an optimisation algorithm which can affect the result. We have tested the algorithms used within both R and Excel.

100. For completeness, we reported the result of aggregating monthly TCSD estimates which was the method we proposed in 2016 in response to the NZCC draft decision. The NZCC's response to that submission was to agree that the TCSD should be estimated as the average over multiple sub-periods rather than by pooling all data into a single period. but was to propose that 6 monthly estimates rather than monthly estimates be adopted.[25] However, in the final decision the NZCC concluded that 6 monthly estimates should be relied on because monthly estimates were prone to outliers in months with few data points.[26]

101. Table 3-2 compares the average of 6 monthly regression estimates of TCSD to the average of monthly regression estimates. In both cases we were using the last 6 years of data and using R software. It can be seen that the monthly average results in a higher estimate 0.16 vs 0.09 but that this is largely explained by two monthly estimates of TCSD, between 2020 May and 2020 June, reached over 2%. Removing these two outliers results in similar estimates.

24 Para 902 to 908 of the 2016 Topic paper 4. The only way we can generate a TCSD closer to 6bp is if we include pre 2013 data – something that the NZCC explicitly agreed should not be done (see para 908 of Topic paper 4).

25 See Paragraph 902 of NZCC Input Methodologies Review Decisions – Topic paper 4 – Cost of Capital Issues, 20 December 2016

26 See Paragraph 903 of NZCC Input Methodologies Review Decisions – Topic paper 4 – Cost of Capital Issues, 20 December 2016

Table 3-2: Six versus one monthly TCSD estimates, R software

	6 monthly regression (NZCC)	Monthly regression (CEG)	Monthly regression (removing 2 outlier estimates)
Average TCSD from June 2016 July to 2022 June	0.091%	0.160%	0.094%

Source: Bloomberg, CEG analysis.

102. In our view, this analysis supports the Commission's decision to adopt a 6 monthly estimation period in preference to a monthly estimation period.

3.2 NZCC draft decision methodology

103. The NZCC's draft decision provides a spreadsheet model[27] for the NSS estimation of the debt risk premium (DRP). Within the spreadsheet model[28], explanations are provided on how the spreadsheet model is used to estimate the 5 year DRP for the TCSD model and how it can be utilised to estimate the TCSD using linear regression.

104. In addition, the NZCC, in an email dated June 21st[29], provided further clarification on the linear regression and the search criteria used to identify the relevant bonds on Bloomberg.

105. In our attempt to replicate NZCC, we find issues with the spreadsheet that makes us unable to replicate NZCC results using the explanations provided by the NZCC. After addressing these issues, we find that the calculated TCSD's to be higher than the estimates provided by the NZCC in its draft decision.[30]

3.2.1 Errors in the NZCC spreadsheet model

106. In our attempt to replicate the NZCC TCSD estimates using the instructions and spreadsheet models provided by NZCC, we identify problems that makes us unable to calculate the DRP which is then used to calculate the TCSD.

27 Part-4-IM-Review-2023-Cost-of-capital-topic-paper-calculations-spreadsheet_-NSS-spreadsheet-model-and-WACC-percentile-spreadsheet-model-June-2023.xlsm

28 Worksheet "Regression Explanation"

29 Email from Ben Harris to sara.carter@adroitsei.co.nz and tom.hird@ceg-ap.com, subject "RE: IM Draft Decision – request for clarity from the ENA [CCNZ-IMANAGE.FID337642]" 12 June 2023, 10:4am

30 NZCC (2023) "Part 4 Input Methodologies Review 2023 – Draft decision, Cost of capital topic paper" Table 3.1

107. We note that the source of the problem varies depending on the order of government bonds in the output list by Bloomberg in the worksheet “Govt bond inputs”. Given the output list of relevant government bonds may vary every time the list is obtained from Bloomberg, the source of the problem may vary every time the spreadsheet refreshes its data source from Bloomberg.

108. In this section we provide an example of the issue in the spreadsheet model. The example is based on the bi-annual sample from September 2015 to February 2016.

109. In order to calculate the daily DRP of each corporate bonds, the first step is to calculate the risk free rate for each corporate bond with the same maturity remaining. This is calculated by interpolating the yields of the government bonds maturing closest to, but immediately before/after, the maturity date of the relevant corporate bond.[31]

110. In the bi-annual sample from September 2015 to February 2016, the risk free rate for the bond MCYNZ 5.029 03/06/19 was not calculated correctly. For this bond, the spreadsheet identifies:

- the first government to mature **after** MCYNZ 5.029 03/06/19 is the 9th government bond in the list[32] which is NZGB 6 2/15/17. This is obviously an error because 2/15/17 is before 03/06/19;
- This is in fact the same government bond identified by the spreadsheet as the last government bond to mature **before** MCYNZ 5.029 03/06/19.[33]

111. The spreadsheet then attempts to interpolate the risk free rate between the same two government bonds.[34] This implies the risk free rate applied to MCYNZ 5.029 03/06/19 is equal to the yield of the government bond NZGB 6 2/15/17[35], a government bond with almost 2 years lower maturity than MCYNZ 5.029 03/06/19. This is despite the fact that there exists a government with a maturity that occurs after MCYNZ 5.029 03/06/19.

112. The effect of this is to overestimate the 5-year DRP and, therefore, in the TCSD calculation, underestimate the extent to which bonds with maturity above 5-years have higher DRP than 5-year bonds.

31 Linear interpolation is used by calculating the difference in the yield of the two government bonds and divided by the maturity length of the two government bonds.

32 TCSD 20160229 check.xlsm Worksheet “RFR & DP” cell “Q785”

33 TCSD 20160229 check.xlsm Worksheet “RFR & DP” cell “Q680”

34 TCSD 20160229 check.xlsm Worksheet “RFR & DP” cell “Q915”

35 The value in cell “Q915” is the same as cell “Q816” in TCSD 20160229 check.xlsm Worksheet “RFR & DP

113. In addition to the incorrect risk free rate used to calculate the DRP, we also find that the same error causes the spreadsheet to unnecessarily exclude data. For the same corporate bond, on 29th October 2015,[36] the spreadsheet also utilises the same government in an attempt to perform interpolation. As a result, it is unable to divide by zero (being the difference I maturity between the same single government bond) and produces an error for that day. Due to the error on that day, the average DRP for the month of October is not calculated and not included in the DRP NSS regression.[37]

114. We note that the issue is not isolated to that single bond. In fact, for the bi-annual period from March 2017 to August 2017, NSS can not be calculated because for nearly all the corporate bonds, the correct maturity lengths of the last government bond before each corporate bond and first government after each corporate bond to mature cannot be calculated. This results in insufficient observations for the regression to be applied.

115. As a result of the issues described above, we are unable to replicate the NZCC TCSD results without additional adjustments.

116. Furthermore, we note that the spreadsheet model is not correctly calculating the monthly DRPs in some scenarios. The monthly DRP is calculated based on the daily DRPs and is used as the input for the NSS regression.

117. The error occurs if the first day of the month is on a weekend which does not have data from Bloomberg. To calculate the average of that month, the spreadsheet model, instead of finding the first day of the month with available data, starts the average period from the last available day from the previous month.[38] As a result, the averaging period mis-calculates by one day. The impact of a one day offset is likely to be small. However, if the first day of the month, that is missing due to being a weekend, is the start of the bi-annual sample period, the spreadsheet model will not be able to find a date with available data before the sample period. As a result, the DRPs of that month will not be included in the NSS regression.

3.3 Correcting the NZCC spreadsheet

118. We find that sorting the government bond by maturity or changing the function to correctly identify the relevant government bonds addresses the identified problem.

36 TCSD 20160229 check.xlsm Worksheet "RFR & DP" cell "BG 915"

37 TCSD 20160229 check.xlsm Worksheet "Averaging" cell "R 314" and worksheet "Estimation" cells B20:B125"

38 Part-4-IM-Review-2023-Cost-of-capital-topic-paper-calculations-spreadsheet_-NSS-spreadsheet-model-and-WACC-percentile-spreadsheet-model-June-2023.xlsm, Worksheet "Averaging", Cells "Q:"

119. We are unable to obtain NZCC's estimated results by following exactly the procedures presented by the NZCC due to issues raised above. However, Table 3-3 below compares our estimates after correcting the NZCC spreadsheet model with the NZCC estimates provided in Table 3.1 of the draft decision.

Table 3-3: TCSD from Sep 2015 to Aug 2022 (bps)

	All data		NZCC exclusions	
	CEG	NZCC	CEG	NZCC
BBB+ only, including 100% govt owned bonds	13.1	11.6	8.6	8.7
BBB+ only, excluding 100% govt owned bonds	13.6	11.0	9.3	8.1
Expanded sample, including 100% govt owned bonds	11.2	10.2	7.3	8.0
Expanded sample, excluding 100% govt owned bonds	6.1	3.8	6.6	6.8
Average	11.0	9.2	8.2	8.2

120. The first set of columns includes all the data. The second set of columns remove the 6 months March 2020 – August 2020. The NZCC states a preference to focus on the latter estimates "due to the large outliers and abnormal observations".

121. The NZCC arrives at its 7.5bp estimate by giving most weight to the 8.0 and 6.8 values in the far right column (average 7.4bp). In doing so, the NZCC gives most weight to the two lowest values in that column.

122. As is plain from the above table, the expanded sample, excluding 100% government owned bonds results in much lower estimates than the other samples. As will be seen below, this is due to a single negative outlier of a -12.5 bppa TCSD estimate that should, in my view, be removed.

3.4 Identifying outliers

123. The NZCC does not provide any details on what the "outliers" were nor how they were identified.

124. However, in the 2016 IM decision the NZCC did provide guidance on how outliers were detected and removed. Specifically, the NZCC removed outliers with anomalously high DRPs leading to negative TCSDs.[39]

> *We have focussed on the period from 2013-2016 due to some anomalously high debt premium's estimates prior to 2013 – leading to negative spread premium estimates on longer-term bonds.*

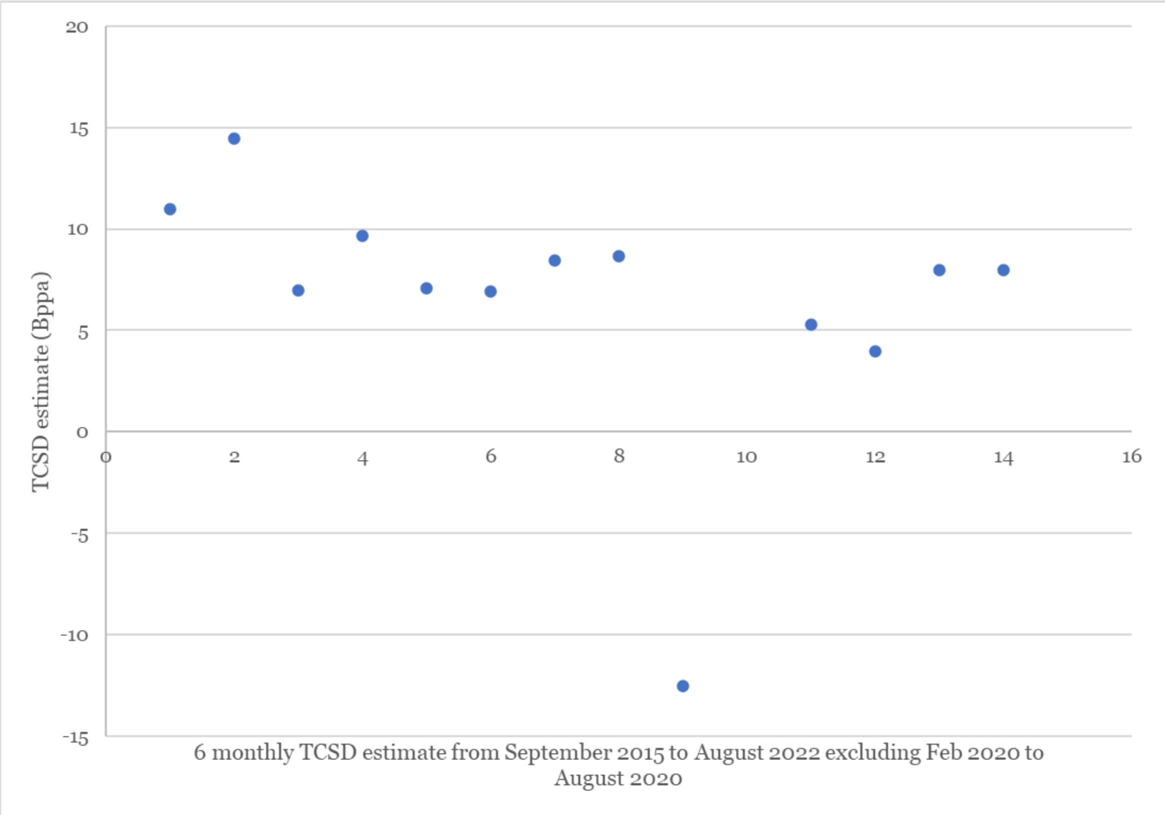
125. Had the NZCC applied this same criteria in 2023 it would have identified not just the 6 months from March 2020 – August 2020 as anomalous but also the immediately

39 NZCC (2016) "Input methodologies review decisions, Topic paper 4: Cost of capital issues" Paragraph 908

preceding 6 months Sep 2019 to Feb 2020. In particular, we estimate that one of the two values given most weight by the NZCC includes a -12.5 bppa TCSD estimate in that period.

126. The nature of this outlier is illustrated in Figure 3-1 below which shows all of the 6 monthly estimates of TCSD that appear[40] to underpin the NZCC's estimate of 6.8bp for the expanded sample, excluding 100% govt owned bonds (i.e., after the NZCC removes February to August 2020).

Figure 3-1: 6 monthly TCSD estimates for the expanded sample, excluding 100% government owned bonds

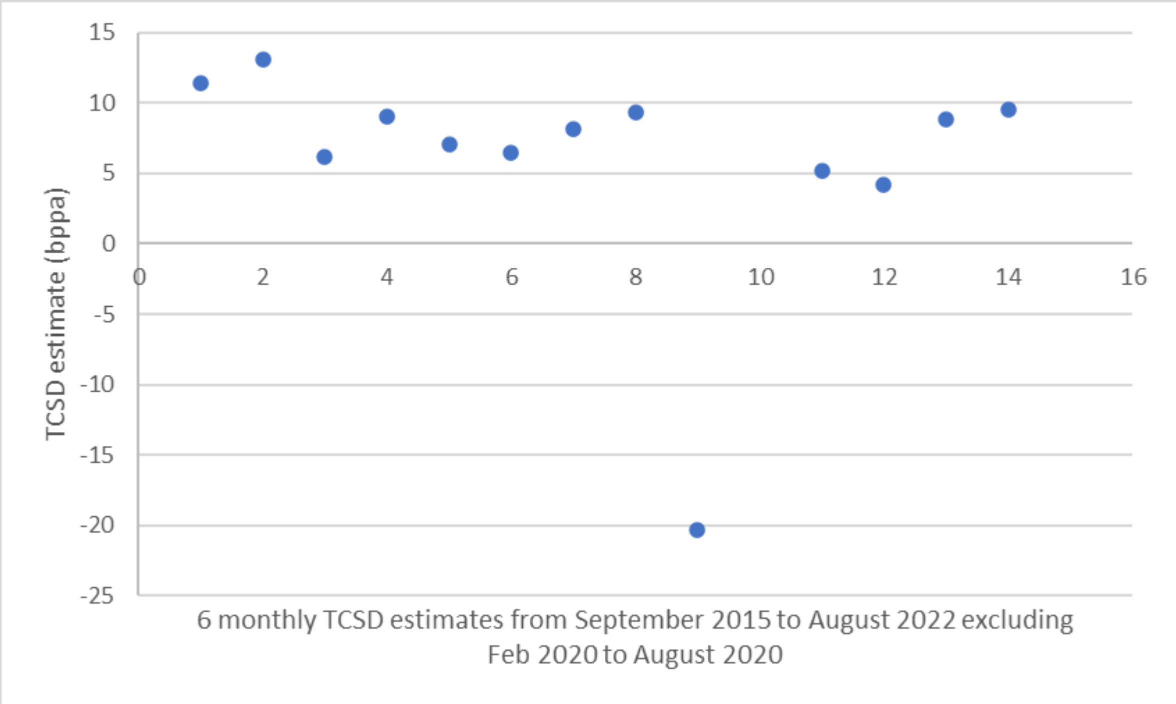


127. The negative 12.5bp estimate is a clear outlier in this sample. Excluding this observation, we estimate the TCSD for this sample rises to by 1.6 bppa. (Our estimate is for a rise from 6.6 to 8.2 bppa (noting that our 6.6 bppa is below the NZCC's equivalent estimate of 6.8 bppa which we are unable to replicate).

128. The same chart can be shown for the other sample most heavily relied on by the NZCC (the expanded sample, including 100% government owned bonds). This is done in Figure 3-2 below.

40 Recalling that we cannot exactly replicate the NZCC estimates.

Figure 3-2: 6 monthly TCSD estimates for the expanded sample, including 100% government owned bonds



129. The negative 9.5 bp estimate is also a clear outlier in this sample. Excluding this observation, we estimate the TCSD for this sample rises to by 1.4 bppa. (Our estimate is for a rise from 7.3 to 8.7 bppa (noting that our 7.3 bppa is below the NZCC's equivalent estimate of 8.0 bppa which we are unable to replicate).

130. The -12.5bppa TCSD estimate implies that a 10 year BBB+ bond would have a 0.63% lower DRP than a five year bond. Given that the five year DRP in that period around 1.3%would imply that a 10 year BBB+ bond would have around half the DRP of a 5 year BBB+ bond. Moreover, as is demonstrated below, the TCSD regression in this periods estimates that A- bonds have higher yields than BBB+ bonds.

131. It follows that, this negative TCSD estimate is both implausible and would have been excluded based on the same methodology to identify outliers used in the 2016 IMs.

132. Moreover, it is no coincidence that there are outliers in both:

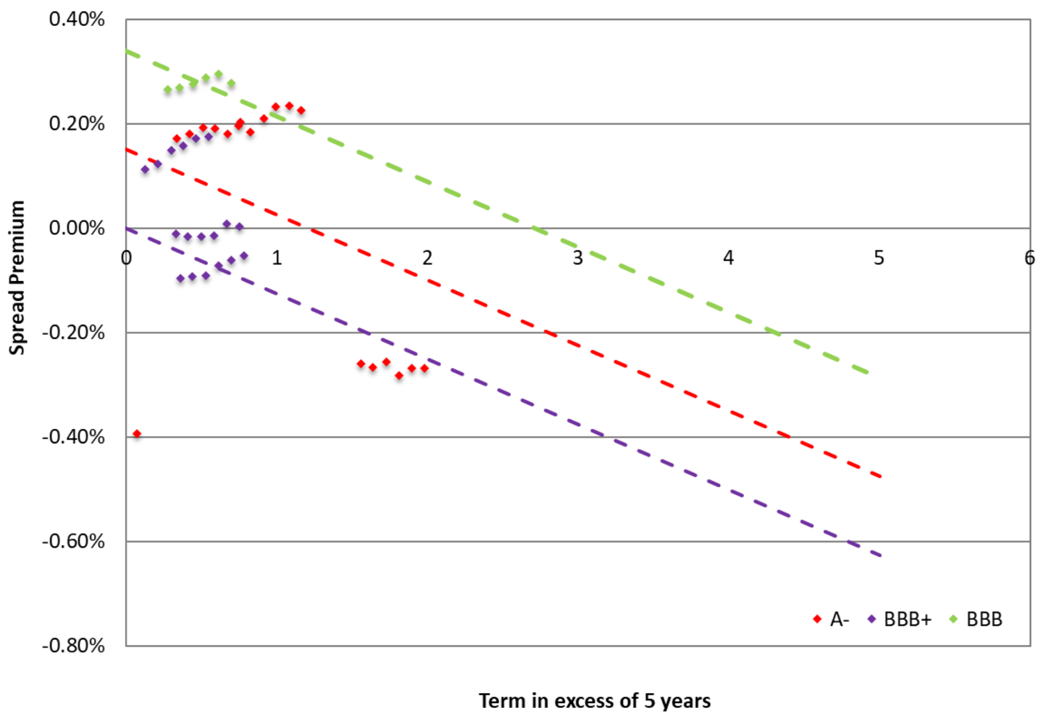
- the 6 months September 2019 to February 2020 as identified by me above; and
- the immediately following 6 months (March 2019 to August 2020) as identified by the NZCC.

133. The anomalous result during both period is due to the low number of bonds in the sample at that time. During September 2019 to February 2020 and in the sample excluding Government owned bonds there were only:

- 3 BBB+ bonds during both periods with maturity greater than 5 years[41]. Moreover, all three of these bonds had a maturity less than 6 years.
- one BBB bond[42] whose maturity was also less than 6 years.
- four A- bonds[43], with one maturity above 6 years but less than 7 years.

134. Figure 3-3 shows the regression used to generate the -20.3bp TCSD. It can be seen that the TCSD slope is dominated by the single A- bond with maturity above 6 years. This bonds observations can be seen as the group of red dots maturity between 6 and 7 years ("Term in excess of 5 years" of between 1 and 2 years on x-axis). There are multiple dots that relate to each bond because there is one observed DRP in each of the 6 months.

Figure 3-3: TCSD sample – from Sep 2019 to Feb 2020, excluding 100% government owned bonds



135. The relevant bond is SPKNZ 3.94 09/07/26 which is issued by a telecommunication provider in New Zealand.

41 The bonds are GENEPO 5 04/03/25, WIANZ 5 06/16/25 and MERINZ 4.21 06/27/25

42 The bond is VCTNZ 3.45 05/27/25.

43 The s are AIANZ 3.51 10/10/24,FCGNZ 5.08 06/19/25, FCGNZ 4.15 11/14/25, and SPKNZ 3.94 09/07/26.

136. A similar analysis can be done for the March 2020 to August 2020. In that case, it is a relatively high DRP for the WIANZ 5 06/16/25 bond that drives the very large TCSD estimates in that period and remaining maturity length less than 6 years. Ultimately, it is the small number of observations in these periods and the very small variation in their maturity that creates the potential for wild swings in the estimated TCSDs.

137. The large impact of these few small samples is reduced with the issuance of the MCYNZ 1.917 10/09/30 bond during the September 2020 to February 2021 period with maturity length approximately 10 years. This is the reason for the return to more stable and sensible TCSD estimates in that period and beyond.

138. This analysis also makes it apparent that it is primarily the small number of (undifferentiated) observation in the regression giving rise to the wild swings in TCSD estimated. While COVID-19 may have contributed to this in the sense that fewer corporate bonds were issued in this period it is not COVID-19 per se that is causing DRP estimates to behave unusually.

139. Table 3-4 shows the impact of excluding not just the 6 months that the NZCC excluded but also the immediately prior 6 months. In our view, this column provides the best estimate of outlier free TCSD estimates.

Table 3-4: TCSD from Sep 2015 to Aug 2022 (bps)

	No exclusions data		Exclude 12 months to August 2020
	CEG	NZCC	CEG
BBB+ only, including 100% govt owned bonds	13.1	11.6	8.9
BBB+ only, excluding 100% govt owned bonds	13.6	11.0	9.7
Expanded sample, including 100% govt owned bonds	11.2	10.2	8.7
Expanded sample, excluding 100% govt owned bonds	6.1	3.8	8.2
Average	11.0	9.2	8.9

140. The average across all the samples is 8.9 bppa. This is most consistent with the NZCC's 2016 IM methodology.

141. In the 2023 draft decision, the NZCC has altered its weighting scheme and now proposes to place most weight on the two expanded samples.[44]

> *We consider that we should place the greatest weight on full samples both including and excluding 100% government owned bonds as they are based on the largest sample.*

44 NZCC (2023) "Part 4 Input Methodologies Review 2023 – Draft decision, Cost of capital topic paper" Paragraph 3.125

142. It is not actually true that the expanded sample excluding 100% government owned bonds is larger than the BBB+ only sample including 100% government owned bonds. Moreover, this logic would imply that the expanded sample, including 100% govt owned bonds should be given the most weight because it always has the largest sample.

143. In any event, if we apply the new 2023 weighting method we would estimate an average for the NZCC's two preferred samples of 8.4 bppa. We note that this is consistent with the NZCC's published NSS estimate in Table 3-1 of the draft decision of 8.2 bppa.

3.5 Giving weight to the 2016 IM estimate of 7.5%

144. In the draft decision the NZCC takes some comfort from the fact the average of its two preferred samples (6.4 bppa) is very close to its 2016 final decision of 7.5 bppa.

> *3.127 The average spread premium result based on our preferred subsamples and time periods is 7.4 bps which is very close to our current spread premium of 7.5 bps. Therefore, we propose to maintain the spread premium of 7.5 bps.*

145. However, as set out in the original CEG report,[45] the 2016 final decision estimate appears to have been infected by similar spreadsheeting errors to those identified above. As noted in our original report, the NZCC estimate was based on a midpoint between its own estimate of the TCSD (4.5 to 6.0 bppa) and our estimate of 9.5-11.0bp.[46]

> *In the 2016 IM final decision the NZCC reported an estimate of the TCSD of 4.5-6.0 bps using its own methodology. However, the NZCC also relied on CEG's estimate of 9.5-11.0 bps. The final decision chose a value in the middle of 7.5 bps.*

146. The relevant passage from the 2016 IM final decision is provided below.[47]

> *There is a common range between around 4.5 – 6 bps p.a. for the Commission estimates, and around 9.5 – 11 bps p.a. for the CEG slope. Giving a greater weight to the [sic] our estimates, we consider that a spread premium of 7.5 bps p.a. is a reasonable estimate.*

45 CEG, Estimating the WACC under the IMs, January 2023.

46 CEG, Estimating the WACC under the IMs, January 2023, paragraph 91.

47 See Paragraph 909 in NZCC Input Methodologies Review Decisions – Topic paper 4 – Cost of Capital Issues, 20 December 2016

147. However, when we attempted to apply the 2016 IM method to the relevant data for the 2016 IM we could not estimate a TCSD below around 10 bppa. The 2023 draft decision does not dispute our calculations or conclusions.

148. Moreover, we have used the 2023 draft decision spreadsheet models to go back and estimate the 2016 IM TCSD. This confirms that there was an error in the NZCC's estimate of a 4.5 to 6.0 bppa TCSD.

149. Based on the hard coded bi-annual TCSD estimate for the 2016 IM decision provided by the NZCC via email,[48] we find the biggest discrepancy lies in the results for Jan 2013 to Jun 2013 and Jul 2015 to Dec 2015. Therefore, we attempt to calculate TCSD estimates based on the most recently provided spreadsheet model[49] after correcting for issues addressed in section 3.2.1.

150. Our results show that hard coded bi-annual TCSD estimate for the 2016 IM decision provided by the NZCC via email significantly differ from estimates based on the most recent NZCC spreadsheet model after correction.

Table 3-5: TCSD estimate comparison from 2016 IM decision

		From Jan 2013 to Jun 2013	From Jul 2015 to Dec 2015
BBB+ only, including 100% govt owned bonds	CEG calculation using current spreadsheet model	7.6	11.4
	NZCC 2016 IM estimates	1.5	4.4
	CEG previous submission	8.0	11.0
BBB+ only, excluding 100% govt owned bonds	CEG calculation using current spreadsheet model	8.5	10.9
	NZCC 2016 IM estimates	1.9	4.4
	CEG previous submission	12.0	11.0

CEG calculation using current spreadsheet model is calculated using "Part-4-IM-Review-2023-Cost-of-capital-topic-paper-calculations-spreadsheet_-NSS-spreadsheet-model-and-WACC-percentile-spreadsheet-model-June-2023.xlsm" after correcting incorrectly calculated risk free rate. NZCC estimates is from results provided in ENA_CEG_TCSD_Query (4502834.1).xlsx in email from Geoff Brooke to Keith Hutchinson 27 September 2022. CEG previous submission estimates is from CEG, "Estimating the WACC under the IMs" February 2023.

151. On this basis, we do not consider that the NZCC 2016 IM estimates of 4.5-6.0 bppa were sound and, therefore, neither was the 7.5 bppa final estimate (arrived at by also giving weight to the CEG estimate of 9.5-11.0 bppa).

48 ENA_CEG_TCSD_Query (4502834.1).xlsx in email from Geoff Brooke to Keith Hutchinson 27 September 2022

49 Part-4-IM-Review-2023-Cost-of-capital-topic-paper-calculations-spreadsheet_-NSS-spreadsheet-model-and-WACC-percentile-spreadsheet-model-June-2023.xlsm

152. On the basis of continuity of method (unaffected by spreadsheeting errors) the 2016 IM method gave an estimate of around 10bppa and the 2023 draft decision method gives:

- 8.9 bppa averaged across all samples (most consistent with 2016 IM method);
- 8.4 bppa averaged across the two wider samples (2023 draft decision weighting scheme).

153. If one were to give weight to the 2016 IM estimate (unaffected by spreadsheet errors) then the 8.9bppa estimate would be closest.

3.6 Conclusion

154. Having corrected errors in the NZCC spreadsheet calculations we arrive at a best estimate of 8.9 bppa. This is most consistent with the NZCC 2016 IM methodology including weighting across samples.

155. If we nonetheless adopt the draft decision weighting scheme, the best estimate of the TCSD is 8.4 bppa (materially below the correctly estimated 2016 IM TCSD estimate).

4 Amortisation of issuance costs

4.1 Recap of our submission

156. In our previous report, we explained that the NZCC has made an error which lowers compensation for debt transaction costs by around 0.5bp (assuming a 5 year tenor and a 5% discount rate).

157. We argued that the 2016 IM final decision made what is, effectively, a mathematical error which should be simple to clarify and correct. In the final Topic 4 paper the NZCC states:

> *Amortisation of upfront costs*
>
> *CEG submitted that upfront debt costs need to be amortised over time using a cost of capital to take into account the time value of money.*
>
> *We disagree with this conclusion because suppliers typically issue some debt each year to manage refinancing risk. They therefore incur some debt issuance costs each year. Assuming that firms issue a consistent amount each year with similar costs, there is no need for a present value adjustment in respect of a portfolio of debt.*

158. In this passage the NZCC's correctly noted that:

- a firm operating a trailing average debt 5-year tenor strategy will refinance 20% of total debt each year;
- assuming the RAB is constant in nominal terms, every year it will incur 20% of the total transaction costs associated with raising its entire debt RAB; and
- if the NZCC simply provides an ongoing annual allowance for 20% of the total transaction costs associated with raising its entire debt RAB then the allowance will fully cover ongoing debt issuance costs.

159. This is mathematically correct (assuming a constant value for the RAB). However, we explained that it does not follow that this means no NPV adjustment is required. If the NZCC were correct it would imply that in a competitive market there is no need for a firm to earn a return on its investment in inventory (no holding cost of inventory).

160. We illustrated this by hypothecating a firm that is importing $1m of product every year and selling it with an average one year lag. In effect, in every year the firm is selling stock imported the previous year and then replenishing those sales with new imports.

161. The Commissions logic would imply that, so long as that firm's price is covering its costs of importing the product in that year it is being fully compensated. This is clearly wrong; the firm needs to recover its costs of importing in the previous year *plus* the time value of money (and any other holding costs) over the time since it imported the stock it is selling.

162. We explained that the entire debt RAB can be thought of as the inventory of debt that is being used up (maturing) and replenished (refinanced) at a rate of 20% per year. The NZCC's proposal to only compensate for the costs of new debt as it is incurred amounts to, in effect, refusing compensate for the costs of prior building and holding of that debt inventory.

163. Put another way, it amounts to taking the money allocated to compensate for past costs and using it to fund current costs. It is true that this will "adequately" compensate for current costs but it does so by leaving past costs completely uncompensated. That is, if the NZCC hypothecates each year's total debt issuance compensation to the debt that has just been raised in that year (being one fifth of the RAB) then that leaves the other four fifths of the RAB uncompensated. That is, at any given time there is an "inventory" of old debt raising costs that is uncompensated.

164. A good test of the NZCC's position would be to attempt to model:

- Debt raising costs at 1.0% per dollar of debt raised on RAB growth from zero to the current levels; and
- Compare this with compensation equal to 0.20% per annum of the outstanding debt portfolio at any given time.

165. If the NZCC can build a model where the present value of the former is the same as the present value of the latter then it can be satisfied that not amortising debt raising costs is reasonable.

166. However, it is our submission that such a result is impossible and the latter value will always be less than the former value. I provide such an illustration below.

4.2 Draft decision response

167. The draft decision responds to our submission along the following lines (emphasis added):

> *3.156 In response to the CEG report on amortisation of debt issuance costs, we do not consider that this additional compensation is required because:*
>
> *3.156.1 Our assumed debt management strategy is that a notional supplier* ***raises debt consistently and on a rolling basis. Therefore, the supplier is compensated for this every***

> ***year through the debt issuance costs that we allow in the WACC****. The supplier can then use interest-rate swaps to fix the risk-free rate portion of existing debt but still issue new debt consistently to manage refinancing risk. Suppliers can respond to our assumed strategy to avoid mismatches with our allowed cost of debt.*
>
> *3.156.2 We do not prescribe specific costs or timing of our debt issuance costs or the cost of debt allowance more generally,* ***we simply provide an allowance based on our assumed debt management strategy*** *and suppliers can respond to this how they like.*
>
> *3.156.3 Even if a supplier was to raise a large amount of debt at one time (****which is where this amortisation cost may arise****), we provide an additional allowance for other 'potential' costs associated with raising debt, in addition to direct issuance and swap costs, which could cover a range of different costs that suppliers may or may not require. This overall allowance can compensate for a range of different debt management strategies and other costs that may be required.*
>
> *3.157 On this basis, we do not consider that a NPV adjustment to debt issuance and associated costs is necessary.*

4.3 Response to the draft decision

168. This response suggests that we have not adequately succeeded in our exposition of the underlying issue.

169. As explained in my previous report, I agree with the draft decision that if the RAB is stable and if one fifth of the debt is being refinanced every year then the IM method will prospective compensation for all future prospective debt raising costs incurred.

170. However, the point that I have been making is that, even if the RAB is stable into the future so debt raising is also stable, the prospectively accurate compensation is only achieved by under-compensation of past debt raising.

171. It is, in effect, robbing the past to pay the future. This is because:

- prior to the RAB stopping growing (which in our thought experiment it has and which is what delivers accurate prospective compensation);
- the RAB must have been growing (otherwise it would not be a positive number); and

- the Commission' method must undercompensate debt raising costs with a growing RAB.

172. This is particularly important in the current context with strong expected growth in EDB RABs to deal with the electrification challenge. To see why the NZCC method does not adequately compensate debt raising costs with a growing RAB I have modelled a debt RAB that starts out at $100m and is financed with five $20m staggered 5 year bonds each of which has a remaining maturity of between 1 and 5 years.

173. I have also assumed that the RAB (and debt RAB) is growing at a constant rate of 5.6% per annum (2.5% nominal and 3.0% real). In this case, the absolute debt raising amounts in the first 10 years are set out below and I compare these with the NZCC assumption that only one fifth of the RAB needs to be refinanced each year.

Table 4-1: Actual debt raising vs NZCC modelled debt raising with RAB growing at 3% real (5.6% nominal)

Year	Debt portion of ORAB	Actual debt raising	NZCC assumed debt raising	Shortfall in compensation	If debt raising costs are amortised
		Debt RAB growth + refinancing new debt	20% of RAB	1% ×actual debt raising less 0.2% of RAB	1% of actual debt raising less 1% of RAB amortised* over 5 years
1	100	26	20	0.06	0.01
2	106	27	21	0.06	0.01
3	111	27	22	0.05	0.00
4	118	28	24	0.04	-0.01
5	124	28	25	0.03	-0.02
6	131	33	26	0.07	0.01
7	138	35	28	0.07	0.01
8	146	35	29	0.06	0.00
9	154	36	31	0.05	-0.01
10	163	37	33	0.05	-0.03
Average				**0.06**	**0.00**

* Amortised at a 7.07% WACC

174. It can be seen that over year 1 the debt RAB grows from $100m to $106m. This means that, in addition to the $20m existing debt needing to be refinanced, $6m in new debt needs to be funded. The amount of debt raising that needs to be undertaken rises gradually over the first five years from $26m to $28m as due to the assumed 5.6% annual growth in the RAB.

175. In year 6, there is a step change debt funding required ($33m) because not only must the $7m in debt RAB growth be financed but the $26m financed in year 1 must now

be refinanced. This cycle continues with another step change required in year 11 (not shown).

176. By contrast, the NZCC compensation assumption essentially assumes that only 20% of the debt RAB is refinanced every year. This is the assumption upon which the NZCC justifies dividing total financing costs (1.0% per dollar raised) by five to arrive at a 0.20% of RAB compensation estimate. If only 20% of RAB is ever being refinanced then this will provide compensation for the costs incurred in that year.

177. However, if the RAB is growing then this is no longer the case. The "shortfall in compensation" column shows that compensation is around $60,000 less than actual debt raising costs (or a little over 0.04% of the debt RAB). By contrast, if debt raising costs are amortised over 5 years (rather than simply being divided by 5 years) then average under-compensation is approximately zero.

178. I note that in this example the problem is not created by the need for a supplier was "to raise a large amount of debt at one time" which the draft decision incorrectly states is "where this amortisation cost may arise". The shortfall here is created by constant 5.6% pa nominal (3% real) RAB growth. A roughly half this shortfall would exist if the RAB was only growing at 2.5% in line with inflation (i.e., was constant in real terms).

179. It is important to also note that amortisation of debt costs is more accurate in this circumstance because it more accurately compensates for past RAB growth and debt raising costs (embedded in the $100m existing RAB in year 1) and this is "used" to cross-subsidise the future debt raising costs associated with a growing RAB.

180. However, the most accurate way to compensate for debt raising costs would be to:

- Allow an amortised return on the current debt RAB; and
- Directly model and compensate for actual debt raising consistent with the future growth in the RAB.

181. The key message from this example is that the NZCC method must undercompensate debt raising costs in the presence of future or past RAB growth. This is because it relies on an assumption that the RAB is permanently stable.

182. Given a RAB value that is greater than zero there must be past growth in the RAB and, therefore, past under-compensation. Even if the NZCC decided not to correct past under-compensation it should attempt to eliminate future under-compensation associated with future RAB growth.

5 Percentile

5.1 Previous findings

183. In our previous submission for the 2023 IM,[50] we start by calibrating our model of the optimal percentile in order to generate the NZCC's 2014 decision to adopt the 67th percentile.

184. We then provide evidence that:

    a. The marginal benefit of a higher percentile has risen reflecting higher risk/cost of underinvestment having due to:

        i. growth in peak demand due to decarbonisation and the changing role of distribution networks as they transition to be "DSOs", and

        ii. materially higher uncertainty around the median projection for demand growth and required investment.

    b. the marginal cost of raising the percentile has fallen due to the NZCC adopting a lower standard error (SE) of the WACC.

5.1.1 Higher risk/cost of underinvestment

185. By the time the 2023 IMs are first implemented in 2025, more than a decade will have passed since the NZCC's 2014 WACC percentile decision. Moreover, another decade will pass before the 2030 IMs first apply to a DPP period beginning in 2035. The period from 2025 to 2035 is expected to be a period of great upheaval in the New Zealand and global electricity markets.

186. We noted that, in 2021 ,the New Zealand Climate Change Commission estimated that by 2025 electric cars will be on a private parity with internal combustion engine (ICE) cars and would be lower cost by 2030. Consistent with this, the Climate Change Commission estimated the following market penetration of light electric vehicles in its "demonstration path" modelling (associated with net zero CO2 emissions by 2050).

50 CEG-report-Percentile-Submission-on-IM-Review-CEPA-report-on-cost-of-capital-26-January-2023.pdf (CEG percentile report)

Figure 5-1: Penetration of EV

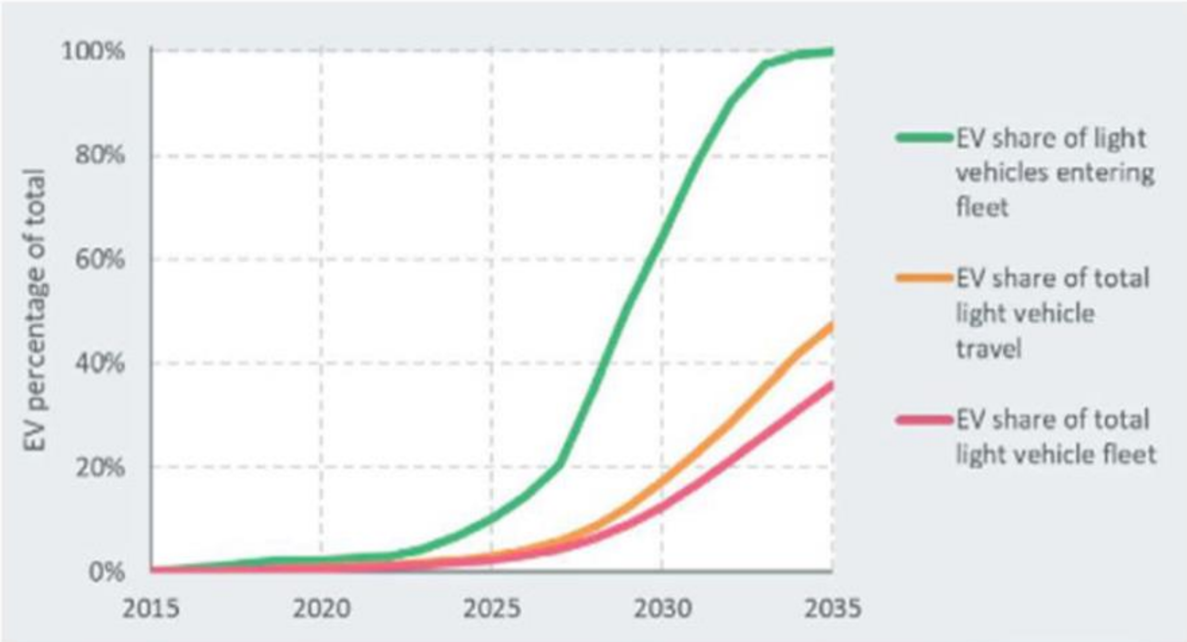


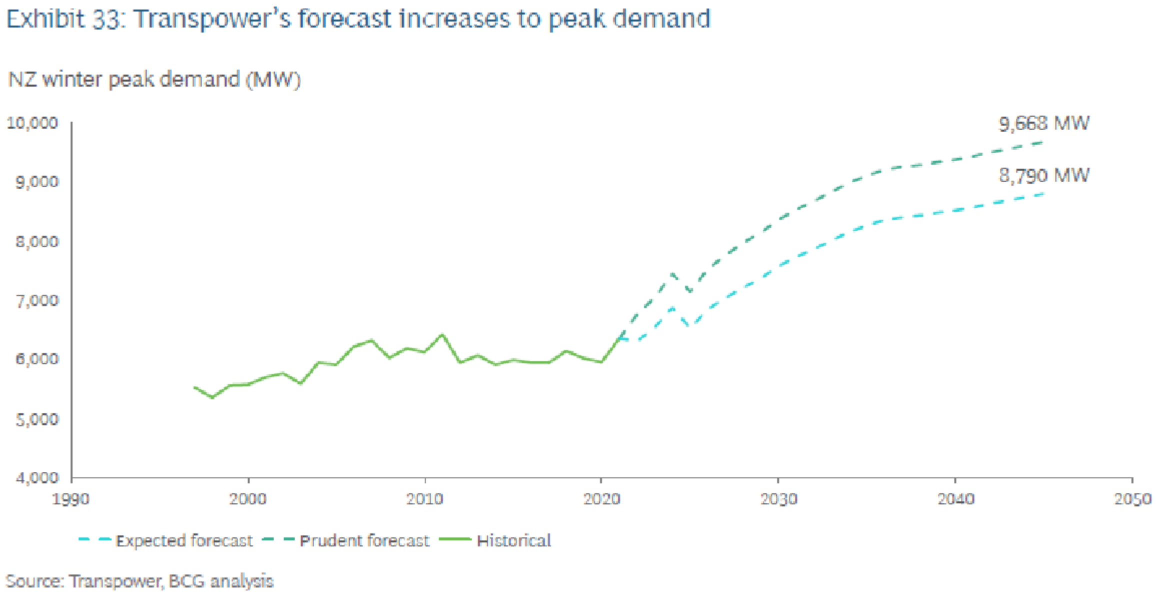
Figure 7.7: Uptake of light EVs in the demonstration path
Source: Commission analysis

Source: Ināia tonu nei: a low emissions future for Aotearoa, May 2021

187. This and other aspects of the energy transition are expected to dramatically increase electricity consumption and generation. Boston Consulting Group (BCG) reports Transpower estimates of peak demand and their analysis is replicated[51] below It can be seen that the demand growth environment from 2025 to 2035 is expected to be radically different to the environment from 2014 to 2025.

[51] BCG, The Future is Electric a Decarbonisation Roadmap for New Zealand's Electricity Sector,2022, p.58

Figure 5-2: Replication of BCG exhibit

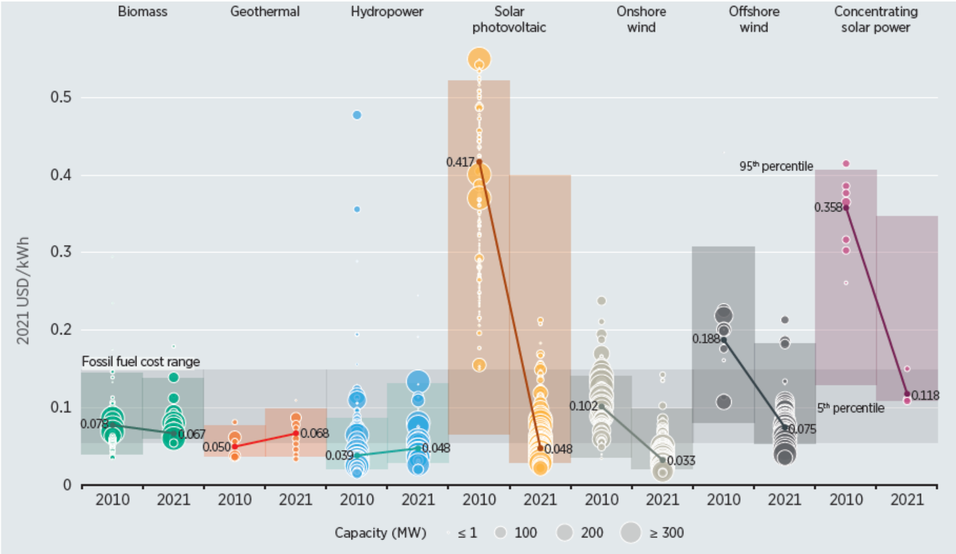


188. BCG estimates that this peak demand will drive annual network costs will be 30% higher per year from 2026 to 2050 than they are today.

189. Moreover, the nature of the generation used to serve this electrification is going to change dramatically. Figure 5-3 below illustrates the dramatic (and ongoing) decline in solar and wind generating costs and is based on data from IRENA.[52]

52 We note that IRENA has separately estimated falls of at 13% to 15% in solar and wind generation costs across 2021 to 2022. Although IRENA have noted this trend may be temporarily disrupted in 2022-23 by materials and supply chain issues – which will equally affect other generation technologies

Figure 5-3: Global weighted average LCOEs from newly commissioned, utility-scale renewable power generation technologies, 2010-2021



Source: IRENA Renewable Cost Database.

190. Consistent with the IRENA evidence, there is expected to be a large increase in the share of intermittent generation (wind and solar PV)

Figure 5-4: Penetration of wind and solar generation

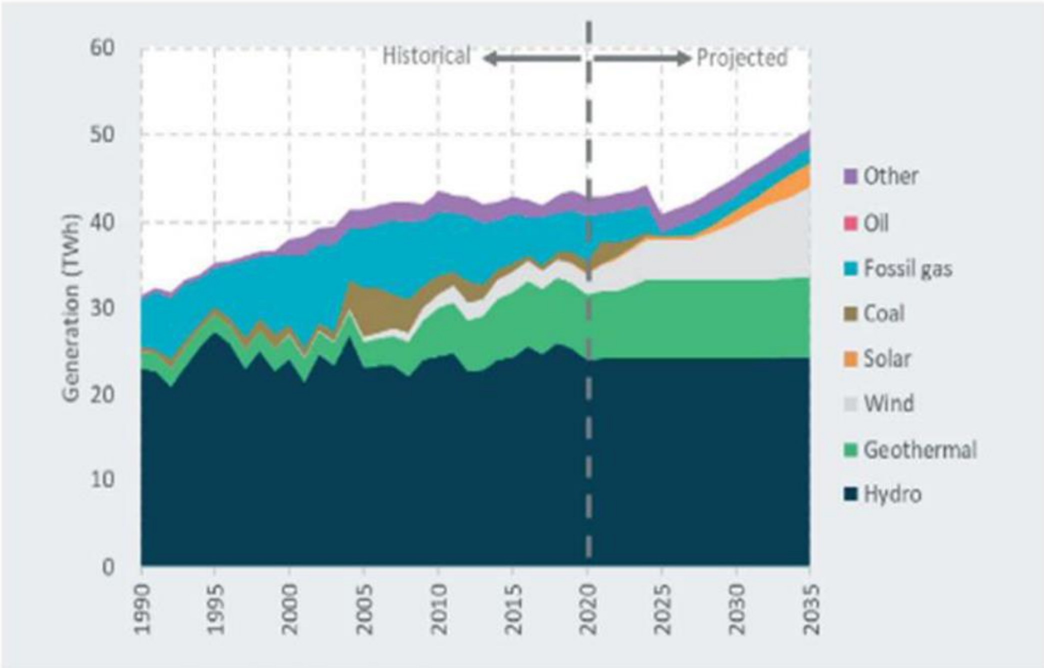


Figure 7.10: Electricity generation by fuel in the demonstration path
Source: Commission analysis

Source: Ināia tonu nei: a low emissions future for Aotearoa, May 2021

191. Altogether, the above factors mean that there will be a commensurate increase in the need for growth in network capacity to efficiently deliver the growing demand for electricity. This growth in network capacity will be a global phenomenon and has the potential to place strains on global supply chains that New Zealand EDBs rely on.

192. In addition, this increasing reliance on intermittent generation along with the rapid rates of advancement in battery storage and smart devices will also result in a radical change in the way EDBs operate.

193. EDBs will form a "flexibility platform" with the potential for coordinating the "responsive assets" layer, such as storage solutions, to optimally match consumption/storage to the generation layer which is becoming increasingly intermittent due to the cost of generating from solar PV and wind.

194. Within the flexibility platform layer sits a range of different actors efficiently adapting their energy use, storage, generation to circumstances on a seasonal/daily/minute by minute basis. We estimate the value of taking the efficient actions described above

will be to reduce supply chain (grid plus generation) costs by 12% to 19% based on the best international evidence.[53]

195. These are all costs that customers would have to pay if EDBs fail to invest in transitioning to DSO capability. This is important in the context of the WACC percentile estimate because it means that a large new source of underinvestment cost, not envisioned in 2014, exists. If a too low WACC resulted in a failure of EDBs to invest in DSO capabilities the annual cost of this can reasonably be estimated at 50% of the EDB's RAB. To put this in context, a cost of underinvestment equal to 50% of the RAB is an order of magnitude larger than Oxera's estimate of the cost of underinvestment due to potential service interruptions of around $1bn pa.

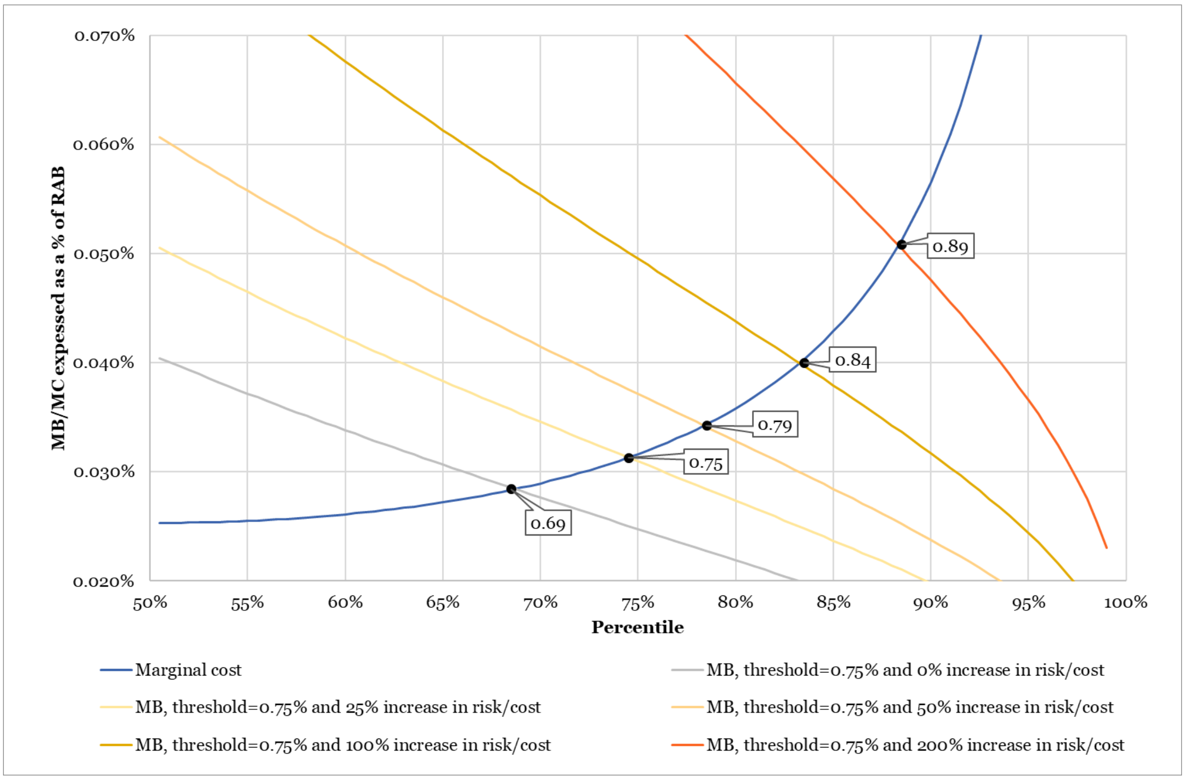
196. CEG modelled four scenarios where the marginal benefit curve (expressed as a percentage of RAB):

- is 25% higher than it was in 2014 (which is less than proportional to the increase in demand growth/uncertainty since 2014);
- is 50% higher than it was in 2014 (which is less than proportional to the increase in demand growth/uncertainty since 2014);
- is 100% higher than it was in 2014 (which is approximately proportional to the increase in demand growth/uncertainty since 2014);
- is 200% higher than it was in 2014 (derived from the ratio of Oxera's "low" and "high" cost of underinvestment estimates being 6.8% and 20.4% of RAB (where 2014 is 200% higher than 6.8)).

197. The results of this midpoint modelling are illustrated in below. The average estimated WACC percentile rises to 75% (79%) if we assume that the risk/cost of underinvestment is 25% (50%) higher (as a percentage of RAB) in 2025 than was the case in 2014. This results in a relatively small 15bp (29bp) higher WACC uplift than in 2014.

53 The US Department of Energy engaged Pacific Northwest National Laboratory to undertake detailed technical and cost modelling of the overall supply chain benefits to end customers associated with developing DSO capabilities. It can be found at: https://www.pnnl.gov/projects/transactive-systems-program/dsot-study

Figure 5-5: Marginal cost and marginal benefit curves with SE=1.01% and assuming a 0.75% threshold and 5.3% of RAB cost of underinvestment



5.2 NZCC draft decision

198. NZCC states that intends to adopt a different tool to incentivise investment in response to decarbonisation instead of WACC percentile. However, it does agree that WACC percentile is the correct tool to respond to the expected cost of outages.[54]

> *While recognising the importance of these investments, and the need for greater investment than has taken place in the recent past, we consider that the WACC percentile is the wrong tool to incentivise these types of investments except to the extent that they relate to the expected costs of outages.*

199. However, the NZCC then goes through a series of calculations that purport to represent the views/results of various submitters calculations (including CEG). The NZCC then uses the calculations to form a large range – which they state is the 55th to the 75th percentile.

54 NZCC (2023), "Part 4 Input Methodology Review 2023 – Draft decision – Cost of capital topic paper" 14 June 2023, paragraph 6.36

Table 5-1: NZCC reports on submitters percentile ranges (paragraph 6.70)

Submitter	1.0% threshold (lower estimate)		0.5% threshold (upper estimate)
CEPA	68%		83%
Oxera	48%		67%
ASCE	52%		70%
CEG	56%		67%
Average	**56%**		**72%**
Average		**64%**	
NZCC stated range	**55%**		**75%**

200. The NZCC then chooses the midpoint of its stated range (being 0.65).

> *6.72 The range of percentiles based on the Oxera, ASCE, and CEG estimates of the cost of outages are similar to the range that Oxera found in 2014 given the inherent range of uncertainty. The only estimate that is materially different is CEPA's, and we note CEPA's concern that their estimate is more likely to be too high than too low. Specifically, while they have updated Oxera's 2014 estimate of $1 billion using the change in the Value of Lost Load, they are concerned that the $1 billion was too high as a starting point.294 We note that the lower end of Oxera's range today is lower than the $1 billion that they used in 2014.*

> *6.73 Overall, the loss analysis model results support the use of a percentile between the 55th and the 75th for PQ regulation, with the 65th percentile as the mid-point of the range.*

201. With respect to CEG's estimates, the NZCC states that the most relevant CEG scenario is:[55]

> *CEG's estimate of outage costs of 6.8% of the RAB of $1.25 billion.*

202. The NZCC then estimated the associated percentile of[56]

55 NZCC (2023), "Part 4 Input Methodology Review 2023 – Draft decision – Cost of capital topic paper" 14 June 2023, paragraph 6.67.4

56 NZCC (2023), "Part 4 Input Methodology Review 2023 – Draft decision – Cost of capital topic paper" 14 June 2023, paragraph 6.70.4.2

6.70.4 The estimate of $1.25 billion based on CEG's use of 6.8% of the RAB yields an optimal percentile of:

6.70.4.1 56% at the 1% threshold; and

6.70.4.2 74% at the 0.5% threshold.

5.3 Critique of the draft decision

5.3.1 Wrong estimates of percentile assuming blackouts cost 6.8% of RAB

203. The NZCC has incorrectly attributed to CEG an optimal percentile of 56% (at the 1% threshold) and 74% (at the 0.5% threshold) associated with a cost of blackouts equal to 6.8% of the RAB.

204. However, the correct application of the CEG model provided to the NZCC for a 6.8% of RAB blackout and a SE of WACC = 1.01% cost is:

- 67th percentile assuming a 1.0% threshold; and
- 82nd percentile assuming a 0.5% threshold.

205. While our report proper does not have these results in it, the first estimate (67th percentile) can easily be approximated from Table 4-1 which shows an optimal 66th percentile with a 1% threshold, SE=1.01% and a 6.7% of RAB cost of blackouts. This is very similar to the 67th (noting that increasing the cost of blackouts from 6.7% to 6.8% has a small increase in optimal percentile (from 66th to 67th).

206. We do not understand how the NZCC arrived at much lower optimal percentiles than are derived from out model. However, these lower values are not correctly attributable to CEG. If we substitute the correct values into Table 5-1 above the average of the submitted values rises from the 64th to the 67th percentile.

Table 5-2: Submitters percentile ranges (paragraph 6.70) updated to include correct CEG values

Submitter	1.0% threshold (lower estimate)	0.5% threshold (upper estimate)
CEPA	68%	83%
Oxera	48%	67%
ASCE	52%	70%
CEG	67%	82.0%
Average	**56%**	**72%**
Average	**67%**	
NZCC stated range	**55%**	**75%**

5.3.2 Draft decision logic suggests that there is no reason to change percentile

207. The draft decision logic (unamended and amended to correct attributions to CEG) suggest that there is no reason to change the percentile. The NZCC identifies a wide, and somewhat arbitrary, range (0.55 to 0.75) where the 2014 decision (67th percentile) is very close to the middle of that range (65th percentile).

208. However, instead of concluding that this supports retaining its previous decision, the NZCC concludes that it supports a very small change to its previous decision (a drop in the percentile from 67th to 65th percentile).

209. In doing so, the NZCC does not actually present any evidence that there have been changes since its 2014 decision that would justify a reduction in its percentile. Rather, the NZCC appears to form a:

- 2023 range that is essentially the same as the 2014 range and is based on largely the same evidence that existed I 2014; and
- then choose a different point in that range than was chosen in 2014;
- without explaining what was wrong with the 2014 decision that it now wishes to depart from it.

210. In our opination, absent any evidence supporting a change in the optimal percentile, the NZCC should have simply retained its 2014 decision.

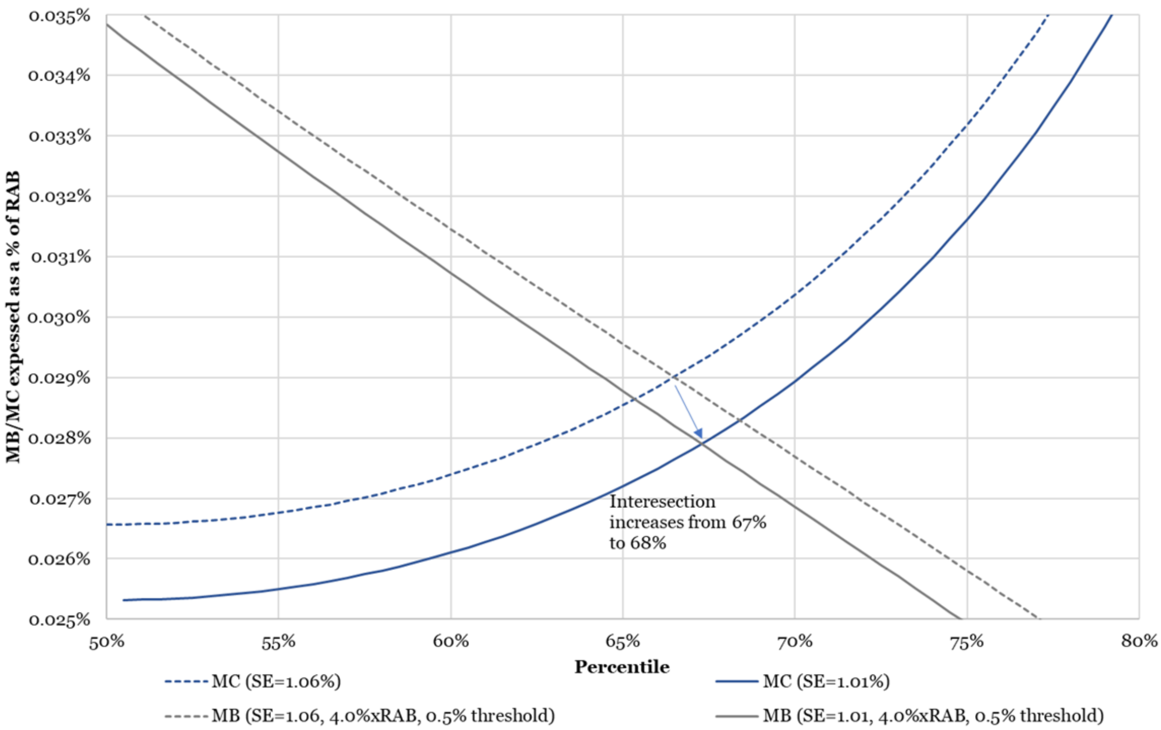
5.3.3 Draft decision logic fails to grapple with reasons for higher percentile

211. One small reason for a higher uplift in 2023 than in 2014 is that the standard error of the WACC is lower (1.01% vs 1.06%). This lowers the marginal cost of raising the percentile (because the actual WACC uplift falls for any given percentile). We explained:[57]

> *Focussing on the midpoint scenarios, updating the standard error (from 1.06% to 1.01%) but leaving the marginal benefit assessment unchanged, results in a slightly higher estimated WACC percentile of 69% and a slightly lower WACC uplift (50bp) relative to 2014.*

212. This is illustrated in the following graphic where both the marginal cost and marginal benefit curves shift down when the SE of WACC is lowered. The end result is a higher percentile (but a lower WACC uplift because the higher percentile is applied to a smaller SE of WACC).

Figure 5-6: Impact of lower SE of WACC on optimal percentile (adapted from Figure 2 4 of CEG original report)



57 CEG-report-Percentile-Submission-on-IM-Review-CEPA-report-on-cost-of-capital-26-January-2023.pdf (CEG percentile report), paragraph 63.

213. However, the main contribution of our analysis was to present evidence for why we would expect that this cost would be materially higher in the period that the 2023 IMs apply to compared to what was the case in 2014. Specifically:

- In section 4.1 we discussed why there was materially higher uncertainty around demand growth now than in 2014 and why this was likely to lead to a greater risk of underinvestment if the WACC was too low;
- In section 4.2 we discussed why there was materially higher expected demand growth now than in 2014 and why this was likely to lead to a greater risk of underinvestment if the WACC was too low;
- In sections 5 and 6 we discussed how the changing role of EDB's meant that blackouts were no longer the only, or even the major, source of cost from underinvestment by EDBs in their emerging roles as DSOs;

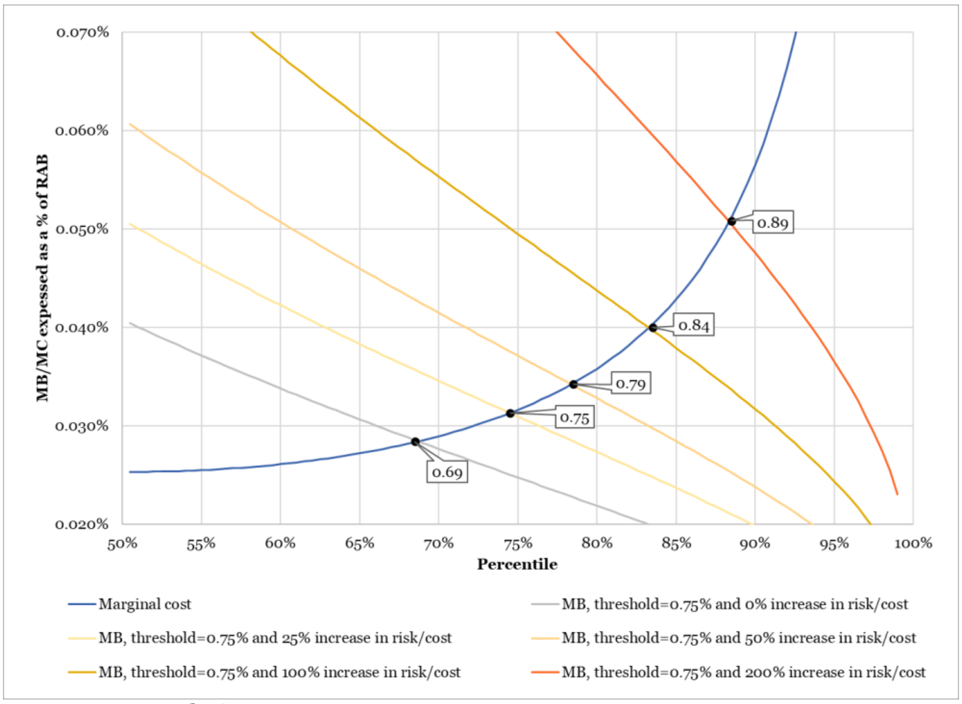
214. The NZCC has explicitly stated that it will use tools other than the percentile to encourage investment in DSO capabilities. Accepting that statement as correct, there remains the evidence we put forward in sections 4.1 and 4.2 that pointed to higher risks of underinvestment looking forward today than was the case in 2014.

215. The draft decision does not disagree with, or acknowledge, that evidence. Consequently, it is not possible for us to critique why the NZCC has given zero weight to that evidence in the draft decision.

216. This is unfortunate as, an important part of a well-functioning consultation process, involves the regulator, if they disagree with propositions/evidence put to them, explaining in its draft decision why it disagreed. This allows the logic of the regulator to be tested and also identifies areas where more evidence may be valuable.

217. This has not occurred in the current context. We can only commend the evidence already presented and reiterate our conclusions below (emphasis added).

Figure 7-1: Midpoint marginal benefit curves intersections with marginal cost curve using a SE of 1.01%



Source: CEG analysis

*Based on this figure, **solely adjusting for the lower standard error would raise the WACC percentile that maximises consumer welfare to 0.69%** (although the WACC uplift would nonetheless fall by 3bp – with the higher WACC percentile more than offset by a narrower distribution of the WACC).*

If one were also to raise the estimated cost of underinvestment by a factor of 25%/50%, then the WACC percentile would increase to 75%/79%. Raising the estimated cost of underinvestment by a factor of 100%/200% would increase the WACC percentile to 84%/89%.

We consider that reasonable interpretations of the evidence in this report could result in a conclusion that the risk/cost of underinvestment in 2025 is likely to be in the order of 25% to 100% higher than it was in 2014 (scaled relative to the respective RAB values).

In our view, the middle of this range would imply a reasonable balance of the costs and benefits to consumers of allowing a higher WACC percentile. This would result in a 79% WACC percentile (associated with a 50% estimated increase in the cost of underinvestment relative to 2014).

6 CPI forecasting and RAB indexation

218. In my previous report we stated that there was no good reason to expose customers and investors to inflation forecast risk on the cost of debt

> *If there was a good economic reason for exposing customers and EDBs to this risk then that would be one thing. However, other than preserving the status quo, there is no good reason for exposing customers and EDBs to inflation forecasting error on the cost of debt. That is, there is no reason to target a real return on debt when it is universally agreed that debt is efficiently incurred as a nominal cost.*

219. The 2023 draft decision has, consistent with our advice, determined to target a nominal return on debt. This means that inflation forecast risk is removed from both customers and investors. I commend this decision.

220. However, I note that the draft decision appears to have determined to implement this in a manner that has the potential to lead to considerable volatility in prices. Specifically, the NZCC appears to be proposing to adjust revenues within the remainder of the regulatory period for any inflation forecast error, for the debt portion of the RAB, in previous years of the regulatory period.

221. This has the potential to create some very large swings in prices. In my view there are two better (and simpler) ways to target a nominal return on debt. These are:

    a. Simply don't escalate the debt portion of the RAB by inflation at all (either within the financial model or the RAB roll-forward model) so there is no forecast error to correct; or

    b. Apply the same forecast inflation used in the financial model in the RAB roll-forward model for the debt portion of the RAB

222. Option a is the simplest but would bring forward the real return of capital relative to the current IMs. Option b is also relatively simple and preserves the current expected profile for the return of capital.

7 Equity raising costs

223. Equity raising costs are transaction costs incurred when EDBs fund capital investment through equity. According to the AER when it first applied equity raising cost in 2009:[58]

> *In raising new equity capital a business may incur costs such as legal fees, brokerage fees, marketing costs and other transaction costs. These are upfront expenses, with little or no ongoing costs over the life of the equity. Whilst the size of the equity a firm will raise is typically at its inception, there may be points in the life of a firm—for example, during capital expansions—where it chooses additional external equity funding (instead of debt or internal funding) as a source of equity capital, and accordingly may incur equity raising costs.*
>
> *The AER has accepted that equity raising costs are a legitimate cost for a benchmark efficient firm only where external equity funding is the least–cost option available.*

224. We provided an equity raising cost model based on the AER's current approach[59] to equity raising costs within the context of the NZCC financial model. The AER's current approach was formulated as part of its own revenue model to provide transparency and consistency.[60]

225. If applied in the current DPP period we estimate the following equity raising costs would have been estimated.

58 AER TransGrid transmission determination 2009-10 to 2013-14, Final decision 28 April 2009

59 Page 90 in AER, "Electricity Distribution Network Service Provider – Post-Tax Revenue Model, Version 4, April 2019

60 Page 5 in AER, "Electricity transmission network service providers, post-tax revenue model - Amendment - Final Decision," December 2010

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Table 7-1: Equity raising costs associated with AER method aggregated over 2021-2025 ($thousands, real 2019/20)

	Aurora	Orion	Unison	Vector	Wellington
Total Equity Raising Cost	628	1,141	402	2,003	126

Powerco not available due to lack of data on Powerco capex in the NZCC financial model.

7.1 NZCC draft decision

226. The draft decision can be summarised in the following quote.

> *4.217 However, we note that the five networks for which CEG presents evidence are expected to generate cashflow returns to equity that are large enough to meet their equity financing needs while maintaining the target leverage ratio.*[235]
>
> *4.218 As ENA and CEG recognised, retained earnings are cheaper than dividend reinvestment programmes. For a firm to pay dividends, and then incur the cost of raising new equity through more expensive means is not efficient.*
>
> *4.219 Therefore, we consider that there is no reason to provide an allowance for equity issuance costs for the EDBs. However, we are aware that capex associated with electrification of the economy may lead to equity raising costs being incurred in the future. We welcome any further evidence on the likelihood that equity raising costs will be incurred and the materiality of these costs. We particularly welcome submissions on whether our draft decision to apply inflation indexation to Transpower's RAB will likely result in Transpower incurring equity issuance costs*
>
> [235] *The sum of 'Dividend at Assumed Payout Ratio' and 'Retained Cashflow Available for Reinvestment under Assumed Payout Ratio' is greater than the 'Equity' component.*

7.2 Response to draft decision

227. In my view this response is problematic. The NZCC expresses the view, based on our modelling for the current DPP, that no equity raising costs would be incurred because equity funding requirements could be fully recovered (at zero cost) by cutting dividends (footnote 235).

228. Even if we accept that no equity raising costs are incurred until dividends fall to zero (which neither we nor the AER accept), it is still important for the NZCC to set out and include in its IMs what happens when retained earnings cannot fund equity raising and a firm is required to raise equity externally.

229. Our modelling provided estimates of these costs (specifically 2% costs associated with external equity raising). The time for the NZCC to respond to these concrete proposals, in the form of a fully-fledged model, was in the draft decision. That is, the draft decision was the place in which the consultation should have been moved forward with the NZCC's alternative model for equity raising costs.

230. Instead, the NZCC has responded along the lines:

> *4.219 Therefore, we consider that there is no reason to provide an allowance for equity issuance costs for the EDBs. However, we are aware that capex associated with electrification of the economy may lead to equity raising costs being incurred in the future. We welcome any further evidence on the likelihood that equity raising costs will be incurred and the materiality of these costs. We particularly welcome submissions on whether our draft decision to apply inflation indexation to Transpower's RAB will likely result in Transpower incurring equity issuance costs.*

231. The CEG report was not asking for EDBs to be compensated in the current DPP for equity raising costs (obviously). We were putting forward a model (based on the AER model) of equity raising costs to be applied in the future – including when the RAB begins to grow at a fast rate with electrification.

232. It is unclear what more we can do in order to elicit views from the NZCC on what its preferred model of equity raising costs would look like. Having missed the opportunity to respond with its own model and assumptions in the draft decision we have no ability to provide "further evidence" than the evidence we already provided.

233. Hopefully the final decision will include a sensible model of equity raising costs that is capable of dealing with electrification and changes to indexation of Transpower's RAB. However, suppliers will have no ability to contribute to that, unless a separate process is opened up, due to the failure of the NZCC to set out its detailed position in this draft decision.

Appendix A Derivative of debt beta to tenor

234. This appendix investigates the mathematical relationship between debt beta and tenor. The relationship between debt beta and tenor is described by Oxera (2020) as shown below.[61]

Figure 7-1: Reproduction of Box 2.3 from Oxera report

Box 2.3 Structural model methodology

The Merton model can be arranged to obtain debt beta:

$$\beta_d = \frac{(1 - N(d_1))}{g} \cdot \beta_a$$

Where:

$$d_1 = \frac{-\ln(g) - \left(y - \frac{\sigma_a^2}{2}\right) \cdot T}{\sigma_a \cdot \sqrt{T}}$$

$\boldsymbol{g}$ gearing; $\boldsymbol{\beta_d}$ debt beta; $\boldsymbol{\beta_a}$ asset beta; $\boldsymbol{N}$ is the cumulative normal distribution; $\boldsymbol{\sigma_a^2}$ asset variance, $\boldsymbol{T}$ time to maturity of the bond; $\boldsymbol{y}$ credit spread

Asset variance needs to be estimated as it is not directly observable. Schaefer and Strebulaev (2008) have presented ways to estimate the volatility and variance of assets.[1]

235. Our analysis shows that for relevant parameters, the debt beta must increase with tenor (which is what Oxera found).

236. The function form for debt beta, as described by Oxera, is shown below.

$$\beta_d = \frac{\left(1 - N(d_1)\right)}{g} \beta_a$$

Where

- β_d is the debt beta
- β_a is the asset beta

61 Oxera, estimating debt beta for regulated entities Prepared for Energy Networks Association8 June 2020, p.16

- g is the gearing that measures the proportion of asset that is funded by debt and it varies between 0 and 1.
- $N(\cdot)$ is the function for cumulative standard normal distribution
- d_1 is defined as $\frac{-ln(g)-\left(y-\frac{\sigma_a^2}{2}\right)T}{\sigma_a\sqrt{T}}$ where
  - σ_a is the volatility of the asset,
  - y is the credit spread and
  - T is the time to maturity.

237. Asset beta does not vary with financing policies including debt tenor. Also gearing is a function of firm's value and total debt, both of which do not depend on the length of maturity of the debt. Therefore:

$$\frac{\delta\beta_d}{\delta T} = \frac{-N(d_1)}{g}\beta_a N'(d_1)\frac{\delta d_1}{\delta T}$$

238. Given that $\frac{N(d_1)}{g}\beta_a N'(d_1)$ are strictly positive,[62] this implies that the sign for $\frac{\delta\beta_d}{\delta T}$ is the opposite of $\frac{\delta d_1}{\delta T}$

239. The derivative of d_1 with respect to T is as follows.

$$\frac{\delta d_1}{\delta T} = \frac{\sigma_a\sqrt{T}\left(-\left(y-\frac{\sigma_a^2}{2}\right)\right)-\left(-ln(g)-\left(y-\frac{\sigma_a^2}{2}\right)T\right)\frac{1}{2}\sigma_a T^{-1/2}}{\sigma_a^2 T}$$

240. This can be simplified to

$$\frac{\delta d_1}{\delta T} = \frac{\frac{1}{2}\sigma_a T\left(\frac{\sigma_a^2}{2}-y\right)+ln(g)\frac{1}{2}\sigma_a}{\sigma_a^2 T\sqrt{T}}$$

241. In order to determine whether $\frac{\delta d_1}{\delta T}$ is positive or negative, the component that matters is

$$T\left(\frac{\sigma_a^2}{2}-y\right)+ln(g)$$

242. This is because the other components, $\frac{\frac{1}{2}\sigma_a}{\sigma_a^2 T\sqrt{T}}$, are strictly positive.

---

62 β_a is assumed to be positive.

243. If $T\left(\frac{\sigma_a^2}{2} - y\right) + ln(g)$ is negative, that implies $\frac{\delta d_1}{\delta T}$ is negative and $\frac{\delta \beta_d}{\delta T}$ is positive. Given g varies between 0 and 1, it implies $ln(g)$ is negative. Therefore, if asset volatility σ_a, is high relative to credit spread, y, then $\frac{\sigma_a^2}{2} - y$ is large enough such that $T\left(\frac{\sigma_a^2}{2} - y\right) + ln(g)$ is positive and $\frac{\delta \beta_d}{\delta T}$ is negative.

244. Oxera (2020)[63] relies on Schaefer and Strebulaev (2008)[64] as a source of asset volatility. Schaefer and Strebulaev (2008) estimates the asset volatility to be approximately 22% for BBB issuers (and issuers with higher credit ratings) with a standard deviation of σ_a within the sample is 8%.

Figure 7-2: Reproduction of Table 7 from Schaefer and Strebulaev (2008)

	All	AAA	AA	A	BBB	BB	B
$\widehat{\sigma_A}$							
Mean	0.22	0.22	0.22	0.21	0.22	0.23	0.28
Median	0.21	0.21	0.22	0.20	0.20	0.21	0.27
Standard deviation	0.08	0.05	0.07	0.08	0.08	0.08	0.08
5% Quantile	0.10	0.13	0.10	0.10	0.11	0.12	0.21
95% Quantile	0.36	0.30	0.34	0.34	0.37	0.39	0.36

245. The tables below shows the sign of $T\left(\frac{\sigma_a^2}{2} - y\right) + ln(g)$ for various parameters of asset volatility and credit spread assuming the length of maturity is 10 years and gearing is 40%. The results show that only when asset volatility is in the top 0.1% of sample and credit spread is low, does $T\left(\frac{\sigma_a^2}{2} - y\right) + ln(g)$ become positive. Obviously, it is very unlikely that asset volatility will be extremely high and credit spreads will be unusually low. For all reasonable estimates, $T\left(\frac{\sigma_a^2}{2} - y\right) + ln(g)$ is negative and $\frac{\delta \beta_d}{\delta T}$ is positive.

246. I note that these tables are for T=10 and T=15. The lower is T the more positive will $\frac{\delta \beta_d}{\delta T}$ be. That is, for low levels of T the increase in debt beta with tenor will be even higher. Thus, Oxera's result that debt beta increases by 0.02 when debt tenor

63 Oxera, Estimating debt beta for regulated entities Prepared for Energy Networks Association8 June 2020, p.16

64 Schaefer and Strebulaev (2008), "Structural models of credit risk are useful: Evidence from hedge ratios on corporate bonds" Journal of Financial Economics, Vol 90, pages 1-19

increases from 10 to 12 years suggests a more than 0.05 increase in debt beta between T=5 and T=10.

Table 2: Sign of $T\left(\frac{\sigma_a^2}{2} - y\right) + ln(g)$ (maturity is 10 years and gearing is 40%)

Asset volatility		Credit spread 0%	0.50%	1%	1.50%	2%
22%	Mean (50% of sample has lower volatility)	<0	<0	<0	<0	<0
30%	One stdev. higher (84% of sample has lower volatility)	<0	<0	<0	<0	<0
38%	Two stdev. higher (98% of sample has lower volatility)	<0	<0	<0	<0	<0
46%	Three stdev. higher (99.9% of sample has lower volatility)	>0	>0	>0	<0	<0

247. The follow table shows the sensitivity of the result when the length of maturity is increased to 15 years or the gearing is increased to 60%. The result consistently shows that for majority of the scenarios, $T\left(\frac{\sigma_a^2}{2} - y\right) + ln(g)$ is negative and $\frac{\delta\beta_d}{\delta T}$ is positive.

Table 3: Sign of $T\left(\frac{\sigma_a^2}{2} - y\right) + ln(g)$ (maturity is 15 years and gearing is 40%)

Asset volatility		Credit spread 0%	0.50%	1%	1.50%	2%
22%	Mean (50% of sample has lower volatility)	<0	<0	<0	<0	<0
30%	One stdev. higher (84% of sample has lower volatility)	<0	<0	<0	<0	<0
38%	Two stdev. higher (98% of sample has lower volatility)	>0	>0	>0	<0	<0
46%	Three stdev. higher (99.9% of sample has lower volatility)	>0	>0	>0	>0	>0

Table 4: Sign of $T\left(\frac{\sigma_a^2}{2} - y\right) + ln(g)$ (maturity is 10 years and gearing is 60%)

Asset volatility		Credit spread 0%	0.50%	1%	1.50%	2%
22%	Mean (50% of sample has lower volatility)	<0	<0	<0	<0	<0
30%	One stdev. higher (84% of sample has lower volatility)	<0	<0	<0	<0	<0
38%	Two stdev. higher (98% of sample has lower volatility)	>0	>0	>0	>0	>0
46%	Three stdev. higher (99.9% of sample has lower volatility)	>0	>0	>0	>0	>0

248.