Low-beta bias

A REPORT PREPARED FOR ACTEWAGL DISTRIBUTION

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1 Executive summary

1.1 Instructions

1 Frontier Economics has been engaged by ActewAGL Distribution to provide expert advice in relation to the issue of low-beta bias when estimating the equity beta as part of the implementation of the Sharpe-Lintner CAPM (SL-CAPM).

2 Specifically, we have been asked to:

a. Explain the concept of low-beta bias in the context of the SL-CAPM;

b. Examine the approaches for correcting for low-beta bias;

c. Summarise the evidence on the quantum of low-beta bias; and

d. Provide our opinion about the reasonableness of the AER's approach to correcting for low-beta bias.

1.2 Background and context

3 'Low-beta bias' is the term that is used to summarise one of the main results of empirical tests of asset pricing models – the SL-CAPM systematically under-states the returns on stocks with beta estimates less than one. That is, low-beta stocks systematically earn higher returns than the SL-CAPM would predict – the model does not fit the observable data.

4 Two methods of correcting for low-beta bias have recently been considered in the Australian regulatory setting:

a. Use the Black CAPM (a modification of the SL-CAPM that was developed for the purpose of correcting for low-beta bias) to estimate the required return on equity; or

b. Continue to use the SL-CAPM, but make an adjustment to the equity beta estimate to correct for low-beta bias.

5 In the recent *PIAC-Ausgrid* merits review case,[1] the Australian Competition Tribunal (Tribunal) determined that there is no error in:

a. Recognising the existence of low-beta bias; or

b. Accounting for low-beta bias by making an adjustment to the equity beta estimate in the SL-CAPM.

[1] Applications by Public Interest Advisory Centre Ltd and Ausgrid [2016] ACompT 1.

1.3 Primary conclusions

6 In this report, we explain the concept of low-beta bias and the theoretical rationale for it. We also summarise the evidence and note that low-beta bias is a standard result that is described in the standard finance textbooks. We examine the methods for correcting for low-beta bias and explain the AER's approach in some detail.

7 We also consider the evidence on the magnitude of low-beta bias and conclude that the majority of studies support an estimate of the zero-beta premium (the additional return, over and above the SL-CAPM forecast, for an asset with a beta of zero) between 2% and 4% and we consider that range to be a reasonable characterisation of the available data. We note that this range is slightly above the range of 1.5% to 3.0% that the AER adopted in its Rate of Return Guideline materials as a range that is "reasonable"[2] and "open to us."[3]

8 Finally, we note that the AER's approach has been to address the evidence of low-beta bias by making an adjustment to the equity beta estimate in the SL-CAPM. The AER's uplift from a best statistical estimate of 0.5 to an allowed beta of 0.7 reflects three considerations, one of which is low-beta bias. We show that even if the entire uplift is attributed to low-beta bias, that would only correct for a low-beta bias of 2.6%, which is at the lower end of the range of empirical estimates.[4] Consequently, we conclude that the AER's approach does not appear to fully correct for low-beta bias. A full correction for the observed low-beta bias would require a greater uplift to the statistical beta estimate than that which the AER has adopted in recent decisions.

1.4 Author of report

9 This report has been authored by Professor Stephen Gray, Professor of Finance at the UQ Business School, University of Queensland and Director of Frontier Economics, a specialist economics and corporate finance consultancy. I have Honours degrees in Commerce and Law from the University of Queensland and a PhD in Financial Economics from Stanford University. I teach graduate level courses with a focus on cost of capital issues, I have published widely in high-level academic journals, and I have more than 20 years' experience advising regulators, government agencies and regulated businesses on cost of capital issues. I have published a number of papers that specifically address beta estimation issues. A copy of my curriculum vitae is attached as an appendix to this report.

10 My opinions set out in this report are based on the specialist knowledge acquired from my training and experience set out above. I have been provided with a copy

[2] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 71.

[3] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 71.

[4] We conclude in Section 6 of this report that the majority of the estimates set out above imply a zero-beta premium between 2% and 4% and we consider that range to be a reasonable characterisation of the available data.

of the Federal Court's Expert Evidence Practice Note GPN-EXPT, which comprises the guidelines for expert witnesses in the Federal Court of Australia. I have read, understood and complied with the Practice Note and the Harmonised Expert Witness Code of Conduct that is attached to it, and agrees to be bound by them.

2 What is low-beta bias?

2.1 Overview

11 Since the AER's 2013 Rate of Return Guideline process, there has been much discussion in the Australian regulatory process about the issue of 'low-beta bias.' This issue has been the subject of numerous submissions, it has been addressed by the AER in its Guideline and in several draft and final decisions, and it was one of the issues raised in the *PIAC-Ausgrid* merits review case.[5]

12 In this report, we explain the concept of low-beta bias and we summarise the empirical and theoretical support for the existence of a systematic low-beta bias. We also document the position that the AER has taken on this point and we summarise the views of the Tribunal.

2.2 The Capital Asset Pricing Model

13 The approach that the AER uses to determine the allowed return on equity is known as the Sharpe-Lintner Capital Asset Pricing Model (SL-CAPM).[6] Under the SL-CAPM, the return on equity that investors would require in the current market conditions, r_e, is given by:

$$r_e = r_f + \beta \times (r_m - r_f)$$

where:

- r_f represents the **risk-free rate** of return. This is the return that is available to investors on an investment that is completely free of risk. Commonwealth government bonds are usually assumed to be such a risk-free investment;
- r_m represents the **expected return on the market**, which is the expected return that investors require to invest in an asset of average risk; and
- $(r_m - r_f)$ represents the **market risk premium**, which is the amount of extra return (over and above the return on a risk-free asset) that investors would require for investing in an asset of average risk; and
- β represents the **equity beta**, which indicates the extent to which the particular investment has more or less risk than average. For example, an equity beta of 1.2 indicates that the investment is 20% more risky than average, in which case it would require a risk premium (over and above the risk-free

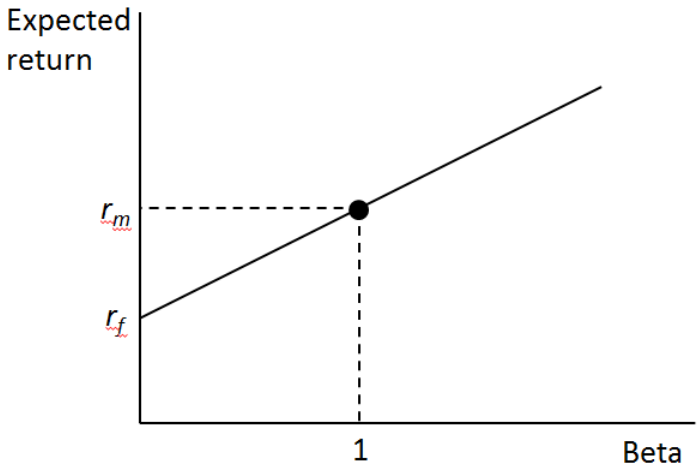
[5] Applications by Public Interest Advisory Centre Ltd and Ausgrid [2016] ACompT 1.

[6] This formula was independently derived by Sharpe (1964) and Lintner (1965). Sharpe, W., 1964, "Capital asset prices: A theory of market equilibrium under conditions of risk," *Journal of Finance,* 19, 425-442; and Lintner, J., 1965, "The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets," *Review of Economics and Statistics,* 13-37.

rate) that is 20% more than would be required for an investment of average risk.

14 The SL-CAPM formula is often displayed in graphical form as in Figure 1 below. This figure shows that firms with higher beta risk require higher expected returns.

Figure 1: Sharpe-Lintner Capital Asset Pricing Model



15 Like all economic models of this type, the SL-CAPM formula was derived by starting with a set of simplifying assumptions and applying a series of mathematical steps to solve for an equilibrium. In the SL-CAPM, the equilibrium pricing formula above is derived by assuming that every investor will trade to maximise their utility (i.e., to obtain the risk/return trade-off that is optimal for them), and by then aggregating over all investors in the market. That is, the SL-CAPM is a theoretical mathematical/economic model that was derived without regard to any market data. Consequently, there is no guarantee that actual market data will be consistent with the predictions of the model.

2.3 The empirical performance of the SL-CAPM[7]

16 Soon after the publication of the Sharpe-Lintner CAPM, researchers began testing whether the predictions (or, more precisely, the empirical implications) of the model were supported in real-world data. The conclusion from this evidence is that the empirical implementation of the SL-CAPM provides a poor fit to the observed data. That is, when the SL-CAPM parameters are empirically estimated and inserted into the SL-CAPM formula, the resulting estimate of the required return on equity bears little resemblance to observed stock returns. The feasible

[7] Much of the material in this section is drawn from SFG, 2014, "Cost of equity in the Black Capital Asset Pricing Model," 22 March.

implementation of the SL-CAPM does not fit the observed data. The remainder of this sub-section summarises some of the relevant evidence.

2.3.1 Black, Jensen and Scholes (1972)[8]

17 A number of empirical tests are based on the following rearranged version of the SL-CAPM equation:

$$r_e - r_f = (r_m - r_f)\beta_e .$$

18 For example, Black, Jensen and Scholes (1972) construct tests of the model in the form of the following regression specification:[9]

$$r_{e,j} - r_{f,j} = \gamma_0 + \gamma_1 \beta_{e,j} + u_j .$$

19 The SL-CAPM implies that $\gamma_0 = 0$ and $\gamma_1 = r_m - r_f$. However, a series of studies including Black, Jensen and Scholes (1972) report that the intercept of this regression model is higher than the SL-CAPM would suggest $(\gamma_0 > 0)$ and the slope is flatter than the SL-CAPM would suggest $(\gamma_1 < r_m - r_f)$. For example, Black Jensen and Scholes (1972) state that:

> The tests indicate that the expected excess returns on high beta assets are lower than (1) [the Sharpe-Lintner CAPM equation] suggests and that the expected excess returns on low-beta assets are higher than (1) suggests.[10]

20 The main result of Black, Jensen and Scholes (1972) is summarised in Figure 2 below. In that figure, the dashed line represents the security market line[11] that is implied by the SL-CAPM and the solid line represents the best fit to the empirical data. The data suggest that the intercept is too high and the slope is too flat to be consistent with the SL-CAPM.

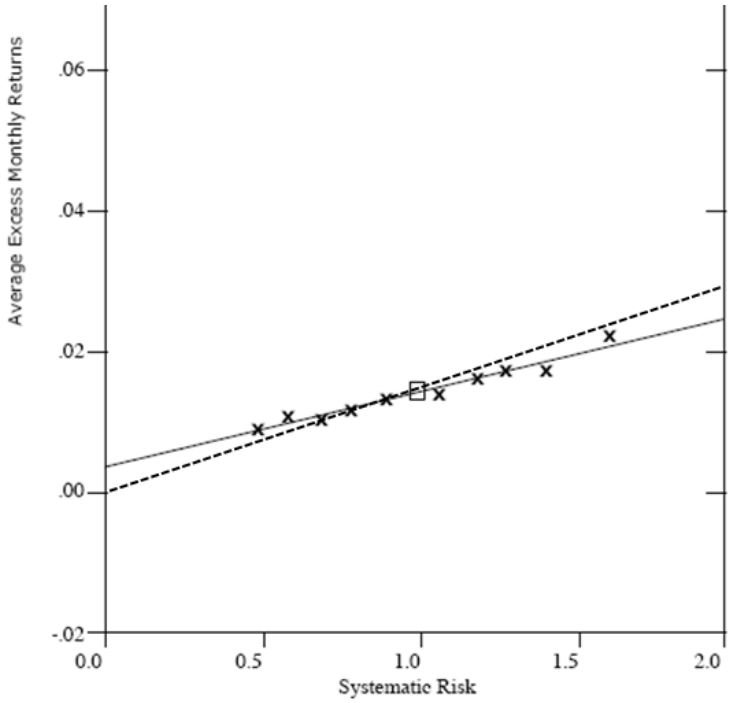
[8] Black, F., M.C. Jensen, and M. Scholes, 1972, "The Capital Asset Pricing Model: Some empirical tests," in *Studies in the Theory of Capital Markets,* Michael C. Jensen, ed., New York: Praeger, 79–121.

[9] See, for example, Black, Jensen and Scholes (1972), p. 3.

[10] Black, Jensen and Scholes (1972), p. 4.

[11] The term "security market line" refers to the linear relationship between beta and expected returns for individual assets or portfolios of assets. In empirical analysis this is typically measured as the line of best fit between beta estimates and realised returns for individual assets or portfolios of assets.

Figure 2: Results of Black, Jensen and Scholes (1972)



Source: Black, Jensen and Scholes (1972), Figure 1, p. 21. Dashed line for Sharpe-Linter CAPM has been added.

21 Black, Jensen and Scholes (1972) go on to define the intercept of the empirical regression line to be R_z, a quantity that has since become known as the "zero beta premium."[12] They report that the zero beta premium over their sample period of 1931 to 1965 was approximately 4% per year.[13] They go on to conclude that:

> These results seem to us to be strong evidence favoring rejection of the traditional form of the asset pricing model which says that Rz should be insignificantly different from zero.[14]

and that:

> These results indicate that the usual form of the asset pricing model as given by (1) [the SL-CAPM] does not provide an accurate description of the structure of security returns.[15]

[12] We have not yet described the Black CAPM, but the term "zero beta premium" refers to the difference between the expected return on an asset with zero systematic risk (a zero beta) and the estimate of the risk-free rate (typically estimated as the yield on a government security).

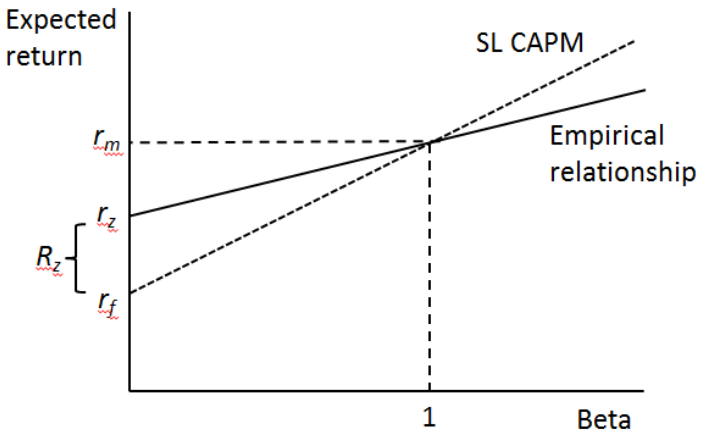
[13] Table 5, p. 38 reports a monthly zero beta premium of 0.338% per month, which is approximately equivalent to 4% per year.

[14] Black, Jensen and Scholes (1972), p. 39.

[15] Black, Jensen and Scholes (1972), pp. 3–4.

22 The empirical relationship and the implications of the SL-CAPM are contrasted in Figure 3 below, which shows the SL-CAPM in its usual form. (Note that in Figure 2 Black, Jensen and Scholes (1972) show *excess* returns, after subtracting the risk-free rate.)

Figure 3: Sharpe-Lintner CAPM vs. empirical relationship.



2.3.2 Friend and Blume (1970)[16]

23 Friend and Blume (1970) define the abnormal return (the Greek letter "eta" or η) to be the observed excess return of a stock (or portfolio) less the expected return from the SL-CAPM:[17]

$$\eta_i = (r_e - r_f) - (r_m - r_f)\beta_e .$$

24 Under the SL-CAPM, η_i should be zero on average and it should be independent of beta. However, Friend and Blume (1970) report a systematic relationship between the abnormal return and beta – *low-beta* stocks generate *higher* returns than the SL-CAPM would suggest and *high-beta* stocks tend to generate *lower* returns than the SL-CAPM would suggest. This relationship is shown clearly in Figure 4 below. Friend and Blume note that:

> The absolute values of the performance measures are in excess of market expectations for funds with Beta coefficients below one and below expectations for higher coefficients. [18]

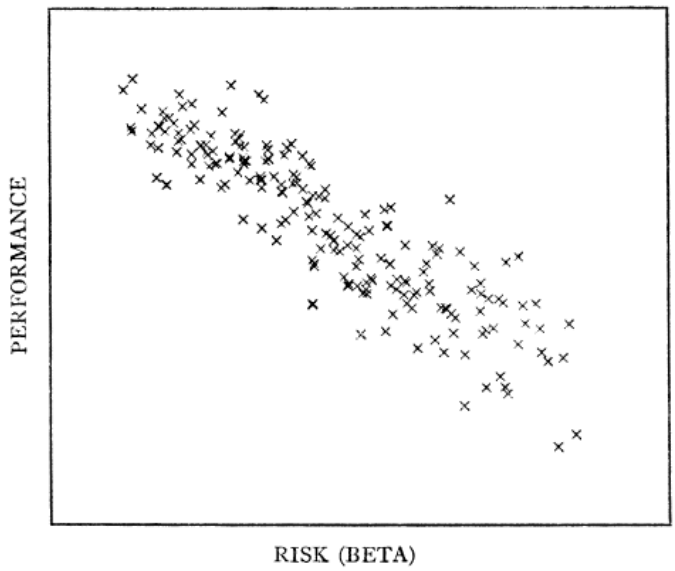
[16] Friend, I., and M. Blume, 1970, "Measurement of portfolio performance under uncertainty," *American Economic Review*, 60, 561–75.

[17] Friend and Blume (1970), p. 563.

[18] Friend and Blume (1970), p. 569.

What is low-beta bias?

Figure 4: The relationship between abnormal returns and beta



Source: Friend and Blume (1970), p. 567.

25 Friend and Blume (1970) go on to consider what it is about the SL-CAPM that results in it providing such a poor fit to the observed data. They conclude that the most likely source of the problem is the SL-CAPM assumption that all investors can borrow or lend as much as they like at the risk-free rate:

> Of the key assumptions underlying the market theory leading to one-parameter measures of performance, the one which most clearly introduces a bias against risky portfolios is the assumption that the borrowing and lending rates are equal and the same for all investors. Since the borrowing rate for an investor is typically higher than the lending rate, the assumption of equality might be expected to bias the one-parameter measures of performance against risky portfolios because, for such portfolios, investors do not have the same option of increasing their return for given risk by moving from an all stock portfolio to an investment with additional stock financed with borrowings at the lending rate.[19]

2.3.3 Fama and MacBeth (1973)[20]

26 Fama and MacBeth (1973) use the following regression specification:[21]

$$r_{e,j} = \gamma_0 + \gamma_1 \beta_{e,j} + u_j .$$

[19] Friend and Blume (1970), p. 569.

[20] Fama, E.F., and J.D. MacBeth, 1973, "Risk, return, and equilibrium: Empirical tests," *Journal of Political Economy*, 81, 607–636.

[21] See Fama and MacBeth (1973), p. 611.

27 Under this specification, the SL-CAPM implies that $\gamma_0 = r_f$ and $\gamma_1 = r_m - r_f$. Fama and Macbeth (1973) note that previous empirical work has demonstrated violations of both of these implications of the SL-CAPM:

> The work of Friend and Blume (1970) and Black, Jensen, and Scholes (1972) suggests that the S-L hypothesis is not upheld by the data. At least in the post-World War II period, estimates of $E[\tilde{\gamma}_{0t}]$ seem to be significantly greater than R_{ft}.[22]

28 Fama and Macbeth (1973) then test the hypothesis that $\gamma_0 - r_f = 0$ on average. They reject that hypothesis in their data and conclude that:

> Thus, the results in panel A, table 3, support the negative conclusions of Friend and Blume (1970) and Black, Jensen, and Scholes (1972) with respect to the S-L hypothesis.[23]

2.3.4 Fama and French (2004)[24]

29 The consistent results in the studies reviewed above are not unique to the data from the periods examined in those studies. Rather, the results have proven to be consistent through time – low-beta stocks generate higher returns than the SL-CAPM would imply and high-beta stocks earn lower returns than the SL-CAPM would imply. With respect to the early tests of the SL-CAPM, Fama and French (2004) summarise the state of play as:

> The early tests firmly reject the Sharpe-Lintner version of the CAPM. There is a positive relation between beta and average return, but it is too "flat."

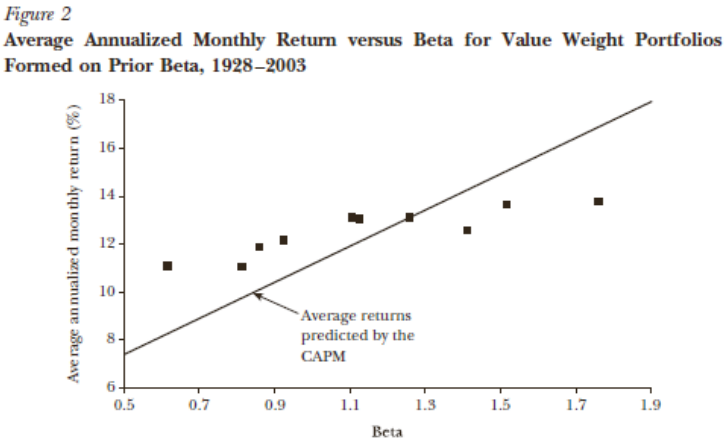
30 Fama and French (2004) then provide an updated example of the evidence using monthly returns on U.S.-listed stocks over 76 years from 1928 to 2003. This analysis is summarised in Figure 5 below. Consistent with the early evidence, realised returns on low-beta stocks are higher than predicted by the SL-CAPM, and realised returns on high-beta stocks are lower than predicted by the SL-CAPM. Stocks with the lowest beta estimates (approximately 0.6) had average returns of 11.1% per year, whereas the SL-CAPM estimate of the expected return was only 8.3% per year. Stocks with the highest beta estimates (approximately 1.8) had average returns of 13.7% per year, whereas the SL-CAPM estimate of the expected return was 16.8% per year.

[22] Fama and MacBeth (1973), p. 630.

[23] Fama and MacBeth (1973), p. 632.

[24] Fama, E.F., and K. French, 2004, "The Capital Asset Pricing Model: Theory and evidence," *Journal of Economic Perspectives*, 18, 25–46.

Figure 5. Average returns versus beta over an extended time period



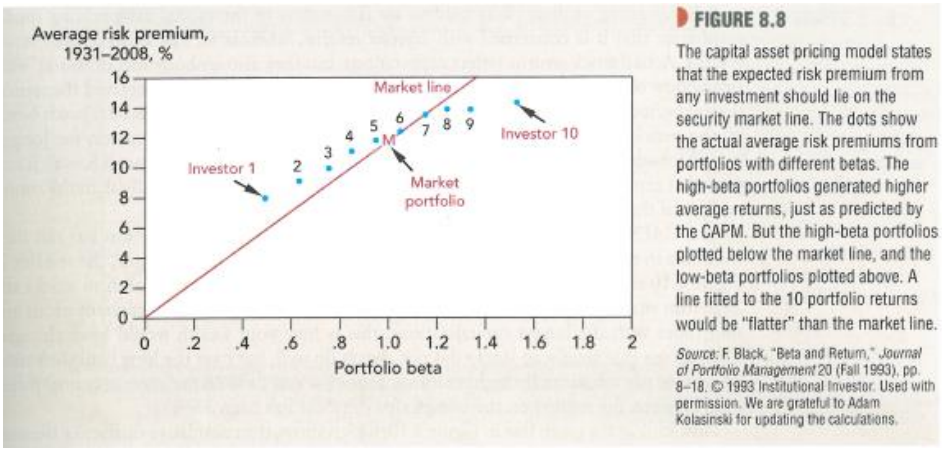
Source: Fama and French (2004), p. 33.

2.3.5 Brealey, Myers and Allen (2011)[25]

31 The evidence of low-beta bias has been so consistent and well-accepted that it is now discussed in standard finance courses and textbooks. For example, Brealey, Myers and Allen (2011), one of the leading finance textbooks, extend the previous analysis another four years to the end of 2008, and provide a similar chart to that presented by Fama and French (2004), but with excess returns on the vertical axis. This chart is presented below in Figure 6. The line represents the relationship between beta and excess return that is implied by the SL-CAPM and each dot represents the observed return for a particular portfolio. Consistent with all of the evidence set out above, the low-beta portfolios still earn higher returns than the SL-CAPM would imply.

[25] Brealey, R.A., S.C. Myers, and F. Allen, 2011, *Principles of Corporate Finance,* 10th ed., McGraw-Hill Irwin.

Figure 6: The relationship between excess returns and beta



Source: Brealey, Myers, and Allen (2011), p. 197.

2.3.6 Berk and DeMarzo (2014)[26]

32 Another leading corporate finance textbook is Berk and DeMarzo (2014). They too consider violations of the SL-CAPM and also the explanations for those violations. They specifically note that if investors are unable to borrow unlimited amounts at the risk-free rate, the empirical relationship that has been documented in the data would be expected to occur. They also note that the result is a relationship between beta and expected returns that has a higher intercept (at r^*) and a flatter slope than the SL-CAPM would imply. They conclude that:

> Because our determination of the security market line depends only on the market portfolio being tangent for some interest rate, the SML still holds in the following form:
>
> $$E[R_i] = r^* + \beta_i\left(E[R_{Mkt}] - r^*\right)$$
>
> That is, the SML holds with some rate r^* in place of r_f.[27]

2.3.7 Summary of the empirical evidence

33 The analysis documented above, compiled over four decades of research and using 80 years of stock returns, all reaches the same conclusion. The researchers uniformly reject the SL-CAPM on the basis that, in the observable data, the relationship between estimated betas and observed stock returns:

a. Has an intercept that is economically and statistically significantly greater than the intercept that is implied by the SL-CAPM; and

b. Has a slope that is economically and statistically significantly less than the slope that is implied by the SL-CAPM.

[26] Berk, J. and P. DeMarzo, 2014, *Corporate Finance,* 3rd global ed., Pearson.

[27] Berk and DeMarzo (2014), p. 399.

2.4 Systematic low-beta bias

34 The evidence set out above suggests that the actual relationship between beta and stock returns has a flatter slope than the SL-CAPM predicts. The result of this is that:

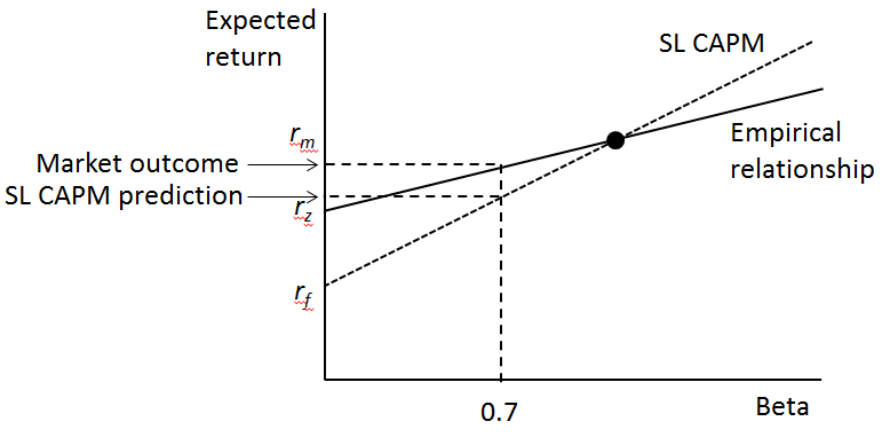
a. The SL-CAPM systematically underestimates the required return on low-beta stocks (i.e., those with a beta estimate less than 1); and

b. The SL-CAPM systematically overestimates the required return on high-beta stocks (i.e., those with a beta estimate more than 1); and

c. The magnitude of the bias is greater when the beta estimate is further away from 1.

35 In the regulatory setting, the focus has been on stocks with a beta less than 1, because regulators tend to consider the infrastructure firms that they regulate to have lower than average systematic risk. Figure 7 below shows that for stocks with a beta less than 1, the SL-CAPM consistently underestimates actual stock returns. This empirical result is known as the 'low-beta bias.'

Figure 7: Sharpe-Lintner CAPM vs. empirical relationship.



3 The theoretical rationale for low-beta bias

36 As set out above, the empirical tests of the SL-CAPM have consistently indicated that the relationship between equity beta and stock returns tends to be flatter than the SL-CAPM would suggest.[28] Black (1972)[29] summarises some of this literature as follows:

> …several recent studies have suggested that the returns on securities do not behave as the simple capital asset pricing model described above predicts they should. Pratt analyzes the relation between risk and return in common stocks in the 1926-60 period and concludes that high-risk stocks do not give the extra returns that the theory predicts they should give.
>
> Friend and Blume use a cross-sectional regression between risk-adjusted performance and risk for the 1960-68 period and observe that high-risk portfolios seem to have poor performance, while low-risk portfolios have good performance.
>
> …Black, Jensen, and Scholes analyze the returns on portfolios of stocks at different levels of β_i in the 1926-66 period. They find that the average returns on these portfolios are not consistent with equation (1) [the Sharpe-Lintner CAPM], especially in the postwar period 1946-66. Their estimates of the expected returns on portfolios of stocks at low levels of β_i are consistently higher than predicted by equation (1), and their estimates of the expected returns on portfolios of stocks at high levels of β_i are consistently lower than predicted by equation (1).[30]

37 In trying to develop a conceptual rationale for this observed and consistent empirical finding, Black (1972) focuses on one of the assumptions that underpins the derivation of the SL-CAPM – that all investors can borrow or lend as much as they like at the risk-free rate. He states that:

> One possible explanation for these empirical results is that assumption (d) of the capital asset pricing model does not hold. What we will show below is that the relaxation of assumption (d) [all investors can borrow or lend as much as they like at the risk-free rate] can give models that are consistent with the empirical results obtained by Pratt, Friend and Blume, Miller and Scholes, and Black, Jensen and Scholes.[31]

38 That is, Black (1972):

a. Notes that there is consistent evidence about the empirical failings of the SL-CAPM; and

b. Augments the SL-CAPM to produce a model that does not suffer from those empirical failings; and then

c. Sets out the conceptual rationale for his augmentation to the SL-CAPM.

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[28] See, for example, Friend and Blume (1970), Fama and Macbeth (1973) and Black, Jensen and Scholes (1972).

[29] Black, F., 1972, "Capital market equilibrium with restricted borrowing," *Journal of Business*, 45, 3, 444-455.

[30] Black (1972), p. 445.

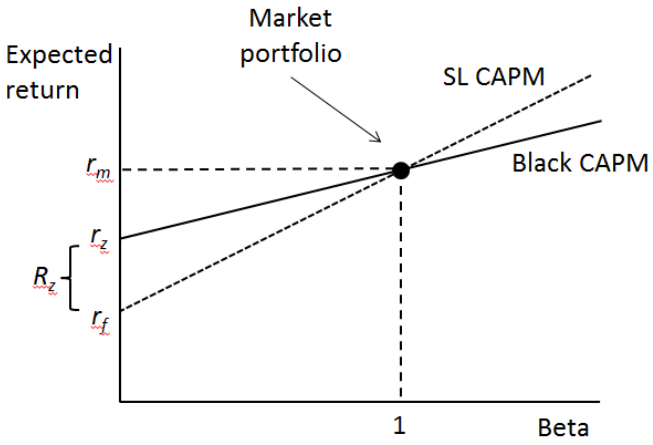
[31] Black (1972), p. 445.

39 Specifically, Black relaxes the SL-CAPM assumption that all investors can borrow or lend unlimited amounts at the risk-free rate, and derives a modified version of the CAPM that has become known as the 'Black CAPM.' The specification of the Black CAPM is as follows:

$$r_e = r_z + \beta(r_m - r_z)$$

where r_z is the new intercept term, which is above the risk-free rate by an amount R_z, which is known as the 'zero-beta premium.' This model is contrasted against the SL-CAPM in Figure 8 below. The figure shows that the Black CAPM, which is a theoretically-derived model based on a modified set of assumptions, produces predictions that conform more closely to the observed empirical evidence.

Figure 8: The Black CAPM



40 That is, there are two models that have been theoretically derived from different sets of assumptions. One has predictions and empirical implications that are consistent with the observed data and the other does not.

4 How to correct for low-beta bias

41 Two methods of correcting for low-beta bias have recently been considered in the Australian regulatory setting:

a. Use the Black CAPM to estimate the required return on equity since that model does not suffer from low-beta bias (indeed the documentation of low-beta bias was the original motivation for its derivation); or

b. Continue to use the SL-CAPM, but make an adjustment to the equity beta estimate to correct for low-beta bias.

42 We illustrate these two approaches via a simple numerical example that is based on the following parameters:

a. Equity beta of 0.4;[32]

b. Market risk premium of 6% (in which case the required return on the market is 10%);

c. Risk-free rate of 4%; and

d. Zero-beta premium of 3% (in which case the intercept term for the Black CAPM is 7%).

43 For this example, the SL-CAPM suggests that the required return on equity is given by:

$$\begin{aligned} r_e &= r_f + \beta(r_m - r_f) \\ &= 4\% + 0.4(10\% - 4\%) = 6.4\%, \end{aligned}$$

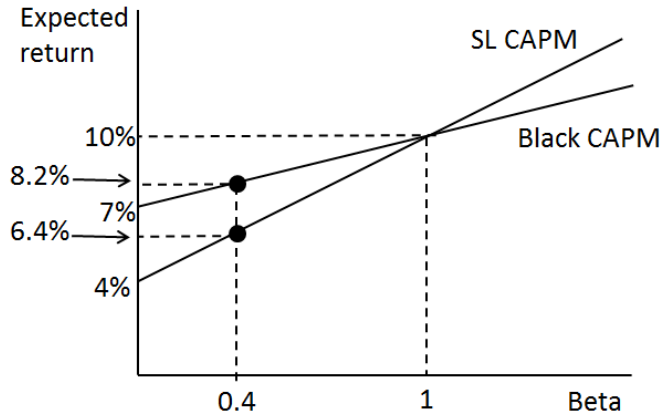
and the Black CAPM suggests that the required return on equity is given by:

$$\begin{aligned} r_e &= r_z + \beta(r_m - r_z) \\ &= 7\% + 0.4(10\% - 7\%) = 8.2\%. \end{aligned}$$

44 The SL-CAPM estimate suffers from low-beta bias, but the Black CAPM estimate does not. This is illustrated in Figure 9 below. Thus, one way to avoid low-beta bias is to use the Black CAPM rather than the SL-CAPM.

[32] These parameters are drawn from the AER's Rate of Return Guideline, Explanatory Statement, Appendix C, Table C.11, p. 71.

Figure 9: Comparison of SL-CAPM and Black CAPM estimates



Source: Frontier Economics calculations.

45 The alternative approach is to pose the question: What beta, when inserted into the SL-CAPM, would produce an estimate of required return of 8.2% so as to be consistent with the evidence from the Black CAPM? Figure 10 below shows that the relevant modified beta estimate is 0.7. That is, the beta estimate would be revised upwards from 0.4 to 0.7 in order to produce an estimate of the required return on equity that is consistent with the Black CAPM evidence.

46 The logic behind these calculations can be summarised as follows:

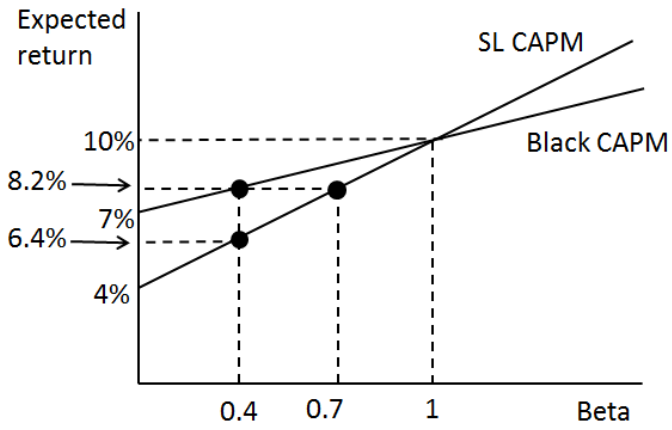
a. Beta is estimated to be 0.4;

b. It is recognised that the theoretical and empirical evidence establishes that if this beta estimate is inserted into the SL-CAPM, the resulting estimate of the required return on equity (6.4%) will be understated;

c. Inserting the beta estimate of 0.4 into the Black CAPM equation would produce an estimate of the required return on equity of 8.2%; and

d. Rather than insert the estimated beta of 0.4 into the Black CAPM, the beta used in the SL-CAPM is adjusted from 0.4 to 0.7. In the SL-CAPM, this also produces an estimate of the required return on equity of 8.2%.

Figure 10: Modifying the SL-CAPM to correct for low-beta bias



Source: Frontier Economics calculations.

47 In summary, there are two ways to correct for the low beta bias in this case:

a. Estimate the parameters of the Black CAPM and insert those parameters into the Black CAPM formula; or

b. Continue to use the SL-CAPM formula, but use an increased beta estimate that is calibrated to offset the bias that arises from applying the SL-CAPM to low-beta stocks.

48 If the adjustment to the beta estimate under the second approach is consistent with the estimate of the zero-beta premium that is required for the first approach, the estimates of the required return on equity will be the same under both approaches.

5 The AER's approach to low-beta bias

5.1 The AER's 2013 Rate of Return Guideline

49 In its 2013 Rate of Return Guideline materials, the AER stated that it will account for the evidence of low-beta bias in the context of the Black CAPM.[33] In this regard, the Guideline materials explain that:

> We account for the Black CAPM because we recognise there is merit to its theoretical basis, particularly when viewed alongside the standard Sharpe–Lintner CAPM.[34]

50 The Guideline materials further explain that the Black CAPM has the theoretical merit of relaxing one of the strongest and most unrealistic assumptions of the SL-CAPM – the assumption that all investors can borrow or lend as much as they like at the risk-free rate:

> The Sharpe–Lintner CAPM assumes there is unlimited risk free borrowing and lending, a simplification that does not hold in practice. The Black CAPM relaxes this assumption and acknowledges that investors may not be able [to] undertake unlimited borrowing or lending at the risk free rate.[35]

51 The AER also states that:

> A key outworking of the Black CAPM is that the Sharpe–Lintner CAPM may underestimate the return on equity for firms with equity betas less than one.[36]

52 The AER goes on to state that it will not estimate the Black CAPM, but rather that it will have regard to the evidence of low-beta bias and the Black CAPM when selecting a beta estimate to insert into its SL-CAPM formula:

> …using the Black CAPM theory to inform our equity beta estimate may mitigate possible low beta bias…we consider this represents a pragmatic approach.[37]

53 That is, the AER recognises the existence of low-beta bias and states that it will adopt the second of the two approaches set out above to correct for it.

54 The AER then goes on to demonstrate how the equity beta can be adjusted to correct for low beta bias. To do this, the AER sets out six worked numerical examples in its Guideline materials.[38] The first of the AER's examples uses the figures that are the basis of the numerical example in the previous section of this

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[33] AER, 2013, Rate of Return Guideline, p. 13.

[34] AER, 2013, Rate of Return Guideline, Explanatory Statement, p. 85.

[35] AER,2013, Rate of Return Guideline, Explanatory Statement, Appendix A, p. 17.

[36] AER, 2013, Rate of Return Guideline, Explanatory Statement, Appendix A, p. 18.

[37] AER, 2013, Rate of Return Guideline, Explanatory Statement, Appendix A, p. 12.

[38] AER, 2013, Rate of Return Guideline, Explanatory Statement, Appendix C, Table C.11, p. 71.

report. The AER shows that, for a zero-beta premium of 3%, an equity beta of 0.4 would have to be adjusted to 0.7 to account for low-beta bias – as in the example above.

5.2 The AER's recent final decisions

55 In its recent decisions, the AER has maintained the position set out in its Guideline insofar as it recognises the Black CAPM/low-beta bias evidence and makes an adjustment in relation to this evidence to the equity beta that is used in the SL-CAPM:

> The theoretical principles underpinning the Black CAPM demonstrate that market imperfections could cause the true (unobservable) expected return on equity to vary from the Sharpe-Lintner CAPM estimate. This is a result of slightly different starting assumptions between the models. The resulting variation in expected return on equity is (in the theoretical principles) larger for businesses with equity betas further from one. We have also considered the empirical evidence that the Sharpe-Lintner CAPM tends to underestimate returns on low beta stocks when examined using ex-post data..
>
> Our empirical and conceptual analysis of equity beta for businesses with a similar degree of risk as TransGrid (in the provision of prescribed transmission services) indicates an equity beta less than one, and within the range of 0.4 to 0.7.756 In this case, where initial considerations indicate an equity beta materially below one, the theory of the Black CAPM may be relevant. As the importance of the theory of the Black CAPM is relative to considerations of the business' equity beta estimate, we consider it is appropriate for the theory of the Black CAPM to inform our equity beta estimate.[39]

56 In its recent Final Decisions, the AER states that its "best empirical estimate" of beta is 0.5:

> We also consider Henry's 2014 results indicate a best empirical estimate of approximately 0.5 for a benchmark efficient entity.[40]

Thus, the AER has stated that its 'starting point' beta estimate is 0.5.

57 The AER goes on to select a point estimate at the top of its range 0.7.[41] The selection of a final point estimate (0.7) above the AER's best empirical estimate (0.5) is said to be based on three considerations:[42]

a. "International estimates" – due to the fact that the weight of evidence from international comparators supports a beta estimate materially above the AER's domestic starting point estimate;

b. "Considerations of the Black CAPM" – due to the fact that the Black CAPM evidence is that the unadjusted SL-CAPM will

[39] TransGrid Draft Decision, 2017, Attachment 3, p. 178.

[40] TransGrid Draft Decision, 2017, Attachment 3, p. 243.

[41] TransGrid Draft Decision, 2017, Attachment 3, p. 283.

[42] TransGrid Draft Decision, 2017, Attachment 3, p. 165.

systematically understate the required return on low-beta stocks; and

c. "Investor certainty" – due to the fact that a larger movement from the AER's previous 0.8 allowance may cause investors to increase their assessment of regulatory risk.

58 Nowhere in its decisions does the AER quantify how much of the uplift from 0.5 to 0.7 is due to each of the three factors that it has documented. Moreover, the AER has not stated whether it considers any of the three factors to be more or less important than the others.

59 In our view, because there is no way of knowing what uplift was applied in relation to each of the three factors, there is no way of knowing whether or not the uplift that was applied in relation to a factor, if any, was reasonable.

5.3 The Tribunal's considerations of low-beta bias

60 The Tribunal has recently considered the issue of low-beta bias, and the adjustments that may be made to correct for it, in the *PIAC-Ausgrid* case.[43] In those proceedings, the Public Interest Advisory Centre (PIAC) submitted that the AER had erred in making any uplift at all to its starting point equity beta estimate of 0.5. However, the Tribunal concluded that there was no error in concluding that there was evidence of low-beta bias and that there was no error in making an uplift to the equity beta in relation to that evidence.

61 In response to PIAC's submission that there was no evidence of low-beta bias that would justify the AER departing from its starting point beta of 0.5, the Tribunal concluded that:

> Upon reviewing the whole of the material before the AER, the Tribunal however is not satisfied that that material does not support a conclusion that the SL CAPM provided a low equity beta bias.[44]

62 In relation to the evidence of low-beta bias, the Tribunal concluded as follows:

> It is, as the AER noted, correct that the three parameters for the SL CAPM – equity beta, risk free rate, and MRP – are recorded as giving a low beta bias for businesses with a beta (that is, the risk of the asset relative to the average asset) of less than 1.0, and that the Network Applicants are all within that group. There was also evidence that the low beta bias is exacerbated when it is combined with conditions of low government bond rates and a high MRP. Those conditions were applicable at the time of the AER Final Decisions.[45]

[43] Applications by Public Interest Advisory Centre Ltd and Ausgrid [2016] ACompT 1.

[44] *PIAC-Ausgrid*, 2016, Paragraph 779.

[45] *PIAC-Ausgrid*, 2016, Paragraph 731.

63 That is, the Tribunal accepted the existence of low-beta bias – that the SL-CAPM systematically understates the returns of low-beta stocks.

64 The Tribunal summarised the detail of the PIAC submission as follows:

> PIAC criticises the AER's view that the Black CAPM would be expected to warrant an upward adjustment (of some unspecified magnitude) to the best empirical estimates derived in accordance with the SL CAPM. That, it says, is found in the Final Decisions and in the RoR 2013 Guideline.
>
> PIAC says the analysis of the AER to justify that approach is an exercise in econometric reverse-engineering; and was to assess whether the AER might be able to justify making an adjustment from any point within the 0.4-0.7 range to the upper bound of that range.[46]

65 The Tribunal then determined that there is no error in:

a. Recognising the existence of low-beta bias; or

b. Accounting for low-beta bias by making an adjustment to the equity beta estimate in the SL-CAPM.

[46] *PIAC-Ausgrid*, 2016, Paragraphs 774-775.

6 Evidence of the magnitude of low-beta bias

Grundy (2010)

66 In the Australian regulatory setting, the first evidence of the magnitude of low beta bias was provided by Grundy (2010).[47] His summary of the relevant evidence is reproduced as Table 1 below.

67 The relevant evidence from Table 1 is the estimates of $\frac{R_m - R_0}{R_m - R_f}$, which can be interpreted as the ratio of the slope of the empirical relationship between beta and returns and the slope of the SL-CAPM. An estimate below 1 indicates that the actual data exhibits a flatter slope than the SL-CAPM implies – consistent with low-beta bias.

68 This estimate of the ratio of the slopes can be converted into an estimate of the zero-beta premium (i.e., the extent to which the actual empirical intercept is above the risk-free rate as in Figure 8 above) as follows:

$$R_z = \left(1 - \frac{R_m - R_0}{R_m - R_f}\right) \times MRP.$$

69 Thus, for an MRP of 6.5%, the mean slope ratio estimate of 0.511 would imply a zero-beta premium of:

$$R_z = (1 - 0.511) \times 6.5\% = 3.2\%.$$

70 That is, the empirical estimate of the intercept in the relationship between beta and stock returns is 3.2% above the risk-free rate.

71 The more recent estimates in Table 1 imply higher zero-beta premiums:

a. Kothari, Shanken and Sloan (1995)[48] implies a zero-beta premium of 3.8%; and

b. Da, Guo and Jagannathan (2009)[49] implies a zero-beta premium of 5.0%.

[47] Grundy, B., 2010, "The calculation of the cost of capital: A report for Envestra," 30 September.

[48] Kothari, S. P., j. Shanken and R. Sloan, 1995, "Another look at the cross section of expected stock returns, *Journal of Finance*, 50, 1, 185-224.

[49] Da, Z., R. Guo and R. Jagannathan, 2009, "CAPM for estimating the cost of equity capital: Interpreting the empirical evidence, NBER Working Paper 14889.

Table 1: Summary of evidence from Grundy (2010)

Paper	Sample period		(Rm-R0)/ (Rm-Rf)
Empirical papers cited by the AER			
Schrimpf, Schroder and Stehle (2007)	1969-2002	Estimate of Rm-R0=0.2% per month. Note that an annual MRP of 6.5% implies a monthly MRP of 0.54% per month	N/A
Ang and Chen (2007)	1926-1963:06	Cannot reject the Sharpe CAPM	N/A
	1963:07-2001	Likelihood the Sharpe CAPM is true is <1%	N/A
Gruaer and Janmaat (2010)	1963-2005	For 7 of the 14 methods for grouping stocks to form portfolios that are examined in the paper, the likelihood of the Sharpe CAPM being true is <5%	N/A
Gregory and Michou (2009)	1975-2005	Examines 35 industries. For only 3 industries would one reject the Sharpe CAPM at the 5% level. For the Gas, Water and Multi-utility industry, returns are statistically significantly higher at the 5% level than predicted by the Sharpe CAPM	N/A
Black (1993)	1926-1965	Likelihood Sharpe CAPM true <1%	N/A
Schwert (2003)	1926-1965	Likelihood Sharpe CAPM true <0.0001%	N/A
Morana (2009	1965-2001	Likelihood Sharpe CAPM true <1%	N/A
Daniel, Titman and Wei (2001)	1975-1997	Likelihood Sharpe CAPM true <0.34%	N/A
Da, Guo and Jagannathan (2009)	1932-2007	Likelihood Sharpe CAPM true <0.002%	0.232
Kothari, Shanken and Sloan (1995)	1927-1990	Likelihood Sharpe CAPM true <0.058%	0.415
Classic tests of the Sharpe CAPM			
Fama and Macbeth (1973)	1935-1968	Likelihood Sharpe CAPM true <0.55%	0.639
Black, Jensen and scholes (1972)	1931-1965	Likelihood Sharpe CAPM true <0.0001%	0.761
Average			**0.511**

Source: Grundy (2010), Table 1, p. 13.

Davis (2011)

72 In a report for the AER, Davis (2011)[50] considers the results of Kothari, Shanken and Sloan (1995) in more detail. Specifically, he makes an adjustment to the way Grundy (2010) had estimated the relative slope,[51] and he considers the full range

[50] Davis, K., 2011, Cost of equity issues: A further report for the AER, May 13.

[51] By dividing the reported annual risk-free rate by 12 to make it consistent with the monthly units of other parameters.

of data sorts rather than just the main sort that had been considered by Grundy.[52] Davis concludes that the estimate of the zero-beta premium varies depending on how the various portfolios are constructed and according to which time period is used.

73 We summarise the estimates for all portfolio formation methods and for both of the data periods considered by Kothari, Shanken and Sloan (1995) in Table 2 below. The table shows that the zero-beta premium ranges from about 2% to over 4%, except for one portfolio sort for one time period where the zero-beta premium was immaterial.

Table 2: Zero-beta premium estimates from Kothari, Shanken and Sloan (1995)

Method	Zero-beta premium
1927-1990	
Ranked on beta	3.0%
Ranked on size	0.0%
Ranked on beta and size independently	2.2%
Ranked on beta then size	1.8%
Ranked on size then beta	1.8%
1941-1990	
Ranked on beta	4.7%
Ranked on size	2.7%
Ranked on beta and size independently	4.4%
Ranked on beta then size	4.1%
Ranked on size then beta	4.0%

Source: Kothari, Shanken and Sloan (1995), Table I, pp. 196-197; Frontier Economics calculations.

74 Davis (2011) also considers the estimates for various 5-year sub-periods in the earlier Fama and Macbeth (1973)[53] study, and notes that the estimates vary across periods. However, such variation is entirely expected since a 5-year period is extremely short when seeking to estimate the slope of the security market line.

[52] The approach of these studies is to form a set of portfolios and then plot the relationship between beta and returns for the set of portfolios. The portfolios can be formed on the basis of beta estimates from a prior period, or size, of industry, or some combination of these characteristics.

[53] Fama, E., and J. Macbeth, "Risk, return, and equilibrium: Empirical tests," *Journal of Political Economy*, 81 (3), 1973, pp. 607-636.

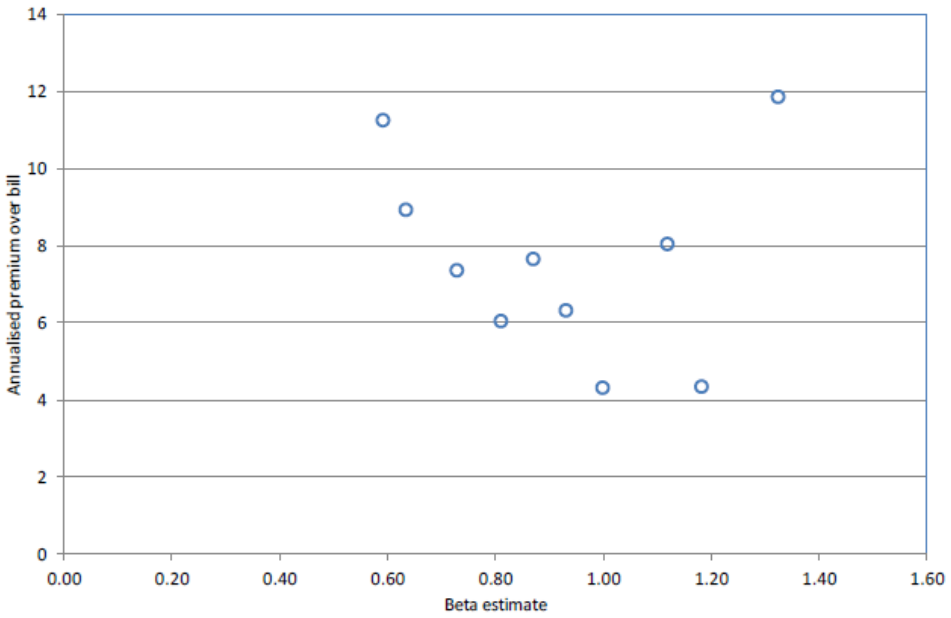
Indeed, the slope of the line for the SL-CAPM is the MRP. It is not at all surprising that the results are unstable when estimates are based on only 5 years of data.

NERA (2013)

75 NERA (2013)[54] demonstrates that, for the Australian data between 1974 and 2012, there is no relationship at all between beta estimates and stock returns. Their results are reproduced in Figure 11 below. NERA forms 10 portfolios by ranking stocks based on their beta estimates. Thus the 10% of firms with the lowest beta estimates are assigned to the first portfolio and so on. The portfolio beta is then graphed against the subsequent annual returns of the portfolio. The Figure below shows that the portfolios with the lowest betas produce returns that are among the highest of all portfolios.

Figure 11: NERA (2013) results

Figure 5.1
Annualised premium over bill against beta estimate for 10 portfolios formed on past beta estimates



Notes: Data are from SIRCA's SPPR database. Annualised premium is in per cent and is the monthly premium multiplied by 12. Estimates are computed using data from 1974 to 2012.

Source: NERA (2013), Figure 5.1, p. 15.

76 The fact that there is no discernible relationship between beta estimates and stock returns means that the empirical security market line is not significantly different from a horizontal line. That is, beta estimates cannot be used to determine whether a stock is likely to generate above-average or below-average returns. NERA (2013) concludes:

[54] NERA, 2013, Estimates of the zero-beta premium, June.

> The fact that estimates of the zero-beta premium do not differ significantly from the values that the AER has chosen in the recent past for the *MRP* is consistent with the evidence that Figure 5.1 provides that there is little relation across stocks between risk, measured by an estimate of beta, and return.[55]

77 This implies that the required return for any stock would be set equal to the estimate of the required return on the market – the sum of the risk-free rate and the MRP.

SFG (2014)

78 The most recent Australian estimate of the zero-beta premium is that of SFG (2014).[56] SFG (2014) recognise that the non-relationship between beta estimates and stock returns in the Australian market is driven by two things:

a. In the Australian market, value stocks (those with a high book-to-market ratio) tend to have low beta estimates and these stocks are well-known to have generated returns in excess of the SL-CAPM predictions; and

b. After controlling for the out-performance of value stocks, there remains a low-beta bias.

79 SFG (2014) notes that any bias associated with the book-to-market ratio would be accommodated by the Fama-French model (FFM), whereas the low-beta bias would be accommodated by the Black CAPM. That is, any outperformance of the SL-CAPM prediction that is due to the fact that the stock has a high book-to-market ratio would be accommodated via the FFM, so there is a need to estimate the degree of outperformance that occurs simply because the stock has a low beta. Thus, the SFG approach is to control for any book-to-market effect so as to isolate the effect that arises simply because a stock has a low beta.

80 The econometric approach used by SFG (2014) is set out in detail in their report. Their conclusion is that the best available point estimate of the zero-beta premium is 3.34%.

81 In its recent final decisions, the AER has stated that:

> We consider SFG's latest estimate of the zero beta premium appears more plausible, as it is not negative and is below the market risk premium.[57]

[55] NERA (2013), p. 16.

[56] SFG, 2014, Cost of equity in the Black Capital Asset Pricing Model, May.

[57] JEN Final Decision, Attachment 3, p. 185.

Summary and conclusion

82 The majority of the estimates set out above imply a zero-beta premium between 2% and 4% and we consider that range to be a reasonable characterisation of the available data.

83 We note that this range is slightly above the range of 1.5% to 3.0% that the AER adopted in its Rate of Return Guideline materials. In its Guideline, the AER stated that:

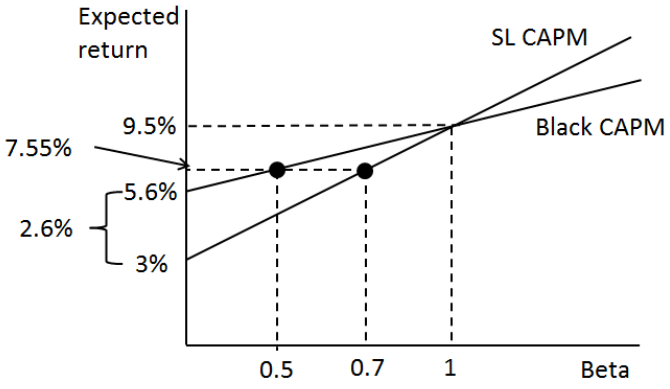
> …the size of the zero beta premium is between 150 basis points and 300 basis points (under a variety of scenarios for the risk free rate and market risk premium). This does not seem implausible, since zero beta premiums of this magnitude are below the market risk premium as required by the definition of the Black CAPM. Further, although the borrowing rates for the representative investor are not readily discernible, these magnitudes appear reasonable,[58]

and:

> this magnitude of adjustment appears open to us.[59]

84 Figure 12 below demonstrates that a beta uplift from 0.5 to 0.7 would be consistent with a zero-beta premium of 2.6%. That is, if the AER's entire uplift was due to low-beta bias, it would correct a zero-beta premium of 2.6%, which is at the lower end of the reasonable range.

Figure 12: AER parameter estimates in the context of the Black CAPM



Source: Parameters from JEN Final Decision, 2016, Attachment 3, p. 12; Frontier Economics calculations.

85 For the reasons set out above, we conclude that the AER's approach does not appear to fully correct for low-beta bias. A full correction for the observed low-beta bias would require a greater uplift to the statistical beta estimate than that which the AER has adopted.

[58] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 71.

[59] AER Rate of Return Guideline, Explanatory Statement, Appendix C, p. 71.

7 Declaration

86 I confirm that I have made all the inquiries that I believe are desirable and appropriate and no matters of significance that I regard as relevant have, to my knowledge, been withheld from the Court.

Professor Stephen Gray

8 Appendix: Instructions

Appendix: Instructions

Professor Stephen Gray
Frontier Economics

By email: Stephen.Gray@frontier-economics.com.au

ACTEWAGL DISTRIBUTION - EXPERT REPORT ON LOW-BETA BIAS

ActewAGL Distribution (**AAD**) is seeking an expert report from Frontier Economics in relation to the issue of low-beta bias when estimating the equity beta, for the purposes of determining the return on equity, in the context of the Australian Energy Regulator's (**AER's**) distribution determination for AAD for the 2019-24 regulatory period.

BACKGROUND

AAD is the distribution network service provider (**DNSP**) for the Australian Capital Territory electricity distribution network.

AAD is currently preparing its regulatory proposal for the 2019-24 regulatory period, which is due to be submitted to the AER in January 2018. AAD's regulatory proposal is required to include a building block proposal for direct control services classified under the proposal as standard control services.

The building block proposal must be prepared in accordance with (among other things) the requirements of Part C of Chapter 6 of the National Electricity Rules (**NER**). In particular, the building block proposal must be prepared in accordance with clause 6.4.3 of the NER, which specifies the building blocks by which the 'annual revenue requirement' for a DNSP for each year of a regulatory control period is to be determined. The building blocks include a return on capital for that year (calculated in accordance with clause 6.5.2 of the NER).

NER provisions

Clause 6.5.2(a) of the NER provides that the return on capital for each regulatory year must be calculated by applying a rate of return for the relevant DNSP for that regulatory year that is determined in accordance with clause 6.5.2 (the allowed rate of return) to the value of the regulatory asset base for the relevant distribution system as at the beginning of that regulatory year. Clause 6.5.2(b) of the NER provides that the allowed rate of return is to be determined such that it achieves the allowed rate of return objective. It further requires that both the return on equity and the return on debt are to be estimated such that they contribute to the achievement of the allowed rate of return objective. The allowed rate of return objective is that the rate of return for a DNSP is to be commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to the DNSP in respect of the provision of standard control services.

Clause 6.5.2(d) of the NER provides that, subject to clause 6.5.2(b), the allowed rate of return for a regulatory year must be:

- a weighted average of the return on equity for the regulatory control period in which that regulatory year occurs (as estimated under clause 6.5.2(f)) and the return on debt for that regulatory year (as estimated under clause 6.5.2(h)); and

- determined on a nominal vanilla basis that is consistent with the estimate of the value of imputation credits referred to in clause 6.5.3.

Under clause 6.5.2(e), in determining the allowed rate of return, regard must be had to:

- relevant estimation methods, financial models, market data and other evidence;

- the desirability of using an approach that leads to the consistent application of any estimates of financial parameters that are relevant to the estimates of, and that are common to, the return on equity and the return on debt; and

- any interrelationships between estimates of financial parameters that are relevant to the estimates of the return on equity and the return on debt.

Clause 6.5.2(f) and (g) of the NER requires that the return on equity must be estimated such that it contributes to the achievement of the allowed rate of return objective, having regard to the prevailing conditions in the market for equity funds.

Rate of Return Guideline

In accordance with clauses 6.2.8(a) and 6.5.2(m) and (n) of the NER, on 17 December 2013 the AER published a Better Regulation Rate of Return Guideline, December 2013 (Rate of Return Guideline) which sets out the AER's proposed approach to determining the allowed rate of return (including the return on equity) in accordance with the National Electricity Law (NEL) and the NER.

Due to recent proceedings in the Australian Competition Tribunal (Tribunal) and Federal Court (discussed below), clause 6.5.2(p) of the NER was amended to provide the AER with up to 5 years (i.e. until December 2018) to review the Rate of Return Guideline. The rule change introduced transitional arrangements for affected service providers (including AAD) that will be part way through the regulatory determination process when the new Guideline is published[1]. To provide regulatory certainty, the transitional arrangements apply the 2013 Rate of Return Guideline to the full 2019-24 regulatory determination process, regardless of when the AER publishes the revised Guideline.

Clause 6.2.8(c) of the NER provides that the Rate of Return Guideline is not mandatory. However, a building block proposal must identify any departure from the methodologies set out in the Rate of Return Guideline and the reasons for that departure, and, if the AER makes a distribution determination that is not in accordance with the Guideline, the AER must state its reasons for departing from the Guideline in that determination (clauses 6.2.8(c) and S6.1.3(9) of the NER).

[1] AEMC 2016, Rule Determination: National Electricity Amendment (Rate of Return Guidelines Review) Rule 16, National Gas Amendment (Rate of Return Guidelines Review) Rule 2016, October.

The Rate of Return Guideline states that the AER's proposed approach to estimating the return on equity is to:

- use the Sharpe Lintner Capital Asset Pricing Model (SL-CAPM) as the 'foundation model'. The SL-CAPM is estimated by adding the product of the equity beta and market risk premium (MRP) to the risk free rate;
- adopt a risk free rate determined by reference to the yields on Commonwealth Government Securities (CGS) with a 10 year term over an averaging period of 20 consecutive business days as close as practicably possible to the commencement of the regulatory control period;
- use a point estimate of 0.7 for the equity beta;
- estimate a range for the MRP having regard to theoretical and empirical evidence, and then select a point estimate from within that range; and
- determine a final point estimate for the expected return on equity equal to the foundation model point estimate, or alternatively, a different value that is a multiple of 25 basis points (drawing on the analysis and evaluation of a range of other information).

The Rate of Return Guideline states that the AER proposes that:

- the Black capital asset pricing model informs the equity beta estimate input to the SL-CAPM;
- dividend growth models inform the MRP estimate input to the SL-CAPM; and
- the Fama-French Three Factor Model has no role.

Return on equity in 2015-19 period

In the AER's distribution determination for AAD for the 2015-19 period, the AER used a foundation model approach to estimating the return on equity and used the SL-CAPM as the foundation model. The AER adopted a risk free rate of 2.55%, an equity beta of 0.7 and a MRP of 6.5% as the input parameter values for the SL CAPM, resulting in a return on equity of 7.1%.

The AER's decision in respect of return on equity was the subject of an application to the Tribunal in 2015. AAD sought a review of the AER's decision in respect of the return on equity estimate, and proposed a return on equity of 9.83% (estimated by reference to four models - the SL-CAPM, Black-CAPM, Fama-French Three Factor Model and Dividend Growth Model).

In the Tribunal proceedings, the Tribunal concluded that the grounds of review in relation to the AER's return on equity estimate were not made out, and did not find error in the AER's use of the SL-CAPM as the foundation model or its selection of an equity beta of 0.7 and MRP of 6.5%. The Tribunal's reasons are set out in *Applications by Public*

Interest Advocacy Service Ltd and Ausgrid Distribution [2016] ACompT 1 (**the Ausgrid decision**).

AAD proposal

AAD proposes to adopt the AER's 2013 Rate of Return Guideline in respect of the return on equity for its regulatory proposal for 2019-24. Specifically, AAD currently anticipates that it will adopt the SL-CAPM as the foundation model, consistent with the decision of the Tribunal on the cost of equity in the Ausgrid decision and estimate the risk free rate using the prevailing yield on 10 year CGS. As set out further below, AAD is seeking your expert opinion on the issue of low-beta bias when estimating the equity beta for the purposes of its regulatory proposal.

SCOPE OF WORK

AAD would like Frontier to provide a report giving your expert opinion on the issue of low-beta bias when estimating the equity beta for the purposes of estimating the return on equity and WACC for AAD for the 2019-24 regulatory period. Your expert report should address the issue of low-beta bias when estimating the equity beta as part of the implementation of the SL-CAPM, including:

- explaining the concept of low-beta bias in the context of the SL-CAPM;
- examining the approaches for correcting for low-beta bias; and
- providing an expert opinion about the reasonableness of the AER's approach to correcting for low-beta bias; and
- any other matters that you consider relevant.

In undertaking the above work, AAD expects Frontier to consider the following information:

- Such information that, in your opinion, should be taken into account to address the questions outlined above.
- Relevant literature on estimating the return on equity.
- The AER's 2013 Rate of Return Guideline, including explanatory statements and supporting expert material.
- Material submitted to the AER as part of its consultation on the Rate of Return Guideline.
- Previous decisions of the AER and other relevant regulators on the return on equity and value of imputation credits, and any supporting expert material, including in expert material relied on by the AER in recent decisions

- Previous decisions of the Tribunal and Federal Court on the return on equity, and the submissions made by the parties in the relevant proceedings before them and any supporting expert material.

EXPERT WITNESS

AAD anticipates providing a copy of your report to the AER.

Attached to this letter is the Federal Court of Australia Expert Evidence Practice Note (GPN-EXPT) including Annexure A (Harmonised Expert Witness Code of Conduct) to that Practice Note. The Practice Note replaces the Federal Court's Practice Note CM 7, titled 'Expert witnesses in Proceedings in the Federal Court of Australia', with effect from 25 October 2016.

Please read the Practice Note carefully and ensure that your report complies with each of its elements, including in particular clause 5 of the Practice Note and clause 3 of the Code, which set out requirements for the content of your report. Please also:

- Confirm in your report that:
    - you have read, complied with and agree to be bound by the Practice Note; and
    - your opinions are based wholly or substantially on specialised knowledge arising from the expert's training, study or experience.
- Declare that you have made all the inquiries you believe are desirable and appropriate (save for any matters identified explicitly in your report) and that no matters of significance which you regard as relevant have, to your knowledge, been withheld.
- Annex your curriculum vitae, containing your qualifications and relevant experience, to your report.

Limitations and qualifications

You must qualify the opinion given in your report if either of the following apply:

- you consider your report may be incomplete or inaccurate without the qualification; or
- you are unable to form a conclusive opinion because of insufficient research, insufficient information, or for any other reason.

If you change your opinion

You must provide a supplementary report if you change your opinion after giving us your original report.

TIMING

AAD requests that Frontier deliver its final report or reports by 20 December 2017.

Please let us know if you have any questions regarding this letter.

Yours sincerely

Alexis Hardin
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Regulatory Affairs, ActewAGL

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9 Appendix: Curriculum Vitae of Professor Stephen Gray

Stephen Gray is Professor of Finance at the University of Queensland Business School and Chairman of Frontier Economics (Australia). He has Honours degrees in Commerce and Law from the University of Queensland and a PhD in financial economics from the Graduate School of Business at Stanford University.

In his university role, he teaches a range of award and executive education courses in financial management, asset valuation, and corporate finance. He has received a number of teaching awards, including a national award for university teaching in the field of business and economics. He has published widely in highly-ranked journals and has received a number of manuscript awards, most notably at the *Journal of Financial Economics*.

Stephen is also an active consultant to industry on issues relating to valuation, cost of capital, and corporate financial strategy. He has acted as a consultant to many of Australia's leading companies, government-owned corporations, and regulatory bodies. His clients include the Independent Pricing and Regulatory Tribunal (IPART), Australian Competition and Consumer Commission (ACCC), Melbourne Water, Qantas, Telstra, Origin Energy, AGL, Foxtel, ENERGEX, Queensland Treasury Corporation, Rio Tinto Alcan and the Australian Securities and Investments Commission (ASIC). Projects include corporate cost of capital reviews, asset valuation, independent valuation of executive stock options, and the assessment of capital structure and financing strategies.

He has also appeared as an independent expert in several court proceedings relating to the valuation of assets and businesses and the quantification of damages.

Key experience

Cost of capital

Energy sector

- **TransGrid (2015) –** Advised the electricity transmission operator in NSW on the appropriateness of the Australian Energy Regulator's (AER's) proposed transitional arrangements before the full introduction of a trailing average approach to setting the cost of debt allowance for regulated networks. The AER recently revised its rate of return methodology. In doing so, the AER announced that it would adopt a trailing average approach to setting cost of debt allowances (similar to the approach used by Ofgem in Great Britain). However, the AER argued that it should phase this approach in to allow

businesses sufficient time to align their debt management practices to the new methodology. Frontier prepared a report on behalf of TransGrid explaining the circumstances in which such transitional arrangements would not be appropriate.

- **Australian Energy Markets Commission (AEMC) (2012)** – The regulator (AER) and a group of large energy users (EURCC) proposed changes to the National Electricity Rules and National Gas Rules (Rules). The AEMC, which is the government agency that is responsible for maintaining the Rules, conducted a year-long review and consultation process in relation to the proposed rule changes. Stephen was appointed to advise the AEMC on rate of return issues. His role involved the provision of advice to the AEMC secretariat and board, the preparation of a number of public reports, the co-ordination and chairing of public hearings, and a series of one-on-one meetings with key stakeholders. The process resulted in material changes being made to the Rules, with revised Rules being published in November 2012.

- **Energy Networks Association (2013) –** The National Electricity Rules and National Gas Rules (Rules) require the regulator to publish a series of regulatory guidelines every three years. The Australian Energy Regulator (AER) conducted a year-long process in 2013 that ended with the publication of its first Rate of Return Guideline. Throughout this process, Stephen advised the Energy Networks Association (ENA) on rate of return issues. This involved working with the ENA's Regulatory Affairs Committee, specialist working groups, and legal advisors, preparing expert reports, drafting submissions, and representing the ENA at stakeholder forums.

- **TransGrid (2013) Return on Debt Analysis –** The 2012 changes to the National Electricity Rules included, inter alia, a provision that permitted the allowed return on debt to be set according to a trailing average approach. TransGrid sought an analysis of the effect that such a change would have on the residual cash flows that were available to its shareholders. Stephen developed a Monte Carlo simulation model that generated many scenarios for the possible future evolution of interest rates, incorporating empirical relationships between government bond yields, credit spreads, and inflation. His analysis quantified the extent to which the trailing average approach would better match the actual cost of servicing debt under TransGrid's longstanding debt management approach, thereby reducing the volatility of the cash flow to equity holders.

- **Aurizon Network (2014) Split Cost of Capital Analysis –** In a discussion paper, the Queensland Competition Authority advocated consideration of a

split cost of capital regulatory approach. Under the proposed approach the regulator would allow a standard "debt and equity" regulated return on assets during their construction, but a "100% debt" return once the asset had been included in the firm's regulatory asset base. Stephen was retained by Aurizon (operator of a regulated coal rail network). His role was to prepare an expert report that considered the economic and financial basis for the proposed approach, and which considered the likely consequences of such an approach. After his presentation to the QCA board, the proposal was shelved indefinitely.

- **Energy Networks (2014-15) Regulatory Reviews –** Stephen has prepared expert reports and submissions on behalf of all businesses that are in the current rounds of regulatory resets. These reports cover the whole range of regulatory cost of capital issues. Clients over the last year include ATCO Gas, DBP, ActewAGL, TransGrid, Jemena, United Energy, CitiPower, Powercor, SA Power Networks, Ausgrid, Essential Energy, Endeavour Energy, ENERGEX, and Ergon Energy.

- **Legal and Appeal Work –** Stephen has assisted a number of regulated business, and their legal teams, through merits review and appeal processes. One example is the 2011 *Gamma* case in the Australian Competition Tribunal. That case involved the "gamma" parameter, which quantifies the impact that dividend imputation tax credits have on the cost of capital. The regulator (AER) proposed an estimate that was based on (a) an assumption that was inconsistent with the observed empirical evidence, and (b) a point estimate that was based partly on a paper with questionable reliability and partly on data that was irrelevant to the task at hand. Stephen's role was to prepare a series of expert reports, to assist the legal team to understand the issues in detail, and to attend the hearings to advise as the matter was heard. The end result was that the Tribunal set aside the entire basis for the AER's proposed estimate and directed us to perform a "state of the art" empirical study. Stephen performed the required study and its results were accepted in full by the Tribunal, who set the estimate of gamma on the basis of it.

Water sector

- **Melbourne Water (2015) –** In preparation for the 2016 Victorian price review, Stephen is part of the Frontier team currently advising Melbourne Water on ways in which the rate of return methodology used by the Victorian regulator, the Essential Services Commission (ESC), could be improved, and the likely revenue impact of any methodological changes. At the last (i.e. 2013) price reset, the ESC indicated that it intended to review its rate of return methodology but to date has not done so. By comparison, most other major

Australian regulators have revised their methodologies significantly, in part due to recognition of the need to make their estimation approaches more resilient to the effects of global financial crises. A comparison of the methodologies used by different regulators in Australia suggests that the ESC's methodology is out of line with best regulatory practice. Frontier's advice has focused on identifying the areas for improvement, and the development of the economic arguments that would support the case for change.

- **Unity Water, SEQ Water, Gladstone Area Water Board (2013-14) –** Stephen has prepared a series of reports for a number of Queensland water utilities. These reports include (a) a response to the QCA's (Queensland regulator) proposed split cost of capital approach (which has now been shelved indefinitely), and (b) a response to the QCA's proposed cost of capital estimates.

Telecommunications sector

- **NBN Co (2012-13) –** Stephen advised NBN Co on a range of cost of capital issues in relation to their proposed special access undertaking. This work included the drafting of expert reports, meetings with and presentations to various NBN Co committees and working groups, and representing NBN Co in discussions with the regulator (ACCC). Key issues included the length of the proposed access arrangement, the extent to which higher risk during the construction and proof-of-concept phases justified a higher allowed return, and the process by which early year losses might be capitalized into the regulatory asset base.

- **C7 Case (2006-07), Federal Court of Australia**

  The Seven Network brought an action against a number of Australian media and entertainment firms in relation to the abandonment of its cable TV business, C7. Seven alleged that the respondents colluded to prevent C7 from securing the rights to broadcast AFL and NRL matches and that this prevented its C7 business from being economically viable.

  Stephen was retained by a group of respondents including PBL, Telstra, and News Corporation. His role was to address various matters relating the quantification of damages. He prepared several reports, was involved in several discussions with other valuation expert witnesses, and was cross examined in the Federal Court.

  The Court found in favour of the respondents.

Transport sector

- **CBH Group (2015) –** Stephen was part of the Frontier team that developed, on behalf of CBH (a major Australian grain producer and access seeker to rail infrastructure in Western Australia) and its legal counsel, a submission to the Economic Regulation Authority (ERA) of Western Australia on the regulator's approach to estimating WACC. The submission focused on, amongst other issues, the ERA's approach to estimating the market risk premium, the estimation approach to beta, and the way in which the WACC ought to be used within the negotiate-arbitrate arrangements within the rail access regime.

- **Brockman Mining Australia (2015) –** Stephen was part of the Frontier team that advised Brockman, a potential access seeker to rail infrastructure in Western Australia, on its submission to the Economic Regulation Authority (ERA) of Western Australia in relation to the ERA's approach to WACC under the Railways (Access) Code 2000. Subsequently, the ERA released a Revised Draft Decision on its proposed WACC methodology. Frontier was engaged again by Brockman to help develop its submission to the ERA on the Revised Draft Decision. The submissions focused on the appropriateness of the beta estimates proposed by the ERA, the methodology used to estimate the market risk premium (and consistency between the methodologies used by the ERA in different sectors), the appropriateness of the ERA's credit rating assumption for the benchmark efficient entity (which affects the cost of debt allowance under the ERA's methodology).

- **Brookfield Rail (2014) –** The WA Railways (Access) Code requires railway operators to provide certain information to access seekers to enable them to compute "floor" and "ceiling" prices as defined in the Code. Brookfield provided access seekers with certain information and other relevant information was available from public sources. Stephen prepared an expert report that considered whether the information available to an access seeker, together with specialist assistance from relevant experts, would be sufficient to compute floor and ceiling prices.

- **Brisbane Airport Corporation (2013-14) –** Stephen was engaged by Brisbane Airport Corporation (BAC) to advise on a range of regulatory and cost of capital issues in relation to the development of the airport's new parallel runway (NPR). BAC identified the need for an additional runway to accommodate steadily increasing demand. The development of a new runway required a large capital commitment ($1.5 billion) and would take approximately eight years to complete. BAC proposed that the airlines would contribute to the financing of the NPR during construction – the alternative being the capitalisation of a return on capital expenditure until completion and a sharp spike in landing fees when the NPR become operational. One of the

key issues in the negotiations with airlines was the WACC that would be used to determine the return on capital. Stephen's role was twofold. He produced an expert report providing a strong basis for BAC's proposed WACC. He also advised BAC on the likely approach of the ACCC (the regulator in question) should they become involved – the regulatory arrangements provide for the parties to negotiate a commercial outcome and for the regulator to become involved if they are unable to do so. BAC was successful in their negotiations with the relevant airlines and the NPR is now under construction.

- **Abbott Point Coal Terminal (2014) –** Stephen was engaged by a consortium of mining companies in relation to arbitration with Adani, the owner and operator of the Abbott Point Coal Terminal. The parties had in place a user agreement that was similar to a regulatory-style building block model. Stephen advised on a range of cost of capital and other issues including detailed reports on the cost of debt and the level of corporate costs.

Financial litigation support

- **APLNG (2014-15)**
  The Australia-Pacific LNG (APLNG) project is a joint venture between Origin Energy, ConocoPhillips and Sinopec that involves the extraction of coal seam methane and processing into liquefied natural gas (LNG) for export. The relevant Queensland royalties legislation provides that a 10% royalty is to be levied on the value of the gas at the first point of disposal. Since the project is integrated from end-to-end, there is no arm's length price at the relevant point. Stephen was retained by APLNG to prepare an expert report on the process for determining what the arm's length price at the first point of disposal would be if such a thing existed. This involves estimating the costs, including a fair return on capital, for a hypothetical upstream gas producer and a hypothetical downstream LNG operator, and allocating any excess profit between the parties.

- **CDO Case (2013)**
  This case involved a class action against the Australian distributor of collateralised debt obligations (CDOs) and the international credit ratings agency that assigned credit ratings to them. The CDOs in question were financial products with a payoff that depended on the number of defaults (or "credit events") among a reference set of 150 different corporate bonds issued by companies in different industries and different geographical locations. A typical CDO structure would involve the investor being repaid all of their initial investment plus an attractive rate of interest so long as there were less than say 7 defaults out of the reference set of 150 bonds during the five-year life of the CDO. However, if there were say 11 or more defaults, the investor would lose their entire investment. If the number of defaults was between 7

and 11, the return to the investor would be proportional (e.g., 8 defaults would involve a 25% loss of principal).

The CDOs in question were created by US investment banks and were distributed in Australia by a large Australian commercial bank. One of the key issues in the case was whether the Australian distributor made proper disclosures about risk to investors, which included individuals, self-managed superannuation funds, and local councils. The CDOs in question were assigned strong investment grade credit ratings by an international ratings agency. The process used to assign those ratings did not properly take into account the correlation between defaults – the empirical fact that during recessions and financial crises many bonds default at the same time.

Stephen's role was to prepare an expert report that explained to the Court how CDOs were structured, how they operated, and what risks were involved. His report also examined the risk disclosures that were contained in the materials that were provided to potential investors and the process by which the credit rating agency assigned ratings.

- **Wright Prospecting litigation (2012-14)**
  Wright Prospecting Pty Ltd (WPPL) is involved in several legal disputes about the payment of royalty streams in relation to iron ore and coal mining operations. WPPL had assigned various rights and licenses in relation to iron ore mines in WA and coal mines in Queensland to other parties, in return for royalties on the revenues received from the sale of the ore. Stephen's role was to prepare a series of expert reports quantifying the present value of the royalty streams.

- **Public Trustee of QLD v. Octaviar Ltd (2009), Supreme Court of Queensland**
  The Octaviar Group (formerly the MFS Group) is a Gold Coast based group of listed companies with funds management and leisure services businesses. Octaviar was unable to refinance a loan in early 2008 and sought to raise equity via a rights issue as part of a substantial corporate restructure. The stock price fell some 70% on this announcement and Octaviar subsequently sold a 65% interest in its leisure business known as Stella. Octaviar then sought to make arrangements with its creditors, including the Public Trustee, as trustee for note holders.

Stephen was retained by the Public Trustee. His role was to prepare several reports on (a) whether the companies in the Octaviar Group were insolvent, (b) the date the companies became insolvent, and (c) whether the note holders would be made better or worse off by the proposed arrangement, relative to a liquidation. He was cross examined by four parties with an interest in these proceedings on issues relating to the date of the insolvency.

- **Telstra v. ACCC (2008), Federal Court of Australia**
  Telstra brought an action against the ACCC in relation to access charges that Telstra was allowed to charge its retail competitors for access to its fixed line and broadband networks – arguing that the return on capital allowed by the ACCC was unreasonably low.

Stephen was retained by Telstra. His role was to prepare several reports on the issue of whether the ACCC has been inconsistent in its application of valuation methods – in a way that reduced Telstra's allowed return. He was also involved in several discussions with other valuation expert witnesses, prepared a joint statement of experts, and was cross examined in the Federal Court individually and in a "hot tub" setting.

- **Alcan Northern Territory Alumina Pty Ltd v. Commissioner of Taxes (2006-07), Supreme Court of Northern Territory**
  First Engagement: Consulting Expert

Alcan bought out the equity of its joint venture partner in a combined bauxite mine and alumina refinery in the Northern Territory. The NT Revenue Authority claimed that the transaction was caught by the NT "land rich" provision, under which the transaction would be subject to stamp duty if more than 60% of the consideration was attributable to land assets.

The key economic issue is the apportionment of value between the mine (predominately land assets) and the refinery (substantially intangible assets arising out of intellectual property and expertise).

Stephen was retained by Alcan as consulting experts. Their role was to prepare a range of financial models and analysis to support the view that a substantial portion of the value of the transaction was attributable to non-land assets in the refinery. This involved complex financial modelling and market analysis. A full integrated model was produced, allowing users to select whether they preferred the appellant's or respondent's submission on each input parameter, and automatically re-calculating the land-rich ratio.

Stephen worked closely with Alcan's legal team, Counsel, and various independent experts. Stephen assisted the legal team during the trial and in preparing sections of final submissions.

Second Engagement: Independent Expert

The initial judgment contained findings about certain matters and was sent back to the Commissioner for re-assessment. A dispute arose between the parties about the effect of the judgment. In particular, the value of a primary 10-year lease had to be disaggregated from the value of an option to continue the project.

Stephen was retained by Alcan to produce an expert valuation report that addressed the matters in dispute. Two expert reports were prepared and Stephen was cross-examined on this material. Stephen prepared an easy to use spreadsheet calculator to assist the Court in testing how different input assumptions (where the experts could not agree) affected the bottom line. This was used by His Honour as an *aide memoire* and was considered to be particularly helpful in the case in terms of simplifying the effects of a number of complex matters.

Judgment was in favour of Alcan. Stephen's evidence was accepted and endorsed by the Court.

Career: Professional

2014-Present	Chair, Frontier Economics
1997-2014	Director, SFG Consulting

Career: Academic

2000 - Present	Professor of Finance, UQ Business School, University of Queensland
1997-1999	Associate Professor of Finance, UQ Business School, University of Queensland
1997-2001	Research Associate Professor of Finance, Fuqua School of Business, Duke University
1995-1997	Assistant Professor of Finance, Fuqua School of Business, Duke University

Education

1987	Bachelor of Commerce (Hons), University of Queensland
1989	Bachelor of Laws (Hons), University of Queensland
1995	PhD, Stanford University

Papers and publications: Cost of capital

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