NERA
ECONOMIC CONSULTING

The Cost of Equity: A Critical Review of the Analysis of the AER and its Advisors

A report for DBP

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Project Team

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Executive Summary

This report has been prepared for DBP by NERA Economic Consulting (NERA). DBP has asked NERA to critically review the analyses of the Australian Energy Regulator (AER), Handley (2015) and Partington (2015) of a report submitted by NERA to the AER in February 2015 on behalf of Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy. [1] NERA's February 2015 report provides the results of both in-sample and out-of-sample tests of a naïve model, the Sharpe-Lintner (SL) Capital Asset Pricing Model (CAPM), the AER's implementation of the SL CAPM (the AER CAPM) and the Black CAPM. [2] The AER and the Economic Regulation Authority (ERA) have for some years used a version of the SL CAPM to estimate the cost of equity for a regulated energy utility. The Black CAPM and a naïve model are alternative models that the AER and ERA could use to estimate the cost of equity.

On 31 December 2014, DBP submitted to the ERA proposed revisions to the access arrangement for the Dampier to Bunbury Natural Gas Pipeline. [3] The proposed revised access arrangement covers the period 1 January 2016 to 31 December 2020. The results of out-of-sample tests of a naïve model, the SL CAPM and the Black CAPM contained in DBP's submission are similar to the results that NERA provides in its February 2015 report. [4]

In January 2015, the ERA published an issues paper on DBP's submission and invited interested parties to make submissions on any elements of the proposed revised access arrangement. [5] DBP has asked NERA to provide a report, which can be submitted to the ERA in response to the call for submissions, which critically reviews the analyses of the AER

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1 AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015.

Handley, J.C., *Report prepared for the Australian Energy Regulator Further advice on the return on equity*, 16 April 2015.

NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

Partington, G., *Report to the AER Return on equity (updated)*, April 2015.

2 The SL CAPM and Black CAPM predict that the market portfolio of all risky assets should be mean-variance efficient – that is, the models predict that the portfolio should have the highest mean return for given variance of return. One cannot observe the return to the market portfolio of all risky assets and so empirical versions of the models use proxies for the market portfolio of all risky assets. All references in this report to tests of the two models are to tests of empirical versions of the models that use the market portfolio of stocks as a proxy for the market portfolio of all risky assets.

3 DBP, *Proposed Revisions DBNGP Access Arrangement 2016 –2020 Regulatory Period Rate of Return Supporting Submission: 12,* December 2014.

4 NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

5 ERA, *Issues paper on proposed revisions to the Dampier to Bunbury Natural Gas Pipeline Access Arrangement 2016 – 2020*, 20 April 2015.

(2015), Handley (2015) and Partington (2015).[6] The report is not intended as a direct response to issues raised in the ERA's Issues Paper itself, but is rather intended to provide further background to aspects of new information which has come to light since DBP submitted its access arrangement proposal in December 2014.

Empirical Results

The central empirical result that NERA provides in its February 2015 report is that models like the SL CAPM and AER CAPM that use beta as a measure of risk and a restriction that a zero-beta portfolio earn either the risk-free rate or, as in the AER CAPM, a rate that sits only a small distance above the risk-free rate provide poor estimates of the return required on equity.[7] In particular, the models tend to underestimate the returns required on low-beta equity portfolios and overestimate the returns required on high-beta equity portfolios.[8] In other words, models that use beta as a measure of risk and a restriction that a zero-beta portfolio earn either the risk-free rate or a rate that sits only a small distance above the risk-free rate produce estimates of required returns that are biased – especially for low-beta and high-beta equity portfolios. Thus estimates of the return required on equity that use the SL CAPM and the AER CAPM will not satisfy Rule 74 (2) of the National Gas Rules. Estimates of the return required on equity that use the SL CAPM or the AER CAPM do not represent the best forecasts possible in the circumstances.

The SL CAPM and the AER CAPM perform so badly that even a naïve model that states that the mean returns to all equities are identical performs better. One cannot reject the hypothesis that the naïve model generates estimates of the return required on an equity portfolio that are unbiased. Similarly, one cannot reject the hypothesis that the Black CAPM generates estimates of the return required on an equity portfolio that are unbiased. Thus estimates of the return required on equity that use the naïve model or the Black CAPM will satisfy Rule 74 (2) of the National Gas Rules.

We emphasise here that the results that NERA finds, which, again, are similar to the results that DBP provides in its December 2014 submission, are similar to the results that Fama and French (1992), Campbell and Vuolteenah (2005) and Lewellen, Nagel and Shanken (2010) provide using US data.[9]

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[6] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015.

Handley, J.C., *Report prepared for the Australian Energy Regulator Further advice on the return on equity*, 16 April 2015.

Partington, G., *Report to the AER Return on equity (updated)*, April 2015.

[7] The AER's implementation of the SL CAPM uses an adjusted estimate of beta that places a weight of two thirds on an unadjusted estimate and a weight of one third on one – or, equivalently, uses the Black CAPM and an estimate of the zero-beta rate that places a weight of two thirds on the risk-free rate and a weight of one third on the mean return to the market.

[8] By construction, of course, the SL CAPM will correctly estimate the return required on a risk-free asset.

[9] Campbell, J. and T. Vuolteenaho, *Bad beta, good beta*, American Economic Review 94, pages 1249-1275.

Fama, Eugene and Kenneth French, *The cross-section of expected returns*, Journal of Finance 47, 1992, pages 427-465.

Issues Raised by the AER and its Advisors

The AER uses difficulties in testing the predictions that the SL CAPM makes about the behaviour of the return to the market portfolio of all risky assets to shield the version of the model that it employs from scrutiny. NERA emphasises in its February 2015 report that the AER does not employ a version of the SL CAPM that uses the return to the market portfolio of *all* risky assets. The version of the model that the AER employs uses the market portfolio of stocks alone as a proxy for the market portfolio of all risky assets. Thus whether the model works when one employs the return to the market portfolio of all risky assets is irrelevant to the issue of how the AER should set the return on equity for a regulated energy utility. The AER employs a version of the SL CAPM that uses the market portfolio of stocks as a proxy for the market portfolio of all risky assets. Thus, what is relevant to the issue of how the AER should set the return on equity for a regulated energy utility is whether the version of the SL CAPM that the regulator employs works. The empirical version of the SL CAPM that the AER employs matches the empirical version of the model that NERA tests in its February 2015 report. [10] So the evidence provided in that report is relevant to determining whether estimates provided by the empirical version of the SL CAPM that the AER employs meet Rule 87 of the National Gas Rules.

The AER (2013) and McKenzie and Partington (2014) refer to the work of Ray, Savin and Tiwari (2009) who show that the finite-sample distribution of the Wald statistic for a test of the SL CAPM need not conform closely to its theoretical asymptotic distribution. [11] As a result of the differences that can occur between the finite-sample and asymptotic distributions of the Wald statistics used to test the SL CAPM, Ray, Savin and Tiwari note that tests of pricing models that rely on the asymptotic distributions of the statistics can reject more frequently than the stated sizes of the tests would suggest. To examine the extent to which the finite-sample distribution of the Wald statistic, which NERA uses in its February 2015 report to test the SL CAPM, differs from its theoretical asymptotic distribution, NERA conducts bootstrap simulations. [12] NERA reports that the result of the simulations indicate that, regardless of how significance is assessed, estimates of the return required on equity that use the SL CAPM will not satisfy Rule 74 (2) of the National Gas Rules. We note here that the AER has not acknowledged that NERA has addressed the issues that Ray, Savin and Tiwari raise.

Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

[10] Similarly, the empirical version of the SL CAPM that the ERA employs matches the empirical version of the model that DBP tests in its December 2014 submission.

DBP, *Proposed Revisions DBNGP Access Arrangement 2016 –2020 Regulatory Period Rate of Return Supporting Submission: 12,* December 2014.

[11] AER, *Better Regulation Explanatory Statement Rate of Return Guideline (Appendices)*, December 2013, page 12.

McKenzie, M. and G. Partington, Report to the AER Part A: Return on equity, SIRCA, October 2014, page 9.

Ray, S., N.E. Savin and A. Tiwari, Testing the CAPM revisited, Journal of Empirical Finance, 2009, pages 721-733.

[12] Similarly, DBP uses simulations to examine the extent to which the finite-sample distribution of the Wald statistic that it uses in its December 2014 report to test the SL CAPM differs from its theoretical asymptotic distribution.

DBP, *Proposed Revisions DBNGP Access Arrangement 2016 –2020 Regulatory Period Rate of Return Supporting Submission: 12,* December 2014.

The AER suggests that a 'limitation' of NERA's results is that they appear 'counterintuitive' and so places little weight on the results. We note, however, that the data that NERA employs in its February 2015 report, and that DBP uses in its December 2014 submission, are primarily from SIRCA and that the AER's advisors, McKenzie and Partington, have in the past stated that many of their reports were written on behalf of SIRCA. McKenzie and Partington have not, though, generated any empirical evidence using data supplied by SIRCA or by any other data provider to produce support for the use of either the SL CAPM or the AER's implementation of the model.

McKenzie and Partington (2014) instead look to the work of Da, Guo and Jagannathan (2012) for support for the SL CAPM.[13] Da, Guo and Jagannathan argue that growth options that firms possess may be largely responsible for the weak relation between return and beta. McKenzie and Partington (2014) state that:[14]

> 'Da, Guo and Jagannathan (2012) argue that the empirical evidence against the capital asset pricing model (CAPM) based on stock returns does not invalidate its use for estimating the cost of capital for projects in making capital budgeting decisions ... their findings justify the continued use of the CAPM irrespective as to one's interpretation of the empirical literature on asset pricing.'

NERA in its February 2015 report states that:

> 'What McKenzie and Partington do not explain is that Da, Guo and Jagannathan do not suggest that the SL CAPM be used in the same way that the AER has been using the model. To construct estimates of beta that can be used in project evaluation, unadjusted common or garden estimates of beta have to be adjusted. Da, Guo and Jagannathan (2012) state that:
>
> > 'In general, both the equity risk premium and the equity beta of a firm are complex functions of the firm's project beta and real option characteristics. If we project them on a set of variables capturing the features of real options using linear regressions, the residual risk premium and the residual beta are option-adjusted and more closely resemble the underlying project risk premium and project beta.'
>
> Since beta is a relative measure of risk, an adjustment must be made even to the betas of firms that have no growth options. Da, Guo and Jagannathan construct option-adjusted betas as the residuals from a cross-sectional regression, without an intercept, of unadjusted betas on book-to-market, idiosyncratic volatility and the return on assets where the three regressors are measured relative to averages for the market. Neither the AER nor its advisers construct estimates of beta in this way. Thus the evidence that Da, Guo and Jagannathan provide is not relevant to assessing estimates of the cost of equity provided by the empirical version of the SL CAPM that the AER employs.'

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[13] Da, Z., R-J. Guo and R. Jagannathan, *CAPM for estimating the cost of equity capital: Interpreting the empirical evidence*, Journal of Financial Economics, 2012, pages 204-220.

McKenzie, M. and G. Partington, *Report to the AER Part A: Return on equity*, SIRCA, October 2014, pages 9-10.

[14] McKenzie, M. and G. Partington, *Report to the AER Part A: Return on equity*, SIRCA, October 2014, pages 9-10.

In his April 2015 report, Partington ignores what NERA has to say about the work of Da, Guo and Jagannathan and reproduces the comments made in the report of McKenzie and Partington of December 2014.

Handley (2015) acknowledges that a low-beta bias exists but argues that since there is not uniform agreement that the bias represents compensation for risk not accounted for by the SL CAPM, then one should ignore the bias in computing an estimate of the cost of equity. That is, one should ignore the evidence that the SL CAPM is wrong. He argues that the National Gas Rules require the allowed rate of return to reflect the risk of a benchmark efficient entity. We note, however, that Rule 87 (3) of the National Gas Rules states that:

> 'The *allowed rate of return objective* is that the rate of return for a service provider is to be commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to the service provider in respect of the provision of reference services (the *allowed rate of return objective*).'

The rule does not state, as Handley asserts, that the rate of return should *reflect* the risk of a benchmark efficient entity – that is, it does not state that the rate of return should constitute *compensation* for risk. The rule states only that the rate of return be *commensurate* with the costs of a benchmark efficient entity with a similar degree of risk – even if some of those costs do not represent compensation for risk, measured in some way. In other words, Rule 87 (3) implies that a benchmark efficient entity should be rewarded on the basis of the costs that it faces and not on the basis of the costs that it would face were some asset pricing model to be true. Thus if the evidence indicates that the market requires firms with low equity betas to deliver returns that are, on average, significantly above those that the SL CAPM indicates that they should deliver, then Rule 87 (3) implies that return on equity provided to low-equity-beta firms should include the additional costs that the firms face beyond those that they would face were the SL CAPM to be true.

1. Introduction

This report has been prepared for DBP by NERA Economic Consulting (NERA). DBP has asked NERA to critically review the analyses of the Australian Energy Regulator (AER), Handley (2015) and Partington (2015) of a report submitted by NERA to the AER in February 2015 on behalf of Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy. [15] NERA's February 2015 report provides the results of both in-sample and out-of-sample tests of a naïve model, the Sharpe-Lintner (SL) Capital Asset Pricing Model (CAPM), the AER's implementation of the SL CAPM (the AER CAPM) and the Black CAPM. [16] The AER and the Economic Regulation Authority (ERA) have for some years used a version of the SL CAPM to estimate the cost of equity for a regulated energy utility. The Black CAPM and a naïve model are alternative models that the AER and ERA could use to estimate the cost of equity.

On 31 December 2014, DBP submitted to the ERA proposed revisions to the access arrangement for the Dampier to Bunbury Natural Gas Pipeline. [17] The proposed revised access arrangement covers the period 1 January 2016 to 31 December 2020. The results of out-of-sample tests of a naïve model, the SL CAPM and the Black CAPM contained in DBP's submission are similar to the results that NERA provides in its February 2015 report. [18]

In January 2015, the ERA published an issues paper on DBP's submission and invited interested parties to make submissions on any elements of the proposed revised access arrangement. [19] DBP has asked NERA to provide a report, which can be submitted to the ERA in response to the call for submissions, which critically reviews the analyses of the AER

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[15] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015.

Handley, J.C., *Report prepared for the Australian Energy Regulator Further advice on the return on equity*, 16 April 2015.

NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

Partington, G., *Report to the AER Return on equity (updated)*, April 2015.

[16] The SL CAPM and Black CAPM predict that the market portfolio of all risky assets should be mean-variance efficient – that is, the models predict that the portfolio should have the highest mean return for given variance of return. One cannot observe the return to the market portfolio of all risky assets and so empirical versions of the models use proxies for the market portfolio of all risky assets. All references in this report to tests of the two models are to tests of empirical versions of the models that use the market portfolio of stocks as a proxy for the market portfolio of all risky assets.

[17] DBP, *Proposed Revisions DBNGP Access Arrangement 2016 –2020 Regulatory Period Rate of Return Supporting Submission: 12,* December 2014.

[18] NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

[19] ERA, *Issues paper on proposed revisions to the Dampier to Bunbury Natural Gas Pipeline Access Arrangement 2016 – 2020*, 20 April 2015.

(2015), Handley (2015) and Partington (2015). [20] The report is not intended as a direct response to issues raised in the ERA's Issues Paper itself, but is rather intended to provide further background to aspects of new information which has come to light since DBP submitted its access arrangement proposal in December 2014.

In particular, DBP has asked NERA to:

- describe the differences between the SL CAPM, Black's CAPM, Brennan's CAPM and Vasicek's CAPM; [21]
- describe the tests that NERA (2015) performs of a naïve model, the SL CAPM, the AER CAPM and the Black CAPM; [22]
- review what the AER (2015), Handley (2015) and Partington (2015) have or have not had to say about NERA's (2015) tests; [23]
- explain what the Vasicek adjustment represents;
- explain whether a tendency for estimates of beta to revert to one over time can explain the evidence that NERA (2015) finds against the SL CAPM and the AER CAPM; [24]
- explain what issues Ray, Savin and Tiwari (2009) raise, whether DBP (2014) and NERA (2015) address the issues and whether the AER (2015), Handley (2015) and Partington (2015) acknowledge that DBP and NERA have addressed the issues; [25]

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[20] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015.

Handley, J.C., *Report prepared for the Australian Energy Regulator Further advice on the return on equity*, 16 April 2015.

Partington, G., *Report to the AER Return on equity (updated)*, April 2015.

[21] Black, Fischer, *Capital market equilibrium with restricted borrowing*, Journal of Business 45, 1972, pages 444-454.

Brennan, Michael, *Capital market equilibrium with divergent borrowing and lending rates*, Journal of Financial and Quantitative Analysis 6, 1971, pages 1197-1205.

Vasicek, Oldrich, *Capital market equilibrium with no riskless borrowing*, Memorandum, Wells Fargo Bank, 1971.

[22] NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

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Partington, G., *Report to the AER Return on equity (updated)*, April 2015.

[24] NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

[25] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015.

- explain what Da, Guo and Jagannathan (2012) have to say, what NERA has to say about what Da, Guo and Jagannathan have to say and whether the AER (2015), Handley (2015) and Partington (2015) acknowledge that NERA has addressed the issues that Da, Guo and Jagannathan raise; [26] and

- address any other relevant issues that the AER (2015), Handley (2015) and Partington (2015) raise or do not raise that need to be addressed. [27]

The remainder of this report is structured as follows:

- section 2 reviews the analysis and empirical evidence provided by NERA in its February 2015 report; and
- section 3 examines whether the AER and its advisors, Handley and Partington, have responded to the analysis that NERA provides in its February 2015 report and what the AER (2015), Handley (2015) and Partington (2015) have had to say. [28]

In addition:

DBP, *Proposed Revisions DBNGP Access Arrangement 2016 –2020 Regulatory Period Rate of Return Supporting Submission: 12,* December 2014.

Handley, J.C., *Report prepared for the Australian Energy Regulator Further advice on the return on equity*, 16 April 2015.

NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

Partington, G., *Report to the AER Return on equity (updated)*, April 2015.

Ray, S., N.E. Savin and A. Tiwari, *Testing the CAPM revisited*, Journal of Empirical Finance, 2009, pages 721-733.

[26] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015.

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[28] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015.

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- Appendix A explains how NERA evaluates AER CAPM and Black CAPM forecasts of the cost of equity;
- Appendix B provides the terms of reference for this report;
- Appendix C provides a copy of the Federal Court of Australia's *Guidelines for Expert Witnesses in Proceeding in the Federal Court of Australia*; and
- Appendix D provides the curriculum vitae of the author of the report.

Statement of Credentials

This report has been prepared by **Simon Wheatley**.

Simon Wheatley is an Affiliated Industry Expert with NERA, and was until 2008 a Professor of Finance at the University of Melbourne. Since 2008, Simon has applied his finance expertise in investment management and consulting outside the university sector. Simon's interests and expertise are in individual portfolio choice theory, testing asset-pricing models and determining the extent to which returns are predictable. Prior to joining the University of Melbourne, Simon taught finance at the Universities of British Columbia, Chicago, New South Wales, Rochester and Washington.

In preparing this report, the author (herein after referred to as 'I' or 'my' or 'me') confirms 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 from this report. 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 have been provided with a copy of the Federal Court of Australia's *Practice Note CM 7, Expert Witnesses in Proceedings in the Federal Court of Australia*, dated 4 June 2013, and my report has been prepared in accordance with those guidelines.

I have undertaken consultancy assignments for DBP in the past. However, I remain at arm's length, and as an independent consultant.

2. Review of NERA's February 2015 Report

Rule 74 (2) of the National Gas Rules, relating generally to forecasts and estimates, states that:

> (2) A forecast or estimate:
>
> (a) must be arrived at on a reasonable basis; and
>
> (b) must represent the best forecast or estimate possible in the circumstances.

NERA was asked, in its February 2015 report, to assess whether two well recognised forms of the CAPM:

- the SL CAPM; and
- the Black CAPM

satisfy this important rule. These two models have been widely used by finance academics over the last 50 years.

NERA also assessed whether a naïve model that states that the mean returns to all equities are identical satisfies Rule 74 (2) and whether the AER's implementation of the SL CAPM (the AER CAPM) satisfies the rule. A naïve model will deliver the same return on equity as setting beta to one and using either the SL CAPM or Black CAPM. NERA assumes that the AER, in implementing the SL CAPM, acts as if it adjusts an estimate of the equity beta of a regulated energy utility solely on the basis of the principles underpinning the Black CAPM. NERA does so, because to evaluate a method for estimating the return required on equity, it must clearly specify the method. Methods that NERA cannot clearly specify, it cannot evaluate. It cannot, for example, evaluate the use by a regulator of its discretion in a way that is not specified and in a way that may vary through time. Based on recent decisions made by the AER, NERA assumes that the AER's implementation of the SL CAPM uses the Black CAPM and an estimate of the zero-beta rate that places a weight of two thirds on the risk-free rate and a weight of one third on the mean return to the market – or equivalently, that the AER uses the SL CAPM and an adjusted estimate of beta that places a weight of two thirds on an unadjusted estimate and a weight of one third on one.

NERA used both in-sample and out-of-sample tests to determine whether there is evidence against the restrictions that each model imposes. If the restrictions imposed by an asset pricing model do not hold, the model will, in general, produce biased estimates of the return required on equity. Consequently, evidence against the restrictions imposed by a model is evidence that the model will generate biased estimates of the return required on equity.

In-sample tests are full-sample tests whereas out-of-sample tests split the full sample up, typically in a recursive manner, into data used to estimate a model and data used to evaluate forecasts generated by the model. Inoue and Kilian (2004) and Diebold (2014) emphasise

that in-sample tests of models represent an efficient use of data. [29] In other words, they emphasise that in-sample tests are more likely to detect that a null hypothesis is untrue than are out-of-sample tests. They also emphasise, however, that out-of-sample tests are simple to interpret and allow one to assess how successful forecasts might be in real time.

Both the SL CAPM and the Black CAPM imply that variation across portfolios in mean return should be completely explained by beta and so NERA uses 10 portfolios formed on the basis of past unadjusted estimates of beta to test the SL CAPM, the Black CAPM, a naïve model and the AER CAPM. [30]

2.1. Empirical Results

The central empirical result that NERA provides in its February 2015 report is that models like the SL CAPM and AER CAPM that use beta as a measure of risk and a restriction that a zero-beta portfolio earn either the risk-free rate or a rate that sits only a small distance above the risk-free rate provide poor estimates of the return required on equity. [31] In particular, the models tend to underestimate the returns required on low-beta equity portfolios and overestimate the returns required on high-beta equity portfolios. [32] In other words, models that use beta as a measure of risk and a restriction that a zero-beta portfolio earn either the risk-free rate or a rate that sits only a small distance above the risk-free rate produce estimates of required returns that are biased – especially for low-beta and high-beta equity portfolios. Thus estimates of the return required on equity that use the SL CAPM and the AER CAPM will not satisfy Rule 74 (2) of the National Gas Rules. Estimates of the return required on equity that use the SL CAPM or the AER CAPM do not represent the best forecasts possible in the circumstances.

The SL CAPM and the AER CAPM perform so badly that even a naïve model that states that the mean returns to all equities are identical performs better. One cannot reject the hypothesis that the naïve model generates estimates of the return required on an equity portfolio that are unbiased. Similarly, one cannot reject the hypothesis that the Black CAPM generates estimates of the return required on an equity portfolio that are unbiased. Thus estimates of the return required on equity that use the naïve model or the Black CAPM will satisfy Rule 74 (2) of the National Gas Rules.

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[29] Diebold, F., *Comparing predictive accuracy, twenty years later: A personal perspective on the use and abuse of Diebold-Mariano tests*, University of Pennsylvania, December 2013.

Inoue, A. and L. Kilian, In-*sample or out-of-sample tests of predictability: Which one should we use*? Econometric Reviews, 2004, pages 371-402.

[30] NERA uses monthly data from SIRCA's Share Price and Price Relative database.

SIRCA Australian Share Price and Price Relative (SPPR) information supplied by RoZetta Technology Pty Ltd (www.rozettatechnology.com).

[31] Again, note that the AER's implementation of the SL CAPM uses an adjusted estimate of beta that places a weight of two thirds on an unadjusted estimate and a weight of one third on one – or, equivalently, uses the Black CAPM and an estimate of the zero-beta rate that places a weight of two thirds on the risk-free rate and a weight of one third on the mean return to the market. An estimate of the zero-beta rate that places a weight of two thirds on the risk-free rate and a weight of one third on the mean return to the market will sit a small distance above the risk-free rate.

[32] By construction, of course, the SL CAPM will correctly estimate the return required on a risk-free asset.

Appendix B of NERA's February 2015 report provides some intuition for why the results for a naïve model and the Black CAPM are similar. In particular, the appendix provides intuition for why the out-of-sample results for the two models are similar. Grasping the intuition can help one understand why the performance of the SL CAPM and the AER CAPM is so poor and so we review the intuition here.

NERA in its February 2015 report examines the out-of-sample performance of forecasts of the return on equity generated by the Black CAPM that use at each point in time past data to assess the relation between mean return and beta across portfolios. NERA generates these forecasts in the same way as the AER implicitly does in using: [33]

> 'the theoretical principles underpinning the Black CAPM to inform the equity beta point estimate'

that it employs for use with the SL CAPM. In other words, NERA uses an adjusted estimate of beta that with the SL CAPM delivers the same return as an adjusted estimate used with the Black CAPM. However, whereas the AER uses theory to guide its choice of an adjusted equity beta, NERA uses past empirical evidence. [34] Appendix A describes how NERA does so. [35] If past data suggests that there is little relation between mean return and beta across portfolios, estimates of the zero-beta premium and market risk premium will come close to matching one another. If estimates of the zero-beta premium and market risk premium come close to matching one another, then adjusted estimates of equity betas selected for use with the SL CAPM to generate forecasts of the return on equity will sit close to one. In other words, under these circumstances estimates produced by the Black CAPM will come close to matching estimates generated by a naïve model.

Figure 2.1 below plots rolling ordinary least squares unadjusted estimates of the betas of the 10 portfolios formed on the basis of past unadjusted estimates of beta that NERA uses in its February 2015 report against time. Figure 2.2, on the other hand, plots the rolling adjusted estimates that NERA uses in constructing forecasts of the return on equity that employ the Black CAPM. A comparison of the two figures indicates that at each point in time, the Black model looks back at past data, finds little relation between mean return and beta across portfolios and so sets the adjusted betas of the 10 portfolios close to one. Following this strategy provides forecasts of the return on equity that are similar to the forecasts generated by a naïve model. NERA's tests cannot reject the hypothesis that both models generate forecasts that are unbiased. In contrast, NERA's tests can reject the hypothesis that forecasts generated by the SL CAPM and the AER CAPM are unbiased.

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[33] AER, *Draft decision Jemena Gas Networks (NSW) Ltd Access arrangement 2015–20: Attachment 3: Rate of return*, November 2014, page 265.

[34] NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015, pages 32-35.

[35] The adjusted beta that NERA employs is identical to what DBP labels betastar in its December 2014 report.

DBP, *Proposed Revisions DBNGP Access Arrangement 2016 –2020 Regulatory Period Rate of Return Supporting Submission: 12,* December 2014.

Figure 2.1
Unadjusted rolling OLS estimates of beta for 10 past beta-sorted portfolios

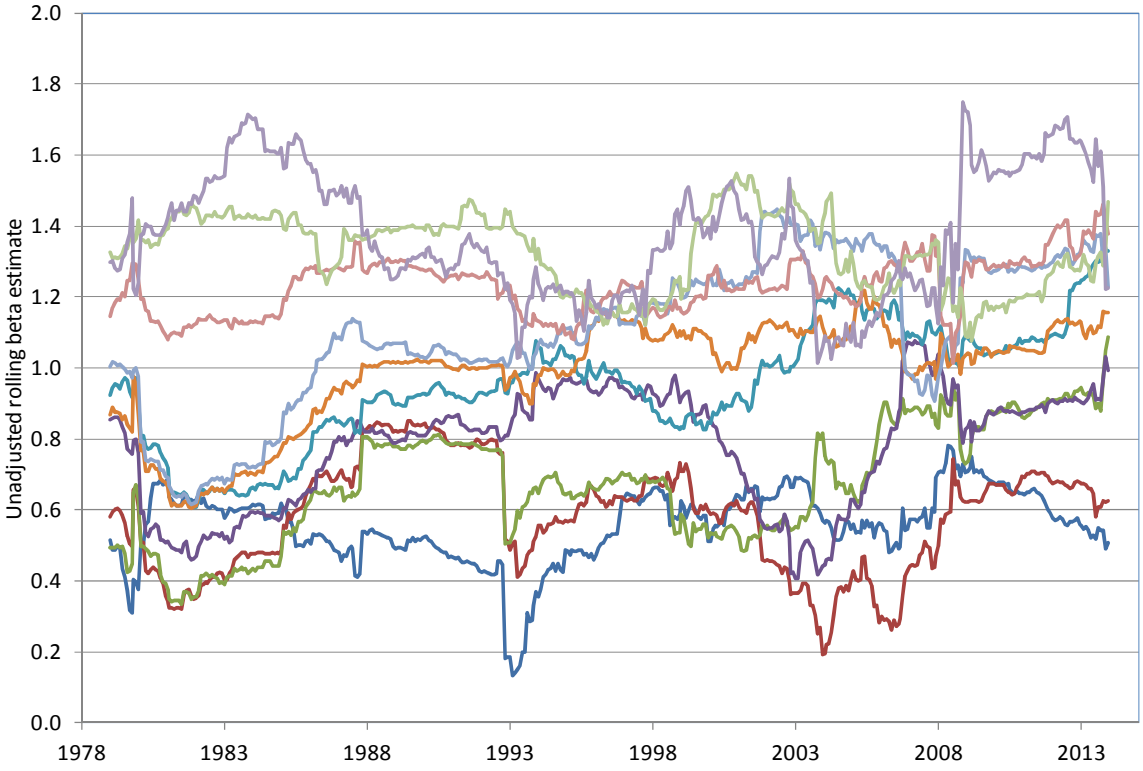

Figure 2.2
Black adjusted rolling estimates of beta for 10 past beta-sorted portfolios

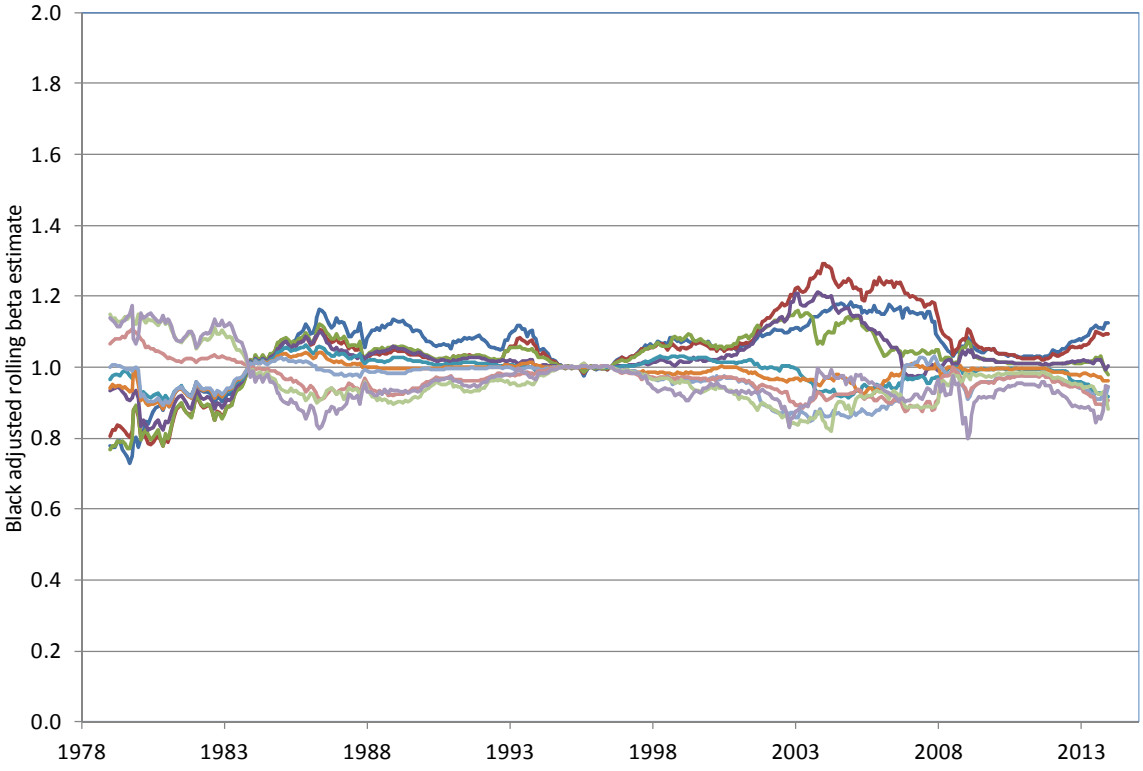

Table 2.1 below summarises the results of NERA's tests.

Table 2.1
Summary of test results

	In-sample	Out-of-sample
Naïve model	Accept	Accept
SL CAPM	Reject	Reject
AER CAPM		Reject
Black CAPM	Accept	Accept

Notes: The table indicates whether a Wald test of each model accepts or rejects the model. The tests use monthly data from January 1974 to December 2013. A Wald statistic uses unrestricted parameter estimates and an estimate of the covariance matrix of the unrestricted parameter estimates to test whether a set of restrictions are true. [36]

2.2. Related Results

The results that NERA provides in its February 2015 report that use Australian data are similar to results that others provide using US data.

As an example, the results that NERA provides are similar to the results that Lewellen, Nagel and Shanken (2010) provide using US data. [37] Davis (2011), Handley (2014) and McKenzie and Partington (2014), in reports written for the AER, endorse the use of the SL CAPM and review, favourably, the work of Lewellen, Nagel and Shanken. [38] The evidence that Lewellen, Nagel and Shanken provide, however, indicates that the SL CAPM does not generate unbiased estimates of the cost of equity.

Lewellen, Nagel and Shanken (2010) use, in their empirical work, quarterly data from 1963 to 2004 on the returns to 25 portfolios formed on the basis of size and book-to-market and 30 industry portfolios. [39] Figure 2.3 below plots the sample mean returns in excess of the risk-free rate on the 25 portfolios formed on the basis of size and book-to-market against estimates of their betas, indicated by the 25 blue markers, together with the relation that Lewellen, Nagel and Shanken estimate exists between mean excess return and beta for the

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[36] Davidson, R. and J.G. MacKinnon, *Estimation and inference in econometrics*, Oxford University Press, 1993, page 89.

[37] Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

[38] Davis, K., *Cost of Equity Issues: A Report for the AER*, University of Melbourne, January 2011.

Davis, K., *Cost of Equity Issues: A further report for the AER*, University of Melbourne, May 2011.

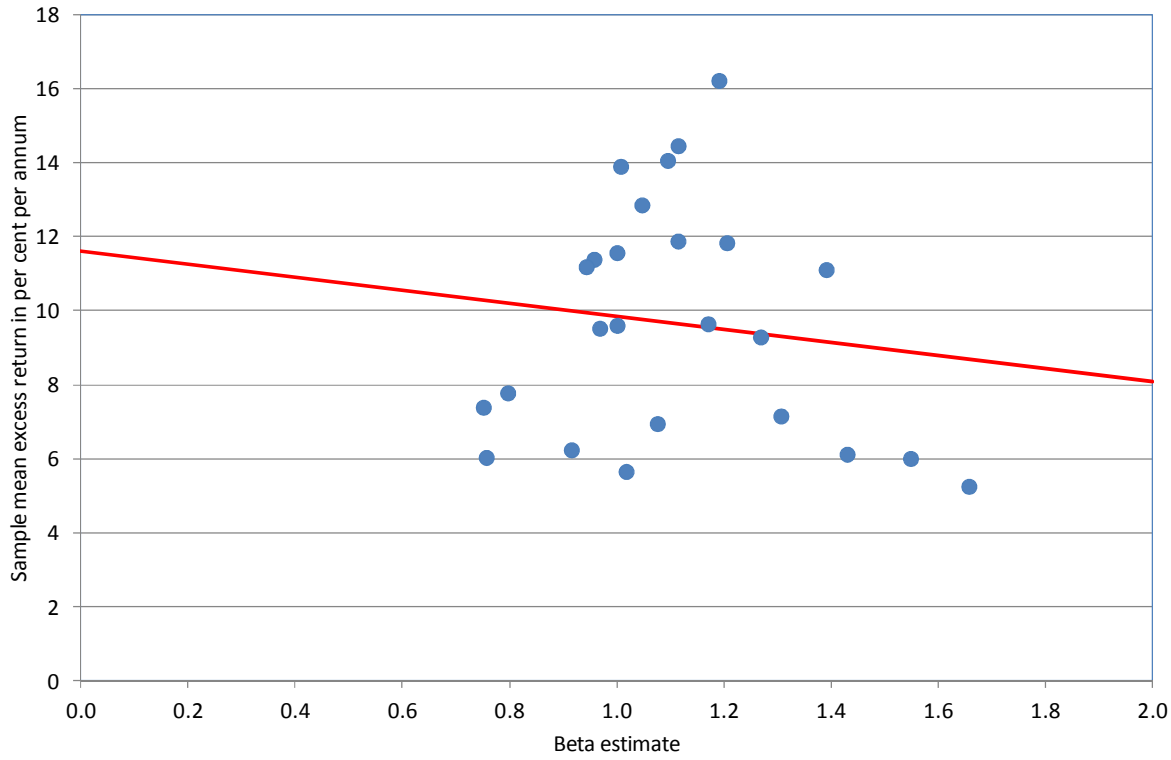
Handley, J., *Advice on the return on equity*, University of Melbourne, October 2014.

McKenzie, M. and G. Partington, *Report to the AER Part A: Return on equity*, SIRCA, 2014.

[39] Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

portfolios, indicated by the red line.[40] The figure shows that Lewellen, Nagel and Shanken find the relation between mean return and beta to be a negative one – as we find in Australian data. Figure 2.4 plots the sample mean returns in excess of the risk-free rate on all 55 portfolios against estimates of their betas, indicated by the 55 blue markers, together with the relation that Lewellen, Nagel and Shanken estimate exists between mean excess return and beta for the portfolios, again indicated by the red line.[41] Figures 2.3 and 2.4 indicate that there is little relation between the sample mean return to a portfolio and an estimate of its beta.

Figure 2.3
Sample mean excess return against beta estimate for 25 US portfolios formed on the basis of size and book-to-market: Quarterly data from 1963 to 2004



Notes: Data are from Ken French's web site and are those used by Lewellen, Nagel and Shanken (2010). The red line plots Lewellen, Nagel and Shanken's estimate of the relation between mean excess return and beta constructed from the 25 portfolios formed on the basis of size and book-to-market. Sample mean excess returns have been annualised by multiplying the quarterly returns by four and are in per cent per annum.

Sources: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Lewellen, J., S. Nagel and J. Shanken, A skeptical appraisal of asset pricing tests, Journal of Financial Economics, 2010, Table 1, pages 188.

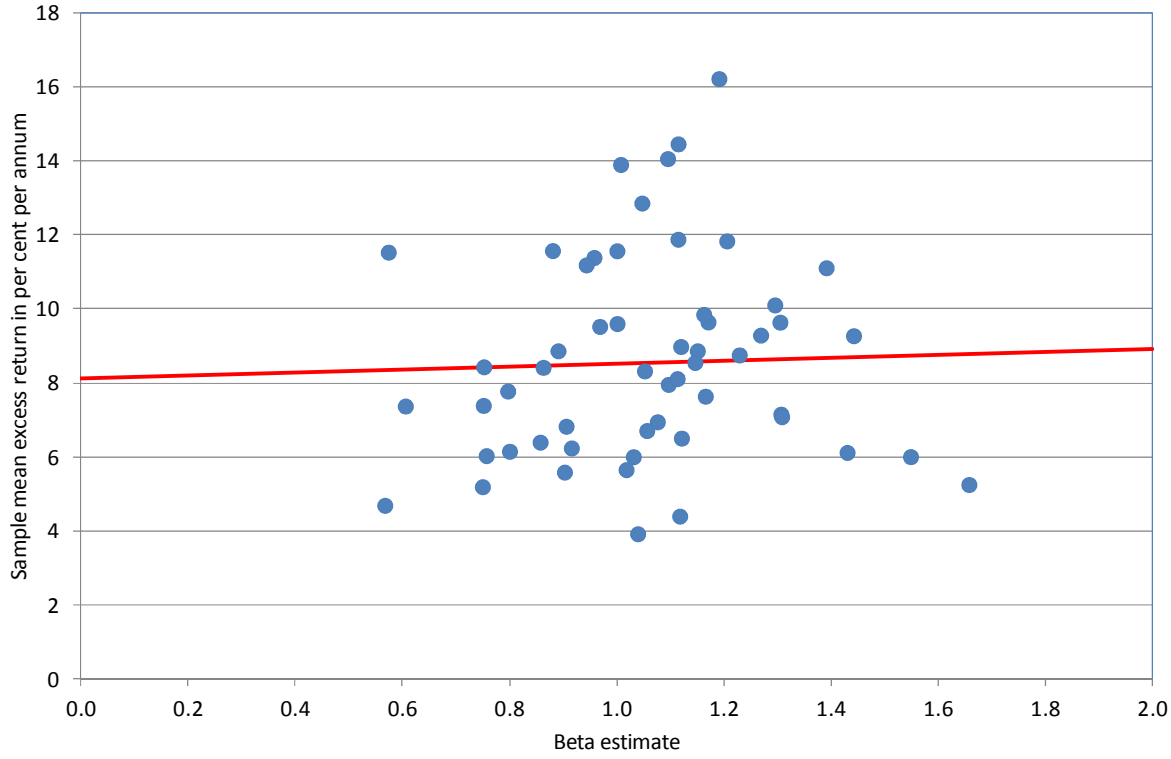
[40] Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

[41] Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

Other authors reach the same conclusion. For example, Fama and French (1992) state in the abstract to their paper that.[42]

> 'the relation between market β and average return is flat, even when β is the only explanatory variable.'

Figure 2.4
Sample mean excess return against beta estimate for 25 US size and book-to-market sorted portfolios and 30 US industry portfolios: Quarterly data from 1963 to 2004



Notes: Data are from Ken French's web site and are those used by Lewellen, Nagel and Shanken (2010). The red line plots Lewellen, Nagel and Shanken's estimate of the relation between mean return and beta constructed from the 25 portfolios formed on the basis of size and book-to-market and the 30 industry portfolios.

Sources: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Lewellen, J., S. Nagel and J. Shanken, A skeptical appraisal of asset pricing tests, Journal of Financial Economics, 2010, Table 1, pages 188.

Similarly, Campbell and Vuolteenah (2005) summarise the evidence in the following way:[43]

> 'It is well known that the CAPM fails to describe average realized stock returns since the early 1960s, if a value-weighted equity index is used as a proxy for the market portfolio. In particular, small stocks and value stocks have delivered higher average

[42] Fama, Eugene and Kenneth French, *The cross-section of expected returns*, Journal of Finance 47, 1992, pages 427-465.

[43] Campbell, J. and T. Vuolteenaho, *Bad beta, good beta*, American Economic Review 94, page 1249.

> returns than their betas can justify. Adding insult to injury, stocks with high past betas have had average returns no higher than stocks of the same size with low past betas.'

2.3. Market Proxies

The SL CAPM and the Black CAPM predict that the market portfolio of *all* risky assets will be mean-variance efficient. [44] As Roll (1977) makes clear, however, one cannot observe the return to the market portfolio of all risky assets and so one may never know whether the models are true. [45]

The AER uses difficulties in testing the predictions that the SL CAPM makes about the behaviour of the return to the market portfolio of all risky assets to shield the version of the model that it employs from scrutiny. The AER, for example, states in the *Appendices* to its *Rate of Return Guidelines* that: [46]

> 'Many of the empirical tests of the Sharpe–Lintner CAPM, however, are themselves the subject of ongoing academic debate. For example, a common test used to demonstrate low beta bias is to plot the average beta of share portfolios against the realised returns on these portfolios. Indeed, similar evidence was included in the report by NERA, and submitted by ENA. In previous decisions we have highlighted the limitations of these tests, as suggested in the academic literature. These limitations include (that) they use a market proxy that does not accord with the Sharpe–Lintner CAPM market.'

NERA emphasises in its February 2015 report that the AER does not employ a version of the SL CAPM that uses the return to the market portfolio of *all* risky assets. The version of the model that the AER employs uses the market portfolio of stocks alone as a proxy for the market portfolio of all risky assets. Thus whether the model works when one employs the return to the market portfolio of all risky assets is irrelevant to the issue of how the AER should set the return on equity for a regulated energy utility. The AER employs a version of the SL CAPM that uses the market portfolio of stocks as a proxy for the market portfolio of all risky assets. Thus, what is relevant to the issue of how the AER should set the return on equity for a regulated energy utility is whether the version of the SL CAPM that the regulator employs works. The empirical version of the SL CAPM that the AER employs matches the empirical version of the model that NERA tests in its February 2015 report. [47] So the evidence provided in that report is relevant to determining whether estimates provided by the empirical version of the SL CAPM that the AER employs meet Rule 87 of the National Gas Rules. Unless otherwise stated, all references to tests of the SL CAPM or Black CAPM in

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[44] A portfolio that is mean-variance efficient is one that has the highest mean return for given variance of return.

[45] Roll, R., *A critique of the asset pricing theory's tests: Part I*, Journal of Financial Economics 4, 1977, pages 129-176.

[46] AER, *Better Regulation Explanatory Statement Rate of Return Guideline (Appendices)*, December 2013, pages 11-12.

[47] Similarly, the empirical version of the SL CAPM that the ERA employs matches the empirical version of the model that DBP tests in its December 2014 submission.

DBP, *Proposed Revisions DBNGP Access Arrangement 2016 –2020 Regulatory Period Rate of Return Supporting Submission: 12,* December 2014.

this report are to tests of empirical versions of the models that use the return to a portfolio of stocks as a proxy for the market portfolio of all risky assets.

Roll (1977) also points out that: [48]

> 'There is an 'if and only if' relation between return/beta linearity and market portfolio mean-variance efficiency.'

Thus the evidence that NERA provides in its February 2015 report using Australian data and the evidence that Fama and French (1992), Campbell and Vuolteenah (2005) and Lewellen, Nagel and Shanken (2010) provide using US data indicate that there is evidence that neither the market portfolio of Australian stocks nor the market portfolio of US stocks is efficient. [49]

2.4. Test Size

The AER (2013) and McKenzie and Partington (2014) refer to the work of Ray, Savin and Tiwari (2009) who show that the finite-sample distribution of the Wald statistic for a test of the SL CAPM need not conform closely to its theoretical asymptotic distribution. [50] The finite-sample distribution refers to the distribution in samples that are not very, very large while the asymptotic distribution refers to the distribution in very, very large samples. Asymptotic results are ones that are strictly true only in the limit as the sample size tends to infinity. [51] As a result of the differences that can occur between the finite-sample and asymptotic distributions of the Wald statistics used to test the SL CAPM, Ray, Savin and Tiwari note that tests of pricing models that rely on the asymptotic distributions of the statistics can reject more frequently than the stated sizes of the tests would suggest. The size of a test or significance level refers to the probability that the test will reject the null hypothesis when the null is true. To examine the extent to which the finite-sample distribution of the Wald statistic, which NERA uses in its February 2015 report to test the SL CAPM, differs from its theoretical asymptotic distribution, NERA conducts bootstrap simulations. [52] Each simulation uses 10,000 replications.

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[48] Roll, R., *A critique of the asset pricing theory's tests: Part I*, Journal of Financial Economics 4, 1977, page 130.

[49] Campbell, J. and T. Vuolteenaho, *Bad beta, good beta*, American Economic Review 94, pages 1249-1275.

Fama, Eugene and Kenneth French, *The cross-section of expected returns*, Journal of Finance 47, 1992, pages 427-465.

Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

[50] AER, *Better Regulation Explanatory Statement Rate of Return Guideline (Appendices)*, December 2013, page 12.

McKenzie, M. and G. Partington, Report to the AER Part A: Return on equity, SIRCA, October 2014, page 9.

Ray, S., N.E. Savin and A. Tiwari, Testing the CAPM revisited, Journal of Empirical Finance, 2009, pages 721-733.

[51] Davidson, R. and J.G. MacKinnon, *Estimation and inference in econometrics*, Oxford University Press, 1993, page 42.

[52] Similarly, DBP uses simulations to examine the extent to which the finite-sample distribution of the Wald statistic that it uses in its December 2014 report to test the SL CAPM differs from its theoretical asymptotic distribution.

DBP, *Proposed Revisions DBNGP Access Arrangement 2016 –2020 Regulatory Period Rate of Return Supporting Submission: 12,* December 2014.

NERA reports that it finds that, consistent with what Ray, Savin and Tiwari (2009) find, the finite-sample behaviour of the Wald statistic for a test of the SL CAPM differs from its theoretical asymptotic distribution.[53] The difference between the finite-sample and theoretical asymptotic distributions, however, is not sufficient to not reverse the inference that NERA draws from its results. The evidence that NERA provides indicates that the SL CAPM can be rejected at conventional levels of significance whether inference is based on the finite-sample or theoretical asymptotic distribution of the Wald statistic. In other words, regardless of how significance is assessed, the results that NERA provides indicate that estimates of the return required on equity that use the SL CAPM will not satisfy Rule 74 (2) of the National Gas Rules.

2.5. Other Issues

In its February 2015 report, NERA also makes a number of points about other issues raised by the AER and its advisors. The AER and its advisors have responded to some of the points that NERA raises and have ignored others. We will delay discussing these other issues until the next section.

[53] Ray, S., N.E. Savin and A. Tiwari, Testing the CAPM revisited, Journal of Empirical Finance, 2009, pages 721-733.

3. Response of the AER and its Advisors

The AER and its advisors have had very little to say about NERA's February 2015 report and in several instances have ignored NERA's report altogether. Here we will review what the AER and its advisors have had to say and make it clear, where it is necessary to do so, that the AER and its advisors have ignored arguments that NERA has made or evidence that NERA has provided.

3.1. Empirical Results

NERA shows in its February 2015 report that the SL CAPM and the AER CAPM tend to provide downwardly biased estimates of the returns required on low-beta equity portfolios and upwardly biased estimates of the returns required on high-beta equity portfolios. NERA, on the other hand, shows that one cannot reject the hypothesis that a naïve model that states that the mean returns to all equities are identical delivers unbiased estimates of the returns required on equity portfolios. Again, a naïve model will deliver the same return on equity as setting beta to one and using either the SL CAPM or Black CAPM.[54] NERA also shows that one cannot reject the hypothesis that the Black CAPM delivers unbiased estimates of the returns required on equity portfolios.

The AER's response to the evidence that NERA provides that the SL CAPM and the AER CAPM provide downwardly biased estimates of the returns required on equity portfolios is that:[55]

> 'Several service providers submitted an empirical test of the SLCAPM and the Black CAPM by NERA. We observe that this material responds to the position we have held since the Guideline. However, we received this material in February 2015 — with JGN's revised access arrangement and with submissions on several revised regulatory proposals. Given the level of technical detail and when we received this report, we have not been able to consider and respond to specific econometric issues in depth. Notwithstanding this, we observe that the results in NERA's report appear counterintuitive. For instance, NERA's in-sample tests indicated there was a negative relation between returns and beta—which is not consistent with the theory underpinning the SLCAPM or the Black CAPM. NERA also provided an estimate of the zero-beta premium of 10.75 per cent. It has been acknowledged that it is implausible for the zero beta premium to be equal to or greater than the MRP.'
>
> 'We consider the empirical information submitted in relation to the ex post performance of the different models does not show our application of the SLCAPM will undercompensate the benchmark efficient entity for it efficient cost of equity.'

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[54] Australian regulators have in the past set the beta of a regulated energy utility to one. See, for example:

AER, *Final decision Electricity transmission and distribution network service providers Review of the weighted average cost of capital (WACC) parameters*, May 2009, page 241.

[55] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015, page 239.

One way of interpreting this very limited response to the evidence that NERA provides is that because the regulator believes the results of the work to be counterintuitive, the AER is suspicious that there is something wrong with NERA's empirical work. We do not believe that there is anything wrong with NERA's empirical work. We have already noted in section 2 that NERA's results based on Australian data are similar to results produced using US data. We should also note that NERA's results are similar to results produced independently by CEG using Australian data in a September 2008 report. [56] SFG (2014) use a relatively short time series and find a relation between mean return and beta that depends on how the equity portfolios used in the analysis are formed but that is, regardless of how the portfolios are formed, insignificant at conventional levels. [57]

The data that NERA employs in its February 2015 report are primarily from SIRCA and we note that McKenzie and Partington have in the past stated that many of their reports were written on behalf of SIRCA. McKenzie and Partington have not, though, generated any empirical evidence using data supplied by SIRCA or by any other data provider to produce support for the use of either the SL CAPM or the AER's implementation of the model.

The AER's statement that: [58]

> 'It has been acknowledged that it is implausible for the zero beta premium to be equal to or greater than the MRP.'

cites as its sources page 92 of NERA's May 2014 report and page 3 of SFG's May 2014 report. [59] Neither NERA's report nor SFG's report, however, support the AER's statement.

Page 92 of NERA's report states that: [60]

> 'our specification of the Black CAPM assumes that the zero-beta premium is equal to the *MRP*. In other words, our specification of the Black CAPM will result in the same mean return for all stocks. This result may appear implausible, but it merely reflects the inability of estimates of beta computed relative to the market portfolio of stocks to track variation in returns across stocks.'

Page 3 of SFG's report states that: [61]

> 'In theory, we would also expect the zero beta return ... to lie below the expected market return ... However, this basic theory will not necessarily show up in the data because two things are measured with imprecision. First, the proxy for the market

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[56] CEG, *Estimation of, and correction for, biases inherent in the Sharpe CAPM formula*, September 2008.

[57] SFG, *Cost of equity in the Black Capital Asset Pricing Model Report for Jemena Gas Networks, ActewAGL, Networks NSW, Transend, Ergon and SA Power Networks*, 22 May 2014, page 3.

[58] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015, page 239.

[59] NERA, *Return on Capital of a Regulated Electricity Network: A report for Ashurst*, May 2014, page 92.

SFG, *Cost of Equity in the Black Capital Asset Pricing Model*, 22 May 2014, page 3.

[60] NERA, *Return on Capital of a Regulated Electricity Network: A report for Ashurst*, May 2014, page 92.

[61] SFG, *Cost of Equity in the Black Capital Asset Pricing Model*, 22 May 2014, page 3.

> portfolio of all risky assets is an index of listed stocks. Second, analysis is performed with respect to realised returns and not expected returns, so relies upon the assumption that there is enough historical information in realised returns for noise in different directions to cancel out.'

Only once in SFG's May 2014 report does the word 'implausible' appear and that is on page 18 in a quote taken from page 71 of the appendices to the AER's own 2013 *Rate of Return Guideline*.[62]

3.2. Market Proxies

We note in section 2 that the AER has in the past criticised tests of the SL CAPM that use the return to the market portfolio of stocks as a proxy for the market portfolio of all risky assets – even though the regulator itself uses the return to the market portfolio of stocks as a proxy for the market portfolio of all risky assets in using the model. We also note that NERA makes clear in its February 2015 report that whether the model works when one employs the return to the market portfolio of all risky assets is irrelevant to the issue of how the AER should set the return on equity for a regulated energy utility. The AER employs a version of the SL CAPM that uses the market portfolio of stocks as a proxy for the market portfolio of all risky assets. Thus, what is relevant to the issue of how the AER should set the return on equity for a regulated energy utility is whether the version of the SL CAPM that the regulator employs works. NERA states that:[63]

> 'The argument that tests of the SL CAPM 'use a market proxy that does not accord' with the model is irrelevant as we have already pointed out. The AER and its advisors use estimates of beta computed relative to the value-weighted market portfolio of stocks and so do the vast majority of empirical tests.'

The AER and its advisors in their most recent reports do not explicitly criticise NERA and other consultants for using – as the AER does when it uses the SL CAPM – the return to the market portfolio of stocks as a proxy for the return to the market portfolio of all risky assets. The AER does, however, quote a passage from Partington's (2015) report that could easily be interpreted as suggesting that there is something unusual or wrong about the 'reference' portfolio or proxy for the market portfolio of all risky assts that NERA uses.[64] Partington states that:[65]

> 'the results of NERA's various empirical analyses (most recently NERA, 2015) show that the reference portfolio they use is not on the efficient set ex-post. If it were, then there would be a perfect linear relation between the returns on securities and their

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62 AER, *Better regulation: Rate of return guideline – Explanatory Statement (Appendices),* December 2013, page 71.

63 NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015, page 52.

64 AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015, page 239.

65 Partington, G., *Report to the AER Return on equity (updated)*, April 2015, page 25.

> betas calculated relative to the reference portfolio. Empirically, however, this is not the case. Therefore, the reference portfolio is not on the efficient set.'

As we note in section 2, there is an 'if and only if' relation between return/beta linearity and market portfolio mean-variance efficiency. Thus a rejection of the hypothesis that there is the positive linear relation between mean return and beta indicates that the equivalent hypothesis that the reference portfolio or proxy for the market portfolio is mean-variance efficient can also be rejected. NERA's rejection of the two hypotheses does not mean that the wrong reference portfolio has been used. It means that there is evidence that the empirical version of the SL CAPM that the AER employs does not work – that is, the model produces biased estimates of the return required on equity.

3.3. Multifactor Models

Partington (2015) suggests that the concerns that the consultants raise are largely driven by the ability of multifactor pricing models to better explain the cross-section of mean returns. [66] In particular, Partington states that:[67]

> 'The consultants raise concerns with the ability of the CAPM to provide an adequate characterisation of the relationship between risk and return. Their concerns are largely driven by the ability of modern multifactor asset pricing models to provide a more adequate explanation of the cross section of realised average returns.'

The statement is incorrect. It is true that many multifactor pricing models are better able to explain the cross-section of mean returns but it is untrue that the concerns of the consultants about the performance of the SL CAPM are largely confined to this issue. It has been known for well over 40 years that a major flaw with the SL CAPM is that it tends to underestimate the returns required on low-beta equities and we and other consultants have expressed concerns about this low-beta bias numerous times in the past. Moreover, as Fama and French (2014) make clear in a recent paper to which McKenzie and Partington (2014) refer, multifactor models also suffer from a low-beta bias. [68]

3.4. Ray, Savin and Tiwari (2009)

The AER (2013) and McKenzie and Partington (2014) refer to the work of Ray, Savin and Tiwari (2009) who show that the finite-sample distribution of the Wald statistic for a test of the SL CAPM need not conform closely to its theoretical asymptotic distribution. [69] As we explain in section 2, for this reason, NERA in its February 2015 report conducts bootstrap simulations to ensure that inference is correctly drawn. The simulation results reveal that the

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66 Partington, G., *Report to the AER Return on equity (updated)*, April 2015, page 29.

67 Partington, G., *Report to the AER Return on equity (updated)*, April 2015, page 29.

68 Fama, E.F. and K.R. French, *A five-factor asset pricing model*, University of Chicago, IL, March 2014.
McKenzie, M. and G. Partington, *Report to the AER Part A: Return on equity*, SIRCA, October 2014, pages 16-18.

69 AER, *Better Regulation Explanatory Statement Rate of Return Guideline (Appendices)*, December 2013, page 12.
McKenzie, M. and G. Partington, Report to the AER Part A: Return on equity, October 2014, page 9.
Ray, S., N.E. Savin and A. Tiwari, Testing the CAPM revisited, Journal of Empirical Finance, 2009, pages 721-733.

SL CAPM can be rejected at conventional levels of significance regardless of whether inference is based on the finite-sample or theoretical asymptotic distribution of the Wald statistic. Thus NERA responds to the concerns that the AER and McKenzie and Partington raise.

Partington (2015), however, ignores NERA's response and states that: [70]

> 'recent work suggests that the evidence against the CAPM may not be as robust as previously thought. For example, Ray, Savin and Tiwari (2009) show that the statistical evidence for rejecting the CAPM is weaker than previously thought when more appropriate statistical tests are used.'

3.5. Da, Guo and Jagannathan (2012)

In recent work, Da, Guo and Jagannathan (2012) argue that growth options that firms possess may be largely responsible for the weak relation between return and beta. [71] McKenzie and Partington (2014) state that:[72]

> 'Da, Guo and Jagannathan (2012) argue that the empirical evidence against the capital asset pricing model (CAPM) based on stock returns does not invalidate its use for estimating the cost of capital for projects in making capital budgeting decisions. Their argument is that stocks are backed not only by projects in place, but also by the options to modify current projects and even undertake new ones. Consequently, the expected returns on equity need not satisfy the CAPM even when expected returns of projects do. Thus, their findings justify the continued use of the CAPM irrespective as to one's interpretation of the empirical literature on asset pricing.'

NERA in its February 2015 report states that:

> 'What McKenzie and Partington do not explain is that Da, Guo and Jagannathan do not suggest that the SL CAPM be used in the same way that the AER has been using the model. To construct estimates of beta that can be used in project evaluation, unadjusted common or garden estimates of beta have to be adjusted. Da, Guo and Jagannathan (2012) state that:
>
> > 'In general, both the equity risk premium and the equity beta of a firm are complex functions of the firm's project beta and real option characteristics. If we project them on a set of variables capturing the features of real options using linear regressions, the residual risk premium and the residual beta are option-adjusted and more closely resemble the underlying project risk premium and project beta.'
>
> Since beta is a relative measure of risk, an adjustment must be made even to the betas of firms that have no growth options. Da, Guo and Jagannathan construct option-

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[70] Partington, G., *Report to the AER Return on equity (updated)*, April 2015, page 29.

[71] Da, Z., R-J. Guo and R. Jagannathan, *CAPM for estimating the cost of equity capital: Interpreting the empirical evidence*, Journal of Financial Economics, 2012, pages 204-220.

[72] McKenzie, M. and G. Partington, *Report to the AER Part A: Return on equity*, SIRCA, October 2014, pages 9-10.

> adjusted betas as the residuals from a cross-sectional regression, without an intercept, of unadjusted betas on book-to-market, idiosyncratic volatility and the return on assets where the three regressors are measured relative to averages for the market. Neither the AER nor its advisers construct estimates of beta in this way. Thus the evidence that Da, Guo and Jagannathan provide is not relevant to assessing estimates of the cost of equity provided by the empirical version of the SL CAPM that the AER employs.'

In his April 2015 report, Partington ignores what NERA has to say about the work of Da, Guo and Jagannathan and reproduces the comments made in the report of McKenzie and Partington of December 2014. [73] Partington states that: [74]

> 'More importantly, Da, Guo and Jagannathan (2012) argue that the empirical evidence against the capital asset pricing model (CAPM) based on stock returns does not invalidate its use for estimating the cost of capital for projects in making capital budgeting decisions. Their argument is that stocks are backed not only by projects in place, but also by the options to modify current projects and even undertake new ones. Consequently, the expected returns on equity need not satisfy the CAPM even when expected returns of projects do. Thus, their findings justify the continued use of the CAPM irrespective as to one's interpretation of the empirical literature on asset pricing.'

A comparison of this passage with the earlier passage above taken from the December 2014 report of McKenzie and Partington shows that Partington has ignored what NERA had to say about the work of Da, Guo and Jagannathan. The AER has also ignored what NERA had to say because it has quoted the passage from McKenzie and Partington in its Jemena Final Decision of April 2015. [75]

3.6. Characteristics or Risk

There has been some debate in the literature about whether the low-beta bias associated with the SL CAPM represents compensation for risk or market inefficiency. With regards to this issue, Handley states that: [76]

> 'the key point is:
>
> (i) given there are multiple possible (but not necessarily mutually exclusive) explanations for the low beta bias – some of which are risk based explanations and some of which are not; and
>
> (ii) the allowed rate of return objective makes it clear that the rate of return should reflect the risk of the benchmark efficient entity,

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[73] McKenzie, M. and G. Partington, *Report to the AER Part A: Return on equity*, SIRCA, October 2014, pages 9-10.

Partington, G., *Report to the AER Return on equity (updated)*, April 2015, pages 29-30.

[74] Partington, G., *Report to the AER Return on equity (updated)*, April 2015, pages 29-30.

[75] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015, pages 62-63.

[76] Handley, J.C., *Report prepared for the Australian Energy Regulator Further advice on the return on equity*, 16 April 2015, pages 5-6.

> then there is doubt as to whether the empirical finding of a low beta bias is relevant for the purposes of determining an appropriate level of compensation since there is doubt as to whether the low beta bias reflects risk (over and above that already captured by the Sharpe-CAPM).'

In other words, Handley argues that if the low-beta bias does not represent compensation for risk not accounted for by the SL CAPM, then one should ignore the bias in computing an estimate of the cost of equity. That is, one should ignore the evidence that the SL CAPM is wrong.

We note firstly that Fama and French (2004) point out that: [77]

> 'The conflict between the behavioral irrational pricing story and the rational risk story for the empirical failures of the CAPM leaves us at a timeworn impasse. Fama (1970) emphasizes that the hypothesis that prices properly reflect available information must be tested in the context of a model of expected returns, like the CAPM. Intuitively, to test whether prices are rational, one must take a stand on what the market is trying to do in setting prices-that is, what is risk and what is the relation between expected return and risk? When tests reject the CAPM, one cannot say whether the problem is its assumption that prices are rational (the behavioral view) or violations of other assumptions that are also necessary to produce the CAPM (our position).
>
> Fortunately ... when estimating the cost of equity capital, one might be unconcerned with whether expected return premiums are rational or irrational since they are in either case part of the opportunity cost of equity capital (Stein, 1996).'

Thus even if the low-beta bias represents a market inefficiency rather than a compensation for risk not accounted for by the SL CAPM, it should be taken into account in determining the cost of equity – at least unless one can be assured that the bias is a temporary phenomenon.

We note secondly that Rule 87 (3) of the National Gas Rules states that:

> 'The *allowed rate of return objective* is that the rate of return for a service provider is to be commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to the service provider in respect of the provision of reference services (the *allowed rate of return objective*).'

The rule does not state, as Handley asserts, that the rate of return should *reflect* the risk of a benchmark efficient entity – that is, it does not state that the rate of return should constitute *compensation* for risk. The rule states only that the rate of return be *commensurate* with the costs of a benchmark efficient entity with a similar degree of risk – even if some of those costs do not represent compensation for risk, measured in some way. In other words, Rule 87 (3) implies that a benchmark efficient entity should be rewarded on the basis of the costs that it faces and not on the basis of the costs that it would face were some asset pricing model to be true. Thus if the evidence indicates that the market requires firms with low equity betas to deliver returns that are, on average, significantly above those that the SL CAPM indicates that they should deliver, then Rule 87 (3) implies that return on equity provided to low-equity-beta firms should include the

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[77] Fama, Eugene and Kenneth French, *The Capital Asset Pricing Model: Theory and Evidence*, Journal of Economic Perspectives 18, 2004, page 40.

additional costs that the firms face beyond those that they would face were the SL CAPM to be true.

3.7. Black, Brennan and Vasicek Models

The AER and its advisors have characterised the Black CAPM as a more difficult model to use than the SL CAPM because in using the Black CAPM not only must one estimate the equity beta of a firm and the market risk premium but one must also estimate the return required on a zero-beta portfolio. One could also characterise the SL CAPM, though, as a more difficult model to use than a naïve model because in using the SL CAPM not only must one estimate the market risk premium but one must also estimate the equity beta of a firm. One might then ask, as the AER and ERA have not, whether it is in fact worthwhile moving from a simple model which gives unbiased results to a complex model which gives biased result.

A naïve model states that the mean return to an asset and its beta are unrelated. The SL CAPM states that there should be a particular positive linear relation between the mean return to an asset and the beta of the asset. The Black CAPM allows one to use the data to determine what relation exists between mean return and beta across assets. We note that while the AER and its advisors have had little to say about NERA's tests of the SL CAPM and the AER's implementation of the model, they have had nothing whatsoever to say about NERA's tests of a naïve model – even though NERA's tests show that a naïve model outperforms the SL CAPM in delivering unbiased estimates of the return required on equity. Partington (2015), however, has had something to say about NERA's tests of the Black CAPM and it is to these arguments that we now turn.

We begin with some basic issues. Partington (2015) states that:

> 'In mean variance space, the efficient frontier is described by a parabolic shape. The sensitivity of the zero beta return to the choice of a reference portfolio (market proxy) will depend on the curvature of the parabola segment separating alternative reference portfolios. It is curvature that determines the slope of tangents to the parabola. In turn, it is the slope of the tangent to the point represented by the reference portfolio that determines where the tangent cuts the return axis and this intercept determines the magnitude of the return on the zero beta portfolio. The greater the curvature, the greater the resulting difference in the estimated zero beta returns for different reference portfolios.'

This analysis is incorrect. In mean-variance space the efficient frontier is a parabola but the zero-beta rate is not located by drawing a line tangent to the frontier at the point where the reference portfolio sits and seeing where the line cuts the mean return axis. Instead, one must draw a line from the reference portfolio through the global minimum variance portfolio and see where this line cuts the mean return axis. In mean return-standard deviation of return space the efficient frontier is a hyperbola and the zero-beta rate is located by drawing a line tangent to the frontier at the point where the reference portfolio sits and seeing where the line

cuts the mean return axis. These basic issues are covered in chapter 3 of the graduate level text *Foundations of Financial Economics* authored by Huang and Litzenberger. [78]

In its February 2015 report NERA notes that Black (1972) examines a world in which investors face no short-sale restrictions but cannot borrow or lend, Vasicek (1971) examines a world in which investors face no short-sale constraints but cannot borrow and Brennan (1971) examines a world in which investors face no short-sale restrictions and can borrow and lend at risk-free rates that differ from one another. [79] NERA also notes, however, as it has done previously, that all three models – aside from restrictions placed on the zero-beta rate – make the same predictions about the mean returns to risky assets. In addition, NERA notes Black's model is a special case of Vasicek's model and Vasicek's model is a special case of Brennan's model. Vasicek's model is a special case of Brennan's model because if the borrowing rate is sufficiently high, no borrowing will take place. Black's model is a special case of Vasicek's model because if the lending rate is sufficiently low, no lending will take place. NERA also notes, as it has done before, that despite this the three models are often referred to as the Black CAPM and that it too continues to follow this convention.

McKenzie and Partington (2014) are critical of this choice and ask in their recent report for the AER: [80]

> 'why (do) NERA (2012, p.4) and NERA (2013b, p. 6) appear to be treating the Brennan and Black models as substitutes?'

Similarly, Partington (2015) states that: [81]

> 'It is unhelpful to continue to refer to the Black, Vasicek and Brennan models as the 'Black' model. Notwithstanding the lengthy arguments of NERA (2015, pp. 17-18), to the best of our knowledge, there is no general usage, such that the Brennan model is referred to as the Black model. This distinction is important if these models are being considered as supplementary sources of information to augment the SL-CAPM model.
>
> In the Black model calculating a zero beta premium above the risk free rate makes little sense. To compute such a premium we have to estimate a return on Black's minimum variance zero beta portfolio, a return that cannot be directly observed, and then subtract from that a risk free rate that does not exist in the world of the Black CAPM. This hardly seems to be a compelling basis for computing a regulated return.'

There are two points to make about these passages. First, the views that Partington holds in 2015 and the views that McKenzie and Partington held in 2014 were not the views that

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78 Huang, C-F. And R.H. Litzenberger, *Foundations of Financial Economics*, North-Holland, 1988..

79 Black, Fischer, *Capital market equilibrium with restricted borrowing*, Journal of Business 45, 1972, pages 444-454.

Brennan, Michael, *Capital market equilibrium with divergent borrowing and lending rates*, Journal of Financial and Quantitative Analysis 6, 1971, pages 1197-1205.

Vasicek, Oldrich, *Capital market equilibrium with no riskless borrowing*, Memorandum, Wells Fargo Bank, 1971.

80 McKenzie, M. and G. Partington, Report to the AER Part A: Return on equity, October 2014, page 22.

81 Partington, G., *Report to the AER Return on equity (updated)*, April 2015, pages 22-23.

McKenzie and Partington held in 2012 because they state in their first report on the Black CAPM in August 2012 that: [82]

> 'The return on the zero beta portfolio for the Black CAPM should lie between the lending and borrowing rates, which are unlikely (sic) have negative values.'

The current position of Partington – as distinct from the position that he held in August 2012 – is that lending and borrowing rates do not exist in the Black model. The historical position held by Partington – that lending and borrowing rates can exist in what is commonly labelled the Black model – clearly allows for a zero-beta premium to exist. This is because if the risk-free borrowing rate is sufficiently high, no borrowing will take place, there will exist lending at a single risk-free rate and the zero-beta rate will, at least in theory, lie above the risk-free rate.

Second, we note that it is standard practice to estimate the zero-beta rate in excess of the risk-free rate. For example, Ferson and Harvey (1991) and Campbell and Vuolteenaho (2004) estimate zero-beta premiums. Harvey was the editor of the Journal of Finance from 2006 to 2012 while Campbell was President of the American Finance Association in 2005.

Partington (2015) also repeats statements that McKenzie and Partington (2014) make incorrectly attributing statements made by SFG to NERA. [83] Partington states that: [84]

> 'The implication of the Black model under either of his two scenarios is that borrowing cost (sic) are higher when there are restrictions on trading the riskless asset. This differs from the proposition "that investors would have to pay a premium above the risk-free rate when borrowing" as in the scenario where there is no risk-free security, such a statement is meaningless. Only under the Brennan (1971) model is the proposition that restrictions on trading in the riskless security result in the investor having to pay a premium above the risk-free rate when borrowing.
>
> Returning to the arguments of SFG ...'

As NERA notes in its February 2015 report, in this passage McKenzie and Partington appear to suggest that the quote "that investors would have to pay a premium above the risk-free rate when borrowing" is from one of NERA's reports. It is not but is a quote from SFG's (2014) report. [85] SFG quite reasonably, like McKenzie and Partington (2012) uses the label 'Black CAPM' to describe the three very similar models that Black (1972), Vasicek (1971) and Brennan (1971) derive. On a more substantive note, the first and second sentences of the passage above, viewed together, make little sense. The first sentence says that in Black's model borrowing costs are higher while the second sentence says that this is not the same as paying more when borrowing. The third sentence is correct there is nothing to prevent the

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[82] McKenzie, M. and G. Partington, *Review of the NERA report on the Black CAPM*, SIRCA, 24 August 2012, page 214

[83] McKenzie, M. and G. Partington, Report to the AER Part A: Return on equity, October 2014.

[84] Partington, G., *Report to the AER Return on equity (updated)*, April 2015, page 42.

[85] SFG, *Cost of equity in the Black Capital Asset Pricing Model: Report for Jemena Gas Networks, ActewAGL, Networks NSW, Transend, Ergon and SA Power Networks*, May 2014, page 12.

borrowing and lending rates in Brennan's model from being sufficiently high and sufficiently low that all borrowing and lending will cease.

Partington (2015) also notes, as do McKenzie and Partington (2012), that if the reference portfolio or proxy is not mean-variance efficient, then not only will there be more than one way of forming a zero-beta portfolio but the zero-beta portfolios formed can have different mean returns. Partington states, for example, that: [86]

> 'The implication of a reference portfolio that is not on the efficient set is that there is an infinite set of zero beta portfolios with differing returns that can be associated with the reference portfolio. In this case, the zero beta return can be more or less arbitrarily chosen. NERA and SFG restrict the choice by fitting a regression model to the data in order to obtain a single estimate.'

To understand what Partington means it will be helpful to look again at Figure 2.4 which we have reproduced below as Figure 3.1. Again, Figure 3.1 plots the sample mean returns in excess of the risk-free rate on the 55 portfolios, that Lewellen, Nagel and Shanken (2010) use, against estimates of their betas, indicated by the 55 blue markers, together with the relation that Lewellen, Nagel and Shanken estimate exists between mean excess return and beta for the portfolios, again indicated by the red line. [87] As Partington points out, the red regression line is not the only line that one could draw through the scatter plot of blue markers. One could, for example, draw the green dashed line through portfolios A and B. A zero-beta portfolio that is long portfolio A and short portfolio B could be formed that would have a sample mean return of around -2.4 per cent per annum. Clearly, however, the use of an estimate of the zero-beta rate of -2.4 per cent per annum will lead to a poor fit in-sample and is likely to lead to poor predictions of returns. It is for this reason that NERA and SFG follow convention and fit regression models. This means that, although there could be an infinite number of zero-beta premiums, there is only one which provides a best fit to the data, and NERA uses this rate. Again, NERA finds in its February 2015 report that it cannot reject the hypothesis that the Black CAPM delivers unbiased estimates of the returns required on equities. Partington does not mention this fact.

3.8. Reversion Confusion

The AER asks Partington whether the following statement is true:

> 'The Foundation Model approach if applied now (as set out in the Guideline, but with updated market information) would be expected to result in a return on equity estimate that is systematically downwardly biased relative to the true unobservable cost of equity capital of a benchmark efficient entity.'

Partington responds by discussing the evidence on whether estimates of the beta of a benchmark efficient entity are likely to be downwardly biased, and does so by examining evidence of a reversion towards one. He ignores the far more important question of whether

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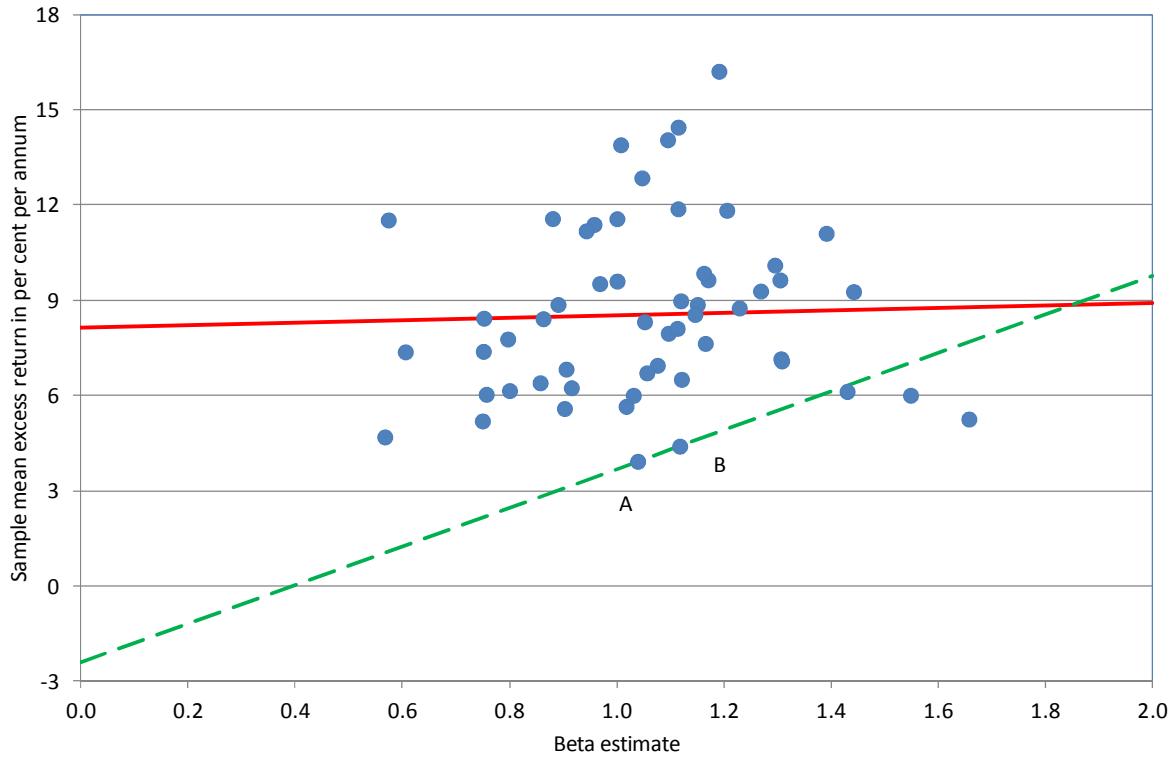
[86] Partington, G., *Report to the AER Return on equity (updated)*, April 2015, page 25.

[87] Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

estimates of the return required on the equity of a benchmark efficient entity that use the SL CAPM are likely to be downwardly biased. He concludes that there is little evidence in the data for mean reversion in betas and so concludes that the use of the SL CAPM will not generate downwardly biased estimates of the cost of equity capital for a benchmark efficient entity. An absence of mean reversion in betas, however, will not be sufficient to guarantee that the use of the SL CAPM will not generate downwardly biased estimates of the cost of equity capital for a benchmark efficient entity.

Figure 3.1
Sample mean excess return against beta estimate for 25 US size and book-to-market sorted portfolios and 30 US industry portfolios: Quarterly data from 1963 to 2004



Notes: Data are from Ken French's web site and are those used by Lewellen, Nagel and Shanken (2010). The red line plots Lewellen, Nagel and Shanken's estimate of the relation between mean return and beta constructed from the 25 portfolios formed on the basis of size and book-to-market and the 30 industry portfolios.

Sources: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Lewellen, J., S. Nagel and J. Shanken, A skeptical appraisal of asset pricing tests, Journal of Financial Economics, 2010, Table 1, pages 188.

3.9. Regulator Usage

Finally, we note that Partington has ignored NERA's analysis of his examination with McKenzie of the use of models by regulators in a number of countries. NERA states that:

'McKenzie and Partington (2014) examine the use of models by regulators in a number of countries and state that:[88]

> 'It remains that (sic) case that the majority of international regulators currently base their decisions primarily on the CAPM framework. (see Table 1).'

Their Table 1 provides a list of the primary and secondary models used by a single regulator in each of six countries. One of the countries is the US and the single regulator chosen is the New York State Public Services Commission. Each state in the US, however, has a public utilities commission as does the District of Columbia and so the table is missing data for 50 US public utilities commissions. Without data for these other public utilities commissions and for regulators from other countries that are also missing it is difficult to see that much weight should be attached to the conclusion that McKenzie and Partington draw.

Another way of assessing the importance to be placed on the choice by regulators in each country of primary and secondary models is to examine the GDP of each country – which should provide a guide as to the relative sizes of the businesses being regulated on aggregate in each country. The CIA Factbook reports that US GDP in 2013 is estimated to be US $16.72 trillion while New Zealand GDP in 2013 is estimated to be US $181.1 billion.[89] This evidence suggests that more weight should be placed on the choices made by US regulators than on regulators in New Zealand. We note that the primary model used by US public utilities commissions is the dividend growth model while the primary model used in New Zealand is the SL CAPM.'

Partington has ignored this analysis.

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88 McKenzie, M. and G. Partington, Report to the AER Part A: Return on equity, October 2014, page 9.

89 https://www.cia.gov/library/publications/the-world-factbook/index.html

Appendix A. Out-Of-Sample Forecasts

This appendix describes how NERA evaluates out-of-sample forecasts generated by the AER CAPM and the Black CAPM.

NERA assumes that the AER acts as if it adjusts an estimate of the equity beta of a regulated energy utility solely on the basis of the principles underpinning the Black CAPM. NERA does so because to evaluate a method for estimating the return required on equity, it must clearly specify the method. Methods that it cannot clearly specify, it cannot evaluate. NERA cannot, for example, evaluate the use by a regulator of its discretion in a way that is not specified and in a way that may vary through time.

To understand how a regulator might adjust an estimate of the equity beta of a regulated energy utility on the basis of the principles underpinning the Black CAPM, recall that the SL CAPM implies that:

$$\mathrm{E}_{t-1}(z_{jt}) = \beta_{jt}\mathrm{E}_{t-1}(z_{mt}) \tag{A.1}$$

where:

$\mathrm{E}_{t-1}(z_{jt})$ = the mean return on risky asset j in excess of the risk-free rate from $t-1$ to t conditional on what is known at $t-1$;

$\mathrm{E}_{t-1}(z_{mt})$ = the mean return to the market portfolio of risky assets in excess of the risk-free rate conditional on what is known at $t-1$

and

$$\beta_{jt} = \frac{\mathrm{Cov}_{t-1}(z_{jt}, z_{mt})}{\mathrm{Var}_{t-1}(z_{mt})}, \tag{A.2}$$

where:

$\mathrm{Cov}_{t-1}(z_{jt}, z_{mt})$ = the covariance between z_{jt} and z_{mt} conditional on what is known at $t-1$; and

$\mathrm{Var}_{t-1}(z_{mt})$ = the variance of z_{mt} conditional on what is known at $t-1$.

The Black CAPM, on the other hand, implies that:

$$\mathrm{E}_{t-1}(z_{jt}) = (1-\beta_{jt})\gamma_{0t} + \beta_{jt}\mathrm{E}_{t-1}(z_{mt}) \tag{A.3}$$

where:

γ_{0t} = the mean return in excess of the risk-free rate on a portfolio that has a zero beta relative to the market portfolio of risky assets – the zero-beta premium.

A regulator using the Black CAPM explicitly would set the cost of equity for a firm equal to:

$$(1-\hat{\beta}_{jt})\hat{\gamma}_{0t}+\hat{\beta}_{jt}\hat{z}_{mt}, \tag{A.4}$$

where a hat denotes a forecast generated from data prior to month *t*. The expression (A.4), however, can also be rewritten as:

$$\beta^{*}_{jt}\hat{z}_{mt}, \tag{A.5}$$

where

$$\beta^{*}_{jt}=\left(1-\frac{\hat{\gamma}_{0t}}{\hat{z}_{mt}}\right)\hat{\beta}_{jt}+\left(\frac{\hat{\gamma}_{0t}}{\hat{z}_{mt}}\right) \tag{A.6}$$

Thus a regulator using the Black CAPM implicitly could use (A.5) to set the cost of equity for a firm instead of (A.4) and would come up with exactly the same result. In other words, the regulator could use the SL CAPM together with an adjusted estimate of the equity beta of a firm to compute the estimate that would have been generated by an explicit use of the Black CAPM. The adjusted estimate of beta is, from (A.6), a weighted average of the unadjusted estimate of beta and one.

To be able to evaluate forecasts of the cost of equity that a regulator would have generated using this scheme, one must know what weight the regulator places on an unadjusted estimate of beta.

In its recent Jemena Draft Decision, the AER states that: [90]

> 'We adopt an equity beta point estimate of 0.7 from a range of 0.4 to 0.7.'

Thus it is reasonable to assume that the AER adjusts upwards an estimate of 0.55 – the midpoint of the range of 0.4 to 0.7 – to 0.7. Simple arithmetic indicates that the AER places a weight of two thirds on an unadjusted estimate of beta and one third on one in deriving its adjusted point estimate of beta. That is:

$$\frac{2}{3}\times 0.55+\frac{1}{3}\times 1=0.7 \tag{A.7}$$

From (A.6), the use of a weight of two thirds on an unadjusted estimate of beta implies that the AER currently acts as if it believes that the zero-beta premium should be one third of the value of the *MRP*. That is:

[90] AER, *Draft decision Jemena Gas Networks (NSW) Ltd Access arrangement 2015–20: Attachment 3: Rate of return*, November 2014, page 267.

$$\left(1-\frac{\hat{\gamma}_{0t}}{\hat{z}_{mt}}\right)=\frac{2}{3}\Rightarrow\hat{\gamma}_{0t}=\frac{1}{3}\hat{z}_{mt} \tag{A.8}$$

Since the AER chooses a value for the *MRP* of 6.5 per cent per annum, then, with the assumptions made, the AER currently acts as if it believes that the zero-beta premium is 2.17 per cent per annum.

NERA labels forecasts generated using the SL CAPM and an estimate of beta that is one third plus two thirds of an unadjusted estimate forecasts generated by the AER CAPM.

NERA also examines forecasts generated by an empirical version of the Black CAPM and follows the scheme outlined above to compute an adjusted estimate of beta for use with the SL CAPM – but instead of relying on 'theory' NERA relies on past empirical evidence.

Appendix B. Terms of Reference

Expert Terms of Reference

The Cost of Equity: A Critical Review of the Analysis of the AER and its Advisors

DBNGP
2016-20 Access Arrangement **2 June 2015**

Since DBP submitted its access proposal in December 2014, a number of East Coast service providers have submitted proposals which contain work by NERA that undertakes similar tests of statistical bias to DBP's model adequacy test. The AER, in its most recent round of Final Decisions, has had the opportunity to consider this evidence, although by its own admission, this consideration has been limited. Please provide an overview of the new evidence presented to the AER, and the AER's consideration of the relevant evidence. In particular:

- describe the differences between the SL CAPM, Black's CAPM, Brennan's CAPM and Vasicek's CAPM; [1]
- describe the tests that NERA (2015) performs of a naïve model, the SL CAPM, the AER CAPM and the Black CAPM; [2]
- review what the AER (2015), Handley (2015) and Partington (2015) have or have not had to say about NERA's (2015) tests; [3]
- explain what the Vasicek adjustment represents;
- explain whether a tendency for estimates of beta to revert to one over time can explain the evidence that NERA (2015) finds against the SL CAPM and the AER CAPM; [4]

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[1] Black, Fischer, *Capital market equilibrium with restricted borrowing*, Journal of Business 45, 1972, pages 444-454.

Brennan, Michael, *Capital market equilibrium with divergent borrowing and lending rates*, Journal of Financial and Quantitative Analysis 6, 1971, pages 1197-1205.

Vasicek, Oldrich, *Capital market equilibrium with no riskless borrowing*, Memorandum, Wells Fargo Bank, 1971.

[2] NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

[3] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015.

Handley, J.C., *Report prepared for the Australian Energy Regulator Further advice on the return on equity*, 16 April 2015.

NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

Partington, G., *Report to the AER Return on equity (updated)*, April 2015.

- explain what issues Ray, Savin and Tiwari (2009) raise, whether DBP (2014) and NERA (2015) address the issues and whether the AER (2015), Handley (2015) and Partington (2015) acknowledge that DBP and NERA have addressed the issues; [5]
- explain what Da, Guo and Jagannathan (2012) have to say, what NERA has to say about what Da, Guo and Jagannathan have to say and whether the AER (2015), Handley (2015) and Partington (2015) acknowledge that NERA has addressed the issues that Da, Guo and Jagannathan raise; [6] and

address any other relevant issues that the AER (2015), Handley (2015) and Partington (2015) raise or do not raise that need to be addressed.

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[4] NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

[5] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015.

DBP, *Proposed Revisions DBNGP Access Arrangement 2016 –2020 Regulatory Period Rate of Return Supporting Submission: 12,* December 2014.

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Partington, G., *Report to the AER Return on equity (updated)*, April 2015.

Ray, S., N.E. Savin and A. Tiwari, *Testing the CAPM revisited*, Journal of Empirical Finance, 2009, pages 721-733.

[6] AER, *Final Decision Ausgrid distribution determination 2015−16 to 2018−19 Attachment 3 – Rate of return*. April 2015.

Da, Z., R-J. Guo and R. Jagannathan, *CAPM for estimating the cost of equity capital: Interpreting the empirical evidence*, Journal of Financial Economics, 2012, pages 204-220.

Handley, J.C., *Report prepared for the Australian Energy Regulator Further advice on the return on equity*, 16 April 2015.

NERA, *Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy*, February 2015.

Partington, G., *Report to the AER Return on equity (updated)*, April 2015.

Appendix C. Federal Court Guidelines

FEDERAL COURT OF AUSTRALIA

Practice Note CM 7

EXPERT WITNESSES IN PROCEEDINGS IN THE FEDERAL COURT OF AUSTRALIA

Practice Note CM 7 issued on 1 August 2011 is revoked with effect from midnight on 3 June 2013 and the following Practice Note is substituted.

Commencement

1. This Practice Note commences on 4 June 2013.

Introduction

2. Rule 23.12 of the Federal Court Rules 2011 requires a party to give a copy of the following guidelines to any witness they propose to retain for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based on the specialised knowledge of the witness (see **Part 3.3 - Opinion** of the *Evidence Act 1995* (Cth)).

3. The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence[91], and to assist experts to understand in general terms what the Court expects of them. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.

Guidelines

1. General Duty to the Court[92]

1.1 An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise.

1.2 An expert witness is not an advocate for a party even when giving testimony that is necessarily evaluative rather than inferential.

1.3 An expert witness's paramount duty is to the Court and not to the person retaining the expert.

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[91] As to the distinction between expert opinion evidence and expert assistance see *Evans Deakin Pty Ltd v Sebel Furniture Ltd* [2003] FCA 171 per Allsop J at [676].

[92] The "*Ikarian Reefer*" (1993) 20 FSR 563 at 565-566.

2. The Form of the Expert's Report[93]

2.1 An expert's written report must comply with Rule 23.13 and therefore must

(a) be signed by the expert who prepared the report; and

(b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and

(c) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge; and

(d) identify the questions that the expert was asked to address; and

(e) set out separately each of the factual findings or assumptions on which the expert's opinion is based; and

(f) set out separately from the factual findings or assumptions each of the expert's opinions; and

(g) set out the reasons for each of the expert's opinions; and

(ga) contain an acknowledgment that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c) above[94]; and

(h) comply with the Practice Note.

2.2 At the end of the report the expert should declare that "[the expert] has *made all the inquiries that* [the expert] *believes are desirable and appropriate and that no matters of significance that* [the expert] *regards as relevant have, to* [the expert's] *knowledge, been withheld from the Court*."

2.3 There should be included in or attached to the report the documents and other materials that the expert has been instructed to consider.

2.4 If, after exchange of reports or at any other stage, an expert witness changes the expert's opinion, having read another expert's report or for any other reason, the change should be communicated as soon as practicable (through the party's lawyers) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court[95].

2.5 If an expert's opinion is not fully researched because the expert considers that insufficient data are available, or for any other reason, this must be stated with an indication that the opinion is no more than a provisional one. Where an expert witness who has prepared a report believes that it may be incomplete or inaccurate without some qualification, that qualification must be stated in the report.

2.6 The expert should make it clear if a particular question or issue falls outside the relevant field of expertise.

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[93] Rule 23.13.

[94] See also *Dasreef Pty Limited v Nawaf Hawchar* [2011] HCA 21.

[95] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565

2.7 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports[96].

3. Experts' Conference

3.1 If experts retained by the parties meet at the direction of the Court, it would be improper for an expert to be given, or to accept, instructions not to reach agreement. If, at a meeting directed by the Court, the experts cannot reach agreement about matters of expert opinion, they should specify their reasons for being unable to do so.

J L B ALLSOP
Chief Justice
4 June 2013

[96] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565-566. See also Ormrod *"Scientific Evidence in Court"* [1968] Crim LR 240

Appendix D. Curriculum Vitae

Simon M. Wheatley

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Blackburn VIC 3130
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Overview

Simon is a consultant and was until 2008 a Professor of Finance at the University of Melbourne. Since 2008, Simon has applied his finance expertise in investment management and consulting outside the university sector. Simon's interests and expertise are in individual portfolio choice theory, testing asset-pricing models and determining the extent to which returns are predictable. Prior to joining the University of Melbourne, Simon taught finance at the Universities of British Columbia, Chicago, New South Wales, Rochester and Washington.

Personal

Nationalities:	U.K. and U.S.
Permanent residency:	Australia

Employment

- Affiliated Industry Expert, NERA Economic Consulting, 2014-
- Special Consultant, NERA Economic Consulting, 2009-2014
- External Consultant, NERA Economic Consulting, 2008-2009
- Quantitative Analyst, Victorian Funds Management Corporation, 2008-2009
- Adjunct, Melbourne Business School, 2008
- Professor, Department of Finance, University of Melbourne, 2001-2008
- Associate Professor, Department of Finance, University of Melbourne, 1999-2001
- Associate Professor, Australian Graduate School of Management, 1994-1999
- Visiting Assistant Professor, Graduate School of Business, University of Chicago, 1993-1994
- Visiting Assistant Professor, Faculty of Commerce, University of British Columbia, 1986

- Assistant Professor, Graduate School of Business, University of Washington, 1984-1993

Education

- Ph.D., University of Rochester, USA, 1986; Major area: Finance; Minor area: Applied statistics; Thesis topic: Some tests of international equity market integration; Dissertation committee: Charles I. Plosser (chairman), Peter Garber, Clifford W. Smith, Rene M. Stulz
- M.A., Economics, Simon Fraser University, Canada, 1979
- M.A., Economics, Aberdeen University, Scotland, 1977

Publicly Available Reports

Review of the Literature in Support of the Sharpe-Lintner CAPM, the Black CAPM and the Fama-French Three-Factor Model A report for Jemena Gas Networks, Jemena Electricity Networks, AusNet Services, Australian Gas Networks, CitiPower, Ergon Energy, Powercor, SA PowerNetworks, and United Energy, March 2015, https://www.aer.gov.au/sites/default/files/United%20Energy%20-%20Submission%20on%20JGN%20draft%20decision%20-%20NERA%20Sharpe-Lintner%20Black%20CAPMs%20-%2027%20March%202015.pdf

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The Fama-French Three-Factor Model: A report for the Energy Networks Association, October 2013, http://www.aer.gov.au/sites/default/files/Essential%20Energy%20-%20Attachment%207.9_NERA_The%20Fama-French%20Three-Factor%20Model%20-%202014.pdf

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AER's Proposed WACC Statement – Gamma: A report for the Joint Industry Associations, 30 January 2009, http://www.aer.gov.au/content/item.phtml?itemId=726698&nodeId=80cf978278d317e99c34ae1878525573&fn=JIA%20Appendix%20Q%20-%20NERA%20-%20AER's%20proposed%20WACC%20statement-Gamma.pdf

The Value of Imputation Credits: A report for the ENA, Grid Australia and APIA, 11 September 2008, http://www.ena.asn.au/udocs/24092008aersub/Appendix%20K%20-%20The%20value%20of%20imputation%20credits%20-%20NERA.pdf

Consulting Experience

NERA, 2008-present

Lumina Foundation, Indianapolis, 2009

Industry Funds Management, 2010

Academic Publications

Imputation credits and equity returns, (with Paul Lajbcygier), 2012, *Economic Record* 88, 476-494.

Do measures of investor sentiment predict returns? (with Robert Neal), 1998, *Journal of Financial and Quantitative Analysis* 33, 523-547.

Adverse selection and bid-ask spreads: Evidence from closed-end funds (with Robert Neal), 1998, *Journal of Financial Markets* 1, 121-149.

Shifts in the interest-rate response to money announcements: What can we say about when they occur? (with V. Vance Roley), 1996, *Journal of Business and Economic Statistics* 14, 135-138.

International investment restrictions and closed-end country fund prices, (with Catherine Bonser-Neal, Greggory Brauer, and Robert Neal), 1990, *Journal of Finance* 45, 523-547 (reprinted in International Capital Markets Volume III, 2003, G. Andrew Karolyi and Rene M. Stulz, editors, Edward Elgar Publishing, Cheltenham, Glos).

A critique of latent variable tests of asset pricing models, 1989, *Journal of Financial Economics* 21, 177-212.

Some tests of international equity market integration, 1988, *Journal of Financial Economics* 21, 177-212 (reprinted in International Capital Markets Volume I, 2003, G. Andrew Karolyi and Rene M. Stulz, editors, Edward Elgar Publishing, Cheltenham, Glos).

Some tests of the consumption-based asset pricing model, 1988, *Journal of Monetary Economics* 22, 193-215.

Working Papers

An evaluation of some alternative models for pricing Australian stocks (with Paul Lajbcygier), 2009.

Intertemporal substitution, small-sample bias, and the behaviour of U.S. household consumption (with Kogulakrishnan Maheswaran and Robert Porter), 2007.

Keeping up with the Joneses, human capital, and the home-equity bias (with En Te Chen), 2003.

Evaluating asset pricing models, 1998.

Time-non-separable preferences or artifact of temporal aggregation? (with Robert Porter), 2002.

Testing asset pricing models with infrequently measured factors, 1989.

Refereeing Experience

Referee for Accounting and Finance, the Australian Journal of Management, Economic Letters, Financial Analysts Journal, Financial Management, Journal of Accounting and Economics, Journal of Business, Journal of Empirical Finance, Journal of Finance, Journal of Financial and Quantitative Analysis, Journal of Financial Economics, Journal of Futures Markets, Journal of International Economics, Journal of International Money and Finance, Journal of Money, Credit, and Banking, Journal of Monetary Economics, Management Science, National Science Foundation, Pacific-Basin Finance Journal, and the Review of Financial Studies.

Program Committee for the Western Finance Association in 1989 and 2000.

Teaching Experience

International Finance, Melbourne Business School, 2008

Corporate Finance, International Finance, Investments, University of Melbourne, 1999-2008

Corporate Finance, International Finance, Investments, Australian Graduate School of Management, 1994-1999

Investments, University of Chicago, 1993-1994

Investments, University of British Columbia, 1986

International Finance, Investments, University of Washington, 1984-1993

Investments, Macroeconomics, Statistics, University of Rochester, 1982

Accounting, 1981, Australian Graduate School of Management, 1981

Teaching Awards

MBA Professor of the Quarter, Summer 1991, University of Washington

Computing Skills

User of SAS since 1980. EViews, Excel, EXP, LaTex, Matlab, Powerpoint, Visual Basic. Familiar with the Australian School of Business, Compustat and CRSP databases. Some familiarity with Bloomberg, FactSet and IRESS.

Board Membership

Anglican Funds Committee, Melbourne, 2008-2011

Honours

Elected a member of Beta Gamma Sigma, June 1986.

Fellowships

Earhart Foundation Award, 1982-1983

University of Rochester Fellowship, 1979-1984

Simon Fraser University Fellowship, 1979

Inner London Education Authority Award, 1973-1977

Report qualifications/assumptions and limiting conditions

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Information furnished by others, upon which all or portions of this report are based, is believed to be reliable but has not been independently verified, unless otherwise expressly indicated. Public information and industry and statistical data are from sources we deem to be reliable; however, we make no representation as to the accuracy or completeness of such information. The findings contained in this report may contain predictions based on current data and historical trends. Any such predictions are subject to inherent risks and uncertainties. NERA Economic Consulting accepts no responsibility for actual results or future events.

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All decisions in connection with the implementation or use of advice or recommendations contained in this report are the sole responsibility of the client. This report does not represent investment advice nor does it provide an opinion regarding the fairness of any transaction to any and all parties.

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