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Estimating beta to be used in the Sharpe-Lintner CAPM

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1 Executive summary

1. In my view the ERA commits a critical error in its assessment of the implications of different asset pricing models. Specifically, the ERA agrees that implementation of the Sharpe-Lintner CAPM should be amended to correct for the potential for 'low beta bias' identified by the Black CAPM. Low beta bias is the tendency for stocks with beta below 1.0 to earn a higher return than predicted by the Sharpe-Lintner CAPM.

2. The ERA proposes to do this by raising the equity beta (β) used in the Sharpe-Lintner CAPM above its best estimate of the actual equity beta. However, the ERA explicitly determines that it will not base the magnitude of the increment on the best empirical evidence of the magnitude of low beta bias that the increment is intended to offset. This is the ERA's error.

3. The ERA provides the following two core arguments (in different forms) for why it is appropriate to ignore the relevant evidence when making the adjustment:

   - basing the adjustment to the Sharpe-Lintner CAPM on empirical evidence violates the integrity of the Sharpe-Lintner CAPM;
   - there is uncertainty in the best estimate of the magnitude of the amendment; and
   - the Black CAPM is not widely used.

4. In my view, the ERA's reasoning on each ground is illogical.

Violation of the Sharpe-Lintner CAPM

5. The ERA appears to believe that:

   - if it adds an increment to its best estimate of β; but
   - does not base that estimate on explicit analysis of the empirical evidence that justifies an increment; then
   - it is not departing from a strict application of the Sharpe-Lintner CAPM.

6. By contrast, because DBPs proposed increment to β is explicitly based on the relevant evidence, the ERA appears to believe that DBP's approach is 'in violation' of the Sharpe-Lintner CAPM while its own approach is not. This is even though both approaches apply an increment to β for the same reason (in order to offset low beta bias in the Sharpe-Lintner CAPM), rendering the approaches identical in terms of their economic substance.

7. I do not regard the ERA's conclusion as rational. Both DBP and the ERA are performing the same amendment for the same reason. If one is a violation of the integrity of the Sharpe-Lintner CAPM then so is the other. The only difference is that

one is evidence based and one is not. In my view, the evidence based approach is the correct one.

There is uncertainty in estimates of the ZBP

8. The draft decision devotes considerable effort to establishing that different estimation techniques and different data sources result in different estimates of the magnitude of low beta bias. However, as one reads these sections it is apparent that the ERA is not attempting to survey the evidence with a view to arriving at its best estimate of low beta bias. Rather, the ERA's focus is to demonstrate that one can employ different estimation techniques and arrive at different estimates. The ERA does this most clearly in its Table 25[1] where the ERA presents 12 different estimates that it has derived of the ratio of the zero beta premium (ZBP) to the market risk premium (MRP) (call this parameter $\frac{ZBP}{MRP}$). This parameter determines the magnitude of low beta bias for any given estimate of β. The ERA's estimates of $\frac{ZBP}{MRP}$ range from 0.61 to 5.57 – all of which indicate a large magnitude of low beta bias.

9. These sit alongside:

   - four other Australian estimates surveyed in this section that range from 0.52 to 1.27 and another ERA estimate of 0.77;[2]
   - a further Australian study, co-authored by myself, which the ERA discusses on page 220 and which estimated values for ZBP/MRP of around 1.0; and
   - four international studies that the ERA reports in Table 39 of Appendix 4 – all of which have economically material positive estimates of the zero beta premium (averaging 7.1% p.a. consistent with a $\frac{ZBP}{MRP}$ of around 1.0 assuming an MRP of around 7%).

10. One might reasonably expect the ERA to conclude from this that the minimum value it should use[3] for $\frac{ZBP}{MRP}$ is 0.61 – being the lowest of its estimates of $\frac{ZBP}{MRP}$ (which is also

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1 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 185.

2 See Table 24 on page 184 of Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return. Note that the ERA estimate of 0.77 in Table 24 appears to be closely related to the 0.73 estimate in Table 25 (with the same ZBP but with a slightly lower estimate of the MRP).

3 When populating equation 5 above to determine the appropriate increment to beta to counteract low beta bias.

lower than all but one of the other estimates that it surveys). However, this is not the conclusion that the ERA comes to. Rather, the conclusion that the ERA reaches is:[4]

> *Until a robust method is developed for estimating the zero-beta return, and the consequences of choosing different values for each decision variable are well understood, then the Black CAPM cannot be considered consistent or robust.*

11. This is an illogical position for the ERA to take. Whether the evidence suggests a wide or a narrow band for the best estimate of low beta bias, it is still incumbent on the ERA to arrive at the best estimate based on the available evidence. The theoretical insight of the Black CAPM is that low beta bias may exist and, if it does, correction will necessitate an adjustment to the Sharpe-Lintner CAPM. The fact that the evidence may not lead to a narrow range for the best estimate of low beta bias is not a rational reason to make that adjustment on some other basis than the available evidence.

12. Were the ERA to apply the same approach to the Sharpe-Lintner CAPM it would determine that it was also not robust because different estimation techniques/data periods result in very different estimates of MRP and beta. The ERA's task, which it accepts in relation to these parameters, is to sift through the evidence and arrive at the best estimate. Indeed, in relation to estimating beta the ERA states:[5]

> *Moreover, the Authority has consistently reiterated that as a consequence of the statistical imprecision inherent in equity beta estimation, a range of values and regression techniques are necessary in order to inform the permissible range of equity beta values. This acts to mitigate the impact an individual firm's equity beta estimate can have on the determined equity beta estimate. The Authority considers that issues of statistical imprecision are best addressed via the use of multiple models and regression techniques to inform the possible range of equity beta estimates*

13. This stands in stark contrast to the ERA's position in relation to estimating $\frac{ZBP}{MRP}$ (the determinant of low beta bias) – whereby the ERA effectively concludes that because different estimation techniques give rise to different values then no evidence should be used.

4 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 186.

5 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return. P. 57.

The Black CAPM is not well established

14. The ERA has also relied on the following conclusion (and others like it):[6]

> *Reflecting these shortcomings, the Black CAPM* ***has not been widely adopted by academics or practitioners*** *in Australia or overseas for estimating a return on equity directly. Consistent with this view, the Authority considers that it is impractical to utilise the Black CAPM to determine the return on equity directly.* [Emphasis added]

15. I do not understand the basis on which the ERA makes such statements. The relevant[7] empirical studies that the ERA surveys all (without exception) find that the Black CAPM is a better fit to the data (i.e., the ZBP is positive). This suggests to me that the Black CAPM is more widely 'used by academics' than the Sharpe-Lintner CAPM in the sense that academics would, based on the literature, agree that a zero beta premium exists. The ERA performs its own estimates that confirm precisely this result. It is simply not reasonable to claim that the existence of a ZBP is not well established. I note that it is sufficiently well established to be included in finance textbooks such as the 10th edition of Brealey, Myers and Allen *Principles of Corporate Finance*.[8] It has also been used by regulators, not least by the ERA albeit indirectly to justify selecting a higher beta than it otherwise would, but directly by regulators such as the New York Public Service Commission.[9]

16. The only supporting evidence for the ERA taking this position is the following statement by Handley (quoted by the ERA):[10]

> The Black CAPM is not widely adopted in practice – there is one very good reason for this. The theoretical prediction which distinguishes the Black-CAPM from the Sharpe-CAPM is that the (shadow) risk free interest rate – more commonly called the zero beta rate – is unspecified except to say that it must be less than the expected return on the market portfolio. In the partially-restricted version of the model, the zero beta rate must also be above the risk free rate. From a practical point of view, this is not very useful due to the wide range of

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6 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 40

7 Studies that have tested the Black CAPM against the Sharpe CAPM.

8 Brealey, R.A., S.C. Myers, and F. Allen, 2011, Principles of Corporate Finance, 10th ed., McGraw-Hill Irwin, New York, NY, USA.

9 See, for example, the January 2008 testimony of the State of New York Department of Public Service Policy Panel to the State of New York Public Service Commission In the Matter of Case 07-M-0906 p. 264.

10 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p.156.

possible values that the zero beta rate may take on. The Black-CAPM therefore presents the non-trivial task of having to estimate the expected zero beta rate which the theory says could be anywhere in a very wide range as well as having to estimate an expected market risk premium relative to the expected zero beta rate.

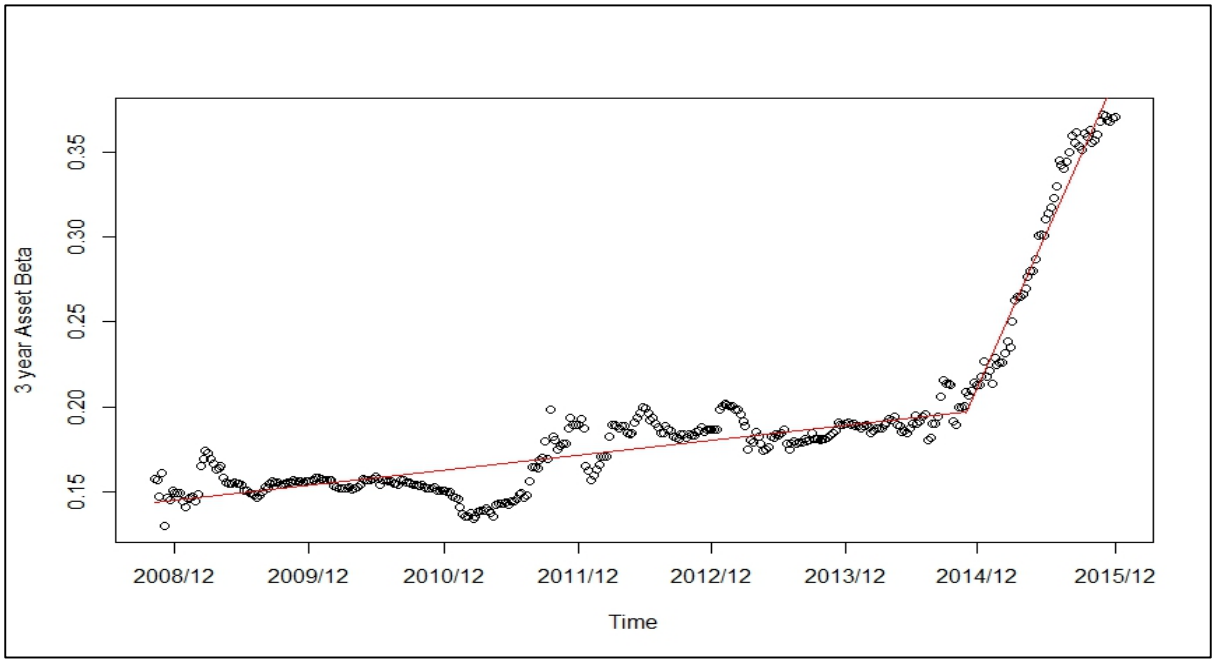
17. I do not agree that this is an accurate statement. The discussion in this report and the ERA's own discussion of the literature makes clear that academics do 'use' the Black CAPM in the sense that they have tested its accuracy and also teach it to their students (including teaching the results of the empirical tests). Exactly what 'practitioners' do I am unable to say because there is no reliable evidence on this and neither the ERA nor any of the experts the ERA quotes refers to any such reliable evidence.

ERA estimates of beta are low relative to most recent estimates

18. The ERA states that its best estimate of beta is 0.5. However, there has been a dramatic rise in both measured five and three year betas. The most recent three year betas average over 0.9[11] which is 0.2 higher than the ERA's selected value of 0.7 (which is inclusive of an increment for low beta bias). (Note that the chart below is for asset beta.) The most recent value for the 3 year average weekly asset beta (to 31 December 2015) is 0.37 and then this is re-levered to 60% gearing the equity beta is 0.91.

[11] Three year weekly (week ended Friday) equity beta (leveraged to 60% gearing) estimates to the end of December 2015 are 0.91/0.85/0.95 for the average of individual betas/equal weighted portfolio beta/value weighted portfolio beta.

Figure 1: 3 year average weekly asset betas – December 2014 break point



Source: Bloomberg, CEG analysis

19. The increase in rolling three year betas has been dramatic and is associated with the most significant structural break in the data over the entire period the sample is available (i.e., from late 2008). Note that a structural break in 3 year rolling asset betas in late 2014/early 2015 implies a structural break in the data at some point over the preceding 3 years (i.e., from late 2011 to early 2012 onwards).

20. Other methods of statistical analysis also points suggests a structural break exists in the data from some time after mid 2012 (with the statistical significance of the measured structural break increasing as later break points are tested up dates in 2014/15). This suggests that, presently, 3 year asset betas are a more reliable estimate of beta is recent market conditions than 5 year assets betas (with the latter including at least a year and a half of data from before the structural break).

2 Introduction

21. My name is Thomas Nicholas Hird and I am a founding director of CEG Asia Pacific (**CEG**) and head of its Melbourne office. I have a Ph.D. in Economics from Monash University. I have more than 20 years of experience in the economic analysis of markets and in the provision of expert advice in regulatory, litigation and policy contexts. I have provided expert testimony before courts and in numerous regulatory forums.

22. I have been asked by DBP to provide an expert assessment of the ERA's treatment of asset pricing models in its draft decision for ATCO.[12] In particular, I have been asked to provide my views on the ERA's decision not to allow empirical estimates of low beta bias to inform the ERA's estimate of the increment to beta necessary to offset that bias.

2.1 Terms of reference

23. My terms of reference for this report are set out below:

> *Review the internal consistency and reasonableness of the ERA's decision in relation to:*
>
> - *the ERA's rejection of the validity of DBP's method for having regard to the Black CAPM when selecting the value of the equity beta used in the Sharpe-Lintner CAPM; given*
> - *the ERA's acceptance that the Black CAPM is relevant for the purpose of estimating a return on equity for regulatory decisions in Australia and that the ERA will do so by having regard to the Black CAPM when selecting the value of the equity beta used in the Sharpe-Lintner CAPM.*
>
> *Provide an assessment of recent movements in measured beta for the ERA's comparable sample (SKI, DUE, AST and APA) and whether recent measures of beta are materially different to past measures.*

2.2 Structure of this report

24. I address the above issues in the remainder of this report, which is structured as follows:

[12] When I refer to the "ATCO draft decision" I mean ERA, Draft Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System (2014).

- **Section 3** describes the ERA's reasoning for not having regard to the relevant empirical evidence to determine the appropriate increment to beta that results from having regard to the theoretical insights of the Black CAPM. This section also explains why I consider this reasoning is flawed;
- **Section 4** provides an empirical assessment of the magnitude of the error that flows from the ERA's failure to have regard to the relevant evidence.
- **Section 5** provides evidence that the most recent values of beta (0.90) are materially above the ERA's selected value for beta (0.70). That is, these estimates are above the ERA's estimate even before any adjustment for the insights of the Black CAPM are applied.

26. I acknowledge that I have read, understood and complied with the Federal Court of Australia's *Practice Note CM 7, Expert Witnesses in Proceedings in the Federal Court of Australia*. I declare that I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld.

Thomas Nicholas Hird

18 February 2016

3 ERA's reasoning

27. The Black CAPM predicts that the Sharpe-Lintner CAPM will underestimate the required return on low beta stocks (i.e., the Sharpe-Lintner CAPM gives rise to 'low beta bias'). The ERA has accepted that this low beta bias is sufficiently important to justify adopting an estimate of the cost of equity that is higher than would otherwise have been chosen absent consideration of the theoretical insights from the Black CAPM. I agree this is appropriate.

28. However, I consider the ERA makes a serious error in implementing this decision. Specifically, the ERA explicitly refuses to use any empirical evidence to arrive at the quantum of the adjustment that it believes should be made. This is the ERA's core error.

29. In my view, it is irrational to:

- conclude that there is theoretical evidence that a bias exists that is sufficiently powerful to require a regulatory policy to be amended to correct for the bias; but
- not base that correction in any way on empirical estimates of the magnitude of the bias.

30. It is my opinion that, as a direct consequence of this error, the actual adjustment applied by the ERA is below the lower bound of the plausible adjustments required to counteract low beta bias based on the empirical literature.

3.1 ERA's decision

31. The ERA's ultimate conclusion is as follows:[13]

> *745. The Authority has come to the view that the Black CAPM is relevant for the purpose of estimating a return on equity for regulatory decisions in Australia. All of its underlying assumptions except for one are the same as those underlying the Sharpe Lintner CAPM. The Black model therefore satisfies the criterion of having a theoretical foundation.*
>
> *746. The concept of zero beta portfolio, however, is not well established. Estimates of the zero beta premium are both unstable and unreliable, particularly in the Australian context. Neither is the Black CAPM widely adopted by academics or practitioners in Australia or overseas for estimating a return on equity directly. None of the estimates of a return on equity that are made using the Black CAPM are sufficiently robust. **The***

[13] ERA, Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020, Appendix 4, p. 157

> ***Authority considers that it is therefore impractical to utilise the Black CAPM to determine the return on equity directly.***
>
> *747. However, the Authority will recognise the theoretical insight from the Black CAPM when estimating a return on equity with the Sharpe Lintner CAPM.* ***The Authority will have regard to these outcomes when estimating the equity beta from within the estimated range.*** *[Emphasis added.]*

32. In the second paragraph of the above quote the ERA presents a view that estimating the magnitude of the low beta bias is difficult. On this basis the ERA concludes that it is "*therefore impractical to utilise the Black CAPM to determine the return on equity directly*". While it is not clear from this phrasing, read in the full context of the decision, the ERA is stating that it will not have regard to empirical results when calibrating the magnitude of the adjustment for low beta bias.

33. In the third paragraph the ERA sets out its basis for making such an adjustment. The ERA states that it will choose a higher equity beta than otherwise would be chosen - but with the final value coming from within 'the estimated range' for equity beta. The ERA does not explain:

- what evidence will inform the final point estimate within that range; nor
- on what basis it has concluded that correcting the 'low beta bias' does not require selection of a value for beta from beyond 'the estimated range' for beta.

34. The remainder of this section is structured as follows:

- section 3.2 explains why it is necessary to look at empirical evidence to determine what adjustment is appropriate and what that evidence is; and
- section 3.3 sets out the ERA's justifications for not having regard to this evidence (and why I consider these justifications are not valid).

35. Section 4 explains why, having full regard to the empirical evidence, the ERA's adoption of a 0.70 value for beta does not correct for the best estimate of the low beta bias in the Sharpe-Lintner CAPM.

3.2 What empirical data should be examined?

36. The Sharpe-Lintner CAPM assumes that investors can borrow at the risk free rate to invest in risky equities. The theoretical insight of the Black CAPM is that, when this assumption is relaxed, the required return on low beta stocks increases relative to the predictions of the Sharpe Lintner CAPM.

37. The predictions of the Black CAPM can be mathematically represented by introducing the concept of a zero beta premium (ZBP) that is analogous to the market risk premium (MRP). The MRP is the return on stocks with average risk (beta of 1.0)

in excess of the risk free rate (RFR).[14] The ZBP is the return on stocks with zero risk (beta of zero) in excess of the RFR. The difference between the Sharpe-Lintner CAPM and the Black CAPM can be expressed mathematically as follows:

$$R^{SL\ CAPM} = RFR + \beta \times MRP \quad \text{Eqn. 1}$$

$$R^{Black\ CAPM} = RFR + ZBP + \beta \times (MRP - ZBP) \quad \text{Eqn. 2}$$

38. If the best empirical estimate of the ZBP equals zero then these two formulae collapse to the same value. I reiterate here the importance of focussing on the best empirical evidence of the value of the ZBP. In the terminology of my previous report[15] this is the Empirical CAPM. In its draft decision the ERA sates that it uses the terminology "Black CAPM" to be the same as the "Empirical CAPM" as I used the term.[16] In order to have consistent terminology with the ERA I use the ERA's terminology in this report, however, I continue to note that the "Black CAPM" as used in this report is informed by an empirical estimate of the ZBP. Therefore, when I use the term 'low beta bias' in the Sharpe-Lintner CAPM relative to the "Black CAPM" it is an empirical estimate of that bias that I refer to.

39. It can be seen from Equation 2. that, if β is equal to 1.0 then both formulae give the same result. However, for all values of β not equal to 1.0 and all values of ZBP greater than zero the Black CAPM will predict a higher/lower return than the Sharpe-Lintner CAPM depending on whether β is less/greater than 1.0.

40. Subtracting the Sharpe-Lintner CAPM estimate from the Black (Empirical) CAPM estimate provides the magnitude of the empirical bias.

$$Bias = R^{Black\ CAPM} - R^{SL\ CAPM} = ZBP \times (1 - \beta) \quad \text{Eqn. 3}$$

41. Obviously, for β less/greater than 1.0 the Sharpe-Lintner CAPM is downward/upward biased. This is the theoretical insight of the Black CAPM to which the ERA refers. Critically, in order to estimate the magnitude of this bias it is necessary to form a view about the best estimate of the ZBP.

42. I note that the ERA's proposed method for correcting this bias is to continue to use the Sharpe Lintner CAPM formula (i.e., not incorporate a value for ZBP into the CAPM formula) but instead to select a value for beta that is above β – call this "β*".

$$ERA\ ammended\ R^{SL\ CAPM} = RFR + \beta^* \times MRP \quad \text{Eqn. 4}$$

14 The rate at which an investor can borrow/lend where there is zero probability of default of any kind.

15 CEG, "ERA treatment of asset pricing models", a report prepared for DBP, December 2014,

16 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 146, para 691.

43. It is relatively simple to solve for the value of β* that corrects the bias in the Sharpe-Lintner CAPM identified in the theoretical insight of the Black CAPM. Simply set Equation 4 equal to Equation 2 and solve for β*. When this is done the value of β* is defined by:

$$\beta^* = \beta + \frac{ZBP}{MRP} * (1 - \beta) \qquad \text{Eqn. 5}$$

44. This is DBPs approach and, for the reasons set out above, it is correct.[17] Equation 5 states that β* must be set above β by an amount equal to the bias estimated in Equation 3 divided by MRP. This is a reflection of the fact that:

- β* is multiplied by the MRP in the Sharpe Lintner CAPM; therefore
- removal of the bias from the Sharpe Lintner CAPM ($ZBP * (1 - \beta)$) requires that β* must be set above β by an increment equal to the bias divided by MRP ($\beta^* - \beta = \frac{ZBP}{MRP} * (1 - \beta)$).

45. Fundamentally, Equation 5 states that, in order to accurately counter any bias that derives from the theoretical insights of the Black CAPM (which manifests in an empirical estimate of $\frac{ZBP}{MRP}$) by applying an increment to beta in the Sharpe-Lintner CAPM, the ERA must arrive at Equation 5. In other words, it must use its best estimate of the ratio of the ZBP to the MRP ($\frac{ZBP}{MRP}$). If one judges that the best estimate of $\frac{ZBP}{MRP}$ is low (close to zero) then a small increment is required. If one judges that the best estimate of $\frac{ZBP}{MRP}$ is high (e.g., close to 1.0) then a larger increment is required (and is largest when the value of β is lowest). By applying an increment to β the ERA is implicitly drawing a conclusion about the value of $\frac{ZBP}{MRP}$, even if the ERA is not doing so explicitly.

46. There is no rational or logical alternative way to arrive at an assessment of the appropriate increment to β that will offset the bias identified by the theoretical insights of the Black CAPM. Equally, in arriving at an estimate of the value of $\frac{ZBP}{MRP}$ it is irrational not base such an estimate on empirical estimates of this ratio. The value of $\frac{ZBP}{MRP}$ is not something that can be divined or intuited via internal introspection or judgment without reliance on data.

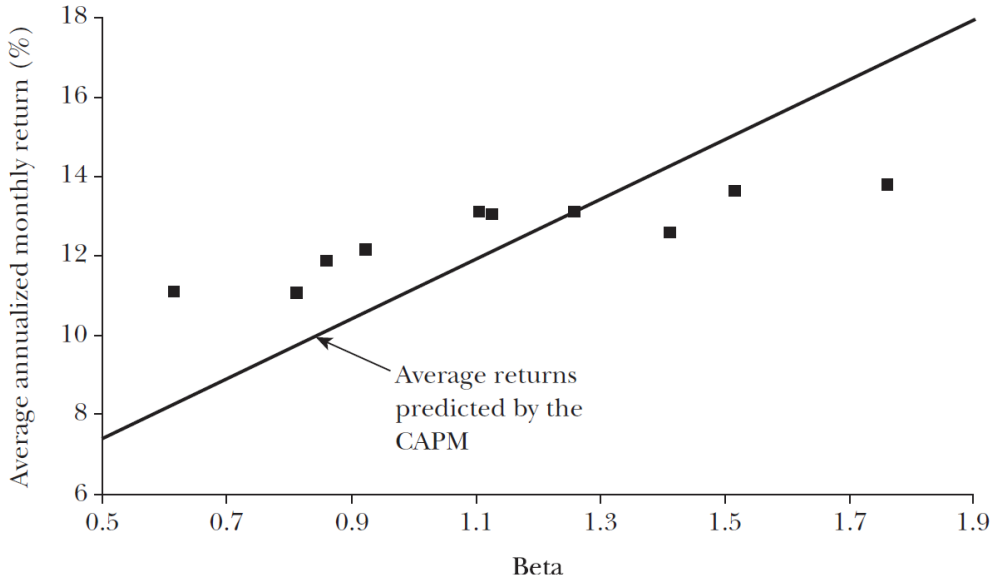
47. In this case, the relevant data is derived from studies that attempt to estimate the actual relationship between the measured beta of a stock (or, more often, a portfolio of stocks with similar beta) and the actual return on those stocks. If the relationship

[17] This approach is directly linked back to the original work on ZBP. For example, see discussion in Black Jenson Scholes (1972) pages 4 and 5 where our Equation 2 is presented and described (although without the decomposition of the zero beta return into risk free rate plus ZBP). If one is to adjust beta to account for the difference between Equation 1 and Equation 2 one inevitably ends up at Equation 5.

between excess[18] stock returns and beta is proportional to the overall excess market return then $\frac{ZBP}{MRP}$ is zero. If the relationship is flatter (less than proportional) then $\frac{ZBP}{MRP}$ is greater than zero. This is classically illustrated by Fama and French[19] in Figure 2 from their 2004 survey of the literature.

Figure 2: Observed vs assumed slope

Average Annualized Monthly Return versus Beta for Value Weight Portfolios Formed on Prior Beta, 1928–2003



Source: Fama and French 2004.

48. The estimate of $\frac{ZBP}{MRP}$ implied by the above study is the difference in the slope of the drawn line shown on the chart (which has a slope equal to the MRP) and the slope of a line of best fit drawn through the actually observed data points (which has slope equal to the MRP less the ZBP). While not reported in the study, casual inference from above chart puts the MRP (slope of the drawn line) at around 7% and value of MRP less ZBP (slope of the line fitted to the observations) at around 2%. This implies a value for ZBP of around 5% and a value for $\frac{ZBP}{MRP}$ of around 0.7.

49. This is the standard result in international studies from the finance literature and is consistent with the ERA's summary of that literature in Table 39 of Appendix 4. In that table the ERA reports US ZBP estimates that averages around 7%.

[18] Over and above the risk free rate.

[19] Fama E., and French K., The Capital Asset Pricing Model: Theory and Evidence, Journal of Economic Perspectives, Volume 18, Number 3, 2004, p. 33.

50. It is my view that the only way to rationally arrive at an increment to β[20] is to do so based on an estimate of $\frac{ZBP}{MRP}$ and the only way to form such an estimate is based empirical estimates of $\frac{ZBP}{MRP}$.

51. I consider it is self-evident that absent such empirical evidence, no adjustment to β should be made. That is, it would be imprudent to make an adjustment to β without first satisfying oneself that the theoretical insight of the Black CAPM actually manifested in a low beta bias (not just that a low beta bias might exist). However, if empirical studies provide evidence to determine sufficient likelihood of bias, such that the ERA considers a corrective action is required, then the only rationale approach is to base the magnitude of the correction on the same empirical studies.

3.3 ERA's rationale for making adjustment not based on empirical studies

52. The ERA provides a number of justifications for not basing its increment to the asset beta on empirical estimates of $\frac{ZBP}{MRP}$. In my opinion these justifications are not reasonable. The ERA's justifications fall into the following three categories:

    a. DBP's proposed calculation of β*, which does utilise an estimate of $\frac{ZBP}{MRP}$, is a "violation" of the integrity of the Black CAPM.

    b. There remains uncertainty/complications in accurately measuring ZBP (and $\frac{ZBP}{MRP}$) and interpreting the measurement. In particular,

        - the estimates are not stable and, therefore, not sufficiently 'robust' to be used by the ERA;
        - the theoretical literature on why a ZBP exists is not settled;
        - there is a debate in the empirical literature about how to best test the existence of a ZBP.

    c. The Black CAPM is not widely used to estimate required returns.

53. In addition the ERA also appears to rely on the following arguments as reasons to reject DBP's specific implementation of the Black CAPM:

    a. DBP's proposal is nonsensical in that it results in risk premiums above the market average; and

    b. DBP's empirical ('model adequacy') tests using Australian data are flawed/unconventional and give rise to nonsensical results.

[20] To offset the bias in the Sharpe-Lintner CAPM identified in the theoretical insights of the Black CAPM.

54. The ERA appears to use these latter arguments as a rationale for not having regard DBP's specific use of empirical evidence within DBP's 'model adequacy test' rather than empirical evidence *per se*. If so, the correctness or otherwise of these claims are not central to the core error that I find the ERA has made – namely the explicit refusal to use empirical evidence of the magnitude of low beta bias to inform the magnitude of its amendment to the Sharpe-Lintner CAPM to address that bias.

55. Moreover, I note that for practical purposes the ERA agrees with the main findings of DBP's model adequacy test; namely that the Black CAPM is relevant and the Fama French model is not relevant as an asset pricing model for Australian regulated utilities. Consistent with my terms of reference, this report takes this finding as a the starting point for the analysis.

56. I note that while DBP arrived at the same conclusions as the ERA in this regard it did so using its 'model adequacy' test which the ERA rejects as being a useful test. The rationale for the ERA's rejection of DBP's test are to some extent specific to DBP's method. However, because DBP's model adequacy test is fundamentally a data driven test some of the ERA's reasons for rejecting reliance on this test might be inferred as reasons for rejecting reliance on empirical estimates of low beta bias more generally. For this reason I address these arguments in Appendix A.

3.3.1 Having regard to empirical data violates the integrity of the Sharpe-Lintner CAPM

57. DBP proposes to use a value for beta in the Sharpe-Lintner CAPM that offsets the low beta bias that is the theoretical insight of the Black CAPM. DBP does so by populating Equation 5 above with an estimate of β and $\frac{ZBP}{MRP}$. As noted above, I consider that this is the only rational way to perform such an adjustment.

58. In a section entitled "The violation of integrity for the Sharpe Lintner CAPM and Black CAPM", the ERA concludes that DBP's approach:[21]

> *On balance, the Authority is of the view that it is inappropriate to consolidate the effect from two components: (i) the systematic risk; and (ii) bias adjustment into the so-called Betastar which is considered as the beta under the Black CAPM but the estimate is then utilised in the formulation of the Sharpe Lintner CAPM.*

59. I do not understand how the ERA can use this reasoning to come to the conclusion that DBPs proposed approach of adjusting β to offset low beta bias is inappropriate while its own approach, which does precisely the same thing, is appropriate. Indeed, on the same page as the above quote the ERA states:

[21] Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 214.

> *…the Authority's current approach is to retain the Sharpe Lintner Capital Asset Pricing Model as the primary method for estimating the return on equity. However, information from other relevant models – including the Black CAPM and the Dividend Growth Model are utilised to establish the value of parameters in the Sharpe Lintner CAPM to ensure that the return on equity reflects the prevailing market condition. The Black CAPM is then considered in the process of selecting a point estimate from an appropriate range of equity beta.*

60. As a matter of economic substance, no distinction exists in terms of the high level approach taken by the ERA and DBP. Both result in an increase in the cost of equity above the level that would otherwise be adopted if the Sharpe-Lintner CAPM were employed without regard to the predictions of the Black CAPM. Moreover, in both cases this is achieved by adjusting the same parameter – raising the value of beta above the level that would be used without having regard to the Black CAPM (call this 'β') to a higher value (call this 'β*'). That is, in economic substance both DBP and the ERA have a 'betastar' estimate.

61. The key difference between the ERA's and DBP's approach is not whether they are utilising the Black CAPM to set the cost of equity and not whether they are forming (be it implicit or explicit) judgements about $\frac{ZBP}{MRP}$. Both DBP and the ERA are proposing an amendment to the Sharpe-Lintner CAPM to correct for a perceived failure in that model. As a matter of semantics one can argue that this involves a 'violation' of the Sharpe-Lintner CAPM – where the phrase 'violation to' can also be read as 'departure from'. However, it is a departure that is justified based on the evidence and it is a departure that both the ERA and DBP propose to make.

62. The key difference between the ERA and DBP is the level of transparency and rigour applied in arriving at the quantum of the adjustment when moving from β to β*. DBP arrive at their adjustment by having regard to estimates of $\frac{ZBP}{MRP}$. The ERA believes that arriving at the adjustment by having regard to empirical evidence on the value of $\frac{ZBP}{MRP}$ involves a 'violation' of the Sharpe-Lintner CAPM while arriving at the adjustment based on some other basis does not involve a violation.

63. In this regard, the ERA appears to believe that it can be 'a little bit pregnant' when it comes to incorporating the theoretical insights of the Black CAPM. Specifically, the ERA appears to believe that:

- if it adds an increment to its best estimate of β; but
- does not base that estimate on explicit analysis of the empirical evidence that justifies an increment; then
- it is not departing from a strict application of the SL CAPM.

64. The ERA appears to believe that DBP's approach explicitly departs from the Sharpe-Lintner CAPM and therefore is 'in violation' of it while its own departure is only implicit and, therefore, is not 'in violation' of the Sharpe-Lintner CAPM. The ERA further appears to believe that this makes its departure from the Sharpe-Lintner CAPM superior. This is even though both approaches are identical in that they both apply an increment to β for the same reason (in order to offset low beta bias in the Sharpe-Lintner CAPM).

65. I note that this position is a departure from the ERA's position in the rate of return guidelines process where the ERA stated: [22]

> *The determination takes into account other relevant material, such as insights from the empirical performance of the Sharpe Lintner CAPM. The Authority considers* ***that relevant empirical evidence supports a view that there is some downward bias*** *in equity beta estimates that are less than one, and upward bias in equity beta estimates that are greater than one.*
>
> *Therefore, for the purposes of this* ***indicative estimate****, the Authority will assume a point estimate for the equity beta that is at the top end of the estimated range, at 0.7, so as to account for potential bias in the estimate.*
>
> *The Authority intends to* ***undertake work to quantify the extent of this potential bias*** *prior to its next decision. This work would then assist in* ***informing the degree to which the Authority might adjust up the point estimate of the equity beta*** *within the estimated range, so as to account for any potential beta bias.* [Emphasis added.]

66. The same sentiment was expressed in the final explanatory statement to the guidelines (and is what I encouraged the ERA to do in my previous report):[23]

> *Nevertheless, as noted above, the Authority intends to* ***account for empirical evidence*** *relating to potential bias in the estimates of the equity beta, that are used in applying the Sharpe Lintner CAPM. The Authority considers that such an approach would account for much of the* ***evidence*** *supporting the use of the Empirical and Black CAPM models.* [Emphasis added.]

67. In my view the only way in which the magnitude of low beta bias can be estimated and the offsetting increment to β calculated is using Equation 5. However, the ERA now adopts the position that Equation 5 cannot be used because to do so is a violation of the Sharpe-Lintner CAPM. However, this effectively means that empirical

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22 ERA , Explanatory Statement for the Draft Rate of Return Guidelines, Appendix 30, p. 217

23 ERA, Appendices to the Explanatory Statement for the Rate of Return Guidelines, 16 December 2013, p. 67.

evidence cannot be used because Equation 5 is the only means by which the relevant empirical evidence can inform the appropriate increment to β.

68. I do not regard the ERA's conclusion as rational. Both DBP and the ERA are performing the same amendment for the same reason. If one is a violation of the integrity of the Sharpe-Lintner CAPM then so is the other. The only difference is that one is evidence based and one is not. In my view, the evidence based approach is the correct one.

3.3.2 Uncertainty/complications in accurately measuring $\frac{ZBP}{MRP}$

69. The ERA's primary justification for making its adjustment without using evidence appears to be that the evidence is less than perfect - with uncertainty as to the best estimate of $\frac{ZBP}{MRP}$. This justification comes in a number of forms and places in the draft decision but is, perhaps, exemplified in the below quote:[24]

> *However, the Authority does not accept the use of the Black CAPM for directly estimating the return on equity, as DBP does.* ***This is principally*** *because estimates of the zero-beta return are unstable and cannot be relied on in the Australian context. As a result, estimates using the Black CAPM are not fit for purpose. Further details of the Authority's analysis of the properties of the Black CAPM are included in Appendix 4A and 4Ai.*
>
> *…*
>
> *DBP ultimately proposes an initial Step 3 estimate for the return on equity that is based on the Sharpe Lintner CAPM, albeit with the estimate of the beta term adjusted to give an estimate consistent with the Black CAPM.* ***The Authority considers that the use of the Sharpe Lintner CAPM, adjusted to take account of the theoretical insights of the Black CAPM, is appropriate, and follows the method set out in the Guidelines.***
>
> *However, the Authority does not agree with the adjustment for beta estimated by DBP – the so-called 'betastar' correction.* ***DBP's adjustment means, in effect, that the estimate is derived from the Black CAPM, rather than using the Sharpe Linter CAPM.*** *In line with this, DBP state explicitly:*
>
> > *The Black CAPM, as implemented through our betastar model, is considered relevant via our model adequacy test, and is used for calculating the*

[24] Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, pp. 40-41

> *permissible ranges of the return on equity in stages two and three of the ERA's process.*
>
> *As set out above,* ***the Authority does not accept estimates that are directly based on the Black CAPM****, as these are not reliable. Accordingly, the Authority will retain the use of the Sharpe Lintner CAPM, albeit with the choice of beta adjusted within its estimated range, so as to account for the theoretical insights of the Black CAPM*. [Emphasis added]

70. The last three paragraphs of the above quote illustrate an unnecessary tension that the ERA has created for itself. The ERA considers DBP's proposal to adopt a higher beta based on the theoretical insights of the Black CAPM is correct. However, the ERA draws the line at using empirical evidence and explicit mathematical adjustments based on that evidence. It regards this as unacceptable because it effectively means explicitly departing from the Sharpe-Lintner CAPM to give effect to the insights from the Black CAPM. The ERA appears to believe that it can account for the insights of the Black CAPM without departing from the Sharpe-Lintner CAPM (i.e., be a little bit pregnant in terms of the model used). The ERA appears to believe that this is achieved by virtue of adjusting the Sharpe-Lintner CAPM without explicitly linking this adjustment to the evidence.

71. As noted in the previous section, I regard this as an illogical approach.[25] However, there is another theme in the above quote that the ERA expands on elsewhere in its decision. This is that the theoretical and empirical evidence of $\frac{ZBP}{MRP}$ may justify a conclusion that the best estimate of this variable is greater than zero. However, because this evidence supports values for $\frac{ZBP}{MRP}$ within a wide band, this evidence cannot be relied on to inform the magnitude of the low beta bias. On this basis, the ERA considers that it is appropriate to make an adjustment for low beta bias on some other, non-evidence based, grounds. (As already noted, this is irrational. If the evidence justifies an adjustment that adjustment must be made with regard to the evidence. If the evidence does not support an adjustment then no adjustment should be made. There is no state of the world where the evidence supports an adjustment but the adjustment should be implemented without recourse to the evidence.)

72. This theme is developed by the ERA in numerous places but is perhaps exemplified in the section entitled "The estimates of zero beta premium".[26] In this section the ERA discusses a range of different Australian studies that put the value for the ZBP between 3.34% and 8.84%. The ERA provides quotes from experts to the effect that

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[25] If the evidence is sufficient to support applying an increment to the value of β then the same evidence should be used to determine the magnitude of the increment. It is irrational determine an increment should be applied but to not use the evidence that supports that conclusion to determine the magnitude of the increment.

[26] Pages 43 to 45 of Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return.

different methodologies can result in different estimates of the ZBP and that "*there is no generally accepted empirical measurement of the zero beta return in the Black CAPM*".[27] Similarly, in the section entitled Estimating the Zero-Beta Return[28] the ERA expands on this theme referencing a range of estimates by other parties and also introducing the ERA's own estimates. Elsewhere the ERA states:[29]

> *Based on its recent analysis, the Authority notes that various approaches have been attempted to estimate the zero-beta portfolio returns.* ***The Authority is of the view that the differences in method illustrate that there are a significant number of decision variables involved in determining how a zero-beta return may be calculated. These different methods can influence the estimates of the zero-beta return. Moreover, the different methods seem to have undue influence on the calculation of the ratio of the zero-beta premium over the market-ratio premium, which from the Authority's estimates range from 0.52 to 1.27 between methods.*** *This ratio is key to the beta star calculation proposed by DBP in its model adequacy test. Further details of the Authority's analysis are included in Appendix 2A.*
>
> *738.* ***In conclusion, the Authority is of the view that the estimates of the zero beta premium are not robust and that there are many different zero beta returns which could be estimated****. Therefore, the differences in the value of the estimates may vary significantly from study to study as previously presented.* [Emphasis added.]

73. However, as one reads these sections it is apparent that the ERA is not attempting to survey the evidence with a view to arriving at its best estimate of $\frac{ZBP}{MRP}$. Rather, the ERA's focus is to demonstrate that one can employ different estimation techniques and arrive at different estimates. The ERA does this most clearly in its Table 25[30] where the ERA presents 12 different estimates that it has derived of $\frac{ZBP}{MRP}$ ranging from 0.61 to 5.57. These sit alongside:

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27 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 44.

28 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, beginning on page 180.

29 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, beginning on page 156.

30 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 185.

- four other Australian estimates surveyed in this section that range from 0.52 to 1.27 and another ERA estimate of 0.77;[31]
- a further Australian study, co-authored by myself, which the ERA discusses on page 220 and which estimated values for ZBP/MRP of around 1.0; and
- four international studies that the ERA reports in Table 39 of Appendix 4 – all of which have economically significant positive estimates of the zero beta premium (averaging 7.1% p.a. consistent with a ZBP/MRP of around 1.0 assuming an MRP of around 7%).

74. One might reasonably expect the ERA to conclude from this that the minimum value it should use[32] for $\frac{ZBP}{MRP}$ is 0.61 – being the lowest of its estimates of $\frac{ZBP}{MRP}$ (which is also lower than all but one of the other estimates that it surveys). However, this is not the conclusion that the ERA comes to. Rather, the conclusion that the ERA reaches is:[33]

> *Until a robust method is developed for estimating the zero-beta return, and the consequences of choosing different values for each decision variable are well understood, then the Black CAPM cannot be considered consistent or robust.*

75. This is an illogical position for the ERA to take. Whether the evidence suggests a wide or a narrow band for the best estimate of $\frac{ZBP}{MRP}$ it is still incumbent on the ERA to arrive at the best estimate based on the available evidence. The theoretical insight of the Black CAPM is that a $\frac{ZBP}{MRP}$ may exist and is likely to be greater than zero; necessitating an adjustment to the Sharpe Lintner CAPM. The fact that the evidence may not lead to a narrow range for the best estimate of $\frac{ZBP}{MRP}$ is not a rational reason to make that adjustment without regard to best available evidence.

76. By way of analogy consider applying such logic to adopting an estimate of the MRP. Depending on the methodology used (e.g., dividend growth model vs historical realised MRP vs Wright methodology) the resulting estimate of the MRP can vary

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31 See Table 24 on page 184 of Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return. Note that the ERA estimate of 0.77 in Table 24 appears to be closely related to the 0.73 estimate in Table 25 (with the same ZBP but with a slightly lower estimate of the MRP).

32 When populating equation 5 above to determine the appropriate increment to beta to counteract low beta bias. Note that this is an empirical issue not a theoretical one.

33 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 186.

significantly. The complexity and uncertainty around the best estimate of the MRP is an issue that the ERA is alive to as evidenced by the below quote:[34]

> *The complicated nature of the estimates of the equity risk premium can be best captured in a summary from the CFA Institute as follows:*[538]
>
> > *The past 10 years have shown that the ERP, far from being a settled matter, continues to challenge analysts. The research and observations in this volume have a number of implications for investment practice and theory. First, investors and analysts should take care to be explicit about their estimates of the ERP. We still too often use different definitions of, assumptions about, and approaches to the ERP, or leave it altogether implicit in our analyses of asset markets and valuations. Further clarity may help reduce the number of occasions when we are talking past each other. Second, we should be clear about what model we are using when we offer a forecast or explanation of the ERP. We have seen that variations in our estimates can be the result of different approaches to objective, circumstantial, and behavioural factors. Third, differing circumstances among investors lead to true, irreducible differences in the ERP that each investor may face at any given time. This final consideration underscores how the interplay of these multiple circumstantial forces can lead to a risk premium that is far more multifaceted and complex than typically envisioned in the standard discount models, even when we take into account structural and cyclical changes in the more objective factors. The papers contained in this volume richly illustrate this interplay.*
>
> *The Authority considers that, while historical data provides relevant information as to future returns, the data is not solely used for estimating the forward looking return on equity. So for example, in its Final Decision for the ATCO Gas Distribution System, the Authority utilised various sources of information for estimating the MRP, including (i) forward looking information such as estimates of the MRP from the DGM; and (ii) backward looking information such as historical data on risk premium in determining the MRP.*

77. Notwithstanding the complexity and uncertainty associated with estimating the MRP the ERA nonetheless rationally uses the available data to arrive at an estimate of the MRP. Moreover, in doing so the ERA also acknowledges that, even using a single consistent methodology, the MRP is not stable over-time (see ERA's Figure 3[35] which shows the DGM estimate of the MRP rising from around 3% to around 9% in the space of two years).

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34 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 210.

35 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 66.

78. It is therefore inexplicable that the ERA concludes that difficulty of estimating $\frac{ZBP}{MRP}$ and/or a lack of stability in estimates the $\frac{ZBP}{MRP}$ provides a reason for not basing its adjustment to the Sharpe-Lintner CAPM for the theoretical insights of the Black CAPM, on an estimate of $\frac{ZBP}{MRP}$. The existence of a zero beta premium is the theoretical insight of the Black CAPM. Attempting to make any adjustment to reflect this insight requires an estimate of the zero beta premium.

79. Nonetheless the ERA's principal justification for not explicitly adopting a value for $\frac{ZBP}{MRP}$ is, as stated in the quote at paragraph 69 above, "… principally because estimates of the zero-beta return are unstable and cannot be relied on in the Australian context." The same reasoning is repeated at many points in the draft decision:

> *On balance, the Authority considers that there are still many unsolved issues in relation to the estimates of the zero beta premiums. As such, the Authority considers that DBP's estimates – which use a single estimate of zero beta premium – disguises* ***the significant instability in the model.*** *Therefore, the Authority does not consider that DBP's model adequacy test is empirically true to the Black CAPM model.* (Pages 45 and 221)
>
> *First, the Authority rejected the use of the Black CAPM in the Rate of Return Guidelines, on the basis that* ***its empirical performance was unreliable****. Second, the Authority noted in the Rate of Return Guidelines that:*
>
> > *… the Authority intends to account for empirical evidence relating to potential bias in the estimates of the equity beta that are used in applying the Sharpe Linter CAPM. The Authority considers that such an approach would account for much of the evidence supporting the use of the Empirical and Black CAPM models*
>
> *246. The implication is that estimates of a return on equity either using Sharpe Lintner CAPM or Black CAPM are best implemented in their own right.* ***However, the Black CAPM outcomes are not robust in the Australian context****.*
>
> *The Authority considers therefore that the Black CAPM is only useful to the extent that it suggests a downward bias in the return on equity generated by the Sharp Linter CAPM for firms with an equity beta less than 1.* ***The Authority is of the view that it is difficult to quantify the extent of any downward bias.*** *Nevertheless, to acknowledge the potential bias inherent in the theory of the Sharpe Lintner CAPM, the Authority* ***considers it may be appropriate to adopt an equity beta in the Sharpe Lintner CAPM which is somewhat higher than the best***

> ***estimate*** *of 0.5, toward the upper end of the estimated range of 0.3 and 0.8.* (Page 56)

80. I note that the ERA states "…the Authority rejected the use of the Black CAPM in the Rate of Return Guidelines, on the basis that its empirical performance was unreliable." I do not understand how the ERA can reach the conclusion that the Sharpe Lintner CAPM is more reliable than the Black (Empirical) CAPM which is based on the best empirical estimate of the ZBP. All of the ERAs estimates (and all of the other estimates the ERA surveys both in Australian and internationally) puts the value of the ZBP materially above zero (the ERA's estimates do not extend below 0.61 and only one other estimate surveyed by the ERA is below this). This means that, by definition, incorporating a positive ZBP (i.e., using the Black CAPM) provides a better fit to the data than assuming a zero value for the ZBP (i.e., using the Sharpe-Lintner CAPM). The ERA would appear to be using a definition of 'reliable' that does not involve a requirement to actually fit the available data. I do not consider that to be reasonable.

81. More generally, in each of the above quotes the same statements apply, and typically with more force, to the Sharpe-Lintner CAPM and estimation of its parameters. The estimates of beta and MRP are not settled and different methodologies result in wildly different estimates. The ERA's task, which it accepts in relation to these parameters, is to sift through the evidence and arrive at the best estimate. This is what the ERA does in relation to the MRP and beta. Indeed, in relation to estimating beta the ERA states:[36]

> *Moreover, the Authority has consistently reiterated that as a consequence of the statistical imprecision inherent in equity beta estimation, a range of values and regression techniques are necessary in order to inform the permissible range of equity beta values. This acts to mitigate the impact an individual firm's equity beta estimate can have on the determined equity beta estimate. The Authority considers that issues of statistical imprecision are best addressed via the use of multiple models and regression techniques to inform the possible range of equity beta estimates*

82. This stands in stark contrast to the ERA's position in relation to estimating $\frac{ZBP}{MRP}$ – whereby the ERA effectively concludes that because different estimation techniques give rise to different values then none should be used.

[36] Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return. P. 57.

3.3.3 Black CAPM is not well established

83. The ERA has also relied on the following conclusions (all emphasis added):[37]

> *Reflecting these shortcomings, the Black CAPM* ***has not been widely adopted by academics or practitioners*** *in Australia or overseas for estimating a return on equity directly. Consistent with this view, the Authority considers that it is impractical to utilise the Black CAPM to determine the return on equity directly.* (Page 40)
>
> *The Authority is convinced that the unsolved issues in relation to the estimates of the zero beta premium may well explain [sic: why?] the Black CAPM* ***has never been adopted by practitioners***. (Page 45)
>
> *Second, the Authority recognises the theoretical principles underpinning the Black CAPM, and the implications for firms with an equity beta below 1.0. Various studies have argued that the Black CAPM may predict a higher return on equity than the Sharpe Lintner CAPM, implying a low asset beta bias.*
>
> ***However, following an extensive literature review, the Authority's view is that this bias is not well established in either the theoretical and empirical studies***. (Page 56)
>
> *Second, DBP concludes that Black CAPM performs best on the test as compared to the Sharpe Lintner CAPM and Fama French models. The Authority notes that this finding* ***is not confirmed by any other studies in Australia or overseas***. (Page 214)

84. I do not understand the basis on which the ERA makes these statements. In relation to the third and fourth quotes, of the relevant[38] empirical studies that the ERA surveys all (without exception) find that the Black CAPM is a better fit to the data (i.e., the ZBP is positive). The ERA performs its own estimates that confirm to this result. It is simply not reasonable to claim that the existence of a ZBP is not well established. I note that it is sufficiently well established to be included in finance textbooks as evidenced by the following extract from the 10th edition of Brealey, Myers and Allen *Principles of Corporate Finance*.[39]

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37 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return.

38 Studies that have tested the Black CAPM against the Sharpe CAPM.

39 Brealey, R.A., S.C. Myers, and F. Allen, 2011, Principles of Corporate Finance, 10th ed., McGraw-Hill Irwin, New York, NY, USA.

Figure 3: Extract from *Principles of Corporate Finance*

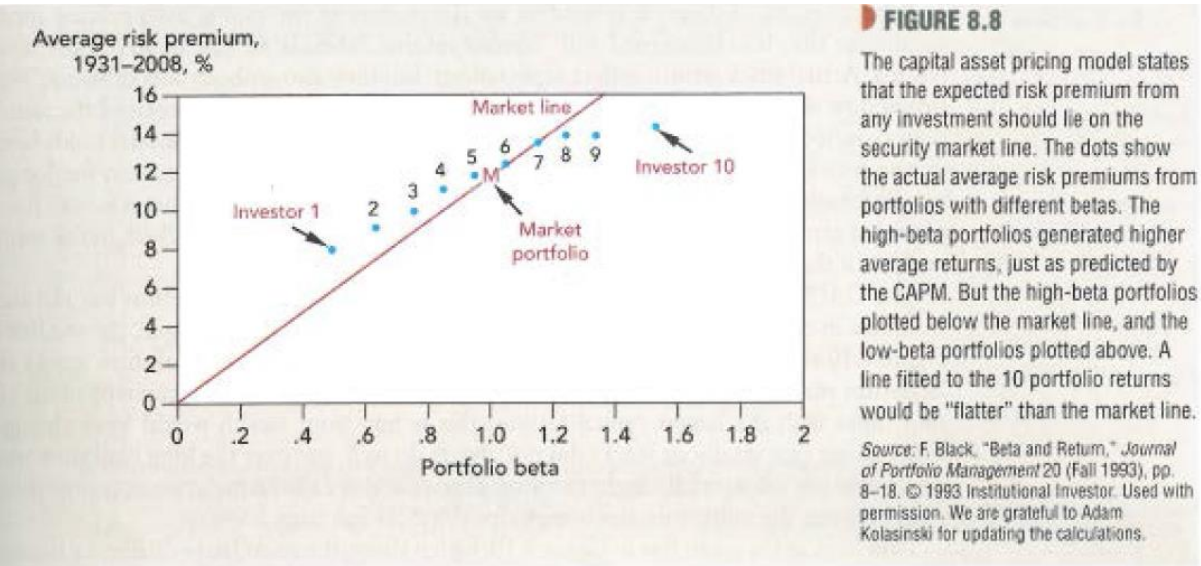

FIGURE 8.8

The capital asset pricing model states that the expected risk premium from any investment should lie on the security market line. The dots show the actual average risk premiums from portfolios with different betas. The high-beta portfolios generated higher average returns, just as predicted by the CAPM. But the high-beta portfolios plotted below the market line, and the low-beta portfolios plotted above. A line fitted to the 10 portfolio returns would be "flatter" than the market line.

Source: F. Black, "Beta and Return," *Journal of Portfolio Management* 20 (Fall 1993), pp. 8–18. © 1993 Institutional Investor. Used with permission. We are grateful to Adam Kolasinski for updating the calculations.

85. With regard to the first and second quote the only supporting evidence for the ERA taking this position is the following statement by Handley (quoted by the ERA):[40]

> *The Black CAPM is not widely adopted in practice – there is one very good reason for this. The theoretical prediction which distinguishes the Black-CAPM from the Sharpe-CAPM is that the (shadow) risk free interest rate – more commonly called the zero beta rate – is unspecified except to say that it must be less than the expected return on the market portfolio. In the partially-restricted version of the model, the zero beta rate must also be above the risk free rate. From a practical point of view, this is not very useful due to the wide range of possible values that the zero beta rate may take on. The Black-CAPM therefore presents the non-trivial task of having to estimate the expected zero beta rate which the theory says could be anywhere in a very wide range as well as having to estimate an expected market risk premium relative to the expected zero beta rate.*

86. I do not agree this is an accurate statement. The discussion in this report and the ERA's own discussion of the literature makes clear that academics do 'use' the Black CAPM in the sense that they have tested its accuracy and also teach it to their students (including teaching the results of the empirical tests). Exactly what 'practitioners' do I am unable to say because there is no reliable evidence on this and neither the ERA nor any of the experts the ERA quotes refers to such evidence.

87. There is a statement by Professor Handley that it is 'not widely adopted in practice' but the only reference he provides is to a NERA report that states this is the case but

[40] Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p.156.

provides no reference at all in support for this statement. Moreover, the page reference of the NERA report[41] referred to by Handley is actually making the point that analysts do tend to estimate a higher cost of equity than predicted by the Sharpe Lintner CAPM – even if they do not explicitly state a value for the ZBP.

88. In this regard, I note that it is common practice for measured betas to be adjusted using the "Blume adjustment"[42] or similar to adjust beta from its 'raw' estimate towards 1.0 – just as occurs in Equation 5. This highlights why it is difficult to make any reliable statement about what practitioners do and do not do. Ultimately, finance professionals can use a variety of adjustments and bring Bayesian prior beliefs to their work and these are generally not observable in any systematic way across the industry. Statements to the effect that practitioners "do X" and "don't do Y" are ultimately not reliable for this reason.[43]

89. Finally, I note that the Black CAPM has also been used by regulators, not least by the ERA albeit indirectly to justify selecting a higher beta than it otherwise would. However, in addition to this other regulators have used a version of the Black CAPM directly as described separately by Jemena to the AER.[44] This list is non-exhaustive. For example, in a process not included in Jemena's survey, staff position put to the State of New York Public Service Commission was to adopt an average of the 'traditional' and 'zero beta' CAPM.[45]

> *The traditional CAPM analysis indicated a 10.12% ROE for the proxy group and the zero beta CAPM produced a 10.25% ROE for the proxy group. The average of these two CAPM approaches is 10.19%.*

90. Note that both versions of the CAPM were implemented with Value Line betas (averaging 0.91 for the comparables).[46] Value Line's stated policy[47] is to publish

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41 NERA, 2014, Return on Capital of a Regulated Electricity Network: A Report for Ashurst, May.

42 The Blume adjustment is a standard 'automatic' adjustment that users can select on data service providers terminals (such as Bloomberg, Value Line and Reuters).

43 I note that this is generally true even if the statement is based on an interpretation of a survey of finance professionals. For example, 80% of respondents may answer "yes" to a question "do you use the CAPM?" but exactly what this means in the mind of the individual respondent will generally be ambiguous.

44 Jemena supplied examples of such precedent to the AER. This is in the form of Attachment 2 listed under 'late submissions' available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/jemena-gas-networks-nsw-access-arrangement-2015-20/draft-decision.

45 Testimony of the State of New York Department of Public Service Policy Panel to the State of New York Public Service Commission In the Matter of Case 07-M-0906, January 2008, p. 264. (The decision page is available at http://www.dps.ny.gov/Case_07-M-0906.html and the relevant staff position is available at the "Policy Panel" link).

46 Ibid, p. 263.

"Blume adjusted" betas (Blume adjusted beta = 0.67*(measured beta) + 0.33*1.0). Thus, even the beta used in the 'traditional CAPM' was adjusted towards 1.0; meaning that the 'traditional CAPM' used was more akin to a version of the Black CAPM with the 'zero beta' CAPM involving a further adjustment. I note that a precedent of adjusting betas towards 1.0 in US regulatory decisions supports a view that the Black CAPM is standard and that the 'pure' Sharpe-Lintner CAPM (with no adjustment to beta) is non-standard.

47 Available at : http://www.valueline.com/Tools/Educational_Articles/Stocks/Using_Beta.aspx#.Vsz3CNBBHVI.

4 Empirical assessment

4.1 Plausible estimates of $\frac{ZBP}{MRP}$

91. I have already set out my view that the appropriate increment to β for low beta bias must be informed by an empirical assessment of $\frac{ZBP}{MRP}$. It is therefore appropriate to survey the relevant evidence and consider whether the ERA's selection of a β* of 0.7 is consistent with it.

92. The ERA has provided a survey of estimates of $\frac{ZBP}{MRP}$ in Australia by other parties. The ERA has also estimated $\frac{ZBP}{MRP}$ in Australia itself. The estimates that the ERA reports are set out in Table 1 below.

Table 1: ERA reported estimates of $\frac{ZBP}{MRP}$ in Australia

Source	$\frac{ZBP}{MRP}$
CEG 2008^ (all stocks)	0.62
CEG 2008^ (largest (300 or fewer) stocks)	≈ 1.0
DBP 2014 (based on NERA 2013)	1.23
SFG 2014	0.52
ERA 2015 (13 estimates)	
Daily return data	2.03 to 5.57
Weekly return data	0.61 to 2.87
Monthly return data only (consistent with standard practice)	0.68 to 1.54
Monthly return data only and 20 year estimation period (consistent with standard practice)	1.27 to 1.54

ERA reports these results in Table 24 and Table 25 of Appendix 4 (pages 184 and 185). ^The ERA references the CEG report (which was the first of its kind using Australian stock returns) on page 220. For some reason this study is absent from the ERA's summary Table 23 on page 183 of Appendix 4.

93. These results in Australia are consistent with the international literature[48] including the international literature that the ERA reports in Table 39 of Appendix 4 – all of which have economically significant positive estimates of the zero beta premium (averaging 7.1% p.a. consistent with a $\frac{ZBP}{MRP}$ of around 1.0 assuming an MRP of around 7%).

[48] For example, as surveyed by Fama and French, The Capital Asset Pricing Model: Theory and Evidence, Journal of Economic Perspectives—Volume 18, Number 3—Summer 2004—Pages 25–46.

94. I also note that Professor Grundy has previously surveyed studies specifically identified by the AER as 'supporting' the use of the CAPM. An extract from Professor Grundy's report was provided in Appendix A of my 2014 report for DBP.[49] The key conclusion from that report is, even when the sample of studies is chosen by a regulator and used in support of the use of the CAPM,[50] all of those studies were consistent with a positive zero beta premium.

95. In a similar vein, the ERA refers to two academic papers in support of a conclusion that "the evidence against the CAPM may not be as robust as previously thought".[51] Of these two, the ERA refers to the paper by Da, Guo and Jagannathan as the more important. The evidence in that paper supported a value for $\frac{ZBP}{MRP}$ of 0.77 (assuming betas are estimated using stock returns as is the ERA's practice). Based on the above studies, the central estimate of $\frac{ZBP}{MRP}$ is a value of around 1.0 or greater.

96. The lowest of any estimate of $\frac{ZBP}{MRP}$ using Australian data is SFG's estimate of 0.52. In my view an estimate of 0.52 is not the best estimate in the current context. This is because SFG's methodology groups portfolios not solely based on beta but also based on size and book-to-market factors. Specifically, each portfolio is designed to have the same size and book-to-market characteristics. Consequently, the estimated $\frac{ZBP}{MRP}$ amounts to an estimate of the residual $\frac{ZBP}{MRP}$ after accounting for the influence of other factors.

97. This is a sensible approach if one is interested in establishing the zero beta premium to use in a model that separately compensates for size and book to market factors. However this is neither DBP's nor the ERA's proposed approach and using 0.52 in a model that does not include these factors will tend to bias down the resulting cost of equity for low beta firms.[52]

98. For the same reason the CEG (all stocks) estimates is not appropriate because it is dominated by small stocks (much smaller than DBP) which have materially higher returns than the market average. CEG (2008) accounted for this by restricting its analysis to the largest stocks. Similarly, the highest estimates are associated with daily and weekly return data (especially when this is combined with a short time

49 CEG, ERA treatment of asset pricing models, December 2014.

50 These papers did typically support the 'CAPM' generally by virtue of a conclusion that beta was a determinant of returns. But they also typically supported a conclusion that the Black CAPM was superior to the Sharpe CAPM (i.e., a zero beta premium existed).

51 ERA, Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020, Appendix 4, p. 149, paragraph 707,

52 Noting that 0.52 is the lowest of all estimates suggesting that low/high beta firms tend to have positive/negative exposure to these other risk factors relative to the average.

period of only 5 years). I am unaware of any similar study that uses such short return periods and/or estimation periods to test an asset pricing model. For this reason I consider that these estimates should receive less weight in any consideration of the best estimate of $\frac{ZBP}{MRP}$. I note that the remaining ERA estimates that are consistent with standard practice are actually very similar to the CEG and NERA estimates.

99. Nonetheless, it is useful to take the lowest estimate of $\frac{ZBP}{MRP}$ estimated by the ERA (0.61) and use this as a minimum threshold to assess the reasonableness of any increment applied by the ERA in moving from β to β*. If the ERA's increment applied in moving from β to β* is less than that implied by a $\frac{ZBP}{MRP}$ value of 0.61 then it can be ruled out as demonstrably inconsistent with the evidence. I not that passing this threshold test does not imply that the ERA's estimate is reasonable – only that it cannot be immediately dismissed as inconsistent with the lowest available estimate of $\frac{ZBP}{MRP}$.

4.2 A β* of 0.7 and $\frac{ZBP}{MRP}$ of 0.61 implies β = 0.23

100. The ERA states that its best estimate of beta is 0.5:[53]

> *Nevertheless, to acknowledge the potential bias inherent in the theory of the Sharpe Lintner CAPM, the Authority considers it may be appropriate to adopt an equity beta in the Sharpe Lintner CAPM which is somewhat higher than the best estimate of 0.5, toward the upper end of the estimated range of 0.3 and 0.8*

101. I note that the midpoint of a 0.3 to 0.8 range is 0.55 and not 0.50. Moreover, this reflects the ERA's conclusion in the 2013 Guideline and it does not appear to have updated this point estimate for the most recent estimates despite describing the range from these as being 0.41 to 0.81[54] – with a midpoint of 0.61. (In addition, as noted in section 4.3, the mean/median of the ERA's estimates is actually 0.66/0.68).

102. However, putting aside these considerations, it is relevant to ask:

- what is the value of β that is consistent with a value of β*=0.7 and $\frac{ZBP}{MRP}$=0.61? and
- how does this compare with the ERA's stated point estimate of β=0.5?

53 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 56.

54 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 52.

103. The answer to the first question is obtained by manipulating Equation 5 to solve for β given β*=0.7 and $\frac{ZBP}{MRP}$ =0.61. The answer is as follows:

$$\beta = \frac{\beta^* - \frac{ZBP}{MRP}}{1 - \frac{ZBP}{MRP}} = \frac{0.70 - 0.61}{1 - 0.61} = 0.23$$

104. The implication of this result is that even if one accepts the lowest ERA estimate of $\frac{ZBP}{MRP}$ as the best the ERA would have to believe that the best estimate of β was 0.23 in order to justify adopting a value for β* of 0.70.

105. A value of 0.23 for β is:

- around one third of the ERA's mean/median beta estimates in the draft decision (see section 4.3 below);
- around half the ERA's claimed best estimate of 0.5; and
- materially below the lower bound of all 18 of the ranges for beta the ERA surveys in Table 4 of Appendix 4.

4.3 β from ERA's estimates in Tables 28 to 30

106. The ERA has published a range of values for β in Tables 28 to 30 of Appendix 4 of its DBP draft decision. These betas are estimated using 5 years of data to October 2015. These estimates are derived using 6 different regression techniques and for each technique there are three different measures of the average beta (the mean of the four individual comparator stock betas and the beta of an equally/value weighted portfolio of those stocks). This gives 18 different beta estimates. The mean/median of these 18 estimates of β is 0.66/0.68 and the range of estimates is 0.56 to 0.78 (with a midpoint of 0.66).

107. However, the ERA states that its range for estimating beta is from 0.41 to 0.81 with a median value within the range 0.60 to 0.65:[55]

> *Based on its 2015 study, the Authority notes that, when all econometric techniques (including the OLS, LAD, MM, and Theil-Sen methods used in the Guidelines, and now also ARIMAX and GARCH) are applied to various portfolios (including equally weighted and value weighted portfolios), equity beta falls within the range of 0.41 (lower bound at 2.5 per cent) and 0.81 (upper bound at 97.5 per cent). The Authority also notes that the median estimates of equity beta fall within the range of 0.60 and 0.65.*

55 ERA, Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020, Appendix 4, p. 52, paragraph 223.

108. This is inconsistent with the mean/median estimates for β of 0.66/0.68 I report above. However, taking the ERA's claim at face value the central estimate of beta is 0.61 or 0.625 (the midpoint of the two stated ranges). These values are materially above 0.5.

109. I now turn to whether the ERA has correctly described its estimates. The first point to note is that the ERA's calculation of an average upper and lower bound is not statistically meaningful.[56] With regards to the ERA's claim that the median estimates of equity beta fall within the range of 0.60 and 0.65. I have not been able to replicate this result. The following table summarises the median betas I am able to calculate from the ERA's reported results and the implied value for $\frac{ZBP}{MRP}$. I also show the implied value of β* associated with the lowest ERA estimates for $\frac{ZBP}{MRP}$ of 0.61. This results in values for β* well above the ERA's actual estimate of 0.70.

Table 2: ERA average betas

Sample	Median (used as an estimate of β)	Implied value for β* (assuming $\frac{ZBP}{MRP}$=0.61)
Four individual stocks	0.64	0.86
Three measures of average across stocks*	0.68	0.87

* Average of four individual betas and the beta for the two portfolios of four stocks.

4.4 Conclusion

110. In order for the ERA to perform the task it sets itself (set a value for β* having regard to the theoretical findings of the Black CAPM) it must estimate value for β and $\frac{ZBP}{MRP}$ and it must use Equation 5 (which is identical to DBP's betastar formula) to determine the appropriate increment to β*. For all plausible values of β and $\frac{ZBP}{MRP}$ this would result in a higher estimate of β* than 0.70. By way of illustration, the ERA's estimate of β*=0.7 implies a value for β of 0.23 even when using the lowest of the

[56] First, one cannot simply average across individual upper/lower bounds and assume that the average reflects the upper/lower bound that results from combining different estimates. Secondly, the ERA's range of 0.41 to 0.81 has been calculated by:

a. first averaging the lower/upper bound estimates across:
   i. each of the four individual stocks; and
   ii. each of the two stock portfolios; then
b. choosing the lowest/highest of these averages to form the overall lower/upper bound.

However, the two portfolios in aii are formed from the same four stocks as in a.i. The two portfolio should, therefore, receive the same weight in any average as the average of the four stocks. However, the ERA's method gives the average of the individual stocks four times the weight as each portfolio. To put it another way, each individual stock gets the same weight as each portfolio.

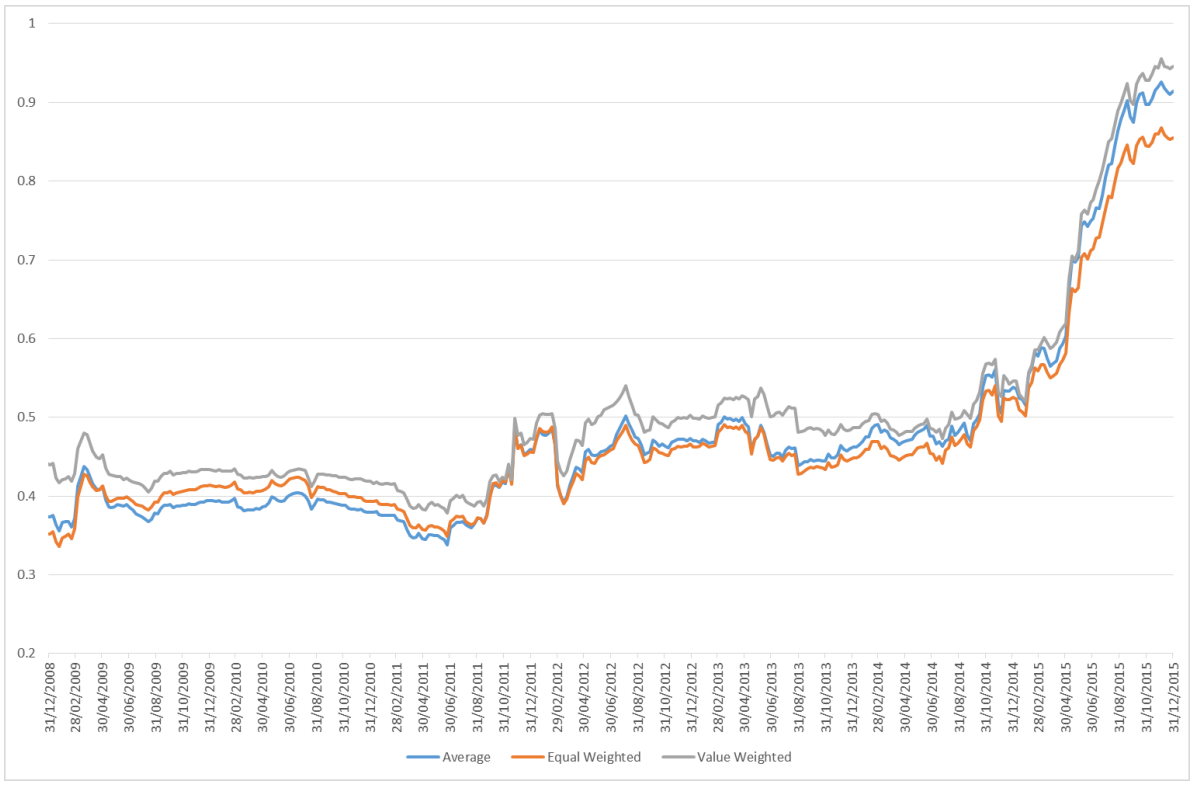
ERA's estimates of $\frac{ZBP}{MRP}$. This implies value of β is well below any credible estimates of the value of β and one third of the ERA's most recent 5 year estimates.

5 More recent estimates of beta

111. I have been asked to examine recent estimates of beta for the ERA's sample of comparators[57] and comment on whether these are materially different to those from earlier periods.

112. In this context the estimated β for the ERA's sample of comparators has increased materially in recent years, the chart below shows the rolling average estimates of the weekly equity beta (geared to 60%). It can be seen that there has been a steep increase in equity betas for the average of the four firms (and for equal/value weighted portfolios formed from these portfolios).

Figure 4: 3 year weekly asset betas



Source: Bloomberg, CEG analysis. Week ended Friday.

113. The most recent estimates of 3 year weekly betas (before any adjustment for bias) are all materially above the ERA's estimate of β* of 0.7. The most recent three year betas average over 0.9[58] which is 0.2 higher than the ERA's selected value of 0.7. It is

57 APA, SKI, AST and DUE.

58 Three year weekly (week ended Friday) equity beta (leveraged to 60% gearing) estimates to the end of December 2015 are 0.91/0.85/0.95 for the average of individual betas/equal weighted portfolio beta/value weighted portfolio beta.

important to note that this is true even though the ERA's estimate of β* is after a (non-transparent) adjustment for low beta bias. As noted in section 4.2, a β* of 0.7 along with a value of 0.61 for $\frac{ZBP}{MRP}$ implies a value for β of 0.23. Current estimates of 3 year betas before any adjustment for bias (0.90) are almost four times this level.

114. It is also relevant to note that the most recent estimates of β are well above even the upper bound of the ERA's estimates of beta in Table 28 to Table 30 which are based on 5 years of data to October 2015. As noted at paragraph 107, the ERA has estimated a lower bound of 0.41 and an upper bound of 0.81 based on the results in these Tables.[59] The fact that the most recent three years of data (to December 2015) results in beta estimates are above the upper bound that the ERA estimated based on 5 years of data (to October 2015) strongly suggests that the most recent 3 years of data is materially different in character to the proceeding earlier data included in the estimation of 5 year betas.

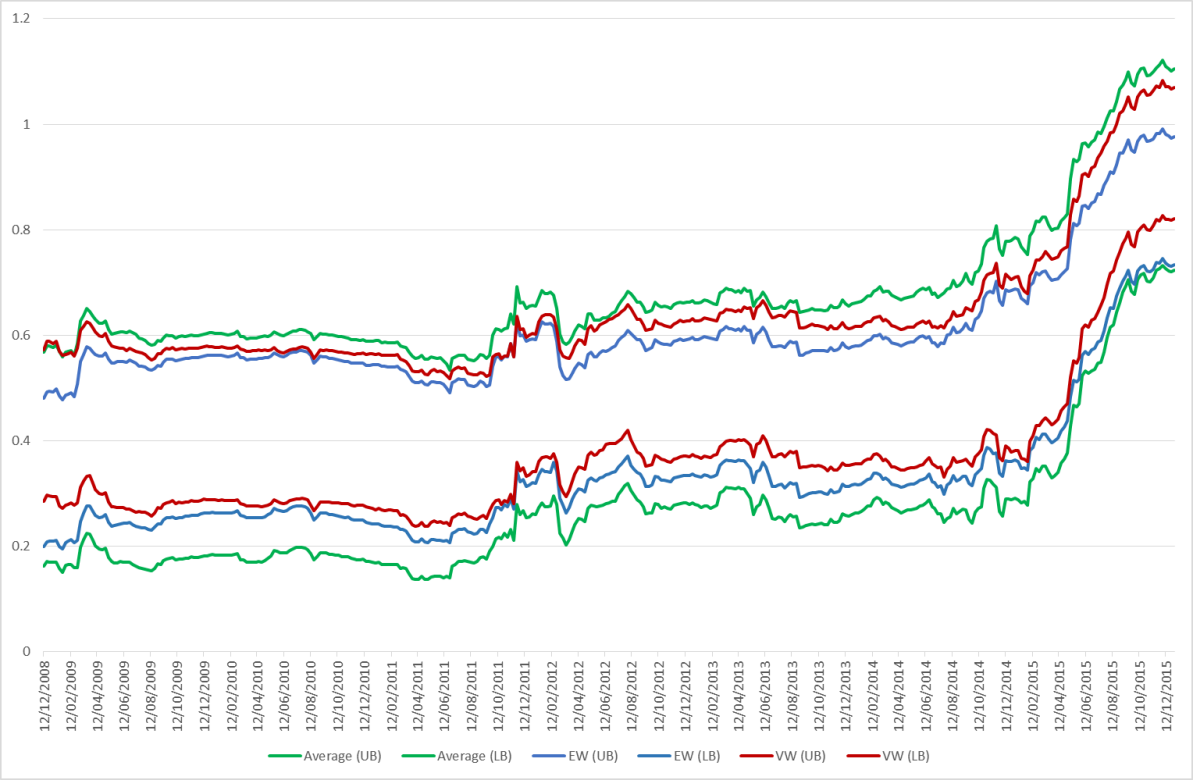
115. The same point can be made by comparing the upper and lower bound of 3 years betas with. The standard error for the most recent 3 year beta estimates to 31 December 2015 are 0.097/0.061/0.063 for average of individual betas/equal weighted portfolio beta/value weighted portfolio beta. These correspond to:

- Upper bounds of 1.10/0.98/1.07; and
- Lower bounds of 0.72/0.73/0.82.

116. Thus, the lower bounds of each estimate is higher not only than the ERA's estimate of median beta over the last five years of 0.60 to 0.65 (see paragraph 107 above) but also higher than the ERA's selected value for β*. The time series for the upper and lower bound associated with each estimation method is illustrated in Figure 5 below. (Note that, as is the case with Figure 4, for the purpose of comparison over time this time series is restricted to the same four comparable companies (even though other comparables are available over parts of the earlier period).

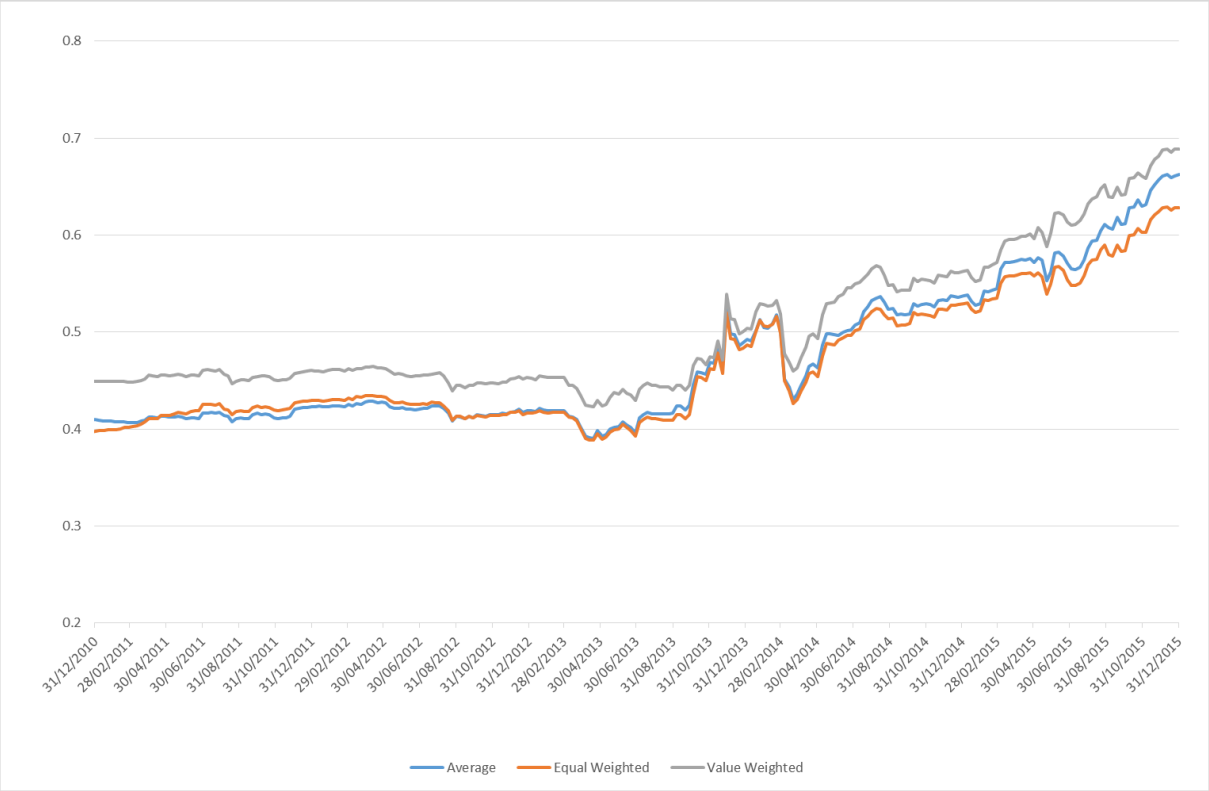
59 ERA, Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020, Appendix 4, p. 52, paragraph 223.

Figure 5: Upper and lower bound for 3 year betas



117. Consistent with the rise in 3 year asset betas there has been a materially slower rise (but a rise nonetheless) in measured 5 year asset betas. This reflects the fact that a 5 year equity beta gives less weight to recent data and so will typically rise/fall more slowly after the point at which beta in the market rises/falls.

Figure 6: 5 year weekly asset betas



Source: Bloomberg, CEG analysis. Week ended Friday.

5.1 Testing for a structural break

5.1.1 Using rolling betas

118. In light of these recent rises in asset beta I have tested for the existence of a structural break. Because AST and SKI were listed only 2005, this implies a consistent sample can only be constructed from late 2010/2008 for the 5/3 year beta estimates.

119. I use the strucchange package[60] available in R to analyse structural changes in beta trends across time. Because rolling beta estimates from adjacent time periods share data[61] it is appropriate to test for changes in trend rather than only changes in levels.

60 Strucchange: Achim Zeileis, Friedrich Leisch, Kurt Hornik, Christian Kleiber, Bruce Hansen, Edgar C. Merkle. strucchange: Testing, Monitoring, and Dating Struchural Changes. R package version 1.5-1 https://cran.r-project.org/web/packages/strucchange/index.html

61 For example, a 5 year beta ending December 2015 shares four years of data with a 5 year beta estimate ending December 2014.

I apply the Bai and Perron test[62] to analyse the optimal number of breaks and the location of the breaks. The test identifies the breakpoints sequentially. It first tests for the first breakpoint using a method similar to the Quandt-Andrews test to determine the most significant breakpoint.[63] After it identifies the first breakpoint, it searches and tests for the two breakpoints. This process is continued until no breakpoints can be identified. Furthermore, in order to find the most significant break, I apply the test with the number of breaks restricted to 1.

120. The test finds multiple number of structural changes for both 3 year window betas and 5 year window betas. The result holds for both weighted averaged betas and unweighted average betas. When the number of breaks is restricted to 1, the test finds the most significant structural break occurs in late November of 2014 or early December of 2014 when 3 year betas are used. When 5 year betas are used, the test finds the structural change occurring in September 2013 when a simple average of individual betas is estimated or when beta is estimated for an equal weighted portfolio. For the weighted average portfolio the structural change occurs in 2012 April.

121. The results of all of the tests are displayed graphically in Appendix B. I illustrate these results showing the most significant breakpoint using 3 and 5 year rolling betas measured as the average of individual betas.

62 See: Bai J., Perron P. 1998, Estimating and Testing Linear Models With Multiple Structural Changes, Econometrica, 66, 47-78; Bai J., Perron P. 2003, Computation and Analysis of Multiple Structural Change Models, Journal of Applied Econometrics, 18, 1-22.

63 For more details see: Andrews, Donald W.K. 1993. "Tests for Parameter Instability and Structural Change with Unknown Change Point." Econometrica. July, 61:4, pp. 821–56; Quandt, Richard. 1960. "Tests of the Hypothesis that a Linear Regression Obeys Two Separate Regimes." Journal of the American Statistical Association. 55, pp. 324–30.

Figure 7: 3 year average weekly betas – December 2014 break point

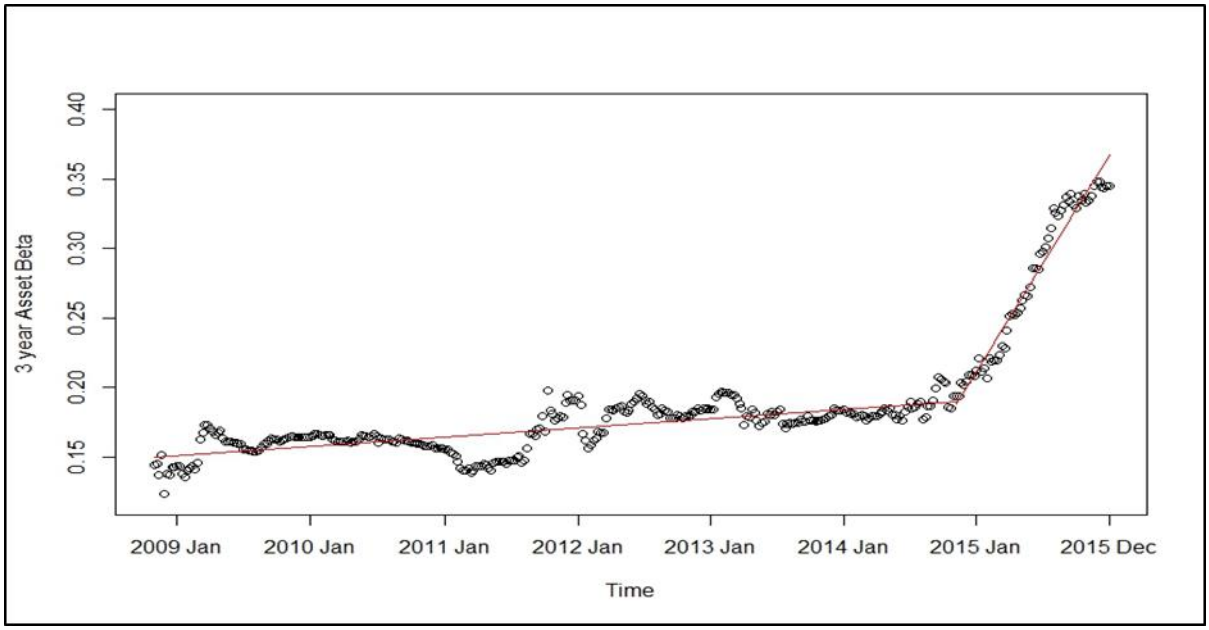
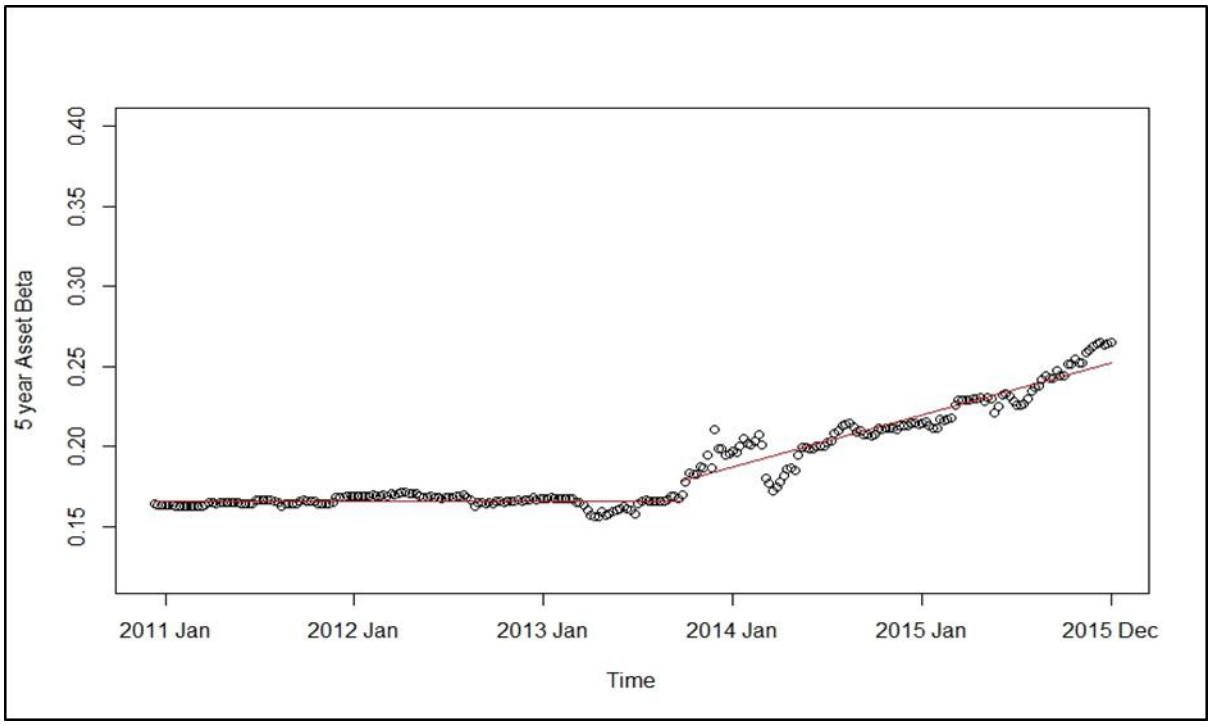


Figure 8: 5 year average weekly betas – September 2013 break point



122. The 3/5 year beta result shows the average beta, after 2014/13, was increasing at a significantly faster pace than prior to late 2014/13. Since the beta has a 3 year window, this indicates sometime during the 3 years prior to 2014, the covariance of these stocks with the market increased materially relative to that of the market alone.

That is, the beta 'in the data' had to increase prior to December 2014 in order to sufficiently affect the estimate of beta using 3 years of data ending December 2014.

123. It is striking that the 5 year structural break occurs around September 2013 which is five years after the dramatic events of September 2008[64] which ushered in the global financial crisis. There is also a notable increase in 3 year average asset betas around this time which is also identified as one of four significant structural breaks in the 3 year average asset beta trend (see Appendix B). On this basis, a plausible explanation for the rising asset betas for these four firms is the fact that data from the GFC and subsequent (primarily European) Sovereign debt crises are falling out of the data.

124. For discussion of the latter events in 2012 see Reserve Bank of Australia (RBA) Governor (Glenn Stevens) statement to the House of Representatives Standing Committee on Economics (24th of August 2012). Part of this speech is extracted below.[65]

> *But, as we said at the last hearing, sorting out the problems in the euro area is likely to be a long, slow process, with occasional setbacks and periodic bouts of heightened anxiety. We saw one such bout of anxiety in the middle of this year, when financial markets displayed increasing nervousness about the finances of the Spanish banking system and the Spanish sovereign. The general increase in risk aversion saw yields on bonds issued by some European sovereigns spike higher, while those for Germany, the UK and the US declined to record lows. This 'flight to safety' also saw market yields on Australian government debt decline to the lowest levels since Federation.*

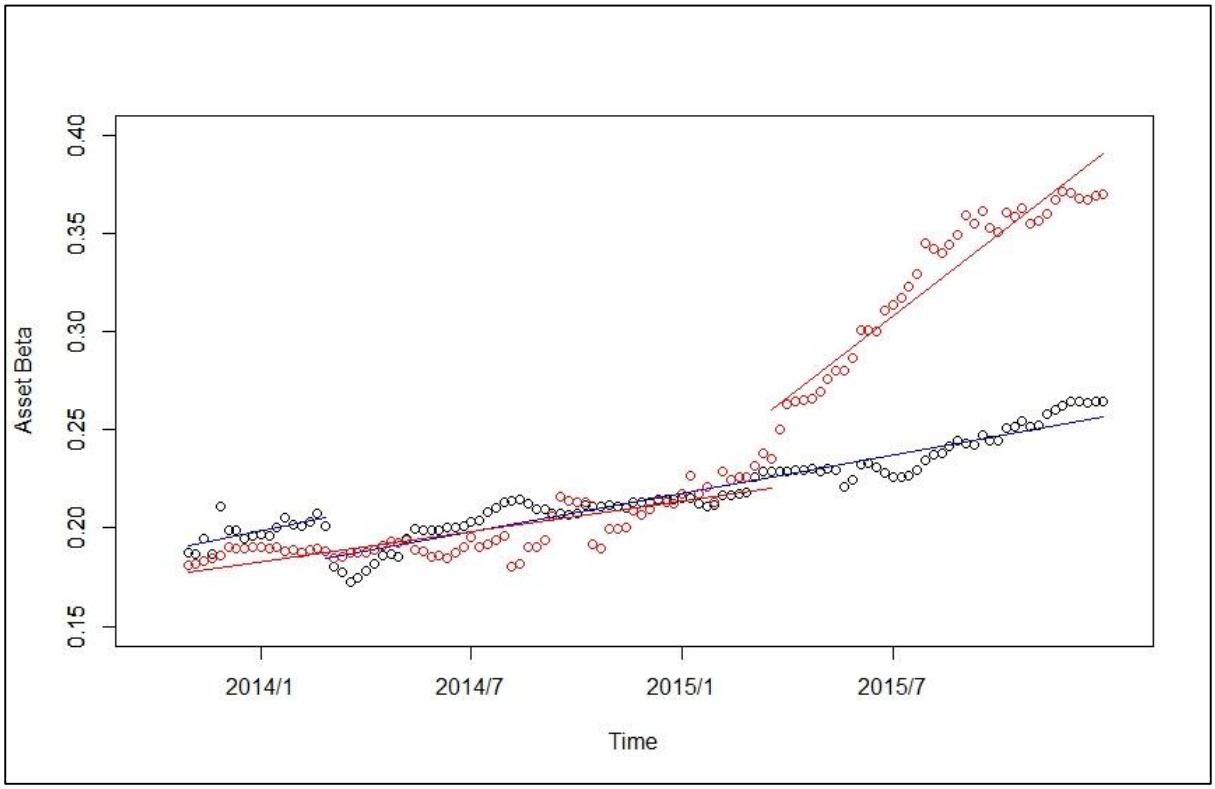
125. Only the 3 year betas to August 2015 and thereafter do not include data from the period referred to by Governor Stevens in the above quote. However, 5 year betas do include data from that period (and will continue to do so for roughly two more years).

126. It is important to note that testing for a structural break in rolling beta estimates results in identification of the first estimation window when enough 'new data' (post structural break) is included in the window such that the there is a detectable change in trend for the rolling beta. In this context, the shorter the window used the more quickly the structural break will be identified (because, for any given date of estimation post structural break, there is a smaller absolute and proportional amount of pre structural break data in the estimation window).

64 The collapse of Lehman Brothers on 15 September 2008 being one such event.

65 Reserve Bank of Australia (RBA) Governor (Glenn Stevens) statement to the House of Representatives Standing Committee on Economics (24th of August 2012).

Figure 9: Identifying a recent structural break using 5 vs 3 year beta estimates



Source: Bloomberg, CEG analysis

127. This is illustrated in the above chart which shows rolling five and 3 year asset betas from late 2013 (with the end of the estimation window described in the horizontal axis). It can be seen that the 3 year betas detect a structural break around the beginning of 2015 while the 5 year betas, which have a longer estimation period, do not. This suggests that, at least at the time of writing, 3 year betas are a more reliable estimate of the beta in recent market conditions than 5 year betas. Assuming no further structural break in the immediate future, we would expect 5 year betas rise over the next two years to the be similar in value to current 3 year betas.

5.1.2 Comparing asset beta in two distinct periods

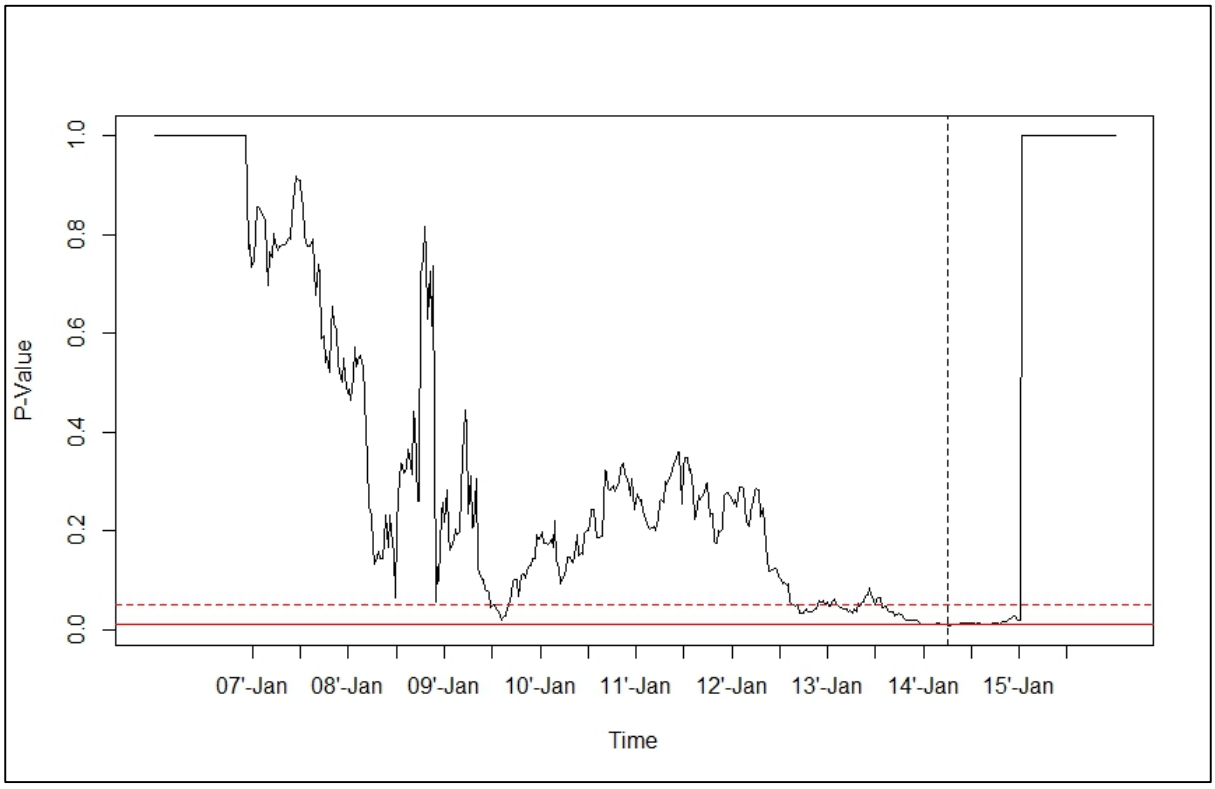
128. An alternative way of testing for a structural break is to ask whether asset beta estimated using two betas estimated using:

- all the data before a specific date; and
- all of beta estimated using all of the data after that date.

Provide a statistically significantly better fit to the data than estimating a single beta using all of the data

129. Figure 10 below shows the p-value[66] for such a test (values are only calculated from December 2006 (one year after all four firms are listed) to 1 January 2015 to ensure enough data is on either side of a potential break point). It shows that the answer to this question is 'yes' (a structural break exists) in early 2014 at the 99% confidence interval (signified by the unbroken red line).

Figure 10: P-value for structural break at specific dates (value weighted portfolio)



Source: Bloomberg, CEG analysis.

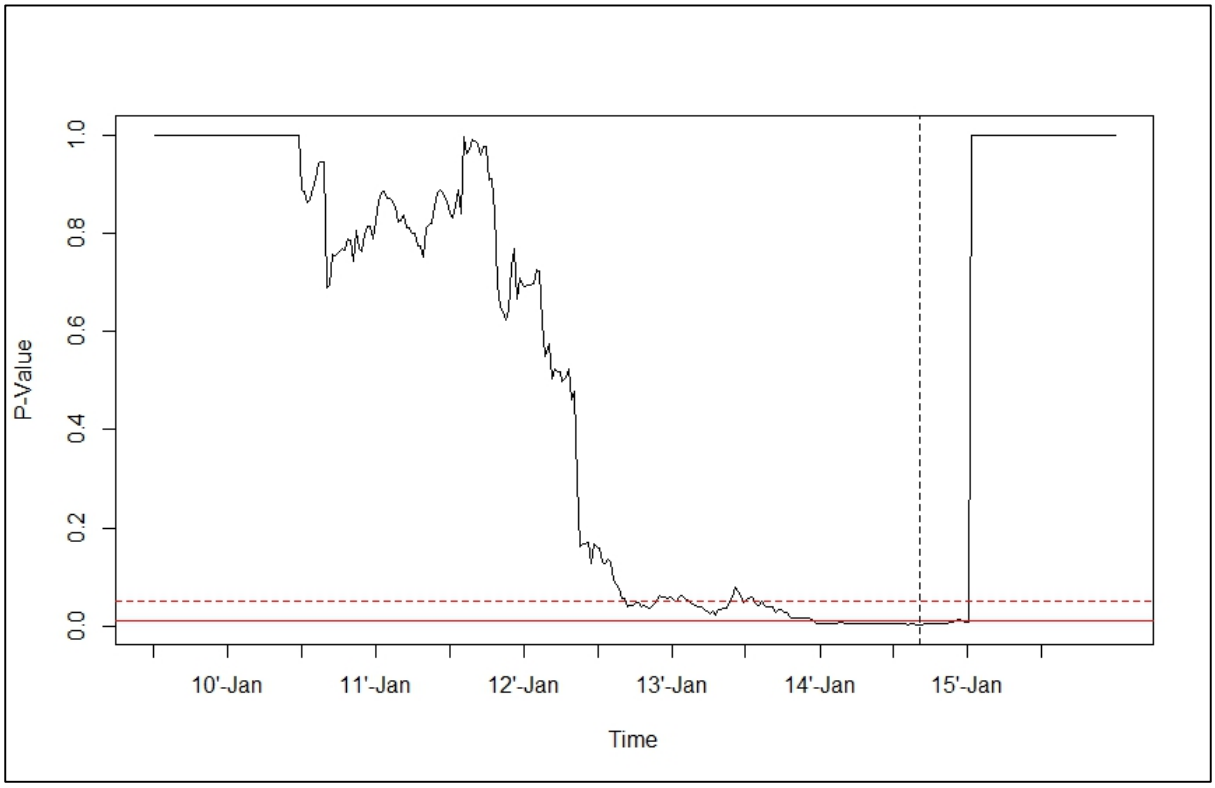
130. At the 95% confidence interval (signified by the dotted red line) a structural break is found to exist at most points from late 2012 onwards – and the confidence associated with the conclusion a structural break exists increases the later the date on which a break is measured up to late 2014. This is consistent with the finding from the previous section that a structural break exists for rolling 3 year betas from late 2014/early 2015 (noting that these betas are measured using data from the 3 years up to that point (i.e., late 2011 and early 2012).

131. It is, however, notable that, at the 95% confidence interval, a structural break is also found to exist in mid-2009 (the p-value falls below 5% in June 2009 and reaches a minimum on 7 August 2009). Notably, this structural break puts the worst of the

[66] In this context the p-value is the probability that a difference in measured betas before and after that date is due to chance measurement rather than a fundamental change in the actual beta.

global financial crisis[67] (GFC) in the 'pre break' period. In order to assess whether the data after the mid 2009 structural break (after the GFC) is different to the post 2012 data it is necessary to remove pre mid 2009 data and repeat the above analysis. The results of doing so are shown in Figure 11.

Figure 11: P-value for structural break at specific dates (post June 2009)



Source: Bloomberg, CEG analysis.

132. It can be seen that, as was the case for the full dataset, even when the data is restricted to post June 2009 data a structural break continues to be found in late 2012 onwards.

5.1.3 Comparing the change in asset beta from before and after a specific date

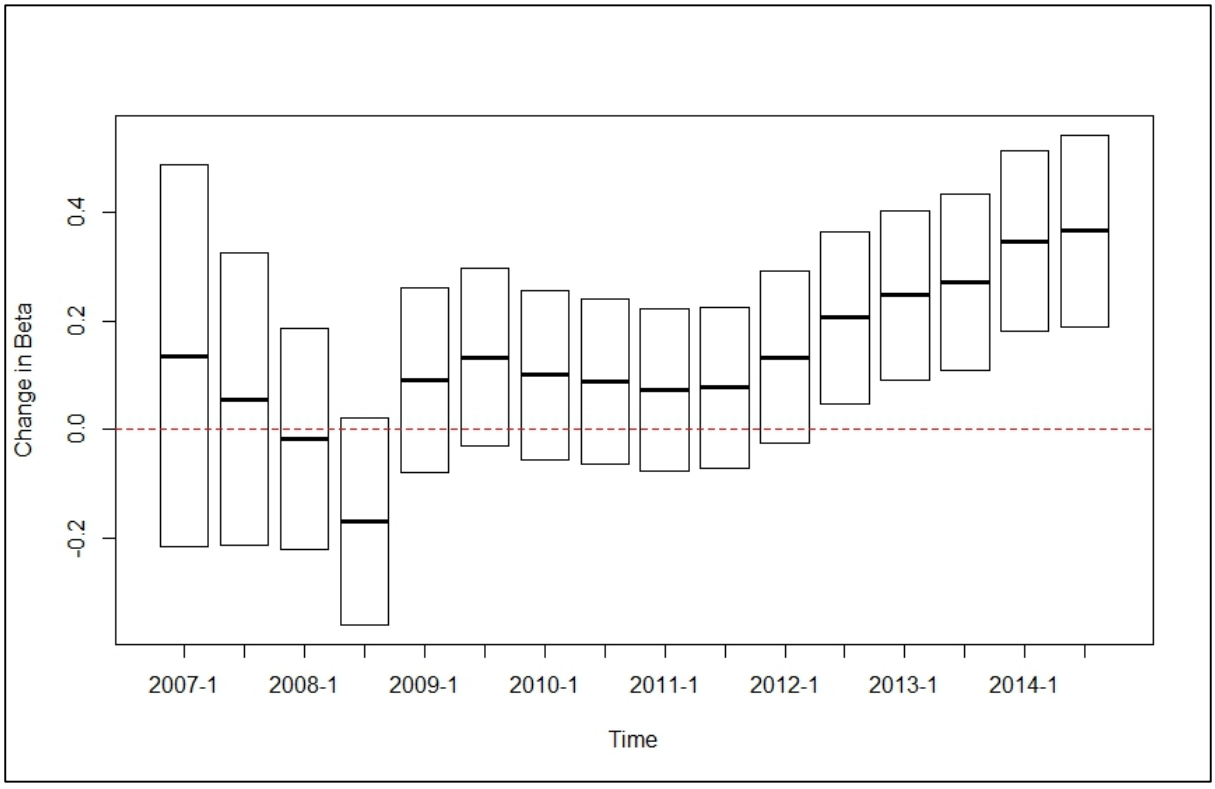
133. Another way to understand the data and the existence of a structural break is to examine the change in beta measured before and after a specific date and ask whether the change in beta is statistically different to zero. This is a similar, but slightly different, question to that asked in the previous section (are two beta estimates statistically significantly more accurate than one). Figure 12 below illustrates the

[67] Generally accepted to be in late 2008 and early 2009 (with Australian and global stock markets hitting their lowest levels in March 2009).

results of this test applied every six months (i.e., on 1 January and 1 July of each year).

134. The dark line within each box is the difference in beta calculated as beta estimated from data after that date less beta estimated from data before that date. The box around each estimate is the 95% confidence interval for difference in beta.

Figure 12: Statistically significance of the change in beta (value weighted portfolio)



Source: Bloomberg, CEG analysis.

135. It can be seen that the chnage in beta statistically significantly different to zero from 1 July 2012 onwards. This is consisted with the conclusions in the previous two sections.

5.2 Implications for best estimate of β

136. When regard is had to the rising level of beta and the structural break results described above then this suggests the best estimate of the most recent β is higher than that reported by the ERA in its draft decision and discussed in section 4.3. Indeed, the most recent mean estimates (not bias adjusted) of 3 year betas are around 0.91 (0.96 when adjusted for low beta bias). Relative to these values, the ERA

proposed value of β*=0.7 is an underestimate even if the best estimate of $\frac{ZBP}{MRP}$ was zero.

Appendix A Criticisms of DBP's empirical estimates

A.1 Alleged failure of the model adequacy test

137. DBP developed a 'model adequacy' test which simply compared the predictions of Sharpe-Lintner CAPM, Black CAPM and Fama French 3 factor model to actual realised market returns on the Australian stock market from the 1960s onward. DBP's model adequacy test, in particular using 'Method B' is essentially a version of the classic tests of the CAPM first performed by Black Jensen Scholes (1972)[68] and Fama and MacBeth (1973)[69] and other subsequent studies (including by CEG)[70].

138. The ERA has critiqued DBP's model adequacy test on the following grounds:

> *The Authority is of the view that DBP's model adequacy test does not follow standard finance/economic/statistical theory. Its approach is not tested and appears unsupported by any source. The Authority considers that DBP's analysis is flawed and its approach does not produce sensible estimates.*
>
> *DBP's model adequacy test fails on both conceptual and empirical considerations. Most importantly, the Authority is of the view that DBP's model adequacy test:*
>
> - *does not test the Authority's forward looking approach to estimating the return on equity using the Sharpe Lintner CAPM, but rather versions based on historic MRP outcomes;*
> - *compares two models that are not robust in the Australian context (the Black CAPM and FFM), with another method that is not relied on either (the Sharpe Lintner CAPM, using an MRP that is based on historic data only).*
>
> *In addition, the Authority is of the view that other fundamental issues such as bias-variance trade-off are too important to be ignored. The Authority considers that it is inappropriate to utilise DBP's model adequacy test to*

68 Black F., Jensen, M.C. and Scholes, M., 1972, "The capital asset pricing model: Some empirical tests" in Jensen, M.C., ed., Studies in the Theory of Capital Markets, Praeger.

69 Fama, E and J. MacBeth, Risk, return, and equilibrium: Empirical tests, Journal of Political Economy 71, pp. 607-636.

70 CEG, Estimation of, and correction for, biases inherent in the Sharpe CAPM formula, September 2008.

> *compare models. If such a task is required, then the cross validation method should be used.*
>
> *In conclusion, the Authority is of the view that DBP's model adequacy test is not fit for the purpose of comparing the prediction properties of models, and as such, the test, as proposed, should not be used.*

139. I do not agree that DBP's model adequacy test does not follow standard finance methodology. The classic empirical investigations of the single factor CAPM models were undertaken by Fama and Macbeth (1973) and Black, Jensen and Scholes (1972). DBP's approach follows closely that of Fama and Macbeth who divide all equities in the sample into ten different portfolios according to their beta (from low to high beta portfolios). The returns for each portfolio are then compared with their beta and a regression is performed to assess the relationship between a portfolio's beta and the excess returns (relative to the risk free rate) on that portfolio. This is done for every month in the sample period. If the Sharpe CAPM is true, the estimated regression line should, on average, pass through the origin (i.e., zero estimated beta should be associated with zero estimated excess returns). If the estimated regression line passes above the origin then this suggests a positive value for $\frac{ZBP}{MRP}$ (and the existence of low beta bias).

140. DBP's model adequacy test takes the same basic approach except, instead of testing for the presence of bias by virtue of running a regression as described above, DBP tests directly for bias by comparing the actual return on each portfolio with the predicted return on each portfolio. If the actual return on low beta portfolios is less than predicted by the Sharpe-Lintner CAPM then this suggests a low beta bias exists – which is precisely what is found.[71] This is the same conclusion that would have been found had the Fama and Macbeth regression been performed – it is simply another means of applying the same test.

141. However, the advantage of DBP's approach in a regulatory setting is that it allows for a test of bias in any model – including DBPs own proposed version of the Black CAPM (or indeed the ERA's version were it to propose one). DBP's test is flexible in the sense that any proposed relationship between measurable risk factors and returns. I find that DBP has clearly set out its model adequacy test and has squarely placed it in the context of the literature. On this basis, I do not agree that it does not follow standard finance/ economic/ statistical theory. Nor do I agree that its approach is not tested and is unsupported by any source.

142. In terms of the two substantive criticisms of DBPs test I note that the first is that DBP has not adequately tested the ERA's current implementation of the Sharpe-Lintner CAPM – which now uses prevailing estimates of the MRP. This statement by the ERA

[71] For example, see Table 6 of DBP's Submission 12, Rate of Return, p. 61.

suggests that it does not fully understand DBP's 'Method B' approach to the test. DBP describes Method B as follows:[72]

> *The estimate of MRP we use is relatively stable through time, but actual market returns are not. This means returns to the market are bringing a great deal of volatility into our valuation of forecasts. We intend to assess the ability of different pricing models to correctly predict the returns to portfolios and not to assess the extent to which the excess return to the market portfolio is predictable. Thus Method B evaluates the forecast:*
>
> $\hat{z}_{jt} = \hat{\beta}_{jt} z_{mt}$ (5)
>
> *Here the forecast of the market risk premium is replaced by the realisation of the return to the market in excess of the risk-free rate for the period being forecast. The interpretation is not that the ERA is clairvoyant, but rather that, whatever forecast it makes is rational. In other words, we assume that the ERA does not systematically overestimate or underestimate the MRP. The practical effect of Method B is to remove noise created by market returns from the forecast errors that we construct, and so allow us to focus on whether the models that we consider have any tendency to systematically overestimate or underestimate the returns required on the 10 portfolios. In practice, however, whilst Method B can help in understanding whether a given model exhibits bias, it cannot be used for making predictions for the next five years, because we do not know the MRP for the next five years. Thus, it is Method A which forms the basis of our final return on equity estimation. Method B is rather used to improve the power of our model adequacy tests.*

143. Once more I note that this is the standard approach in the literature testing asset pricing models (including by Fama and Macbeth (1973)). Put simply, Method B is a test of an asset pricing model assuming that investors, on average, predict excess market returns correctly. On the assumption that the ERA's forward looking estimate of the MRP is, on average, accurate the Method B test applies directly as a test of that Method. If the ERA's forward looking estimate of MRP is, on average, systematically biased this is not necessarily true. However if this was the case, rather than critiquing DBPs model adequacy test on this basis, the appropriate course of action would be to correct the bias in the ERA's MRP estimates.

144. The second rationale for rejection of DBPs test is that it tests models that "are not robust in the Australian context" (namely the Black CAPM and the Fama-French model). That is, the ERA appears to be arguing that based on prior analysis it has determined that the Black CAPM is not 'robust' and, therefore, it is inappropriate for DBP to test the accuracy of it.

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72 DBP, Submission 12, Rate of Return, p. 61.

145. The prior analysis would appear to be that examined by me in section 3.3.2. For the reasons set out there, I do not consider that this conclusion is reasonable. Moreover, I note that the fact that DBP's version of the Black CAPM performs well in the model adequacy test (and better than the Sharpe-Lintner CAPM) is entirely to be expected based on the discussion in section 3.3.2.

146. The ERA's position is essentially that the Black CAPM should not be tested against the data because estimates of $\frac{ZBP}{MRP}$ are uncertain/unstable. Yet, when DBP performs a test with a stable value for $\frac{ZBP}{MRP}$ from the 1960s onward it performs better than the Sharpe-Lintner CAPM. The ERA's dismissal of this result on the basis of a predetermined 'unreliability' is an error of the same genus as the ERA's unwillingness to rely on empirical evidence of $\frac{ZBP}{MRP}$ when determining the correct increment to beta for the theoretical insights of the Black CAPM.

147. In this regard I also the following ERA statement:

> *Given that the only robust model for estimating the return on equity in the Australian context is the Sharpe Lintner CAPM, the Authority does not see any current need for data sourced from the SIRCA SPPR database, as suggested by DBP. The SPPR database was required by DBP to form long time series of predictions for the model adequacy test. As need for the model adequacy test has been rejected, then so too has the need for the SPPR database.*

148. In this quote the ERA begins with a conclusion (that the Sharpe Lintner CAPM is the only robust model) that is not only not based on the evidence but is in direct contravention to it – including the ERA's 13 reported estimates of $\frac{ZBP}{MRP}$ above 0.6. The ERA then uses this incorrect conclusion to justify not further comparing the models using the best available data source in Australia to do so (which I note is the same dataset used by CEG in 2008).

A.2 Alleged nonsensical results

149. The ERA notes that DBP's proposal to set a value of $\frac{ZBP}{MRP}$ greater than 1.0 (based on empirical evidence) results in a value for β* of greater than 1.0 – implying higher risk for DBP than the market as a whole. The ERA argues that this is nonsensical. [73]

150. This result is only nonsensical if one starts with a strongly held prior view that low beta stocks must have lower returns than the market. However, as I noted in section 3.1.5 of my previous report:

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73 Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: Appendix 4 Rate of Return, p. 224.

> *…this is not an incredible finding. This is a finding that has been found in varying degrees in many studies. For example, Da, Guo and Jagannathan (2012)[74] provide evidence in support of a zero beta premium of 77% of the market risk premium. Campbell and Vuolteenaho (2004)[75] have estimated that the return on zero beta equity is above the market return.*
>
> *Rejecting an empirical finding because it does not accord with a prior belief is, as a general matter of principle, unsound. It is especially unreasonable when that empirical finding is consistent with other studies and your prior belief is not consistent with any empirical studies.*

151. Another interpretation of the ERA's statement is that, abstracting from measured beta, the ERA believes that utilities should have lower risk than the average for the market. Such a view appeals to my own intuition. However, even if this is accepted as true the comparison needs to be made on an "apples for apples" basis. That means adjusting for corporate gearing. Of course, a firm with lower absolute risk than another may still have higher equity risk if its gearing is higher.

152. The ERA sets the cost of equity based on a benchmark gearing of 60%. However, average gearing on the ASX200 is substantially less than this. The RBA states:[76]

> *The aggregate capital structure of Australian listed companies has varied considerably over time, reflecting the investment cycle and shifts in the use of the different forms of external funding. Nevertheless, listed companies have historically maintained aggregate gross leverage of around 60 per cent on a book-value basis, with considerable variation between sectors.*

153. The reference to 'leverage' here is debt divided equity rather than debt divided by total firm value (debt plus equity). Making the relevant conversion implies an ASX average gearing (relative to total firm value) of around 0.375 (=0.6/1.6). This is almost half the gearing the ERA assumes for DBP. Therefore, it is entirely consistent that DBP could have lower fundamental risk than the average firm in the market but still have higher risk when it is geared by almost double the average amount in the market.

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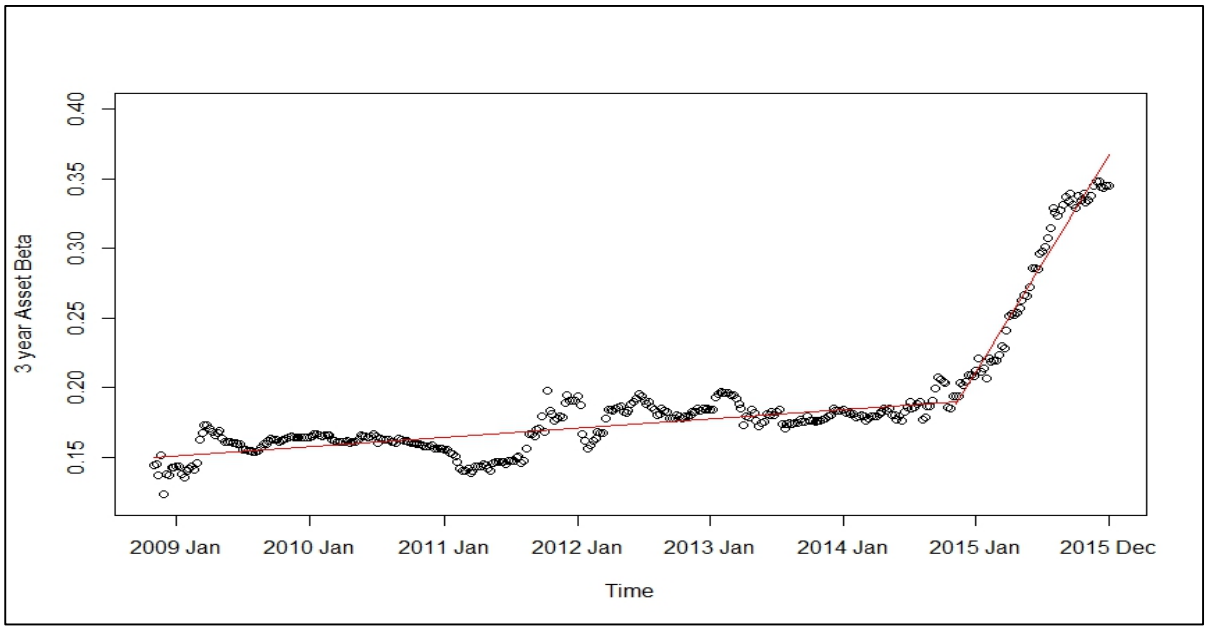
74 Da, Zhi, Re-Jin Guo and Ravi Jagannathan. 2012. CAPM for Estimating the Cost of Equity Capital: Interpreting the Empirical Evidence. Journal of Financial Economics. 103(1): 204-220

75 Campbell, John Y. and Tuomo Vuolteenaho, 2004, "Bad beta, good beta," American Economic Review 94, pp. 1249-1275

76 RBA, Trends in Australian Corporate Financing, RBA Bulletin, December 2015.

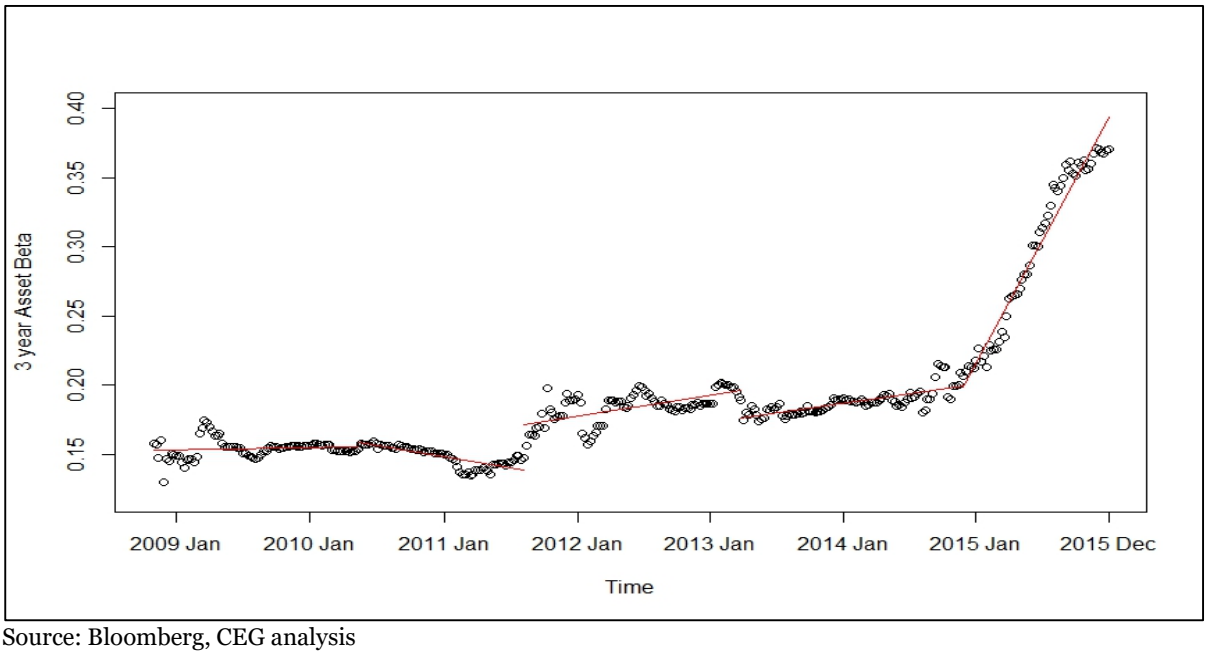
Appendix B Structural change break points

Figure 13: Average 3 year asset beta (1 breakpoint)



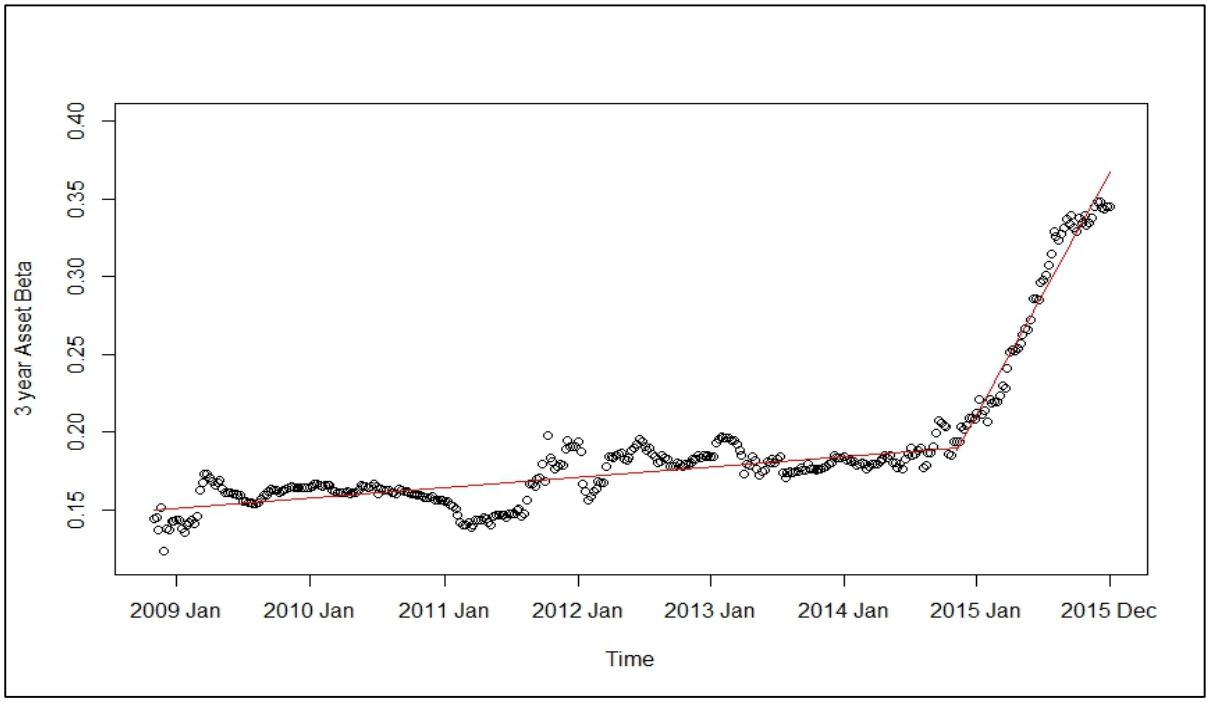
Source: Bloomberg, CEG analysis

Figure 14: Average 3 year equity beta (multiple breakpoints)



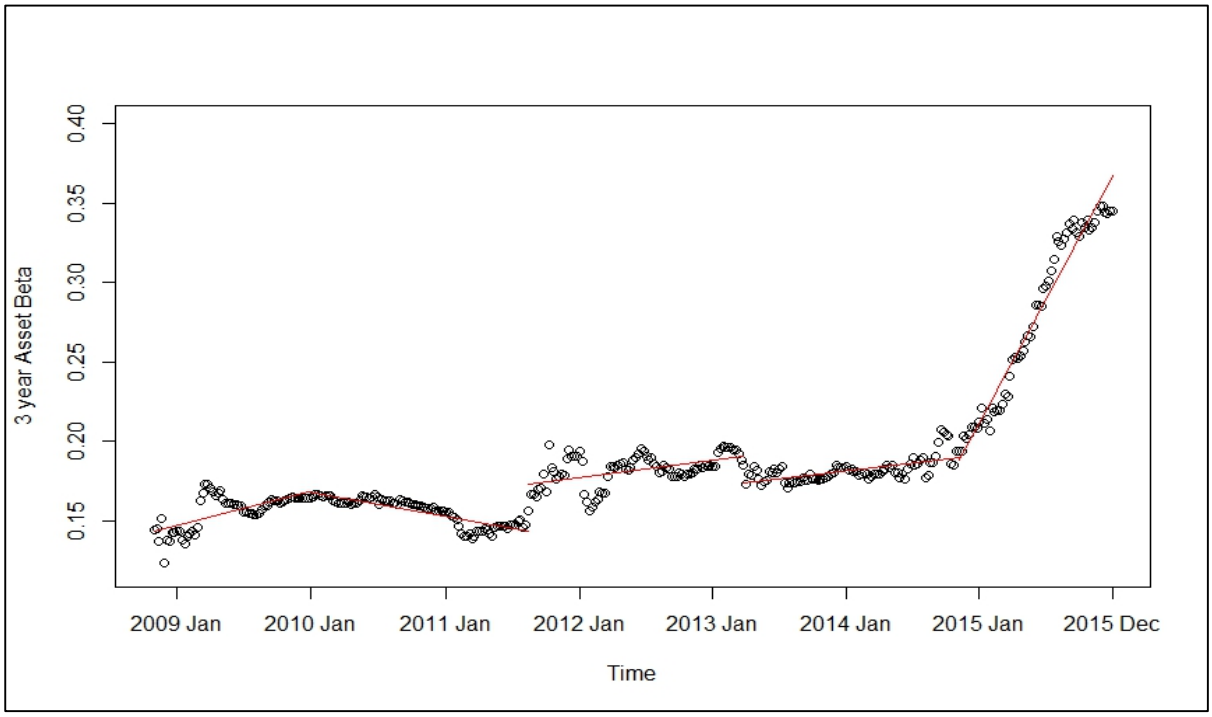
Source: Bloomberg, CEG analysis

Figure 15: Equal weighted portfolio 3 year asset beta (1 breakpoint)



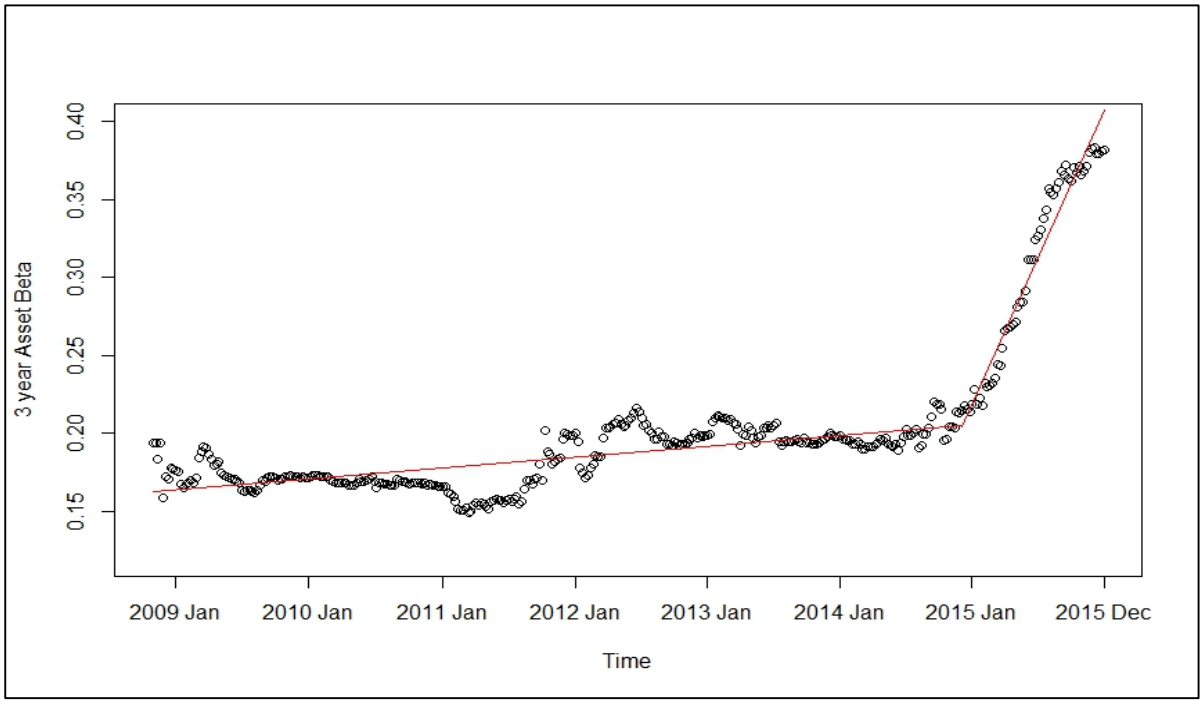
Source: Bloomberg, CEG analysis

Figure 16: Equal weighted portfolio 3 year asset beta (multiple breakpoints)



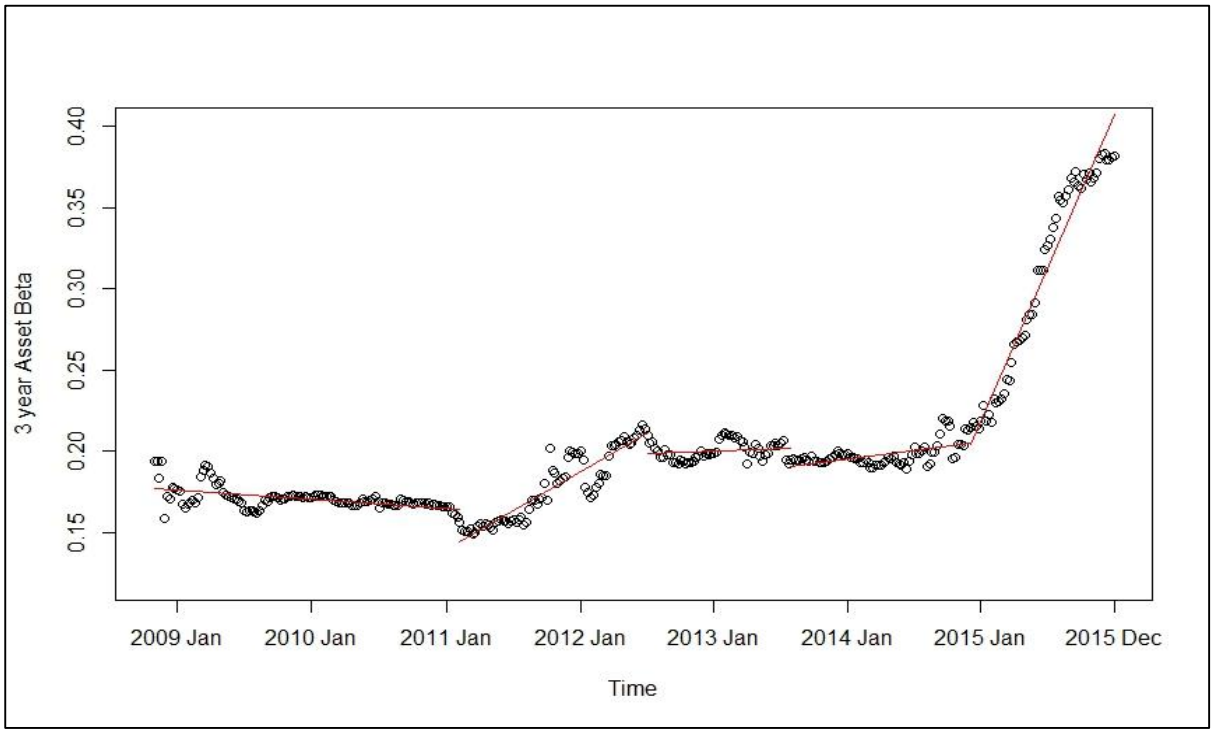
Source: Bloomberg, CEG analysis

Figure 17: Value weighted portfolio 3 year asset beta (1 breakpoint)



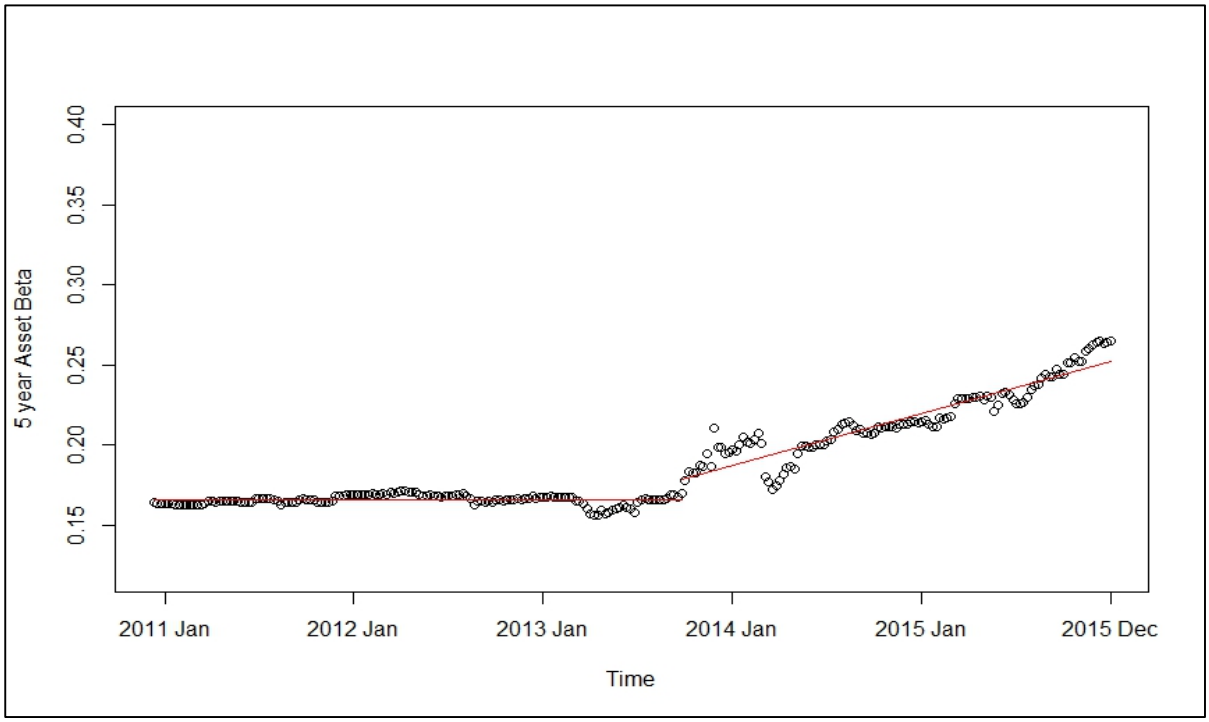
Source: Bloomberg, CEG analysis

Figure 18: Value weighted portfolio 3 year asset beta (multiple breakpoints)



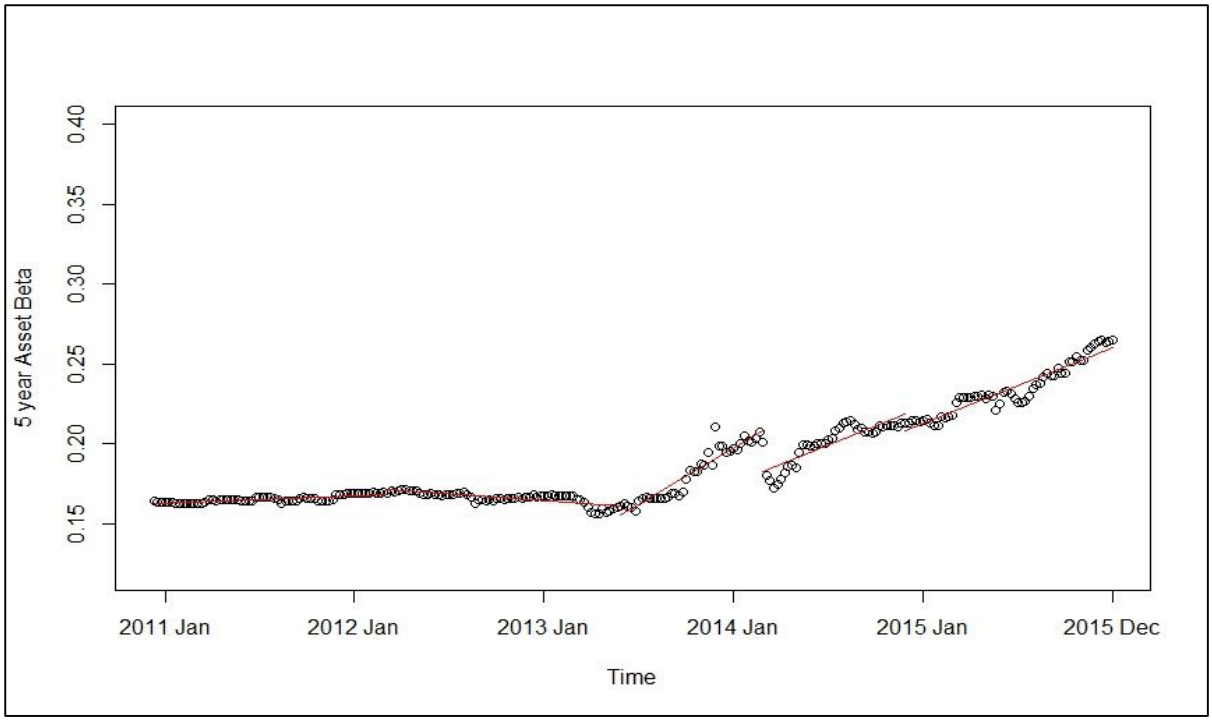
Source: Bloomberg, CEG analysis

Figure 19: Average 5 year asset beta (1 breakpoint)



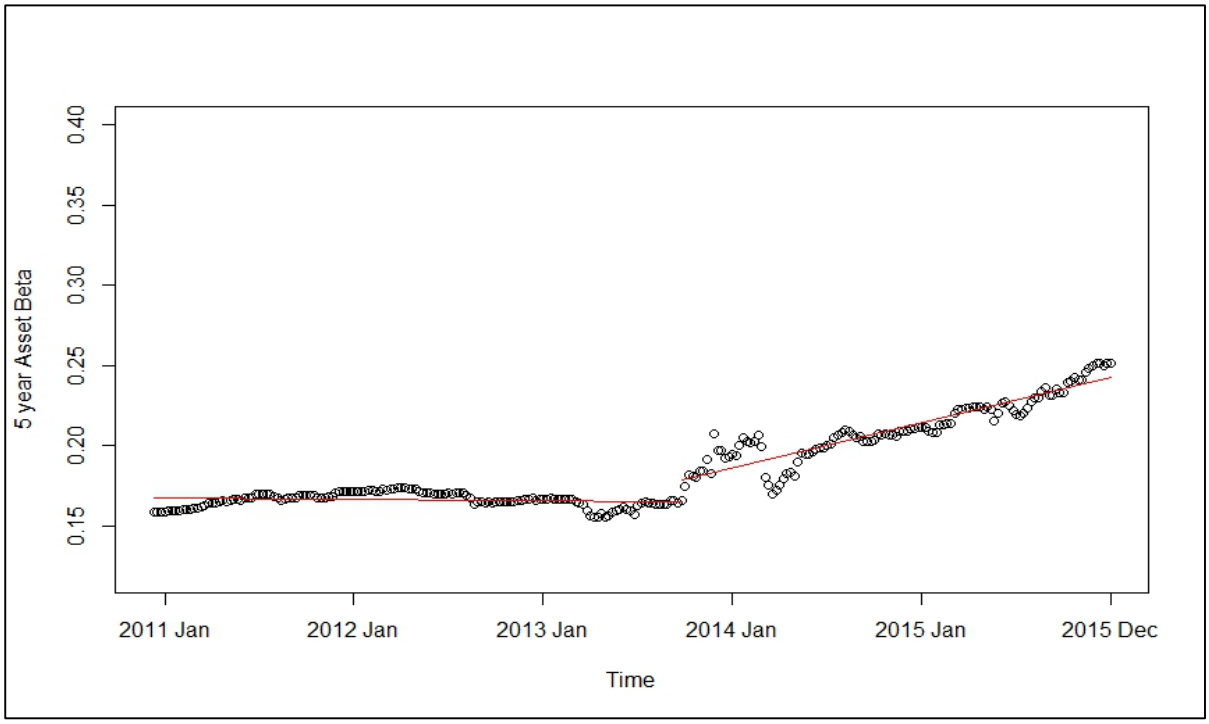
Source: Bloomberg, CEG analysis

Figure 20: Average 5 year asset beta (multiple breakpoints)



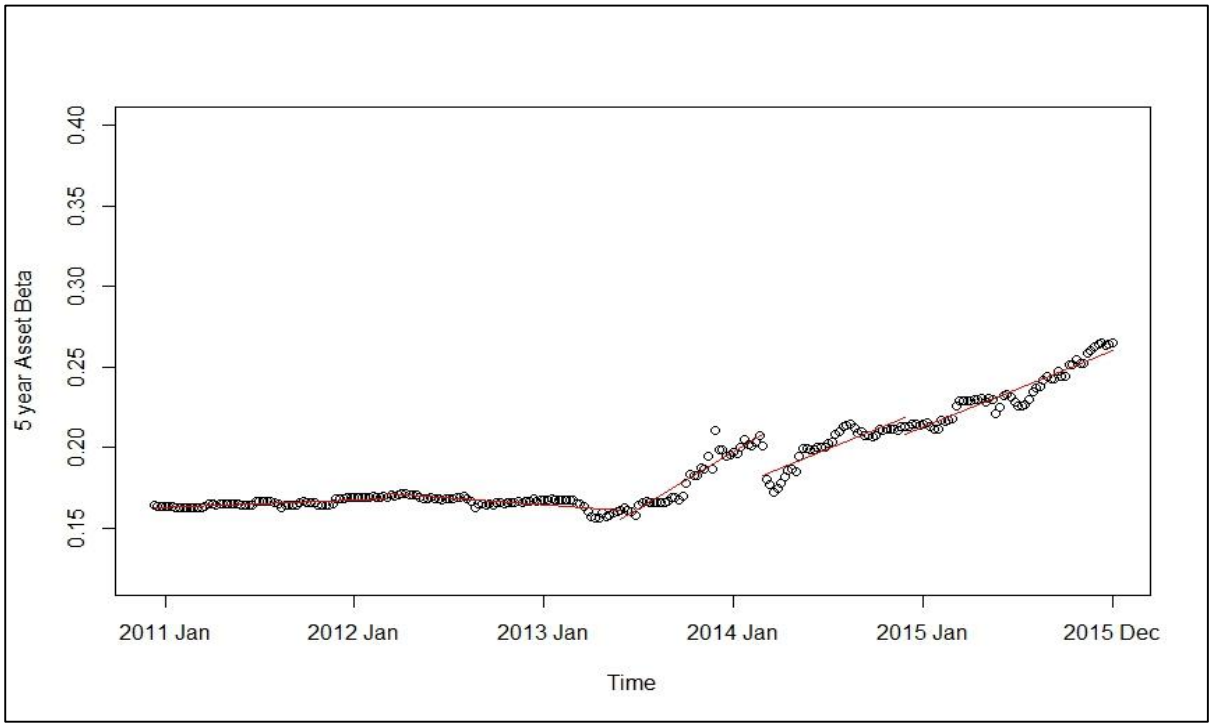
Source: Bloomberg, CEG analysis

Figure 21: Equal weighted portfolio 5 year asset beta (1 breakpoint)



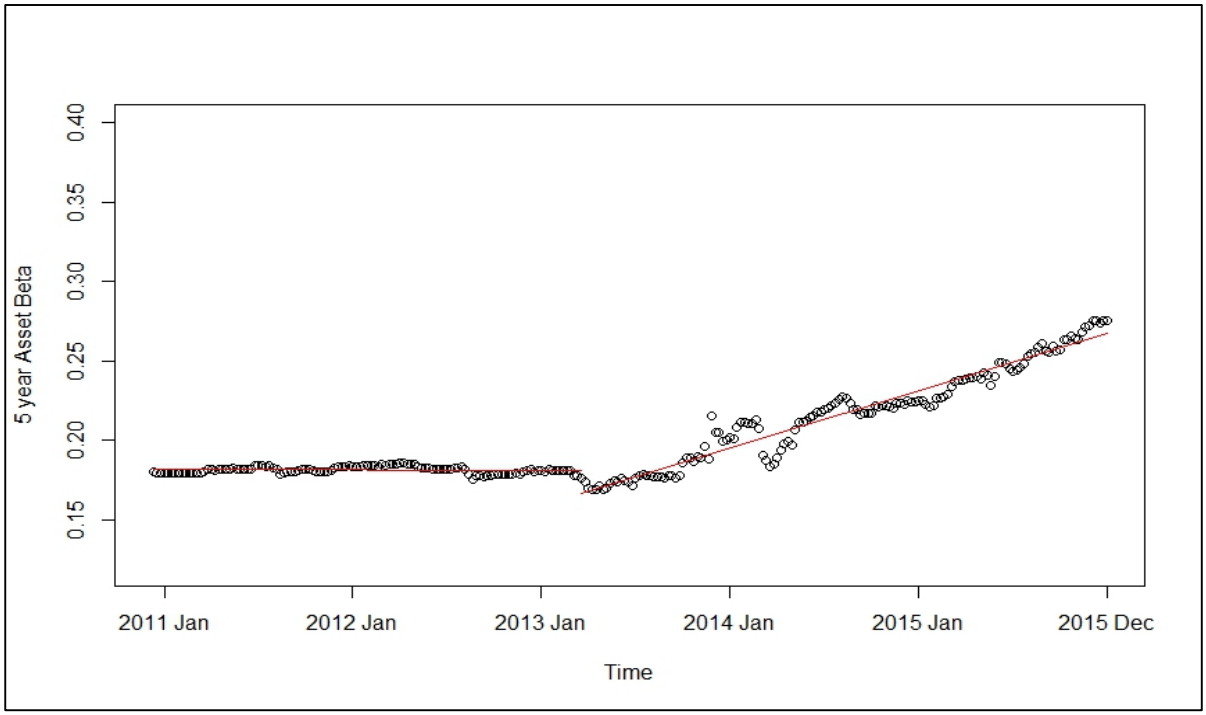
Source: Bloomberg, CEG analysis

Figure 22: Equal weighted portfolio 5 year asset beta (multiple breakpoints)



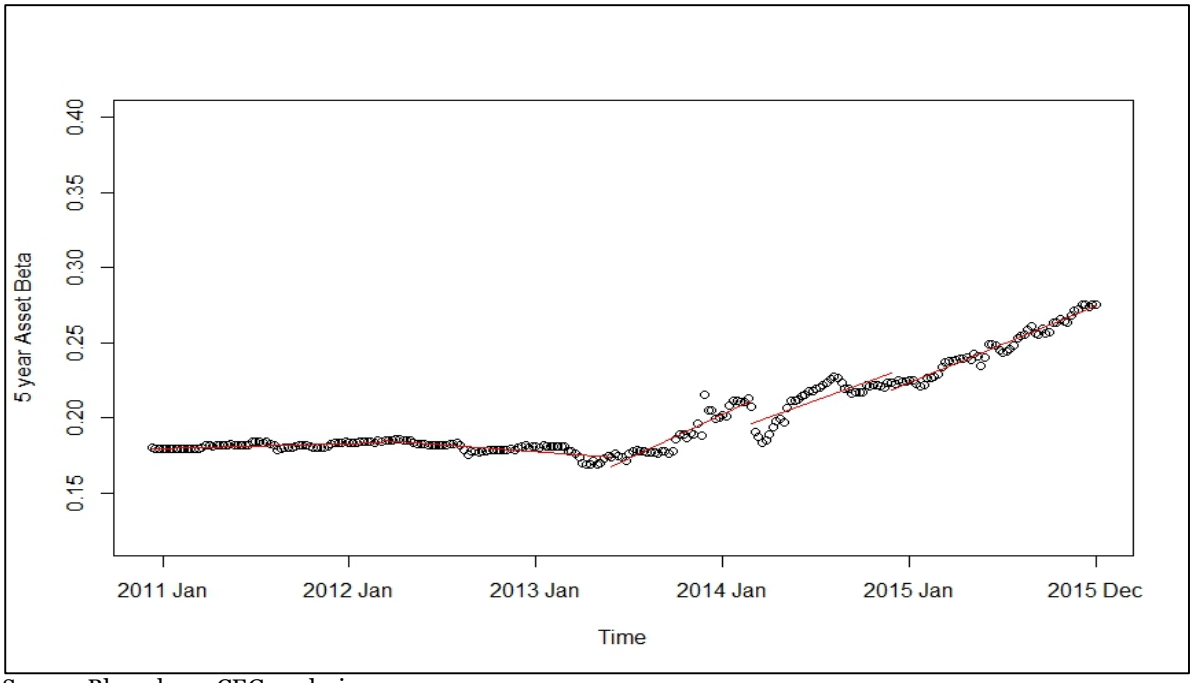
Source: Bloomberg, CEG analysis

Figure 23: Value weighted portfolio 5 year asset beta (1 breakpoint)



Source: Bloomberg, CEG analysis

Figure 24: Value weighted portfolio 5 year asset beta (multiple breakpoints)



Source: Bloomberg, CEG analysis