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Economists

# The Cost of Equity and the Low-Beta Bias

A Report for Multinet

November 2016

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## Disclaimer

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# Executive Summary

The evidence indicates that the equity of a benchmark efficient entity has a low beta – that is, a beta less than one – and that estimates of the return required on a low-beta asset, delivered by the Sharpe-Lintner (SL) Capital Asset Pricing Model (CAPM), are biased downwards. Both the Australian Energy Regulator (AER) and the Australian Competition Tribunal (ACT) acknowledge that in past data the SL CAPM underestimates the returns to low-beta assets.

The AER, in its 2013 *Rate of Return Guidelines*, notes that departures from the assumptions underpinning the SL CAPM can lead the relation between mean return and beta to be flatter than the relation that the SL CAPM predicts should hold between the two quantities.[1] So the AER, in its *Guidelines* and in its most recent decision, chooses an equity beta point estimate of 0.70 from a range of 0.40 to 0.70.[2] In other words, the AER chooses as an estimate of the equity beta of a benchmark efficient entity a number, 0.70, that lies above the midpoint, 0.55, of its range of 0.40 to 0.70. In its 2016 Public Interest Advocacy Centre (PIAC) and Ausgrid decision, the ACT rejects a submission by the PIAC challenging the AER's decision to choose an equity beta point estimate from the top of the AER's range for the equity beta of a benchmark efficient entity and instead supports the idea that a low-beta bias is associated with estimates of the return required on equity produced by the SL CAPM.[3]

Multinet has provided HoustonKemp with a best estimate of the equity beta of a benchmark efficient entity, based on data that are more recent than the data on which the AER's range is based, of 0.70. This best estimate, which has not been adjusted in any way, lies above the midpoint of the AER's range, which is, again, based on older data. Multinet has, consequently, asked HoustonKemp, in light of the new empirical evidence that it has assembled, to assess what adjustments should now be made to estimates of the return required on the equity of a benchmark efficient entity, delivered by the SL CAPM, for the estimates to exhibit no significant bias.

In particular, Multinet has asked HoustonKemp to:

(a) determine the smallest fraction of an estimate of the equity's alpha that, when added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit, in past data, significant bias; and

(b) determine the weighted average of an ordinary least squares (OLS) estimate of the equity's beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit, in past data, significant bias.

An equity's alpha is the systematic error with which the SL CAPM measures the equity's mean return. An equity's beta is a measure of the equity's systematic risk.

Multinet has also asked HoustonKemp to review the evidence on the existence of a low-beta bias and to address issues about the low-beta bias raised by the AER, the Economic Regulation Authority (ERA) and advisers to the two regulators in recent decisions and reports.[4] In particular, Multinet has asked

[1] AER, *Better regulation explanatory statement: Rate of return guideline (Appendices),* December 2013, pages 70-71.

[2] AER, *Better regulation explanatory statement: Rate of return guideline (Appendices),* December 2013, page 35.

AER, *Draft decision AusNet Services transmission determination 2017-18 to 2021-22: Attachment 3 – Rate of return*, July 2016, page 63.

[3] Australian Competition Tribunal, *Applications by Public Interest Advocacy Centre Ltd and Ausgrid [2016] ACompT 1*, paragraphs 731 and 779.

[4] The term 'low-beta bias' was coined by the AER's adviser, Handley, in a 2011 report for the regulator. The term has since been adopted by the ACT, the AER, the ERA, advisers to the regulators and consultants to the regulated businesses.

Handley, J., *Peer review of draft report by Davis on the cost of equity*, University of Melbourne, January 2011, page 2.

HoustonKemp to assess the view, recently adopted by the ERA – though not by the AER – that regulators should not use evidence of a low-beta bias in setting the cost of equity for a benchmark efficient entity. [5]

## Empirical Results

We begin by testing whether forecasts generated by four models are unbiased. These models are a naïve model, the SL CAPM, a regression model and the AER's implementation of the CAPM. A naïve model presumes that the mean return on every risky asset is identical – or, equivalently, that the SL CAPM is true and that the beta of every risky asset is one. We test these models because estimates of the return required on a benchmark efficient entity that use the SL CAPM and alpha adjustments are weighted averages of estimates delivered by the SL CAPM and a regression model while estimates of the return that use the SL CAPM and beta adjustments are weighted averages of estimates delivered by the SL CAPM and a naïve model. The AER forms a range of 0.40 to 0.70 for the equity beta of a benchmark efficient entity but chooses as its point estimate 0.70. This suggests that, in choosing a point estimate, the AER effectively places a weight of two thirds on the midpoint of its range of 0.55 and a weight of one third on one.

Our empirical work uses 10 portfolios formed on the basis of past estimates of beta. Employing monthly data provided by SIRCA, we assess out-of-sample return forecasts from January 1979 to December 2015 that use, at each point in time, only past data.[6] We find that forecasts generated by a naïve model and by a regression model exhibit no significant bias while forecasts generated by the SL CAPM and by the AER's implementation of the SL CAPM are biased. In particular, we find that forecasts generated by the SL CAPM and the AER's implementation of the SL CAPM exhibit, for low-beta assets, a downwards bias that is significant at conventional levels. This evidence suggests that were the AER to use the SL CAPM to estimate the cost of equity for a benchmark efficient entity and to adopt the approach employed in its *Guidelines* to adjust Multinet's new estimate of the entity's equity beta of 0.70, it is likely that the regulator would produce an estimate of the cost of equity for the entity that would be downwardly biased.

We determine in two ways the smallest fraction of an estimate of the equity alpha of a benchmark efficient entity that, when added to a forecast, delivered by the SL CAPM, of the required return to the entity's equity, will ensure that the forecast of the return does not exhibit, in past data, significant bias.

First, using individual portfolios separately, we determine from past data the smallest fraction of an OLS estimate of alpha that, when added to a return forecast, delivered by the SL CAPM, will ensure that the forecast of the return does not exhibit bias that is statistically significant at conventional levels. We determine the fraction to lie between 0.31 and 0.43. It follows from the estimates that we produce and by interpolation that, for an equity that has a beta of 0.70, the smallest fraction of a current OLS estimate of the equity's alpha that, when added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias will lie between 1.46 per cent per annum and 1.58 per cent per annum.

Second, using all portfolios simultaneously, we determine the smallest fraction of each estimate of alpha that, when added to each return forecast, delivered by the SL CAPM, of the required return to each of the 10 portfolios, will ensure that each forecast does not exhibit significant bias. We determine the fraction to be 0.27. It follows from the estimates that we produce and by interpolation that, for an equity that has a beta of 0.70, an alternative value for the smallest fraction of a current OLS estimate of the equity's alpha that, when added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias will lie between 1.14 per cent per annum and 1.17 per cent per annum.

Choosing the lower limits of the two ranges that we produce – to be conservative – we conclude that, for an equity that has a beta of 0.70, the smallest fraction of a current OLS estimate of the equity's alpha that, when

[5] ERA, *Final Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020 Submitted by DBNGP (WA) Transmission Pty Limited Appendix 4 Rate of Return*, June 2016, page 99.

[6] These data are provided to SIRCA by the Australian Securities Exchange. SIRCA Australian Share Price and Price Relative information supplied by RoZetta Technology Pty Ltd (www.rozettatechnology.com).

added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias will lie between 1.14 per cent per annum and 1.46 per cent per annum.

We note that estimators of the return required on equity that use tests to determine what weight to place on a restricted estimator and what weight to place on an unrestricted estimator are pre-test estimators and will be biased if a low-beta bias exists. In particular, they will be downwardly biased estimators of the returns required on low-beta assets if a low-beta bias exists. Thus estimates of the return required on a benchmark efficient entity that use the estimators are likely to be conservative in the sense that use of the estimates will provide regulated firms with returns that are on average too low.

We also determine in two ways the weighted average of an OLS estimate of the equity beta of a benchmark efficient entity and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the required return to the entity's equity, will ensure that the forecast of the return does not exhibit, in past data, significant bias.

First, using individual portfolios separately, we determine the weighted average of each OLS estimate of beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the required return to a portfolio, will ensure that the forecast does not exhibit significant bias. We determine the weight on the estimate to lie between zero and 0.29. It follows from the estimates that we produce and by interpolation that, for an equity that has a beta of 0.70, the minimum uplift applied to a current OLS estimate of the equity's beta that will ensure that a forecast of the return on equity that uses the SL CAPM does not exhibit significant bias will be 0.27. The AER in its most recent decision adopts a value for the market risk premium (*MRP*) of 6.50 per cent per annum. With this value for the *MRP*, an uplift of 0.27 to beta will correspond to an uplift of 1.75 per cent per annum to the cost of equity otherwise determined by the SL CAPM.

Second, using all portfolios simultaneously, we determine the weighted average of each OLS estimate of beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the required return to each portfolio, will ensure that each forecast does not exhibit significant bias. We determine the weight to be 0.44. It follows from the estimates that we produce and by interpolation that, for an equity that has a beta of 0.70, the minimum uplift applied to a current OLS estimate of the equity's beta that will ensure that a forecast of the return on equity that uses the SL CAPM does not exhibit significant bias will be 0.17. With a value for the *MRP* of 6.50 per cent per annum, an uplift of 0.17 to beta will correspond to an uplift of 1.10 per cent per annum to the cost of equity otherwise determined by the SL CAPM.

We conclude that, for an equity that has a beta of 0.70, the minimum uplift applied to a current OLS estimate of the equity's beta that will ensure that a forecast of the return on equity that uses the SL CAPM does not exhibit significant bias will lie between 0.17 and 0.27. With a value for the *MRP* of 6.50 per cent per annum, an uplift of between 0.17 and 0.27 to beta will correspond to an uplift of between 1.10 and 1.75 per cent per annum to the cost of equity otherwise determined by the SL CAPM.

Estimators of the return required on equity produced in this way are also pre-test estimators and are likely to be biased downwards if a low-beta bias exists. Thus estimates of the return required on a benchmark efficient entity that use the estimators are also likely to be conservative in the sense that use of the estimates will provide regulated firms with returns that are on average too low.

## Issues Raised by the AER, ERA and their Advisers

The ERA argues that theory suggests that deviations from the SL CAPM will be bid away.[7] We point out that this argument is incorrect and that one cannot rule out significant deviations from the SL CAPM on

[7] ERA, *Final Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020 Submitted by DBNGP (WA) Transmission Pty Limited Appendix 4 Rate of Return*, June 2016, page 64.

theoretical grounds. First, both NERA and SFG make clear that the use of a portfolio of stocks as a proxy for the market portfolio of all risky assets may be responsible for the deviations from the SL CAPM that one observes in the data.[8] Second, the recent work of Hong and Sraer (2016) shows that when investors face short-sale constraints and do not share the same beliefs, significant deviations from the SL CAPM can appear in the data even in the absence of measurement problems.[9] In particular, Hong and Sraer show that under these conditions there can be, at least for some assets, a negative, rather than a positive, relation between mean return and beta.

Partington and Satchell acknowledge that the weight of academic opinion takes the evidence to be against the SL CAPM but suggest that regulators should set aside the evidence.[10] Partington and Satchell argue that deviations from the SL CAPM may represent disequilibria in the capital markets.[11] We emphasise that there are strong forces in the capital markets that will prevent deviations from equilibrium from lasting for very long. In particular, we point out that it is not credible that the returns that investors require on low-beta assets have been sitting below the expected returns on the assets for the last 40 years.

Partington and Satchell argue, in addition, that even were the SL CAPM to be true, one would expect to see evidence of a low-beta bias in past data because OLS estimators of the intercept and slope coefficient in a simple regression will be, by construction, negatively correlated with one another when the mean of the independent variable is positive.[12] First, we show that their analysis is incorrect – they provide the wrong formula for the covariance between the two estimators. Second, using the correct formula, we show that the impact of the negative relation to which Partington and Satchell refer is too small to explain the low-beta bias, associated with estimates of the returns that investors require that use the SL CAPM, which appears in the data.

Finally, Partington and Satchell claim that the method that we use to evaluate forecasts of returns presumes that investors have perfect foresight.[13] We show this claim to be incorrect and demonstrate that the method that we use presumes only that regulators are rational.

[8] NERA, *Return on Capital of a Regulated Electricity Network: A report for Ashurst*, May 2014, page 82.

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

[9] Hong, H. and D.A. Sraer, *Speculative betas*, Journal of Finance, 2016, pages 2095-2144.

[10] Partington, G. and S. Satchell, *Report to the AER: Return of (sic) equity and comment on submissions in relation to JGN*, May 2015, page 9.

Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, pages 15-16.

[11] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, pages 7, 15 and 34.

[12] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, pages 17-18.

[13] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, page 20.

# 1. Introduction

The evidence indicates that the equity of a benchmark efficient entity has a low beta – that is, a beta less than one – and that estimates of the return required on a low-beta asset, delivered by the Sharpe-Lintner (SL) Capital Asset Pricing Model (CAPM), are biased downwards. Both the Australian Energy Regulator (AER) and the Australian Competition Tribunal (ACT) acknowledge that in past data the SL CAPM underestimates the returns to low-beta assets.

The AER, in its 2013 *Rate of Return Guidelines*, notes that departures from the assumptions underpinning the SL CAPM can lead the relation between mean return and beta to be flatter than the relation that the SL CAPM predicts should hold between the two quantities.[14] So the AER, in its *Guidelines* and in its most recent decision, chooses an equity beta point estimate of 0.70 from a range of 0.40 to 0.70.[15] In other words, the AER chooses as an estimate of the equity beta of a benchmark efficient entity a number, 0.70, that lies above the midpoint, 0.55, of its range of 0.40 to 0.70. In its 2016 Public Interest Advocacy Centre (PIAC) and Ausgrid decision, the ACT rejects a submission by the PIAC challenging the AER's decision to choose an equity beta point estimate from the top of the AER's range for the equity beta of a benchmark efficient entity and instead supports the idea that a low-beta bias is associated with estimates of the return required on equity produced by the SL CAPM.[16]

Multinet has provided HoustonKemp with a best estimate of the equity beta of a benchmark efficient entity, based on data that are more recent than the data on which the AER's range is based, of 0.70. This best estimate, which has not been adjusted in any way, lies above the midpoint of the AER's range, which is, again, based on older data. Multinet has, consequently, asked HoustonKemp, in light of the new empirical evidence that it has assembled, to assess what adjustments should now be made to estimates of the return required on the equity of a benchmark efficient entity, delivered by the SL CAPM, for the estimates to exhibit no significant bias.

In particular, Multinet has asked HoustonKemp to:

(a) determine the smallest fraction of an estimate of the equity's alpha that, when added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias; and

(b) determine the weighted average of an ordinary least squares (OLS) estimate of the equity's beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias.

An equity's alpha is the systematic error with which the SL CAPM measures the equity's mean return. An equity's beta is a measure of the equity's systematic risk.

Multinet has also asked HoustonKemp to review the evidence on the existence of a low-beta bias and to address issues about the low-beta bias raised by the AER, the Economic Regulation Authority (ERA) and advisers to the two regulators in recent decisions and reports.[17]

[14] AER, *Better regulation explanatory statement: Rate of return guideline (Appendices),* December 2013, pages 70-71.

[15] AER, *Better regulation explanatory statement: Rate of return guideline (Appendices),* December 2013, page 35.

AER, *Draft decision AusNet Services transmission determination 2017-18 to 2021-22: Attachment 3 – Rate of return*, July 2016, page 63.

[16] Australian Competition Tribunal, *Applications by Public Interest Advocacy Centre Ltd and Ausgrid [2016] ACompT 1*, paragraphs 731 and 779.

[17] The term 'low-beta bias' was coined by the AER's adviser, Handley in a 2011 report for the regulator. The term has since been adopted by the ACT, the AER, the ERA, advisers to the regulators and consultants to the regulated businesses.

The rest of the report is organised as follows:

- section 2 reviews the evidence on the existence of a low-beta bias;
- section 3 describes the methodology that we use in determining what adjustments one must make to the SL CAPM to ensure that estimates of the return required on equity, delivered by the model, exhibit no significant bias in past data;
- section 4 provides evidence on the adjustments that one must make to the SL CAPM to ensure that estimates of the return required on equity, delivered by the model, exhibit no significant bias; and
- section 5 responds to issues that the AER, the ERA and advisers to the two regulators raise about the cost of equity and the low-beta bias.

In addition:

- Appendix A1 provides the terms of reference for this report;
- Appendix A2 provides a copy of the Federal Court of Australia's *Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia*; and
- Appendix A3 provides the curriculum vitae of the author of the report.

## Statement of Credentials

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

**Simon Wheatley** is a Special Adviser to HoustonKemp and was until 2008 a Professor of Finance at the University of Melbourne. Since 2008, Simon has applied his finance expertise in consulting and investment management outside the university sector. Simon's interests and expertise are in how assets are priced. 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 Multinet in the past. However, I remain at arm's length, and as an independent consultant.

Australian Competition Tribunal, *Applications by Public Interest Advocacy Centre Ltd and Ausgrid [2016] ACompT 1*, paragraph 731.

AER, *Final decision Envestra Ltd Access arrangement proposal for the SA gas network 1 July 2011 – 30 June 2016*, June 2011, page 44.

ERA, *Appendices to the Explanatory Statement for the Rate of Return Guidelines*, December 2013, page 64.

Handley, J., *Peer review of draft report by Davis on the cost of equity*, University of Melbourne, January 2011, page 2.

NERA, *Cost of equity in the ERA DBNGP draft decision: A report for DBNGP*, May 2011, page 38.

Partington, G. and S. Satchell, *Report to the AER: Analysis of criticism of 2015 determinations*, October 2015, page 22.

# 2. Review of Existing Evidence

Investors will only invest in a regulated energy utility if the return that they can expect to earn is competitive with the return that they require on investments of similar risk. Regulators are charged with setting the rates of return that investors in regulated firms can expect to earn and, in setting these rates, regulators often use asset pricing models. Asset pricing models can allow regulators to compute estimates of the returns that investors require that may be more precise than alternative estimates.[18] While the estimates may be more precise, however, they may also be biased.

While both regulated and unregulated firms use pricing models to construct estimates of the return required on equity, the costs of choosing a model that delivers a poor estimate of the return will in general be far greater for a regulated firm than for an unregulated firm. As Grout (1995) makes clear:[19, 20]

> 'For non-regulated activity prices are not directly dependent of the cost of capital. Firms aim to maximize profit and the precise value of the cost of capital, since it is used as a hurdle rate, will only affect the marginal projects. If the cost of capital is mistakenly set too high then some marginal projects that are good are rejected and if it is too low then some bad projects are accepted. However, almost all will be unaffected by the exact value that is attached to the cost of capital. In contrast, for regulated activities almost all regulated prices will be affected by the cost of capital. If the cost of capital is over-estimated then the price of all these activities will be set too high, and if it is under-estimated then all prices will be too low. Obviously, the relationship will be stronger and more direct for rate of return regulation than for price cap regulation, but the general principle holds good. *The economic implications of errors in the cost of capital are far greater in the regulated sector than in the private non-regulated sector and, not surprisingly, the pressure to provide precise estimates is greater both from the regulators and those within the regulated industries than in the private non-regulated sector.*'
>
> [The emphasis is ours]

A poor estimate for the return required on equity will affect all of a regulated firm's activities while a poor estimate for the return will affect only the projects that an unregulated firm may or may not undertake that are marginal. It is important, therefore, that in computing an estimate of the return required on equity the AER not use a model that, empirically, delivers biased estimates.

The AER has for many years used the SL CAPM to estimate the return required on the equity of a benchmark efficient entity. There is, however, a considerable amount of evidence that indicates that estimates of the return required on equity, produced by the model, are biased. In particular, there is a considerable amount of evidence that indicates that estimates of the returns required on low-beta equities, delivered by the model, are biased downwards. The AER and its advisers acknowledge that this evidence exists.

[18] Asset pricing models can allow regulators to compute estimates of the returns that investors require that may be more precise than alternative estimates because the models impose restrictions on the cross-section of mean returns.

[19] Grout, P., *The cost of capital in regulated industries*, in M. Bishop, J. Kay and C. Mayer (eds.), The regulatory challenge, Oxford University Press, 1995, pages 386-407.

[20] It is obvious that here Grout intends a 'precise estimate' to be an accurate estimate rather than solely an estimate to which is attached a low standard error.

The Oxford Dictionary definition of precision is 'accuracy or exactness'. In statistics the precision of a random variable is the reciprocal of its variance. So in statistics a precise estimator can be exact but inaccurate.

Davidson, R. and J. G. MacKinnon, *Estimation and inference in econometrics*, Oxford University Press, Oxford, 1993, page 144.

Fowler, F.G. and H.W. Fowler, *Pocket Oxford Dictionary*, Oxford University Press, Oxford, 1966, page 623.

The AER, for example, in a recent decision states that:[21]

> 'We acknowledge that the Sharpe-Lintner CAPM tests poorly using ex post returns data, and appears to underestimate the ex post returns for businesses with an equity beta less than one.'

The AER's advisers, Partington and Satchell state that:[22]

> 'Despite the difficulties in testing the CAPM, referred to above, it would be fair to say that a substantial weight of academic opinion takes the evidence to be against the CAPM.'

while Satchell, in work with Muijsson and Fishwick, is more explicit and states that:[23]

> 'One of the observations over the cross section of stocks is that the historical risk-return trade-off is flat or inverted: within the CAPM, we would expect that stocks with high systemic risk would outperform their low risk counterparts, but results have shown otherwise.'

The ACT also acknowledges that evidence of a low-beta bias exists. The ACT, in its 2016 PIAC and Ausgrid decision, states that: [24]

> 'It is, as the AER noted, correct that the three parameters for the SL CAPM – equity beta, risk free rate, and MRP – are recorded as giving a low beta bias for businesses with a beta (that is, the risk of the asset relative to the average asset) of less than 1.0, and that the Network Applicants are all within that group.'

In this section, we briefly review the evidence of a low-beta bias. It will be helpful first, however, to review the theory behind the SL CAPM. A review of the theory will reveal on what assumptions the SL CAPM relies and the difficulties that one faces in using the SL CAPM.

## 2.1 Theory

In the SL CAPM, risk-averse investors: [25]

(i) choose between portfolios on the basis of the mean and variance of each portfolio's return measured over a single period; [26]

(ii) share the same investment horizon and beliefs about the distribution of returns;

(iii) face no taxes (or the same rate of tax on all forms of income) and no transaction costs; and

(iv) can borrow or lend freely at a single risk-free rate.

These assumptions are, of course, unrealistic. Investors almost surely look more than a single period ahead in making their investment decisions. Investors do not share the same beliefs. Investors face taxes and transaction costs and investors face lending rates and borrowing rates that differ.

Nevertheless, with these assumptions, all investors will hold a portfolio that is mean-variance efficient or, identically, a portfolio that has the highest possible Sharpe ratio. A portfolio's Sharpe ratio is the ratio of the mean return to the portfolio in excess of the risk-free rate to the portfolio's risk, measured by standard

[21] AER, *Draft decision AusNet Services transmission determination 2017-18 to 2021-22: Attachment 3 – Rate of return*, July 2016, page 167.

[22] Partington, G. and S. Satchell, *Report to the AER: Return of (sic) equity and comment on submissions in relation to JGN*, May 2015, page 9.

[23] Muijsson, C., E. Fishwick and S. Satchell, *The low beta anomaly and interest rates*, in J. Emmanuel (ed.), Risk-based and factor investing, Elsevier, 2016, page 305.

[24] Australian Competition Tribunal, *Applications by Public Interest Advocacy Centre Ltd and Ausgrid [2016] ACompT 1*, paragraph 731.

[25] Sharpe won the Nobel Prize in Economics in 1990.

[26] Investors who are expected utility maximisers will only care about the mean and variance of each portfolio's return if they display quadratic utility or if returns are multivariate normally distributed. See Ingersoll (1987).

Ingersoll, J., *Theory of financial decision making*, Rowman & Littlefield, 1987, pages 95-97.

deviation of return.[27] It is the ratio of what is good about a portfolio to what is bad about the portfolio and is a measure of portfolio performance.

In the SL CAPM, some investors combine the portfolio that has the highest Sharpe ratio with risk-free borrowing while some combine the portfolio with risk-free lending. All investors, though, because they share the same beliefs, hold the same portfolio of risky assets and no other. So, for markets to clear, the portfolio of risky assets that investors hold must be the market portfolio of risky assets. Thus the SL CAPM predicts that the market portfolio of risky assets must be mean-variance efficient or, identically, must have the highest possible Sharpe ratio.

The fact that in the SL CAPM the market portfolio must be mean-variance efficient has important implications. To understand what these implications are, it will be useful to consider the following regression:

$$z_{jt} = \alpha_{jt} + \beta_{jt} z_{pt} + \varepsilon_{jt} \qquad (1)$$

where:

| | | |
|---|---|---|
| $z_{jt}$ | = | the return from $t-1$ to $t$ to risky asset $j$ in excess of the risk-free rate; |
| $\alpha_{jt}$ | = | the intercept of the regression; |
| $\beta_{jt}$ | = | the slope coefficient of the regression; |
| $z_{pt}$ | = | the return to portfolio $p$ in excess of the risk-free rate; and |
| $\varepsilon_{jt}$ | = | a zero-mean disturbance that is uncorrelated with $z_{pt}$. |

The regression parameters $\alpha_{jt}$ and $\beta_{jt}$ can be given economic interpretations. $\alpha_{jt}$ measures whether adding a small position in asset $j$ to portfolio $p$ will create a new portfolio that has a higher Sharpe ratio than $p$ and is another measure of performance.[28] If $\alpha_{jt} > 0$ ($\alpha_{jt} < 0$), adding a small position in asset $j$ to portfolio $p$ will create a new portfolio with a higher (lower) Sharpe ratio.

$\beta_{jt}$ measures the contribution of asset $j$ to the risk, measured by standard deviation of return, of portfolio $p$. If $\beta_j > 1$ ($\beta_j < 1$), adding a small position in asset $j$ to portfolio $p$ will create a new portfolio with more (less) risk, measured by the standard deviation of return.

If the market portfolio of risky assets has the highest Sharpe ratio – that is, if the market portfolio is mean-variance efficient – then one cannot add a position in an asset to the portfolio to create a new portfolio with a higher Sharpe ratio. If one could do so, then the market portfolio would not be efficient.

So if the SL CAPM is true, each asset's alpha computed relative to the market portfolio must be zero. In other words, if the SL CAPM is true, then the following simple condition must hold:

$$\mathrm{E}_{t-1}(z_{jt}) = \beta_{jt} \mathrm{E}_{t-1}(z_{mt}) \qquad (2)$$

where:

| | | |
|---|---|---|
| $\mathrm{E}_{t-1}(z_{jt})$ | = | the mean return from $t-1$ to $t$ to risky asset $j$ in excess of the |

[27] The standard deviation of the return to a portfolio is the square root of the variance of the return to the portfolio.

[28] An asset's alpha can be a sensible measure of performance if one intends to add the asset to a portfolio. It will not be a sensible measure of performance if one intends to hold the asset alone. In contrast, an asset's Sharpe ratio can be a sensible measure of performance if one intends to hold the asset alone. An asset's Sharpe ratio will not be a sensible measure of performance if one intends to add the asset to another portfolio.

risk-free rate conditional on what is known at $t-1$;

$E_{t-1}(z_{mt})$ = the mean return to the market portfolio of risky assets in excess of the risk-free rate conditional on what is known at $t-1$, that is, the market risk premium (*MRP*).

As Roll (1977) makes clear, the SL CAPM predicts that the market portfolio of all risky assets must be mean-variance efficient – it does not predict that the market portfolio of stocks must be mean-variance efficient.[29] The empirical version of the model that the AER and others use measures the risk of an asset relative to a portfolio of stocks alone. Stocks have readily available and transparent prices relative to other risky assets such as debt, property and human capital. Stocks, though, make up a relatively small fraction of all risky assets, so the return to a portfolio of stocks need not track closely the return to the market portfolio of all risky assets.[30] Thus the empirical version of the SL CAPM that the AER and most practitioners who use the model actually employ differs from the theoretical model proposed by Sharpe and Lintner. The empirical version of the model that the AER employs does closely resemble, though, the version that academic work tests.[31]

Roll (1977) points out that difficulties in measuring the return to the market portfolio of all risky assets mean that it is not possible to test the SL CAPM.[32] One may be able to reject an empirical version of the model that uses the market portfolio of stocks as a proxy for the market portfolio of all risky assets, but this rejection will not imply that the theoretical model itself is wrong. The issue that concerns us, though, is not whether the theoretical SL CAPM is correct, but whether the empirical version of the SL CAPM applied by the AER and practitioners who use the model works. In other words, we are interested in whether the empirical version of the model that is generally employed by those who use the model will generate unbiased estimates of the return required on the equity of a benchmark efficient entity.

In what follows all references to the empirical performance of the SL CAPM, unless otherwise stated, are to the empirical performance of a version of the model that uses the market portfolio of stocks as a proxy for the market portfolio of all risky assets.

Tests of the SL CAPM typically use either a multivariate methodology or a two-pass methodology. The multivariate methodology tests whether the alpha of each of a set of portfolios is zero. The two-pass methodology tests whether the mean excess return to a portfolio that has a zero beta, the zero-beta premium, is zero – as the SL CAPM implies should be true. The first pass of the methodology uses past data to estimate the beta of each of a set of portfolios. The second pass regresses – typically each month – the returns to the portfolios in excess of the risk-free rate on the first-pass beta estimates. Fama (1976) shows that an estimate of the intercept from the second-pass regression is the excess return to a portfolio and that

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

[30] The mean value of an Australian household's direct investment in stocks in 2014 was $44,166 and the mean value of the household's superannuation account – part of which would have been invested in stocks – was $186,011. The mean net wealth of a household in 2014 was $742,209. Thus the average Australian household in 2014 invested no more than 100 × (44,166 + 186,011)/742,209 = 31 per cent of its net non-human wealth in stocks. Baxter and Jermann (1997), however, estimate that human capital for a nation as a whole represents around 60 per cent of total wealth. Thus an estimate of the proportion of total wealth that is invested in stocks will be no more than (1 – 0.6) × 31 = 12.4 per cent.

Baxter, M. and U. Jermann, *The international diversification puzzle is worse than you think*, American Economic Review, 1997, pages 17-180.

Melbourne Institute, *The Household, Income and Labour Dynamics in Australia Survey: Selected findings from waves 1 to 14*, 2016, page 59.

[31] The only differences between the version of the model that the AER employs and the version that academic work typically tests are that (i) academic work typically employs a one-month bill rate as a measure of the risk-free rate whereas the AER uses a 10-year bond yield and (ii) academic work typically assigns no value to imputation credits whereas the AER assigns a value to imputation credits distributed. An exception to this rule is a paper by Lajbcygier and Wheatley (2012) that tests the model that the AER uses and finds evidence against the proposition that the market places a value on credits distributed and against the hypothesis that a zero-beta portfolio earns the risk-free rate.

Lajbcygier, P. and S.M. Wheatley, *Imputation credits and equity returns*, Economic Record, 2012, pages 476-494.

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

the first-pass estimate of the portfolio's beta is, by construction, zero.[33] By averaging these intercept estimates over time one can produce an estimate of the zero-beta premium. Since the SL CAPM will not either underestimate or overestimate the mean return to the market portfolio, evidence that the zero-beta premium exceeds zero is evidence that the SL CAPM exhibits a low-beta bias. In other words, evidence that the zero-beta premium is positive is evidence that the SL CAPM tends to underestimate the returns required on low-beta assets and tends to overestimate the returns required on high-beta assets.

## 2.2 US Evidence

### 2.2.1 Black, Jensen and Scholes (1972)

It has been known for almost 50 years that empirical versions of the SL CAPM tend to underestimate the returns to low-beta assets and overestimate the returns to high-beta assets. Mehrling (2005), for example, reports that:[34]

> 'The very first [Wells Fargo] conference was held in August 1969 at the University of Rochester in New York State ... The focus of the first Wells Fargo conference was on empirical tests of the CAPM ... the most significant output of the first conference was the paper of Fischer Black, Michael Jensen, and Myron Scholes (BJS), titled "The Capital Asset Pricing Model: Some Empirical Tests," eventually published in 1972. ... One important consequence of the BJS tests was to confirm earlier suggestions that low-beta stocks tend to have higher returns and high-beta stocks tend to have lower returns than the theory predicts.'

Black, Jensen and Scholes (1972) use monthly US data from 1931 to 1965 to conduct two sets of tests of the SL CAPM:[35, 36]

- time series tests that provide estimates of the alphas of 10 portfolios of stocks formed on the basis of past estimates of beta; and
- cross-sectional tests that use the returns to the 10 portfolios to provide estimates of the zero-beta premium.

As Black, Jensen and Scholes note:[37]

> 'Although the model … which we wish to test is stated in terms of expected returns, it is possible to use realized returns to test the theory.'

They find that their time series tests:[38, 39]

> 'indicate that the expected excess returns on high-beta assets are lower than [the SL CAPM] suggests and that the expected excess returns on low-beta assets are higher than [the SL CAPM] suggests. In other words, that high-beta stocks have negative alphas and low-beta stocks have positive alphas.'

They also find, however, that the evidence provided by their time series tests against the SL CAPM is stronger in the second half of their data that in the first – the first half of their data being a period of

[33] Fama, E.F., *Foundations of Finance*. Basic Books, New York, 1976, Chapter 9.

[34] Mehrling, Perry, *Fischer Black and the revolutionary idea of finance*, Wiley, 2005, pages 104-105.

[35] Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

[36] Scholes won the Nobel Prize in Economics in 1997.

[37] Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

[38] Black, Jensen and Scholes use as a proxy for the market portfolio of all risky assets, an equally weighted portfolio of all New York Stock Exchange (NYSE) stocks.

[39] Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

heightened volatility. Their cross-sectional tests similarly find stronger evidence against the SL CAPM in the second half of their data than in the first. Black, Jensen and Scholes report about these tests that: [40]

> 'the mean value of the [zero-beta premium] over the whole period has a "*t*" value of only 1.64. However, as hypothesized earlier, it was negative in the first subperiod and positive and successively larger in each of the following subperiods. Moreover, in the last two subperiods its "*t*" values were 4.03 and 4.49, respectively. These results seem to us to be strong evidence favoring rejection of the traditional form of the asset pricing model which says that [the zero-beta premium] should be insignificantly different from zero.'

The estimates of the zero-beta premium that Black, Jensen and Scholes provide for the second half of their data are economically as well as statistically significant. Black, Jensen and Scholes split their data into four 105-month subperiods and state about the results that they produce over these subperiods that: [41]

> 'the mean [return to a zero-beta portfolio] has had a positive trend over the period 1931-65 and was on the order of 1.0 to 1.3% per month in the two sample intervals we examined in the period 1948-65. This seems to have been significantly different from the average risk-free rate and indeed is roughly the same size as the average market return of 1.3 and 1.2% per month over the two sample intervals in this period. This evidence seems to be sufficiently strong enough to warrant rejection of the traditional form of the model [that is, the SL CAPM].'

While Black, Jensen and Scholes use, as a proxy for the risk-free rate, the return on a one-month bill, the AER uses, as a proxy, the yield on a 10-year government bond. The mean difference between the return on a one-month bill and the yield on a 10-year government bond, computed on a monthly basis over the second half of the period that Black, Jensen and Scholes examine, however, is just 8.5 basis points. [42] As a result, one can show that the inference drawn by Black, Jensen and Scholes would have been largely unaffected were they to have used the yield on a 10-year government bond as a proxy for the risk-free rate instead of the return to a one-month bill.

### 2.2.2 Fama and MacBeth (1973)

Fama and MacBeth (1973) conclude, like Black, Jensen and Scholes (1972), that one can reject the SL CAPM. [43, 44] Black, Jensen and Scholes use the returns to 10 portfolios formed on the basis of past estimates of beta and data from 1931 to 1965 while Fama and MacBeth use the returns to 20 portfolios formed on the basis of past estimates of beta and data from 1935 to 1968. [45] So the data that the two sets of authors use are similar and, not surprisingly, the inferences that they draw about the SL CAPM are also similar. Like Black, Jensen and Scholes, Fama and MacBeth find little evidence against the SL CAPM in the first half of their sample but strong evidence against the SL CAPM in the second half of their sample. On average over the whole of their sample, Fama and MacBeth find that the zero-beta premium differs significantly from zero at conventional levels and is 0.48 per cent per month – that is, 12 × 0.48 = 5.76 per cent per annum. This positive value for the zero-beta premium implies that Fama and MacBeth, like Black,

[40] Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

[41] Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

[42] We compute the difference between the return on a one-month bill and the yield on a 10-year government bond, on a monthly basis, using data from French's web site and Shiller's web site.

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

http://www.econ.yale.edu/~shiller/data.htm

[43] Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

Fama, E.F. and J.D. MacBeth, *Risk, return and equilibrium: Empirical tests*, Journal of Political Economy 81, 1973, pages 607-636.

[44] Fama won the Nobel Prize in Economics in 2013.

[45] Also, like Black, Jensen and Scholes, Fama and MacBeth use as a proxy for the market portfolio of all risky assets, an equally weighted portfolio of all NYSE stocks.

Jensen and Scholes, find that the SL CAPM underestimates the returns to low-beta portfolios and overestimates the returns to high-beta portfolios.

### 2.2.3 Reinganum (1981)

The work of Black, Jensen and Scholes (1972) and Fama and MacBeth (1973) examines the question of whether a low-beta bias exists in US data up until the mid-to-late sixties.[46] The first work to examine later data is a paper written by Reinganum (1981) who, like Black, Jensen and Scholes, examines the behaviour of the returns to 10 portfolios formed on the basis of past estimates of beta.[47] Reinganum tests whether from 1964 to 1979 the mean returns to the portfolios differ using Hotelling's T-squared statistic and finds that the mean returns do not differ significantly from one another. He concludes that:[48]

> 'The test results demonstrate that estimated betas are not systematically related to average returns across securities. The average returns of high beta stocks are not reliably different from the average returns of low beta stocks. That is, portfolios with widely different estimated betas possess statistically indistinguishable average returns. Thus, estimated betas based on standard market indices do not appear to reliably measure a "risk which is priced in the market." These findings, along with the evidence on empirical "anomalies," suggest that the CAPM may lack significant empirical content.'

### 2.2.4 Fama and French (1992)

Fama and French (1992) further update the tests that Black, Jensen and Scholes (1972) and Fama and MacBeth (1973) conduct using data from 1963 to 1990 and find that:[49, 50]

> 'the relation between market beta and average return is flat.'

Fama and French do not provide estimates of alphas or of the zero-beta premium because their focus is on the extent to which a selection of variables besides beta can explain the cross-section of mean returns. They find, contrary to the predictions of the SL CAPM, that size and book-to-market are better predictors of returns than estimates of beta. Fama and French do, though, provide an estimate of the market price of risk. They estimate the market price of risk, from a regression of returns on estimates of beta, to be 0.15 per cent per month with a standard error attached to the estimate that can be inferred to be 0.33.[51] This standard error implies that a 95 per cent confidence interval for the market price of risk is, for their sample, -5.87 per cent per annum to 9.47 per cent per annum. This wide confidence interval means that one cannot infer from their results that a significant low-beta bias continues to exist.[52] There is, however, plenty of other work that does

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[46] Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

Fama, E.F. and J.D. MacBeth, *Risk, return and equilibrium: Empirical tests*, Journal of Political Economy 81, 1973, pages 607-636.

[47] Reinganum, M.R., *A new empirical perspective on the CAPM*, Journal of Financial and Quantitative Analysis 16, 1981, pages 439-462.

[48] Reinganum, M.R., *A new empirical perspective on the CAPM*, Journal of Financial and Quantitative Analysis 16, 1981, page 439.

[49] Unlike Black, Jensen and Scholes, Fama and MacBeth and Reinganum, who use an equally weighted portfolio of stocks as a proxy for the market portfolio of all risky assets, but like all of the other work that we will review, Fama and French use a value-weighted portfolio of stocks as a proxy for the market portfolio.

Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

[50] Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

Fama, E.F. and J.D. MacBeth, *Risk, return and equilibrium: Empirical tests*, Journal of Political Economy 81, 1973, pages 607-636.

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

[51] Their Table III indicates that the *t*-statistic attached to the estimate of 0.15 is 0.46. It follows that the standard error attached to the estimate is 0.15 ÷ 0.46 = 0.33.

[52] An estimate of the market risk premium computed from data that French supplies on his web site is 4.14 per cent per annum for the period from July 1963 to December 1990 that he and Fama use.

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

allow one to infer that a low-beta bias exists in data that postdates the Black, Jensen and Scholes and Fama and MacBeth samples.

### 2.2.5 Campbell and Vuolteenaho (2004)

As an example, Campbell and Vuolteenaho (2004), using 25 portfolios formed on the basis of size and book-to-market and 20 portfolios formed on the basis of past estimates of risk, estimate the zero-beta premium to be 8.24 per cent per annum, and significantly different from zero at conventional levels, in data from July 1963 to December 2001 and so state that: [53]

> '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 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.'

Campbell and Vuolteenaho estimate the zero-beta premium, on the other hand, to be insignificantly different from zero in data from January 1929 to June 1963. They ascribe the difference between the pre-1963 and post-1963 results to a change in the risks of value and growth portfolios.

Campbell and Vuolteenaho break the beta of a stock into two components: a component reflecting news about future cash flows and a component reflecting news about discount rates. They find that a model in which a higher price is placed on cash-flow risk than on discount-rate risk does a better job of explaining the cross-section of the mean returns to their 45 portfolios than does the SL CAPM. They find that from January 1929 to June 1963 value stocks tend to have higher cash-flow betas than growth stocks and higher discount-rate betas and so also higher market betas. From July 1963 to December 2001 they find that while value stocks have higher cash-flow betas than growth stocks, they have much lower discount-rate betas and so also lower market betas. As value stocks deliver higher returns than growth stocks in both periods, there is evidence against the SL CAPM in the more recent period but not in the earlier period. Since the price of cash-flow risk is higher, however, than the price of discount-rate risk, the data do not reject the two-factor model of Campbell and Vuolteenaho in either period.

### 2.2.6 Lewellen, Nagel and Shanken (2010)

As another example, Lewellen, Nagel and Shanken (2010), using 25 portfolios formed on the basis of size and book-to-market, estimate the zero-beta premium to be 11.60 per cent per annum, and significantly different from zero at conventional levels, in data from 1963 to 2004 and, using these portfolios together with 30 industry portfolios, 8.12 per cent per annum, and significantly different from zero in data also from 1963 to 2004. [54]

### 2.2.7 Frazzini and Pedersen (2014)

Frazzini and Pedersen (2014) examine data over a longer period. Using 10 equally weighted portfolios of US stocks formed on the basis of past estimates of beta and data from 1931 to 2012, they find evidence of a low-beta bias. [55] They also find evidence of a low-beta bias from 1989 to 2012 using 10 equally weighted portfolios of stocks from 19 other countries formed on the basis of past estimates of beta. [56] Figure 1 below illustrates these results.

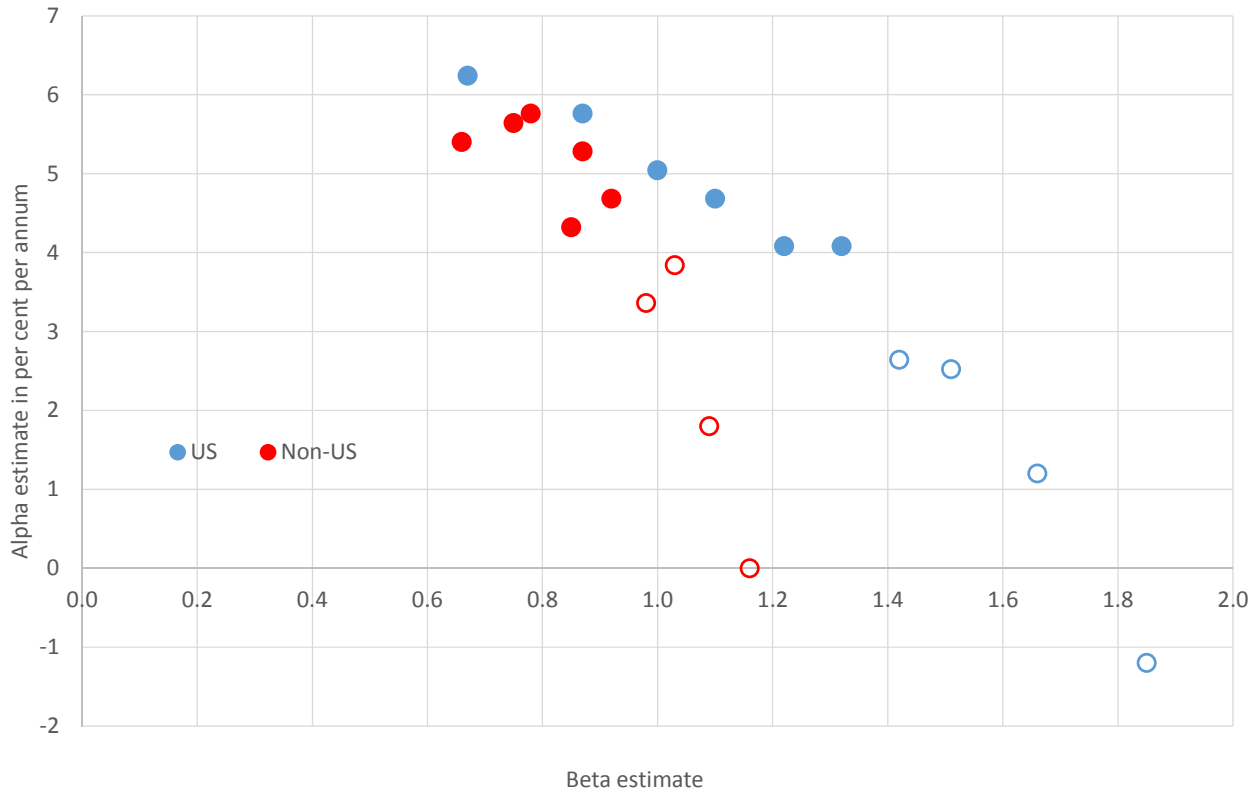
[53] Campbell, J. and T. Vuolteenaho, *Bad beta, good beta*, American Economic Review 94, pages 1249-1275.

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

[55] Frazzini, A. and L.H. Pedersen, *Betting against beta*, Journal of Financial Economics 111, 2014, pages 1-25.

[56] Note that while the portfolios are equally weighted, the proxies for US and world market portfolios that Frazzini and Pedersen use are value-weighted. So an average of each set of 10 alpha estimates does not necessarily have to be zero.

Figure 1: Plot of Alpha Estimate against Beta Estimate: US and Non-US Data from 1931 to 2012




*Note: Solid (hollow) points are alpha estimates that differ (do not differ) significantly from zero at the five per cent level. Blue points use US data from 1931 to 2012 while red points use data for 19 other countries from 1989 to 2012.*

*Source: Frazzini, A. and L.H. Pedersen, Betting against beta, Journal of Financial Economics 111, 2014, pages 1-25.*

### 2.2.8 Hong and Sraer (2016)

Hong and Sraer (2016) examine the impact on the theoretical predictions made by the SL CAPM of relaxing the assumption that the model makes that investors share the same beliefs.[57] Like Black (1972), their work is motivated by the evidence against the SL CAPM.[58] For example, Hong and Sraer state in the introduction to their work that:[59]

> 'There is compelling evidence that high risk assets often deliver lower expected returns than low risk assets. This is contrary to the risk and return trade-off at the heart of neoclassical asset pricing theory. This high-risk, low-return puzzle literature, which dates back to Black (1972) and Black et al. (1972), shows that low risk stocks, as measured by a stock's co-movement with the stock market or Sharpe (1964)'s Capital Asset Pricing Model (CAPM) beta, have significantly outperformed high risk stocks over the last thirty years. Baker et al. (2011) show that the cumulative performance of stocks since January 1968 actually declines with beta. For instance,

[57] Hong, H. and D.A. Sraer, *Speculative betas*, Journal of Finance, 2016, pages 2095-2144.

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

[59] Baker, M., B. Bradley, and J. Wurgler, 2011, *Benchmarks as limits to arbitrage: Understanding the low-volatility anomaly*, Financial Analysts Journal 67, pages 1-15.

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

Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

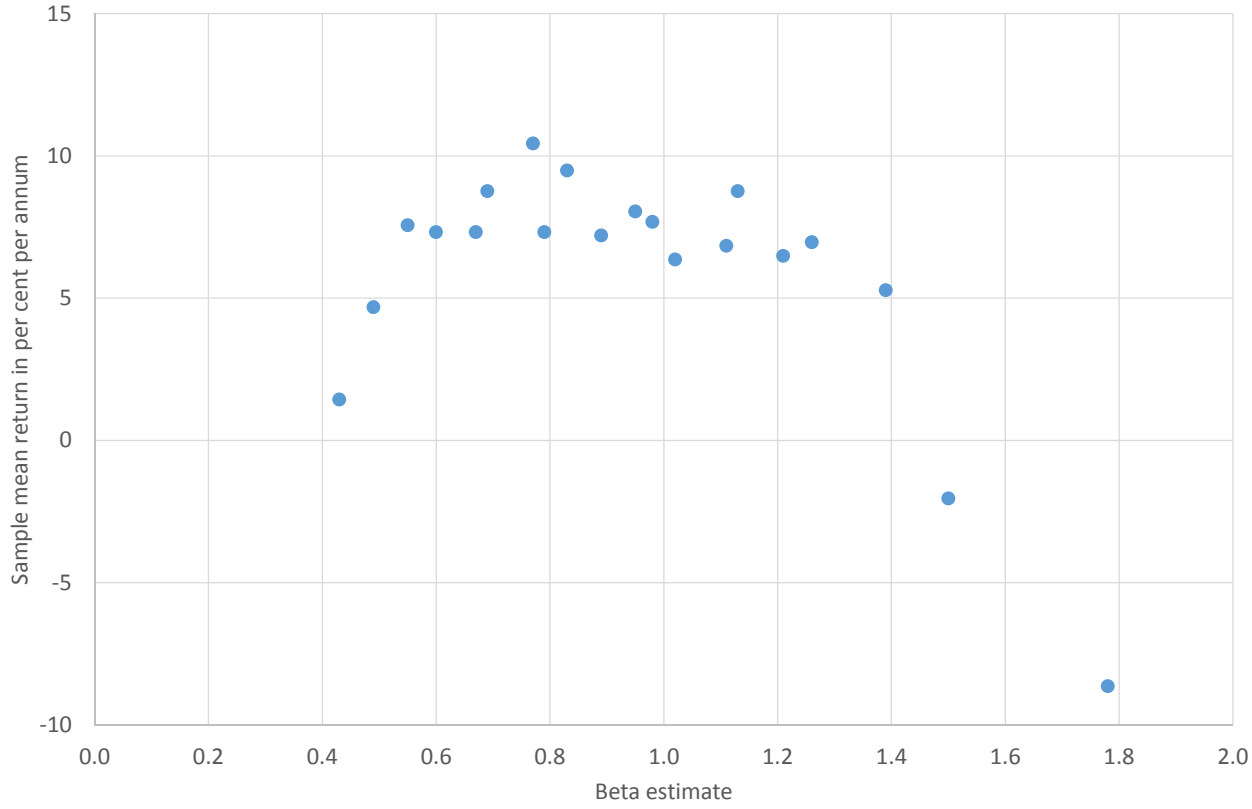
Hong, H. and D.A. Sraer, *Speculative betas*, Journal of Finance, 2016, pages 2095-2144.

> a dollar invested in a value-weighted portfolio of the lowest quintile of beta stocks would have yielded $96.21 ($15.35 in real terms) at the end of December 2010. A dollar invested in the highest quintile of beta stocks would have yielded around $26.39 ($4.21 in real terms).'

Hong and Sraer show that, as a theoretical matter, when some investors face short-sale constraints and investors hold differing beliefs, the relation between mean return and beta can be hump-shaped or downward sloping. In their model optimistic investors raise the prices of high-beta assets because while pessimists view the assets as overpriced, short-sale constraints prevent pessimists from shorting the assets.[60]

Figure 2 below, which uses empirical results that Hong and Sraer report, illustrates that there is some support for their theory. Hong and Sraer use 20 value-weighted portfolios formed on the basis of past estimates of beta rather than the 10 equally weighted portfolios that Frazzini and Pedersen (2014) employ. [61]

Figure 2: The Relation between Mean Return and Beta: US Data from 1981 to 2014




*Note: The figure is based on the results that Hong and Sraer provide in their Table 1. These results use 20 value-weighted portfolios formed on the basis of past estimates of beta.*

*Source: Hong, H. and D.A. Sraer, Speculative betas, Journal of Finance, 2016, pages 2095-2144.*

[60] We discuss the model of Hong and Sraer further in section 5 of the report.

[61] Frazzini, A. and L.H. Pedersen, *Betting against beta*, Journal of Financial Economics 111, 2014, pages 1-25.

### 2.2.9 Cederburg and O'Doherty (2016)

Cederburg and O'Doherty (2016) examine whether the evidence of a low-beta bias survives when a conditional rather than an unconditional version of the CAPM is used to predict returns.[62] They conclude that the evidence does not and they summarize their work in the following way.[63]

> 'Prior studies find that a strategy that buys high-beta stocks and sells low-beta stocks has a significantly negative unconditional Capital Asset Pricing Model (CAPM) alpha, such that it appears to pay to "bet against beta." We show, however, that the conditional beta for the high-minus-low beta portfolio covaries negatively with the equity premium and positively with market volatility. As a result, the unconditional alpha is a downward biased estimate of the true alpha. We model the conditional market risk for beta-sorted portfolios using instrumental variables methods and find that the conditional CAPM resolves the beta anomaly.'
>
> 'The unconditional and conditional versions of the CAPM are both rejected at the 5% level. The average absolute and squared conditional alphas across the ten portfolios, however, are substantially reduced relative to the corresponding unconditional estimates.'

The true alpha here refers to the alpha of a portfolio computed using the conditional version of the SL CAPM that Cederburg and O'Doherty employ.

The use of the conditional version of the SL CAPM that Cederburg and O'Doherty employ removes evidence of a low-beta bias for two reasons. First, as Cederburg and O'Doherty show, there is less dispersion in the mean estimates of the conditional betas of the 10 portfolios that they use than in the estimates of the unconditional betas of the portfolios. The mean estimate of the conditional beta of the lowest-beta (highest-beta) portfolio, for example, is higher (lower) than the estimate of its unconditional beta. Second, there is evidence that the conditional betas of low-beta (high-beta) portfolios covary positively (negatively) with the *MRP*. These two effects imply that the conditional CAPM will tend to generate higher predictions of the mean returns to low-beta assets and lower predictions of the mean returns to high-beta assets than the unconditional CAPM.

Cederburg and O'Doherty restrict the conditional beta of a portfolio to be a linear function of lagged values of beta, the dividend yield and the default spread. As a result, estimates of the beta of a zero-investment position that is long a high-beta portfolio and short a low-beta portfolio fluctuate substantially over time. Cederburg and O'Doherty find, for example, that an estimate of the beta of the position rises from around 0.50 in 1996 to around 2.80 in 2001.

Davis (2011) has in the past argued that the AER uses a conditional version of the SL CAPM. He states in a 2011 report that:[64]

> 'Recognition that time variation in beta exists implies that a purely "static" CAPM, in which parameters such as beta are assumed never to change, is rejected. It does not, however, follow that implementation of a single period CAPM at different points in time, for each of which beta is freshly estimated is necessarily inappropriate. The AER approach could, I suggest, be viewed as an "implicit conditional CAPM" approach in which there is regular review of beta, the risk free rate and the MRP. While that does not explicitly capture the effect of the conditioning factor(s), there is little agreement on what those factors are in practice.'

While the AER may regularly review its choices for the equity beta of a benchmark efficient entity, the risk-free rate and the *MRP*, it does not follow that the AER's implementation of the SL CAPM will produce

[62] Cederburg, S. and M.S. O'Doherty, *Does it pay to beta against beta? On the conditional performance of the beta anomaly*, Journal of Finance, 2016, pages 737-774.

[63] Cederburg, S. and M.S. O'Doherty, *Internet appendices for "Does it pay to beta against beta? On the conditional performance of the beta anomaly"*, University of Arizona, 2015, page 16.

Cederburg, S. and M.S. O'Doherty, *Does it pay to beta against beta? On the conditional performance of the beta anomaly*, Journal of Finance, 2016, pages 737-774.

[64] Davis, K., *Cost of equity issues: A further report for the AER*, May 2011, page 9.

estimates of the cost of equity for the entity that are unbiased. The AER does not presume that the beta of a benchmark efficient entity is a linear function of lagged values of beta, the dividend yield and the default spread. Merely updating the risk-free rate and estimates of the equity beta of the entity and of the *MRP* will not guarantee that estimates of the cost of equity for the entity will exhibit no bias. That this is true is clear from the results of the tests that Fama and MacBeth (1973) conduct.[65] Their tests use rolling estimates of beta and place no restrictions on the evolution of the *MRP* or the risk-free rate but still reject the hypothesis that forecasts of the return on equity generated by the SL CAPM are unbiased.

## 2.3 Australian Evidence

There is no evidence on whether a conditional version of the SL CAPM can explain the cross-section of mean returns to portfolios formed on the basis of past estimates of beta. Aside from this fact, however, the Australian evidence largely mirrors the evidence found in US data.

### 2.3.1 CEG (2008)

CEG (2008) finds no significant relation between the returns to 10 portfolios, formed from stocks that are among the largest 300 by market capitalisation listed on the Australian Securities Exchange (ASX) and on the basis of past estimates of beta, and estimates of the betas of the portfolios in data from 1974 to 2007.[66] Using value-weighted portfolios of the largest 100, 200 and 300 firms, CEG estimates the zero-beta premium to lie between 6.53 per cent per annum and 10.31 per cent per annum and to be significantly different from zero at conventional levels.

### 2.3.2 NERA (2013)

NERA (2013) estimates the zero-beta premium using both portfolios of stocks and individual stocks.[67]

Using the returns to 10 value-weighted portfolios from 1974 to 2012, formed from stocks that are at the start of each year among the largest 500 by market capitalisation listed on the ASX and on the basis of past estimates of beta, NERA estimates the zero-beta premium to lie between 11.23 per cent per annum and 13.95 per cent per annum and to be significantly different from zero at conventional levels.

Using the returns to stocks, from 1974 to 2012, that are at the start of each year among the largest 500 by market capitalisation listed on the ASX, NERA estimates the zero-beta premium to lie between 8.74 per cent per annum and 11.05 per cent per annum and to be also significantly different from zero at conventional levels.

### 2.3.3 SFG (2014)

SFG (2014) estimates the zero-beta premium using data from 1994 to 2014 and portfolios formed in two ways.[68]

First, it uses portfolios formed on the basis of past estimates of beta but constructed so as to minimise any differences in average book-to-market, industry membership and size between the portfolios. Using the returns to these portfolios, SFG provides an estimate of the zero-beta premium of 3.34 per cent per annum that does not differ significantly from zero at conventional levels.

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

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

[67] NERA, *Estimates of the zero-beta premium: A report for the Energy Networks Association*, June 2013.

[68] 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.

Second, it uses portfolios formed purely on the basis of past estimates of beta – that is, in the same way that CEG and NERA form portfolios. Using the returns to these portfolios, SFG provides an estimate of the zero-beta premium of 9.28 per cent per annum that does differ significantly from zero at conventional levels.

It is well known that value stocks tend to have low betas relative to the market portfolio of stocks while growth stocks tend to have high betas. It is also well known that value stocks tend to earn high returns while growth stocks tend to earn low returns. Consequently, were one to compute an estimate of the zero-beta premium using just two portfolios – a value portfolio and a growth portfolio – the estimate would likely exceed the *MRP*. SFG tries with its first method of forming portfolios to eliminate the impact of this empirical relation between return, beta and book-to-market on its results. CEG (2008) and NERA (2013), like Black, Jensen and Scholes (1972) and Fama and MacBeth (1973), do not try to do so and so do not try to prevent beta from behaving as a proxy for missing measures of risk. [69]

### 2.3.4 HoustonKemp (2016)

HoustonKemp (2016) provide evidence that forecasts of returns that use the SL CAPM exhibit a low-beta bias. [70] They form for each month the forecast error:

$$z_{jt} - \hat{\beta}_{jt} z_{mt} \qquad (3)$$

where:

$\hat{\beta}_{jt}$ = an estimate of $\beta_{jt}$ that uses what is known at $t-1$.

If the SL CAPM is true and the betas of portfolios do not wander through time, then the expected value of the forecast error should be zero. [71]

HoustonKemp show that for low-beta portfolios the mean forecast errors tend to be positive and significantly different from zero at conventional levels and for high-beta portfolios they tend to be negative and significantly different from zero at conventional levels. Figure 3 summarises their results. The figure uses 10 portfolios formed on the basis of past estimates of beta and data from 1979 to 2014. The portfolios are formed in two ways – on the basis of rolling estimates of beta that use the previous five years of data and on the basis of recursive estimates of beta that use all past data. The figure shows that the SL CAPM tends to underestimate the returns to low-beta stocks – the mean forecast errors are positive – and overestimate the returns to high-beta stocks – the mean forecast errors tend to be negative.

[69] Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests*, in Studies in the Theory of Capital Markets, M.C. Jensen, ed., Praeger, 1972.

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

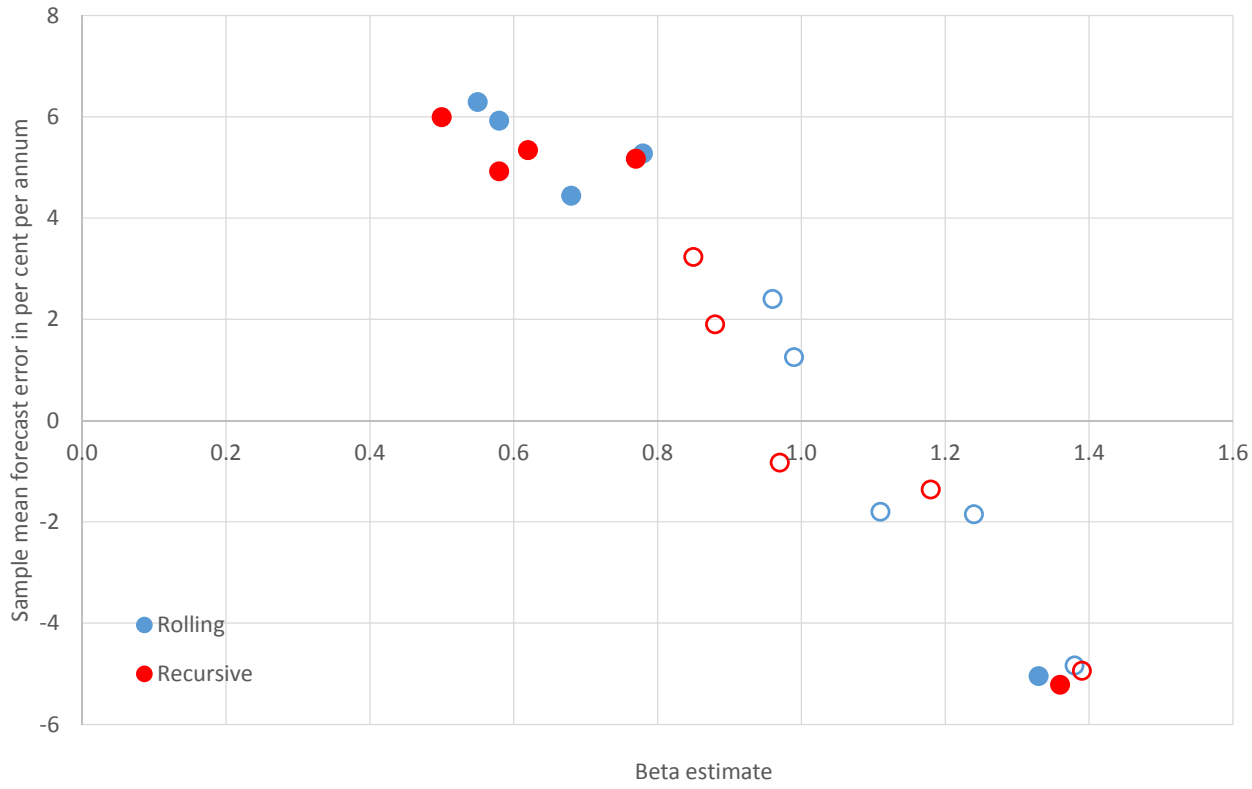
Fama, E.F. and J.D. MacBeth, *Risk, return and equilibrium: Empirical tests*, Journal of Political Economy 81, 1973, pages 607-636.

NERA, *Estimates of the zero-beta premium: A report for the Energy Networks Association*, June 2013.

[70] HoustonKemp, *The cost of equity: Response to the AER's draft decisions for the Victorian Electricity Distributors, ActewAGL Distribution and Australian Gas Networks: A report for ActewAGL Distribution, AusNet Services, Australian Gas Networks, CitiPower, Jemena Electricity Networks, Powercor and United Energy*, January 2016.

[71] If the betas of portfolios do wander through time, then the expected value of the forecast error should be approximately, rather than precisely, zero.

Figure 3: Bias Associated with Forecasts of the Return on Equity that Use the SL CAPM: Australian Data from 1979 to 2014




*Note: Solid (hollow) points are mean forecast errors that differ (do not differ) significantly from zero at the five per cent level. Blue points employ estimates of beta in forecasting returns that use the previous five years of data. Red points employ estimates of beta that use all past data.*

*Source: HoustonKemp, The cost of equity: Response to the AER's draft decisions for the Victorian Electricity Distributors, ActewAGL Distribution and Australian Gas Networks: A report for ActewAGL Distribution, AusNet Services, Australian Gas Networks, CitiPower, Jemena Electricity Networks, Powercor and United Energy, January 2016.*

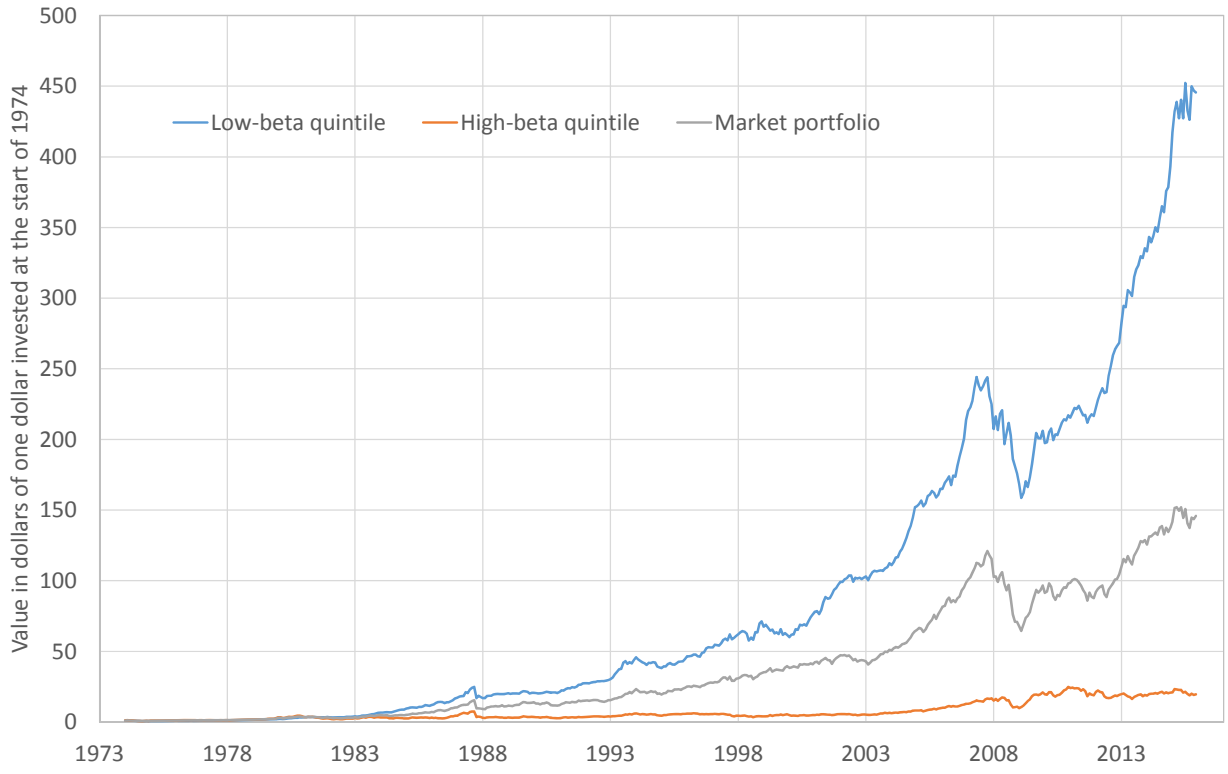
### 2.3.5 Performance of low-beta and high-beta portfolios

Hong and Sraer (2016) motivate their work by noting that a value-weighted portfolio of the lowest beta quintile of stocks has outperformed a value-weighted portfolio of the highest beta quintile of stocks in US data over the last 40 years or so.[72] Figure 4 illustrates that it is also true that a value-weighted portfolio of the lowest beta quintile of stocks has outperformed a value-weighted portfolio of the highest beta quintile of stocks in Australian data over approximately the same period. The figure uses data from SIRCA's Share Price and Price Relative (SPPR) database from 1974 to 2015.[73] A dollar invested in the low-beta portfolio at the start of 1974 would have yielded $445.55 at the end of 2015 while a dollar invested in the high-beta portfolio at the start of 1974 would have yielded $19.57 at the end of 2015. As Hong and Sraer emphasise, evidence of this kind is inconsistent with the predictions of the SL CAPM.

[72] Hong, H. and D.A. Sraer, *Speculative betas*, Journal of Finance, 2016, pages 2095-2144.

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

## Figure 4: The Performance of Low-Beta and High-Beta Quintiles: 1974 to 2015




*Note: The graph uses data from SIRCA's Share Price and Price Relative database. At the start of each year stocks are allocated to quintiles on the basis of estimates of beta computed over the previous five years. The graph plots the value of one dollar invested at the start of 1974 in a value-weighted portfolio of the lowest-beta quintile of stocks, the value of one dollar invested at the start of 1974 in a value-weighted portfolio of the highest-beta quintile of stocks and the value of one dollar invested at the start of 1974 in the market portfolio against time.*

# 3. Methodology

The AER, in its 2013 *Rate of Return Guidelines*, notes that departures from the assumptions underpinning the SL CAPM can lead the relation between mean return and beta to be flatter than the relation that the SL CAPM predicts should hold between the two quantities.[74] In addition, in its most recent decision, the AER states about the empirical evidence that:[75]

> 'We acknowledge that the Sharpe-Lintner CAPM tests poorly using ex post returns data, and appears to underestimate the ex post returns for businesses with an equity beta less than one.'

The AER, in its 2013 *Rate of Return Guidelines* and in its most recent decision, chooses an equity beta point estimate of 0.70 from a range of 0.40 to 0.70.[76] In other words, the AER chooses as an estimate of the equity beta of a benchmark efficient entity a number, 0.70, that lies above the midpoint, 0.55, of its range of 0.40 to 0.70.

In its 2016 PIAC and Ausgrid decision, the ACT rejects a submission by the PIAC challenging the AER's decision to choose an equity beta point estimate from the top of the AER's range for the equity beta of a benchmark efficient entity and instead supports the idea that a low-beta bias is associated with estimates of the return required on equity produced by the SL CAPM. The ACT states that:[77]

> 'It is, as the AER noted, correct that the three parameters for the SL CAPM – equity beta, risk free rate, and MRP – are recorded as giving a low beta bias for businesses with a beta (that is, the risk of the asset relative to the average asset) of less than 1.0.'

> 'As with the submissions of Networks NSW, supported by the Vic/SA Interveners and Ergon (although differently focused), the Tribunal can readily understand PIAC's reasons for urging error on the part of the AER. However, for much the same reasons, it has not taken the step of concluding that the AER was in fact in error in finding that the proper point estimate was 0.7 for equity beta. There are reasons why it might have chosen another point estimate. But the Tribunal accepts that the AER was entitled to start with a range. Upon reviewing the whole of the material before the AER, the Tribunal however is not satisfied that that material does not support a conclusion that the SL CAPM provided a low equity beta bias. When, therefore, it comes to the selection of a point estimate, and having regard to the range of data available to the AER, the Tribunal must consider whether it is satisfied of the correctness of an alternative to that adopted by the AER. The short answer is that it is not so satisfied.'

Multinet has provided HoustonKemp with a best estimate of the equity beta of a benchmark efficient entity, based on data that are more recent than the data on which the AER's range is based, of 0.70. This best estimate, which has not been adjusted in any way, lies above the midpoint, 0.55, of the AER's range of 0.40 to 0.70. Multinet has, consequently, asked HoustonKemp, in light of the new empirical evidence that it has assembled, to assess what adjustments should now be made to estimates of the return required on the equity of a benchmark efficient entity, delivered by the SL CAPM, for the estimates to exhibit no significant bias.

In particular, Multinet has asked HoustonKemp to:

[74] AER, *Better regulation explanatory statement: Rate of return guideline (Appendices),* December 2013, pages 70-71.

[75] AER, *Draft decision AusNet Services transmission determination 2017-18 to 2021-22: Attachment 3 – Rate of return*, July 2016, page 167.

[76] AER, *Better regulation explanatory statement: Rate of return guideline (Appendices),* December 2013, page 35.

AER, *Draft decision AusNet Services transmission determination 2017-18 to 2021-22: Attachment 3 – Rate of return*, July 2016, page 63.

[77] Australian Competition Tribunal, *Applications by Public Interest Advocacy Centre Ltd and Ausgrid [2016] ACompT 1*, paragraphs 731 and 779.

(a) determine the smallest fraction of an estimate of the equity's alpha that, when added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return exhibits no significant bias; and

(b) determine the weighted average of an OLS estimate of the equity's beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return exhibits no significant bias.

In this section, we explain how we determine the smallest fraction of an estimate of the equity's alpha that, when added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return exhibits no significant bias – where significance is assessed at conventional levels.

As we will make clear below, estimators of the return required on equity produced in this way are pre-test estimators and will be biased if a low-beta bias exists. In particular, they will be downwardly biased estimators of the returns required on low-beta assets if a low-beta bias exists. Thus estimates of the return required on a benchmark efficient entity that use the estimators are likely to be conservative in the sense that use of the estimates will provide regulated firms with returns that are on average too low.

We also explain how we determine the weighted average of an OLS estimate of the equity beta of a benchmark efficient entity and one, which places the largest weight on the estimate, that, when used with the SL CAPM in computing a forecast of the equity's return, ensures that the forecast of the return exhibits no significant bias. Estimators of the return required on equity produced in this way are also pre-test estimators and are likely to be biased downwards if a low-beta bias exists.

Before we describe how we construct the estimators that we employ, we explain why we believe it important that a significant weight be placed on whether the evidence indicates that estimators of the return required on equity exhibit a low-beta bias.

## 3.1 Importance of Evidence

The AER's decision about how to adjust an estimate of the return required on the equity of a benchmark efficient entity, generated by the SL CAPM, will be based on evidence and theory, and the decision about what weight to place on evidence and weight to place on theory will be dictated by: [78]

- the strength of the evidence – that is, the significance of the results; and
- the strength of the theory – that is, the extent to which predictions made by the theory are robust to reasonable departures from the assumptions on which the theory is based.

For example, if the evidence of a low-beta bias were to be weak – which is not the case – one would not want to place a large weight on the evidence, all else constant. As another example, if the predictions made by the SL CAPM were to be sensitive to reasonable departures from the assumptions that the theory makes – which is the case – one would not want to place a large weight on the theory, all else constant.

We begin by considering how theory might guide the AER's decision about what adjustments to make to the SL CAPM to eliminate the low-beta bias associated with the model. As a theoretical matter, deviations from the SL CAPM do not, in general, offer arbitrage opportunities – that is, they do not offer the opportunity to make a profit without bearing risk and without making an investment. Deviations from the SL CAPM offer the

[78] In general, the decision about what weight to place on evidence can also depend on the extent to which the data on which the evidence is based are accurate, that is, reliable. The data on which the evidence of a low-beta bias is based are among the most reliable used by economists and so reliability is not an issue that the AER need consider in exercising judgement.

For a discussion of reliability, see:

United States Government Accountability Office, *Assessing the reliability of computer-processed data*, July 2009, pages 4-5.

opportunity to make a profit but, in general, only by bearing additional risk. For this reason, one cannot expect arbitrageurs on their own to eliminate any deviations from the model that occur.

As an illustration of how arbitrageurs will, in general, be unable to eliminate deviations from the SL CAPM and of how the predictions made by the model are sensitive to departures from the assumptions that underpin the model, it will be helpful to consider two recent pieces of work. The first is the work of Frazzini and Pedersen (2014) while the second is the work of Hong and Sraer (2016). [79]

Frazzini and Pedersen examine a model in which even though investors can borrow or lend at a single risk-free rate, they face leverage constraints. These leverage constraints lead low-beta assets to have positive alphas and high-beta assets to have negative alphas. As Frazzini and Pedersen emphasise, it is likely that, in practice, many investors face leverage constraints. Frazzini and Pedersen show that investors who face few leverage constraints – arbitrageurs – will tend to take levered positions in low-beta assets. In other words, they will try and take advantage of the attractive returns offered by low-beta assets. Because of the additional risk that arbitrageurs face in doing so, however, the relation between return and beta will nevertheless be flatter than in the SL CAPM.

Hong and Sraer examine a model in which investors can borrow or lend at a single risk-free rate, some investors face short-sale constraints and investors hold differing beliefs. The SL CAPM makes no assumption about whether investors face short-sale constraints but does assume that investors share the same beliefs. In practice, as Markowitz (2005) makes clear, investors face short-sale constraints. He states, for example, about the Black CAPM – which presumes that investors face no short-sale constraints – that:[80, 81]

> 'The alternate CAPM assumes that the proceeds of a short sale can be used, without limit, to buy securities long. For example, the alternate CAPM assumes that an investor could deposit $1,000 with a broker, short $1,000,000 worth of Stock A, then use the proceeds and the original deposit to buy $1,001,000 of Stock B. The world does not work in this way.'

The AER also holds the same view. It states in its recent AusNet decision that: [82]

> 'Unlimited short selling does not hold in practice.'

It is a fact of life that investors do not share the same beliefs. In financial markets, it is common for investors to hold differing beliefs about the future path of prices and to take differing positions that reflect those beliefs. Kandel and Pearson (1995) provide support for the idea that the volume-return relation that one observes around public announcements reflects differing interpretations of the announcements on the part of traders. They state that: [83]

> 'on a practical level, it is trivially obvious that people disagree about the probabilities of events even when exposed to seemingly identical evidence. In the economics literature … Rubinstein … seems to think it obvious that agents have different interpretations of information: "… Agents reading the same morning newspapers with the same stock price lists will interpret the information differently" … We show that relaxing the assumption that agents interpret public information identically changes predictions about volume of trade. More important, we provide

[79] Frazzini, A. and L.H. Pedersen, *Betting against beta*, Journal of Financial Economics 111, 2014, pages 1-25.

Hong, H. and D.A. Sraer, *Speculative betas*, Journal of Finance, 2016, pages 2095-2144.

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

Markowitz, H.M., *Market efficiency: A theoretical distinction and so what?* Financial Analysts Journal 61, 2005, page 18.

[81] Markowitz won the Nobel Prize in Economics in 1990.

[82] AER, *Draft decision AusNet Services transmission determination 2017-18 to 2021-22: Attachment 3 – Rate of return*, July 2016, page 157.

[83] Kandel, E. and N.D. Pearson, *Differential interpretation of public signals and trade in speculative markets*, Journal of Political Economy 103, 1995, page 832.

Rubinstein, A., *On price recognition and computational complexity in a monopolistic model*, Journal of Political Economy 101, 1993, pages 473-84.

> empirical evidence that the assumption that agents interpret information identically is overly restrictive.'

In the model of Hong and Sraer, low-beta assets also have positive alphas and high-beta assets, negative alphas. This is true even though investors exist in the model who hold beliefs that are correct, who can borrow and lend freely at the risk-free rate and who face no short-sale constraints. These arbitrageurs are discouraged from aggressively levering up positions in low-beta assets by the risk that they would face in doing so. As a result, in the model of Hong and Sraer, deviations from the SL CAPM are not eliminated and there can be a hump-shaped relation between mean return and beta – that is, for at least some assets there can be a negative relation between mean return and beta.

These two recent pieces of work make it clear that it will be difficult for the AER to use theory alone to determine the adjustment that one must make to the equity beta of a benchmark efficient entity to render an estimate of the return on equity for the entity, generated by the SL CAPM, unbiased. A reliance on theory will require the regulator determine what set of assumptions regarding leverage constraints, differences between borrowing and lending rates, short-sale constraints and the extent to which beliefs differ across investors makes sense – and determining what set will be difficult. A reliance on theory will be ill-advised because the predictions made by the SL CAPM and related models like the Black CAPM are sensitive to reasonable departures from the assumptions that the models make.

Besides this difficulty, we note that the SL CAPM predicts that the market portfolio of all risky assets must be mean-variance efficient – it does not predict that the market portfolio of stocks must be mean-variance efficient. The SL CAPM states that the risk of an asset should be measured relative to the market portfolio of all risky assets whereas empirical versions of the model – like the version of the SL CAPM that the AER uses – measure the risk of an asset relative to a portfolio of stocks alone. It follows that one should not expect the zero-beta premium in an empirical version of the model to sit close to zero. The SL CAPM does not impose a restriction on the mean return in excess of the risk-free rate to a portfolio that has a zero beta relative to the market portfolio of stocks.

The AER has not back-tested its approach of providing a limited uplift to an estimate of the equity beta of a benchmark efficient entity to determine whether the uplift is sufficient to ensure that an estimate of the required return on the entity's equity, generated by the SL CAPM, does not exhibit significant bias. One reason for the AER's failure to back-test its approach may be that the regulator's advisers, Partington and Satchell, argue that back-testing the approach is not feasible. Partington and Satchell state that: [84]

> 'We sympathise with Frontier's (2015, Key) argument that the AER should present some measure of the quality of its cost of equity estimate and provide a quantitative analysis of the adjustments it makes to the CAPM returns. This might be done relatively easily if the estimate involved was just the OLS estimator for a given set of data. However, when a value is chosen from a range of values and the overall process involves both judgement and estimation the exercise becomes very difficult to carry out. With well-defined priors on the part of the AER, perhaps a Bayesian approach could be adopted, but we expect this would just shift the debate to arguments about the priors. There is no straightforward solution to the demands by Frontier (2015, Key). However, the role of judgement by the AER in such exercises seems to us entirely warranted and indeed inescapable.'

We believe that Partington and Satchell exaggerate the difficulties involved in assessing the AER's judgement and we believe it to be desirable that the AER's approach of providing a limited uplift to an estimate of the equity beta of a benchmark efficient entity be back-tested. The AER's adviser, Henry, in a 2015 report, produces estimates of the equity beta of a benchmark efficient entity and the AER provides a limited uplift to the estimates that he provides in the hope that the use of the uplift may produce a better estimate of the return required on the entity. [85] Testing whether this limited uplift is sufficient to render a

[84] Partington, G. and S. Satchell, *Report to the AER: Analysis of criticism of 2015 determinations*, October 2015, page 22.

[85] Henry, O., *Estimating β: An update*, April 2014.

forecast of the return on equity generated by the SL CAPM unbiased we do not believe to be a complicated task.

Since the ACT, in its 2016 PIAC and Ausgrid decision, does not proscribe the use of past data to evaluate the impact of adjustments to the equity beta of a benchmark efficient entity on the properties of estimates of the return required on the entity's equity, in this report, we use past data to evaluate the impact. [86]

## 3.2 Our Approach

If the regulator's expectations are rational, then its assessment, made at the end of period $t-1$, of the *MRP* over period *t* will be: [87]

$$\hat{z}_{mt} = \mathrm{E}_{t-1}(z_{mt}) \tag{4}$$

That is, if the regulator is rational, its assessment of the *MRP* will be unbiased in the sense that it will use correctly all information available at time $t-1$ in forming its expectations. Rationality on the part of the regulator does not imply that the regulator has perfect foresight. In other words, (4) does not imply that the regulator will know the excess return to the market in advance. It assumes only that the regulator will use all available information correctly in predicting the unknown excess return.

We are interested in whether we can expect an estimate of the return required on equity delivered by the regulator's use of the SL CAPM to be unbiased. That is, we are interested in whether:

$$\mathrm{E}\left(z_{jt} - \hat{\beta}_{jt}\hat{z}_{mt}\right) = 0 \tag{5}$$

Note, however, that using (4) and the law of iterated expectations, we can express this expectation as: [88]

$$\mathrm{E}\left(z_{jt} - \hat{\beta}_{jt}\hat{z}_{mt}\right) = \mathrm{E}\left\{\mathrm{E}_{t-1}\left(z_{jt} - \hat{\beta}_{jt}\hat{z}_{mt}\right)\right\} = \mathrm{E}\left\{\mathrm{E}_{t-1}\left(z_{jt} - \hat{\beta}_{jt}z_{mt}\right)\right\} = \mathrm{E}\left(z_{jt} - \hat{\beta}_{jt}z_{mt}\right) = 0 \tag{6}$$

Thus, so long as the regulator forms expectations rationally, we can test whether an estimate of the return required on equity delivered by the SL CAPM is unbiased without a series of regulator assessments of the *MRP*.

The condition:

$$\mathrm{E}\left(z_{jt} - \hat{\beta}_{jt}z_{mt}\right) = 0 \tag{7}$$

in fact will hold even if the regulator is only rational *on average* through time, that is, if:

$$\mathrm{E}(\hat{z}_{mt}) = \mathrm{E}(z_{mt}) \tag{8}$$

so long as

$$\mathrm{Cov}\left(\hat{\beta}_{jt}, z_{mt} - \hat{z}_{mt}\right) = 0 \tag{9}$$

[86] Australian Competition Tribunal, *Applications by Public Interest Advocacy Centre Ltd and Ausgrid [2016] ACompT 1*, paragraphs 777 and 779.

[87] For a definition of what it means for expectations to be rational, see Sargent's text, *Macroeconomics*. Sargent won the Nobel Prize in Economics in 2011.

Sargent, T., *Macroeconomics*, Academic Press, New York, 1979, page 357.

[88] For a discussion of the law of iterated expectations, see:

Hamilton, J.D., *Time series analysis*, Princeton University Press, New Jersey, 1989, page 742.

that is, so long as an estimate of beta made using information available at the end of period $t-1$ is not correlated with the error with which the regulator forecasts at the end of period $t-1$ the excess return to the market over period $t$.

Using (8) and (9), we can express the expectation (5) as:

$$\mathrm{E}\left\{ z_{jt} - \hat{\beta}_{jt} z_{mt} + \hat{\beta}_{jt} \left( z_{mt} - \hat{z}_{mt} \right) \right\} = \mathrm{E}\left( z_{jt} - \hat{\beta}_{jt} z_{mt} \right) = 0 \qquad (10)$$

We test whether the restriction (7) holds true by examining whether its sample counterpart:

$$\frac{1}{T} \sum_{t=1}^{T} \left( z_{jt} - \hat{\beta}_{jt} z_{mt} \right) \qquad (11)$$

differs significantly from zero, where $T$ denotes the number of monthly observations.[89]

### 3.2.1 Alpha adjustments

We also determine the smallest fraction of an OLS estimate of the alpha associated with a benchmark efficient entity that, when added to a forecast, delivered by the SL CAPM, of the equity's return, will ensure that the forecast of the return exhibits no significant bias – where significance is assessed at conventional levels. That is, we search for the value for the smallest fraction $\lambda$ that ensures that the quantity:

$$\frac{1}{T} \sum_{t=1}^{T} \left( z_{jt} - \lambda \hat{\alpha}_{jt} - \hat{\beta}_{jt} z_{mt} \right) \qquad (12)$$

does not differ significantly from zero at conventional levels, where

$\hat{\alpha}_{jt}$ = an OLS estimate of $\alpha_{jt}$ that uses what is known at $t-1$; and where here

$\hat{\beta}_{jt}$ = an OLS estimate of $\beta_{jt}$ that uses what is known at $t-1$.

If $\alpha_{jt}$ and $\beta_{jt}$ constant through time, then it will be true that:

$$\mathrm{E}\left( z_{jt} - \hat{\alpha}_{jt} - \hat{\beta}_{jt} z_{mt} \right) = 0 \qquad (13)$$

regardless of the value of $\alpha_{jt}$. It follows that if $\alpha_{jt} > 0$ ($\alpha_{jt} < 0$), an estimator of the return required on a benchmark efficient entity that uses an estimate of the fraction $\lambda$ that ensures that the quantity (12) does not differ significantly from zero will be biased downwards (upwards). This is because some of the time the value for $\lambda$ selected will be less than one.

An estimator of the return required on a benchmark efficient entity that adds a fraction $\lambda$ of an estimate of the alpha associated with the entity to an estimate, delivered by the SL CAPM, of the equity's return, where the fraction $\lambda$ is determined by running a pre-test to assess whether (12) differs significantly from zero at conventional levels is known as a pre-test estimator. Judge and Bock (1983) describe the properties of pre-test estimators with a particular focus on the mean squared error of alternative estimators.[90] Our focus here

[89] Thus the tests that we use in this report employ what NERA in its February 2015 report labels Method B.

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.

[90] Judge, G.G. and M.E. Bock, *Biased estimation*, in Handbook of Econometrics, Volume I, Z. Griliches and M.D. Intriligator, ed., North-Holland, 1983, pages 617-627.

is on bias because a regulated company that does not expect to earn a competitive rate of return will find it difficult to survive – at least, in the long run.

The pre-test estimator of the return required on a benchmark efficient entity that adds a fraction $\lambda$ of an estimate of the alpha associated with the entity to an estimate, delivered by the SL CAPM, of the equity's return does not presume that a particular alternative prising model is true. This is because the estimator does not presume that a particular restriction placed on $\alpha_{jt}$ is necessarily true.

### 3.2.2 Beta adjustments

Finally, we determine the weighted average of an OLS estimate of the equity beta of a benchmark efficient entity and one, which places the largest weight on the estimate, that, when used with the SL CAPM in computing a forecast of the equity's return, ensures that the forecast of the return exhibits no significant bias – where significance is, again, assessed at conventional levels. That is, we search for the largest value for the fraction $\phi$ that ensures that the quantity:

$$\frac{1}{T}\sum_{t=1}^{T}\left(z_{jt} - \left(\phi\hat{\beta}_{jt} + 1 - \phi\right)z_{mt}\right) \qquad (14)$$

does not differ significantly from zero at conventional levels.

An estimator of the return required on a benchmark efficient entity that uses a weighted average of an OLS estimate of the equity beta of a benchmark efficient entity and one, with a weight of $\phi$ placed on the estimate, and the SL CAPM, where the weight $\phi$ is determined by running a pre-test to assess whether (14) differs significantly from zero at conventional levels is also a pre-test estimator. The pre-test estimator, like its counterpart that uses a pre-test to assess whether (12) differs significantly from zero at conventional levels, can be biased. This is because the estimator is based on the largest value for $\phi$ that ensures that the quantity (14) does not differ significantly from zero at conventional levels. Use of the pre-test estimator for the return required on a benchmark efficient entity is likely to remove some but not all of any low-beta bias that exists.

# 4. Empirical Evidence

## 4.1 Data

We use monthly data from January 1969 to December 2015 from SIRCA's SPPR database to evaluate forecasts of the return on equity. Thus our tests use the data that HoustonKemp employs in its January 2016 report updated to December 2015.[91] These data are the longest reliable series of returns on a large cross-section of Australian stocks that are available. The SPPR database uses data provided by the ASX.

Like Black, Jensen and Scholes (1972), Fama and MacBeth (1973), Campbell and Vuolteenaho (2004) and Lewellen, Nagel and Shanken (2010), we test pricing models using the returns to portfolios of stocks.[92] The model that the AER chooses as its 'foundation' model is the SL CAPM and this model implies that variation across equities in their mean returns will be completely explained by variation in their betas. So a sensible way of constructing portfolios to be used in evaluating the empirical performance of forecasts of the return on equity is to form portfolios, like Black, Jensen and Scholes and Fama and MacBeth, on the basis of past estimates of beta.[93]

To form portfolios on the basis of past estimates of beta, we begin by extracting data from January 1969 to December 2015 for individual stocks from the SPPR database.[94] The SPPR database does not provide market capitalisations before December 1973 and so we do not begin to record the returns to the portfolios that we construct until January 1974. We use past estimates of betas to allocate stocks to portfolios, however, and so we use data from before January 1974 to determine in which portfolios to place stocks in the early years of the time series that we construct. To minimise the impact of market microstructure effects, at the end of each year we use past data to estimate the betas only of stocks that are in the top 500 by market capitalisation. We choose the top 500 because the All Ordinaries Index is constructed from the top 500 stocks and the AER uses this index in computing an estimate of the *MRP*.

We form value-weighted portfolios on the basis of past beta estimates in the following way. At the end of December each year we use data for the prior five years to estimate the betas of all stocks relative to the market portfolio, dropping those that do not have a full 60 months of data. We then place the stocks into 10 portfolios on the basis of the estimates and record the returns to these portfolios for each month of the following year. So, for example, we compute beta estimates using data from January 1969 to December 1973 for stocks that are in the top 500 by market capitalisation at the end of December 1973. We allocate these stocks to 10 portfolios on the basis of these estimates and then record the returns to the portfolios for each month of 1974. Next, we compute beta estimates using data from January 1970 to December 1974 for stocks that are in the top 500 by market capitalisation at the end of December 1974, allocate these stocks to 10 portfolios on the basis of the estimates and then record the returns to the portfolios for each month of

[91] HoustonKemp, *The cost of equity: Response to the AER's Draft Decisions for the Victorian Electricity Distributors, ActewAGL Distribution and Australian Gas Networks: A Report for ActewAGL Distribution, AusNet Services, Australian Gas Networks, CitiPower, Jemena Electricity Networks, Powercor and United Energy*, January 2016.

[92] Black, F, M. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests, in Studies in the Theory of Capital Markets*, ed. M. Jensen, Praeger, New York, 1972.

Campbell, J. and T. Vuolteenaho, *Bad beta, good beta*, American Economic Review, 2004, page 1249.

Fama, E. F. and J. D. Macbeth, *Risk, return and equilibrium: Empirical tests*, Journal of Political Economy, 1973, pages 607-636.

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

[93] Black, F, M. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests, in Studies in the Theory of Capital Markets*, ed. M. Jensen, Praeger, New York, 1972.

Fama, E. F. and J. D. Macbeth, *Risk, return and equilibrium: Empirical tests*, Journal of Political Economy, 1973, pages 607-636.

[94] We exclude the very small number of price relatives that are negative. On the other hand, we do not exclude those stocks that are in the SPPR database that are headquartered abroad. We find that the results are not sensitive to the exclusion of stocks headquartered abroad.

1975. And so on. We also form a value-weighted portfolio of the top 500 stocks by market capitalisation and use the portfolio as a proxy for the market portfolio.

We compute the returns to the portfolios that we use inclusive of a value assigned to imputation credits. In particular, we assign a value of 35 cents to each dollar of imputation credits distributed. Thus the partially franked returns that we use are the unfranked returns plus 35 percent of the difference between the fully franked and unfranked returns. [95]

We use as a measure of the risk-free rate the yield, computed on a monthly basis, on a 10-year Commonwealth Government Security. We do so because the AER uses the 10-year yield as its measure of the risk-free rate.[96] We extract the end-of-month yields on these bonds from the Reserve Bank of Australia.

## 4.2 Tests

We begin by testing whether forecasts generated by four models are unbiased. These models are a naïve model, the SL CAPM, a regression model and the AER's implementation of the CAPM. We test these models because estimates of the return required on a benchmark efficient entity that use the SL CAPM and alpha adjustments are weighted averages of estimates delivered by the SL CAPM and a regression model while estimates of the return that use the SL CAPM and beta adjustments are weighted averages of estimates delivered by the SL CAPM and a naïve model.

A naïve model that sets the return required on equity to be a constant across all equities will generate the same forecast as the model originally prescribed by the National Electricity Rules (NER) for transmission network service providers (NSPs). The NER originally prescribed that transmission NSPs use the SL CAPM and an equity beta of one and constraining the beta of every equity to be one will result in a forecast of the return on equity that is a constant across all equities. [97] A pricing model should at least be able to outperform, empirically, a naïve model of this kind.

The SL CAPM has been widely used by finance academics over the last 50 years. As section 2 makes clear, however, it has been known for almost 50 years that there is evidence against the SL CAPM. Thus finance academics use the model primarily as a teaching device – because of its simplicity – rather than in research.

The failure of the SL CAPM to explain the behaviour of returns suggests that the use of a simple regression model that relaxes the zero-alpha restriction imposed by the SL CAPM may provide return forecasts that are less likely to be biased. We examine whether this is true by using the simple model (1). Thus we compute the sample mean forecast error as (12) with the fraction placed on alpha, $\lambda$, set to one.

As section 3 makes clear, the AER chooses an equity beta for use with the SL CAPM of 0.70 from a range of 0.40 to 0.70. This choice amounts to placing a weight of two thirds on the midpoint of the range, 0.55, and a weight of one third on one. We label a policy of placing a weight of two thirds on an unadjusted estimate of beta and one third on one and then using the SL CAPM to estimate the return required on equity a policy of using the 'AER CAPM'. The choice of label is, of course, unimportant. What is important is that we specify clearly a method that a regulator might use in estimating a return required on equity for a regulated electricity NSP and that we use time series of returns to evaluate the method. Methods that we cannot specify clearly,

[95] In other words, we assume that theta, the value of a one dollar credit distributed, is 0.35. With a distribution rate for imputation credits of 0.70, gamma, the product of the distribution rate and theta, will then be 0.25.

We also examine whether our results are sensitive to changes in the assumption. In particular, we examine whether our results are significantly altered by replacing the assumption that theta is 0.35 with an assumption that theta is 0.70. We find that the performance of the SL CAPM deteriorates as theta rises but, for the portfolios that we use here, that the impact is negligible.

[96] AER, *Preliminary decision Jemena distribution determination2016–20: Attachment 3: Rate of return*, October 2015, page 89.

[97] National Electricity Rules Version 52, 6A.6.2 (b), page 691.

Available at http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Rules/National-Electricity-Rule-Version-52

Fama, E. F. and J. D. Macbeth, *Risk, return and equilibrium: Empirical tests*, Journal of Political Economy, 1973, pages 607-636.

we cannot evaluate. We 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 in an unspecified manner through time.

We are interested in knowing whether estimates of the return required on equity produced using the AER CAPM exhibit significant bias because if they were not to, we could simply suggest to Multinet that it employ the approach that the AER uses in its *Rate of Return Guidelines* and in its most recent decision. In other words, we could suggest that Multinet use an equity beta of 0.70 × (2/3) + (1/3) = 0.80.

Again, the AER's advisers have portrayed the task of evaluating the AER's approach in choosing an estimate of the equity beta of a benchmark efficient entity as being difficult to carry out because the judgement of the AER is difficult to model. We do not believe that the judgement exercised by the AER is difficult to model. The AER has, rightly, provided an uplift to the equity beta of a benchmark efficient entity – the question is whether the magnitude of the uplift is sufficient to eliminate the evidence of a low-beta bias associated with forecasts of the return on equity generated by the SL CAPM. We would like to discover the answer to the question because we would like to determine what adjustment to Multinet's new estimate of the entity's equity beta of 0.70 will ensure that an estimate of the cost of equity, which uses the adjustment and the SL CAPM, will exhibit no significant bias.

Table 1 below indicates that forecasts of the return on equity that use the AER CAPM exhibit less of a low-beta bias than forecasts generated by the SL CAPM, but that both sets of forecasts exhibit a low-beta bias that is economically as well as statistically significant. For the SL CAPM and AER CAPM, Wald tests reject the hypothesis that each of the series of 10 return forecasts is unbiased. In contrast, forecasts of the return on equity that use either the naïve model or the simple regression model exhibit little significant bias. For the naïve model and simple regression model, Wald tests do not reject the hypothesis that each of the series of 10 return forecasts is unbiased.

In the remainder of this section:

(a) we determine the smallest fraction of an OLS estimate of an equity's alpha that, when added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias; and

(b) we determine the weighted average of an OLS estimate of an equity's beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias.

We begin by determining the smallest fraction of an estimate of an equity's alpha that, when added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias.

## 4.3 Alpha Adjustments

We focus our attention initially on portfolios 1 to 4 because the evidence indicates that the benchmark efficient entity has a low equity beta. Table 1 indicates that, for portfolios 1 to 4, the SL CAPM generates return forecasts that are downwardly biased whereas the simple regression model generates return forecasts that exhibit no significant bias. So the table indicates that, for portfolios 1 to 4, a positive fraction of an OLS estimate of alpha must be added to a return forecast, delivered by the SL CAPM, if the forecast is to exhibit no significant bias.

Figure 5 below plots the p-value associated with a test of the hypothesis that a return forecast is unbiased against the fraction of an OLS estimate of alpha that is added to a return forecast delivered by the SL CAPM. If the fraction is zero, the return forecast generated by the SL CAPM is used without any adjustment being made. So, not surprisingly, Figure 5 indicates that if the fraction is set to zero, the p-value associated with a test of the hypothesis that the return forecast is unbiased is also around zero. If the fraction of an estimate of alpha that is added to a return forecast, delivered by the SL CAPM, is one, the return forecast generated by the simple regression model is used. As a result, Figure 5 indicates that if the fraction is set to one, the p-

value associated with a test of the hypothesis that the return forecast is unbiased exceeds five per cent – by some margin. Figure 5 indicates that the smallest fraction of an OLS estimate of alpha that, when added to a return forecast, delivered by the SL CAPM, will ensure that the forecast of the return does not exhibit significant bias ranges, for portfolios 1 to 4, between 0.31 and 0.52. Table 2 provides the fraction for each portfolio.

Table 1: Out-of-Sample Tests of a Naïve model, the SL CAPM, the Regression Model and the AER CAPM, Recursive Estimates of Beta and Portfolios Formed on the Basis of Past Estimates of Beta

| | | Mean forecast error | | | |
|---|---|---|---|---|---|
| Portfolio | Beta | Naïve model | Sharpe-Lintner CAPM | Regression model | AER CAPM |
| 1 | 0.50 | 3.42 | **6.16** | 1.07 | **5.24** |
| | | (2.12) | (1.81) | (1.81) | (1.81) |
| 2 | 0.62 | 3.36 | **5.34** | 0.89 | **4.68** |
| | | (1.98) | (1.76) | (1.76) | (1.78) |
| 3 | 0.58 | 2.71 | **4.97** | 0.98 | **4.22** |
| | | (1.85) | (1.70) | (1.72) | (1.67) |
| 4 | 0.77 | **3.76** | **4.87** | -0.71 | **4.50** |
| | | (1.70) | (1.63) | (1.63) | (1.63) |
| 5 | 0.85 | 2.52 | 3.20 | **-3.34** | 2.98 |
| | | (1.67) | (1.67) | (1.67) | (1.66) |
| 6 | 0.89 | 1.33 | 1.96 | -0.96 | 1.75 |
| | | (1.44) | (1.45) | (1.45) | (1.44) |
| 7 | 0.97 | -0.72 | -0.65 | -0.17 | -0.67 |
| | | (1.64) | (1.64) | (1.64) | (1.64) |
| 8 | 1.19 | -0.55 | -1.52 | 0.95 | -1.20 |
| | | (1.88) | (1.79) | (1.79) | (1.81) |
| 9 | 1.36 | -3.31 | **-5.15** | 0.68 | **-4.54** |
| | | (2.34) | (2.16) | (2.17) | (2.17) |
| 10 | 1.39 | -3.64 | -5.66 | -0.62 | -4.98 |
| | | (3.71) | (3.56) | (3.58) | (3.58) |
| Wald | | 9.15 | **31.54** | 6.80 | **24.39** |
| | | [0.52] | [0.00] | [0.74] | [0.01] |

*Notes: The results are for the period January 1979 to December 2015. Sample mean forecast errors in per cent per annum are outside of parentheses while the standard errors of the means are in parentheses. Estimates of beta are the averages of the recursive estimates. Wald statistics for tests of each model are outside of brackets while the p-values associated with the statistics are in brackets. Mean forecast errors that differ significantly from zero at the five per cent level are in bold. Wald statistics that lead to a rejection of a model at the five per cent level are also in bold. Each Wald statistic uses a vector of sample mean forecast errors and an estimate of the covariance matrix of the forecast errors to test whether each of the 10 the forecasts is unbiased.*

We have been instructed to assume that the best estimate of the equity beta of a benchmark efficient entity is 0.70 and have been asked to determine the smallest fraction of an OLS estimate of an equity's alpha that,

when added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias.[98] Estimates of the alphas of portfolios 3 and 4 that use data from January 1974 to December 2015 are 3.92 and 4.42 per cent per annum – slightly below the mean forecast errors that appear in Table 1. Using these estimates and the fractions that appear in Table 2, we determine the smallest fraction to be, in per cent per annum, for portfolio 3:

$$0.41 \times 3.92 = 1.61 \tag{15}$$

and for portfolio 4:

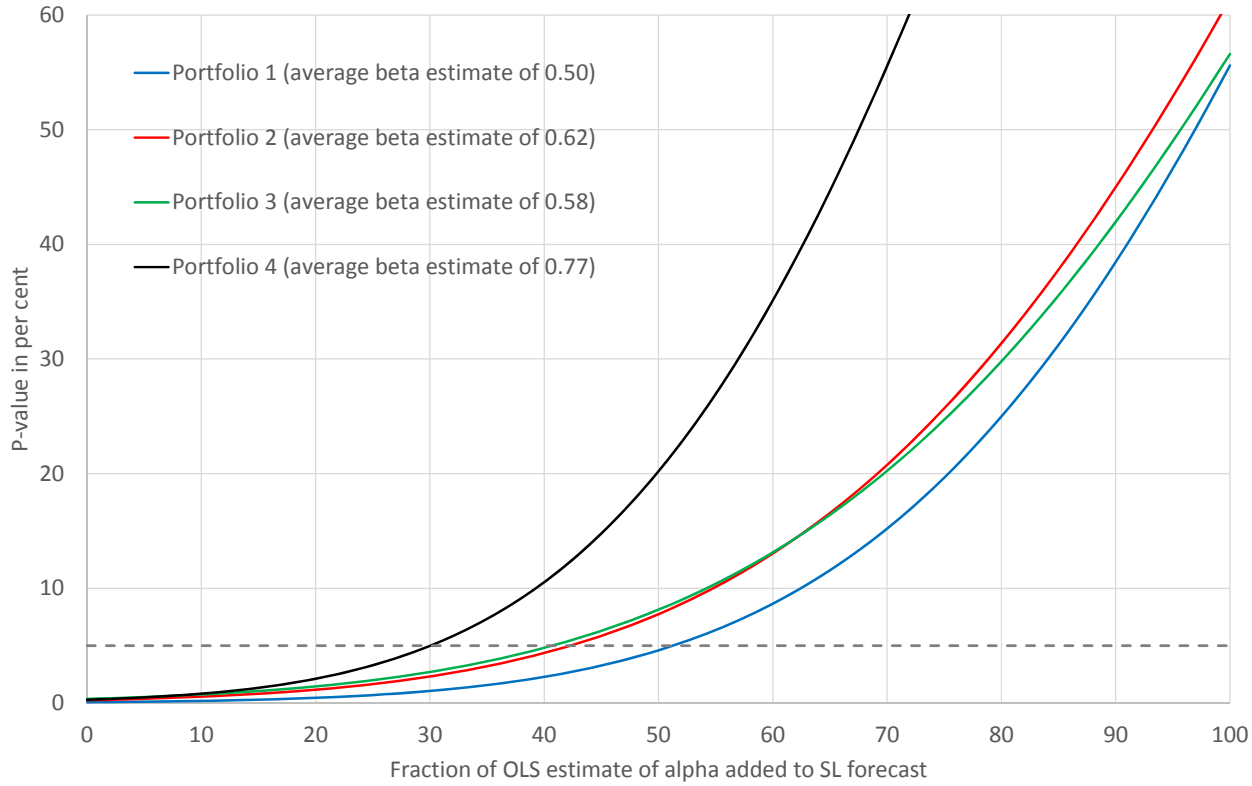
$$0.31 \times 4.42 = 1.37 \tag{16}$$

Using these results and interpolation we determine the smallest fraction, in per cent per annum, for a portfolio that has a beta of 0.70 to be:

$$1.61 + \left(\frac{0.70 - 0.58}{0.77 - 0.58}\right) \times (1.37 - 1.61) = 1.46 \tag{17}$$

Using portfolios 2 and 4 produces a smallest fraction of 1.58.

Figure 5: P-Value for Test of Unbiasedness Using Individual Portfolios against Fraction of OLS Estimate of Alpha Added to SL Forecast




*Note: The horizontal grey dashed line indicates a p-value of five per cent.*

[98] The estimate of 0.70 is based on other work that Multinet has had commissioned and has not been adjusted to take into account the low-beta bias associated with estimates of the return required on the equity of a benchmark efficient entity that use the SL CAPM.

We also determine the smallest fraction of each estimate of alpha that, when added to each return forecast, delivered by the SL CAPM, of the required return to each of the 10 portfolios, will ensure that each forecast does not exhibit significant bias.

Table 2: Fractions Used of OLS Estimates of Alpha

| | Portfolio | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | All |
| Beta | 0.50 | 0.62 | 0.58 | 0.77 | |
| Fraction | 0.52 | 0.43 | 0.41 | 0.31 | 0.27 |

*Notes: The results are for the period January 1979 to December 2015. Estimates of beta are the averages of the recursive estimates. Each fraction provided is the smallest fraction of an OLS estimate of a portfolio's alpha that, when added to a forecast delivered by the SL CAPM, of the portfolio's required return, will ensure that the forecast does not exhibit a bias that is significant at the five per cent level.*

Figure 6 below plots the p-value associated with a Wald test of the hypothesis that each return forecast is unbiased against the fraction of an OLS estimate of alpha that is added to each return forecast delivered by the SL CAPM. If the fraction is zero, return forecasts generated by the SL CAPM are used without any adjustment being made. Thus Figure 6 indicates that if the fraction is set to zero, the p-value associated with a test of the hypothesis that each return forecast is unbiased is also around zero. If the fraction of an estimate of alpha that is added to each return forecast, delivered by the SL CAPM, is one, return forecasts generated by the simple regression model are used. As a result, Figure 6 indicates that if the fraction is set to one, the p-value associated with a test of the hypothesis that each return forecast is unbiased is 0.74 – as in Table 1. Figure 6 indicates that the smallest fraction of an OLS estimate of alpha that, when added to each return forecast, delivered by the SL CAPM, will ensure that each of the 10 return forecasts exhibits no significant bias is 0.27.

Again, estimates of the alphas of portfolios 3 and 4 that use data from January 1974 to December 2015 are 3.92 and 4.42 per cent per annum. Using these estimates and interpolation, an estimate of the alpha of a portfolio that has a beta of 0.70 will be:

$$3.92 + \left(\frac{0.70 - 0.58}{0.77 - 0.58}\right) \times (4.42 - 3.92) = 4.24 \quad (18)$$

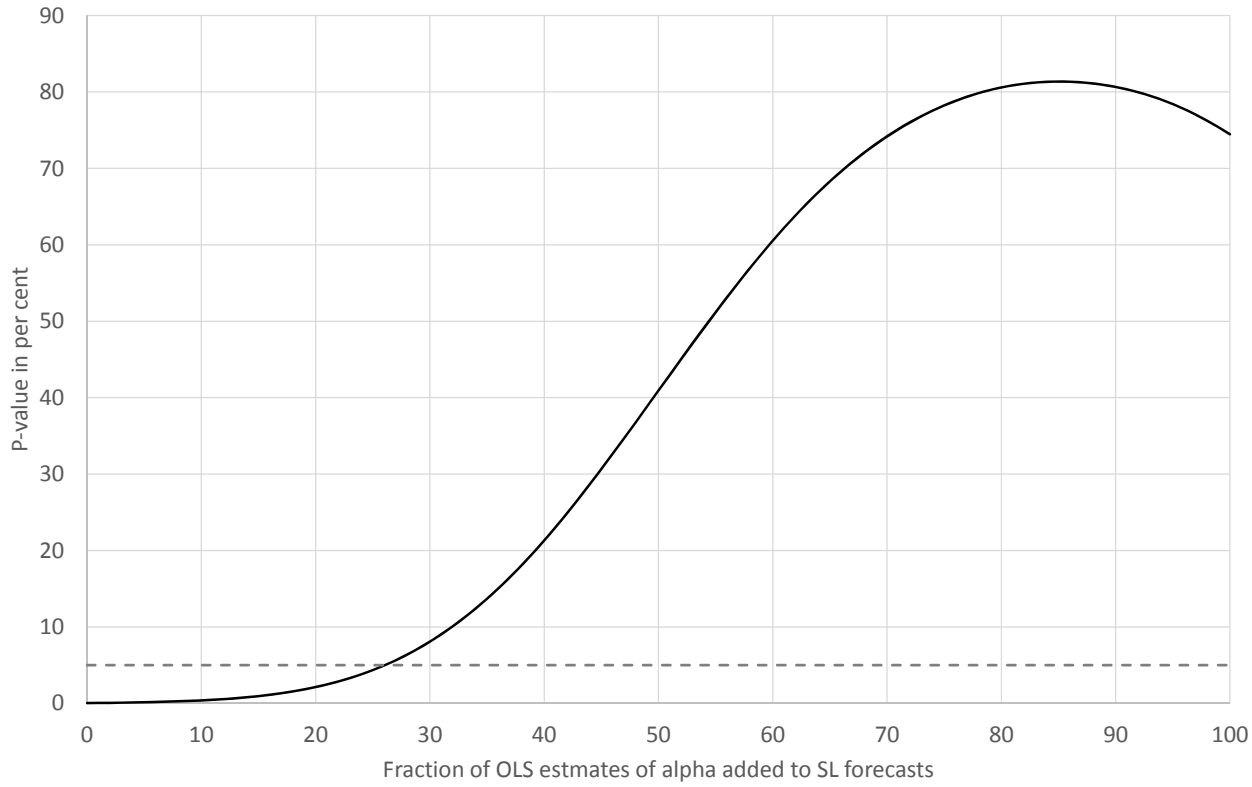
It follows that, for an equity that has a beta of 0.70, an alternative value for the smallest fraction of an OLS estimate of the equity's alpha that, when added to a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias will be, in per cent per annum:

$$0.27 \times 4.24 = 1.14 \quad (19)$$

Using portfolios 2 and 4 and this method produces a smallest fraction of 1.17.

We now turn to determining the weighted average of an OLS estimate of an equity's beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias.

Figure 6: P-Value for Wald Test of Unbiasedness Using All Portfolios against Fraction of OLS Estimates of Alpha Added to SL Forecasts



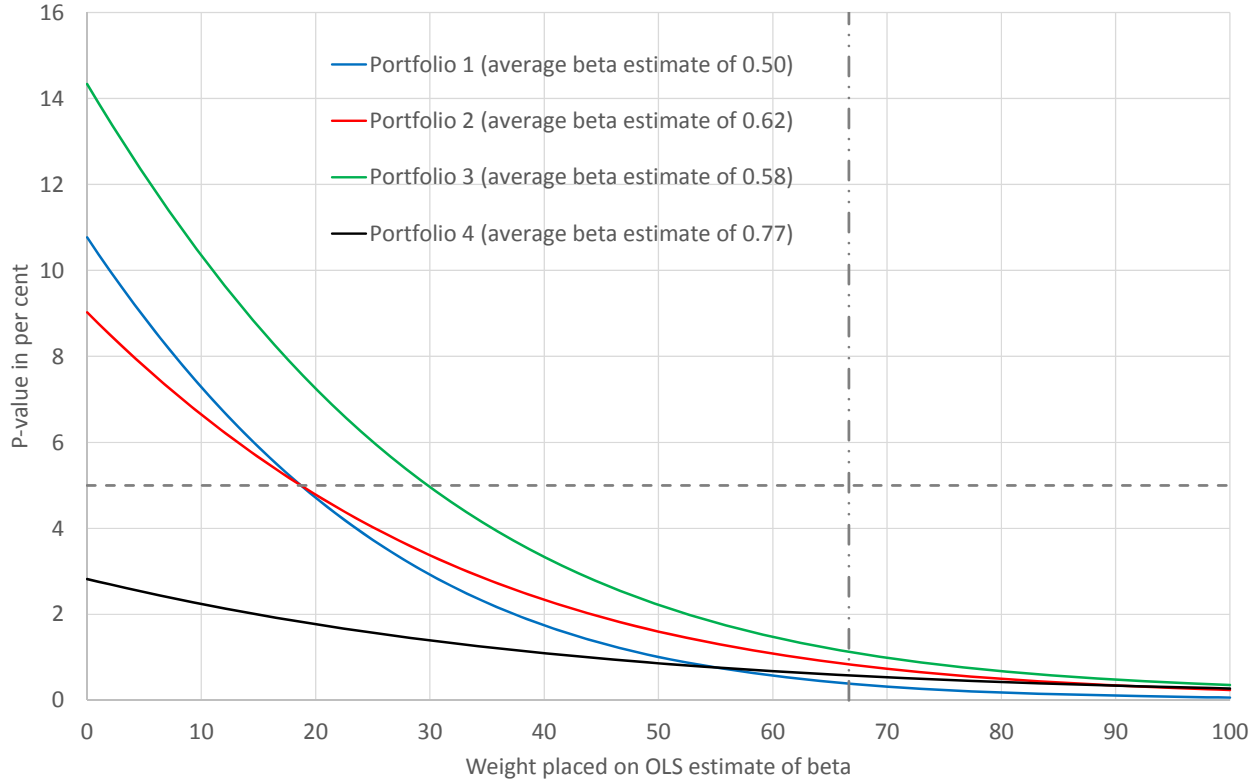

*Note: The grey dashed line indicates a p-value of five per cent.*

## 4.4 Beta Adjustments

Again, we focus our attention initially on portfolios 1 to 4 because the evidence indicates that the benchmark efficient entity has a low equity beta. Table 1 indicates that, for portfolios 1 to 4, the AER CAPM generates return forecasts that exhibit less of a low-beta bias than forecasts generated by the SL CAPM, but that both sets of forecasts exhibit a low-beta bias that is significant. So the table indicates that for a return forecast, delivered by the SL CAPM, which uses a weighted average of an OLS estimate of beta and one, to exhibit no significant bias, the weight placed on an OLS estimate of beta must lie below two thirds.

Figure 7 plots the p-value associated with a test of the hypothesis that a return forecast, delivered by the SL CAPM, is unbiased against the weight placed on an OLS estimate of beta. If the weight is zero, the return forecast generated by the naïve model is used. Figure 7 shows, consistent with the evidence provided by Table 1, that, for portfolios 1 to 3, if the weight is set to zero, the p-value associated with a test of the hypothesis that the return forecast is unbiased exceeds five per cent. For portfolio 4, on the other hand, if the weight is set to zero, the p-value associated with a test of the hypothesis that the return forecast is unbiased is less than five per cent – indicating that the hypothesis that a forecast generated by the naïve model is unbiased can be rejected. This evidence is also consistent with the evidence provided by Table 1. Figure 7 indicates that, for portfolios 1 to 3, for a return forecast, delivered by the SL CAPM, which uses a weighted average of an OLS estimate of beta and one, to exhibit no significant bias, the weight placed on an OLS estimate of beta should not exceed between 0.18 and 0.29. Table 3 provides the weights for portfolios 1 to 3. For portfolio 4, even a return forecast, delivered by the SL CAPM, which uses a beta of one exhibits significant bias – albeit less bias than a forecast that uses a weighted average of an OLS estimate of beta and one, where a positive weight is placed on the estimate.

Figure 7: P-Value for Test of Unbiasedness Using Individual Portfolios against Weight Placed on OLS Estimate of Beta




*Note: The horizontal grey dashed line indicates a p-value of five per cent. The vertical grey dashed line indicates the AER approach of allocating a weight of two thirds to an OLS estimate of beta and a weight of one third to one.*

We have been instructed to assume that the best estimate of the equity beta of a benchmark efficient entity is 0.70 and have been asked to determine the weighted average of an OLS estimate of an equity's beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the equity's required return, will ensure that the forecast of the return does not exhibit significant bias. Using portfolio 3 and 4, the weights that appear in Table 3 and interpolation, we determine the largest weight to be no more than:

$$0.29 + \left(\frac{0.70 - 0.58}{0.77 - 0.58}\right) \times (0.00 - 0.29) = 0.11 \quad (20)$$

It follows that the minimum uplift that must be applied to the equity beta of an equity that has a beta of 0.70 will be:

$$(0.11 \times 0.70 + (1 - 0.11) \times 1.00) - 0.70 = 0.27 \quad (21)$$

Using portfolios 2 and 4 and interpolation provides a largest weight of 0.08 and a minimum uplift also of 0.27.

The AER in its most recent decision uses a value for the *MRP* of 6.50 per cent per annum.[99] With this value for the *MRP*, the uplift to an estimate of the cost of equity for a benchmark efficient entity would be, in per cent per annum:

$$0.27 \times 6.50 = 1.75 \quad (22)$$

Note that we use the AER's value for the *MRP* for illustrative purposes. We are not endorsing this figure.

Table 3: Weights Placed on OLS Estimates of Beta

| | Portfolio | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | All |
| Beta | 0.50 | 0.62 | 0.58 | 0.77 | |
| Weight | 0.18 | 0.18 | 0.29 | < 0.00 | 0.44 |

*Notes: The results are for the period January 1979 to December 2015. Estimates of beta are the averages of the recursive estimates. We determine the weighted average of an OLS estimate of beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the required return to a portfolio, will ensure that the forecast does not exhibit significant bias. We also determine the weighted average of each OLS estimate of beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the required return to each of the 10 portfolios, will ensure that each forecast does not exhibit significant bias. The table provides these largest weights.*

We also determine the weighted average of each OLS estimate of beta and one, which places the largest weight on the estimate, that, when used in computing a forecast, delivered by the SL CAPM, of the required return to each of the 10 portfolios, will ensure that each forecast does not exhibit significant bias.

Figure 8 plots the p-value associated with a Wald test of the hypothesis that each return forecast, delivered by the SL CAPM, is unbiased against the weight placed on each OLS estimate of beta. If the weight is zero, return forecasts generated by the naïve model are used. Thus Figure 8 indicates that if the weight is set to zero, the p-value associated with a test of the hypothesis that each return forecast is unbiased is 0.52 – as in Table 1. If the weight is one, return forecasts generated by the SL CAPM are used. As a result, Figure 8 indicates that if the weight is set to one, the p-value associated with a test of the hypothesis that each return forecast is unbiased is around zero. Figure 8 indicates that for each return forecast, delivered by the SL CAPM, which uses a weighted average of an OLS estimate of beta and one, to exhibit no significant bias, the weight placed on each OLS estimate of beta must be no more than 0.44.

It follows that an alternative value for the minimum uplift that must be applied to the equity beta of an equity that has a beta of 0.70 will be:

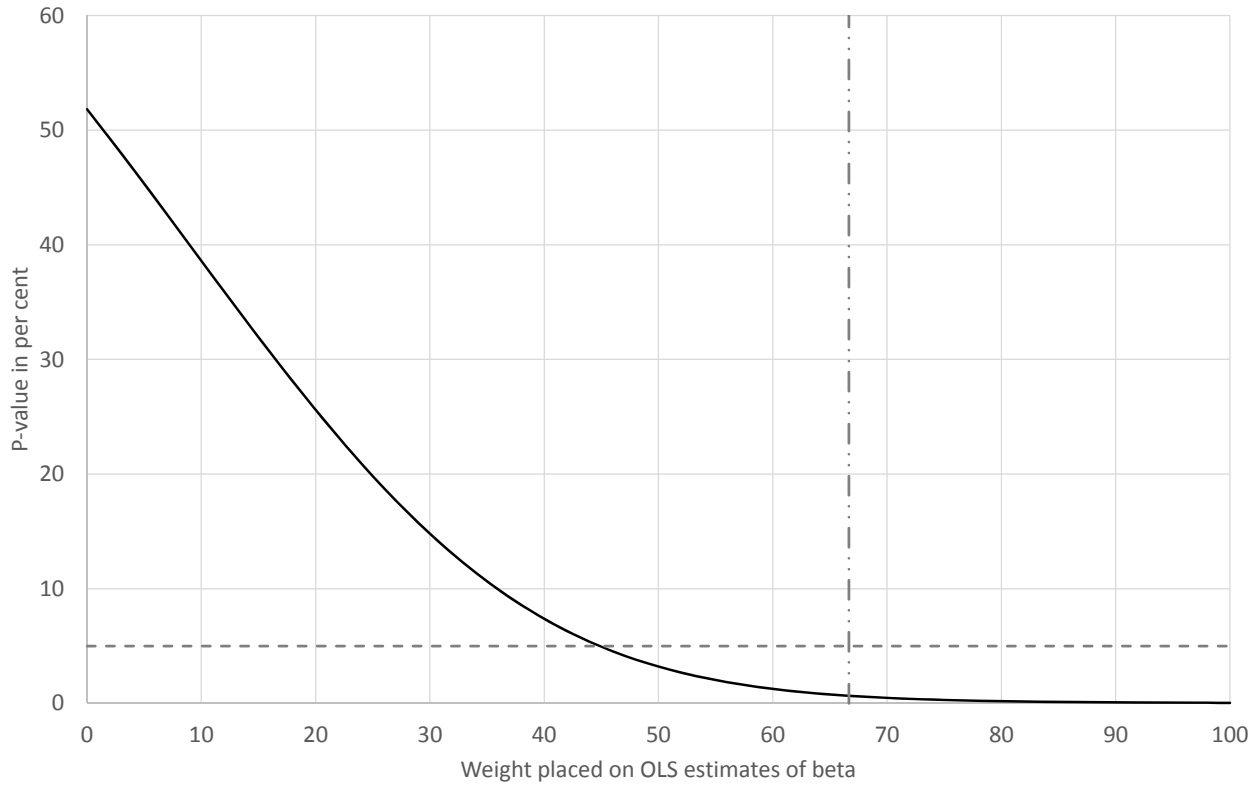
$$(0.44 \times 0.70 + (1 - 0.44) \times 1.00) - 0.70 = 0.17 \quad (23)$$

With the AER's value for the *MRP* of 6.50 per cent per annum, the uplift to an estimate of the cost of equity for a benchmark efficient entity would be, in per cent per annum:

$$0.17 \times 6.50 = 1.10 \quad (24)$$

[99] AER, *Draft decision AusNet Services transmission determination 2017-18 to 2021-22: Attachment 3 – Rate of return*, July 2016, page 12.

Figure 8: P-Value for Wald Test of Unbiasedness Using All Portfolios against Weight Placed on OLS Estimates of Beta




*Note: The grey dashed line indicates a p-value of five per cent.*

## 4.5 Implications for the Cost of Equity

The uplifts, which we compute to the cost of equity for a benchmark efficient entity, that are consistent with the alpha and beta adjustments necessary to remove evidence in past data of a bias associated with forecasts of the return on equity, generated by the SL CAPM, range from 1.10 to 1.75 per cent per annum.

The uplift that the AER would apply to an unadjusted estimate of the equity beta of a benchmark efficient entity were it to follow the approach that it has used in recent decisions would be:

$$(2/3)\times 0.70 + (1/3)\times 1.00 - 0.70 = 0.10 \quad (25)$$

Thus, again using the AER's value for the *MRP*, the uplift that the AER would apply to the cost of equity would be, in per cent per annum:

$$0.10 \times 6.50 = 0.65 \quad (26)$$

This uplift falls below the range that we provide because, as Table 1 makes clear, the evidence indicates that the AER's approach is insufficient to remove evidence in past data of a bias associated with forecasts of the return on equity generated by the SL CAPM.

# 5. Issues Raised by the AER, ERA and their Advisers

The AER, in its *Rate of Return Guidelines*, chooses a point estimate, for the equity beta of a benchmark efficient entity, of 0.70 from a range of 0.40 to 0.70. The AER describes its rationale for choosing this point estimate and ignoring suggestions made by the Major Energy Users (MEU) and the PIAC that it adopt a point estimate around the midpoint of its range as follows: [100]

> 'MEU and PIAC both specified that it would be more appropriate to adopt a point estimate around the mid-point of the range. PIAC submitted that, as a matter of policy, we should adopt a point estimate around 0.5 to 0.6 and only depart from this if there is a compelling case to do so. We consider the evidence currently before us is sufficiently strong to justify applying an equity beta point estimate at the upper end of the 0.4 to 0.7 range of empirical estimates. Adopting a point estimate around the mid-point would be more reasonable if our intention was to base the allowed return on equity on the Sharpe–Lintner CAPM and empirical estimates alone. However, the rules require us to have regard to relevant estimation method, financial models, market data and other evidence when determining the allowed rate of return. When this information is taken into account, we consider it reasonable to select a point estimate from the upper end of the range of empirical equity beta estimates.'

The ERA, on the other hand, in its most recent decision takes, on the advice of its advisers, Partington and Satchell, a different stance. The ERA states that: [101]

> 'The Authority acknowledges that there is much debate about whether an adjustment needs to be made to the SL-CAPM. This was recognised by the Authority in the Guidelines and Draft Decision, with reference to the theoretical properties of (sic) Black CAPM. However, analysis since, by the Authority and its consultants, in response to DBP, has made the Authority concerned that it would likely be making a greater error by making an adjustment to the SL-CAPM – through alpha – than by making no adjustment. The Authority is not convinced such an adjustment would meet the allowed rate of return objective, or the requirements of the NGO or the RPP.
>
> Accordingly, the Authority has determined to retain the use of the 'vanilla' SL-CAPM for this Final Decision, with the beta parameter based on the central, best estimate. Further, in light of the foregoing, no adjustment is made for alpha.
>
> The Authority is satisfied that the resulting return on equity derived using the SL-CAPM is consistent with the allowed rate of return objective, and with the other requirements of the NGL and NGR.'

In this section we respond to issues raised by the AER, the ERA and advisers to the regulators about the cost of equity and the low-beta bias, placing a particular focus on whether the evidence supports the view of the AER, as expressed in its *Rate of Return Guidelines*, or the ERA, as expressed in its most recent decision.

## 5.1 Issues Raised by the AER's Advisers and ERA's Advisers

### 5.1.1 Ignoring evidence

Partington and Satchell suggest in their May 2016 report for the ERA that the large amount of evidence that we review that indicates that a low-beta bias exists does not imply that any uplift need be provided in using

[100] AER, *Better regulation explanatory statement: Rate of return guideline (Appendices),* December 2013, pages 76-77.

[101] ERA, *Final Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020 Submitted by DBNGP (WA) Transmission Pty Limited Appendix 4 Rate of Return*, June 2016, page 95.

the SL CAPM to estimate the cost of equity for a benchmark efficient entity. [102] In particular, Partington and Satchell state that: [103]

> 'The 'problem' thrown up by many SL CAPM tests is that they have a positive intercept. The financial industry tends to regard this as 'smart beta' i.e. low risk stocks outperform high risk stocks; this outperformance is often understood in behavioural terms. In this context, if an adjustment is necessary, it would be to subtract the intercept rather than adjust beta. This merits some explanation as it contrasts with the usual claim for a need to adjust the risk free rate upwards, as in the usual arguments for adopting the Black CAPM.
>
> This usual argument for the Black CAPM is based on the premise that actual returns are equal to equilibrium returns on average and thus a positive intercept in tests of the SL CAPM are assumed to be driven by the SL CAPM underestimating (overestimating) realised returns for low (high) beta stocks. An alternative premise is that the results are a consequence of actual returns outperforming (underperforming) equilibrium returns for low (high) beta stocks. In the parlance of funds management such outperformance is expressed as alpha. Thus low beta stocks have positive alphas. In this case an estimate of the equilibrium return is obtained by subtracting alpha from the actual return. Whether the resulting return is then higher or lower than the regulated return is an open question and will depend upon the magnitude of alpha and beta.'
>
> 'If an adjustment is considered necessary, we make a case for a downward adjustment to returns.'

To understand what advice Partington and Satchell are providing and whether or not the advice makes sense, it will be helpful to introduce a number of return definitions. For convenience, we lay these out in Table 4 below.

In terms of algebraic notation, the expected excess return to asset *j* is $\mathrm{E}(z_j)$, the modelled excess return to the asset is $\beta_j \mathrm{E}(z_m)$ – where the model is the SL CAPM – and the difference between the two is $\alpha_j$.

Partington and Satchell are proposing that one set aside the evidence of a low-beta bias and compute an estimate of the cost of equity using the formula:

$$\bar{z}_j - \hat{\alpha}_j = \hat{\beta}_j \bar{z}_m, \quad \text{where } \bar{z}_j = \frac{1}{T}\sum_{t=1}^{T} z_{jt},\ \bar{z}_m = \frac{1}{T}\sum_{t=1}^{T} z_{mt},\ \hat{\alpha}_j = \bar{z}_j - \hat{\beta}_j \bar{z}_m$$

$$\text{and } \hat{\beta}_j = \left(\sum_{t=1}^{T}(z_{mt} - \bar{z}_m)^2\right)^{-1} \sum_{t=1}^{T}(z_{jt} - \bar{z}_j)(z_{mt} - \bar{z}_m) \qquad (27)$$

The advice of Partington and Satchell is that no matter how large an estimate of $\alpha_j$ turns out to be, attribute the estimate to 'outperformance' and deduct the estimate from the sample mean of the series of realised returns. This is unusual advice.

The sample mean of the series of returns will be an unbiased estimator for the expected return while an estimator that uses the SL CAPM will only be unbiased if the model is correct – that is, if alpha is zero. If the model is false, that is, if alpha differs from zero, then using the model will deliver an estimate that is biased. Typically where evidence is provided against a model one would refrain from using the model without making some sort of an adjustment. The advice that Partington and Satchell provide is to go ahead and use an estimator that employs the SL CAPM whether or not there is evidence against the model and so whether or not the estimator is biased.

[102] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016.

[103] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, pages 15-16.

We emphasise, again, that deviations from the SL CAPM do not in general offer up arbitrage opportunities nor are substantial deviations from the model theoretically implausible. In other words, one cannot rule out significant deviations from the SL CAPM on theoretical grounds.

Table 4: Return Definitions

| Term | Definition |
|---|---|
| *Realised* return | A *realised* return is the return that an investor realises on his or her investment over some period. If the investment is risky, the realised return will not be known in advance. |
| *Expected* return | An *expected* return is the expected value of a future realised return. While the expected return to an asset will, in principle, be known in advance, it typically cannot be observed, because it is generally impossible to see inside the heads of investors and understand what their expectations are. |
| *Required* return | A *required* return is the return that investors require on an investment. While the required return to an asset will also, in principle, be known in advance, it too typically cannot be observed. |
| *Equilibrium* return | If markets are in equilibrium, then the expected return to holding an asset will equal the return that investors require on the asset and the common return can be labelled the *equilibrium* return to holding the asset. Like the expected and required returns, the equilibrium return will, in principle, be known in advance, but will typically not be observed. |
| *Modelled* return | Regulators often use asset pricing models to estimate the return that investors require on an asset. A measure of the required return produced by an asset pricing model can be labelled a *modelled* return. If all of the assumptions underpinning a particular asset pricing model are correct, then the modelled return will equal the expected return. The asset pricing model, however, may not be correct and the modelled return may differ from the expected return it seeks to measure. The difference between the expected return and the modelled return to a portfolio is typically referred to as the portfolio's *alpha*. |

We also emphasise that using the phrase 'equilibrium expected return' and the word 'CAPM' in the same sentence will provide no guarantee that an estimate of the return required on the equity of a benchmark efficient entity, that uses the SL CAPM, will be unbiased. In other words, using the phrase 'equilibrium expected return' and the word 'CAPM' in the same sentence will provide no guarantee that the SL CAPM is true. Partington and Satchell use the phrase and word together in a sentence on no less than eight occasions in their April 2016 report for the AER. In particular, they state that: [104]

> 'The SLCAPM is based on a theoretical model of equilibrium expected returns.'
>
> 'In the context of HoustonKemp's report it does not mean that beta is downward biased, neither does it necessarily mean that the equilibrium expected returns from the CAPM are downward biased. In the current context, low beta bias means that equilibrium expected returns given by

[104] Partington, G. and S. Satchell, *Report to the AER: Cost of equity issues 2016 electricity and gas determinations*, April 2016, pages 40-41, 43, 47 and 51.

> the CAPM for low beta portfolios are lower than the subsequent realised returns for those portfolios. The interpretation that HoustonKemp makes of this is that the equilibrium expected returns from the CAPM are downward biased, this is a possible explanation, but it is not necessarily the true explanation.'
>
> 'The SLCAPM can still be used in the usual manner to compute the equilibrium expected return to the asset.'
>
> 'It is also widely agreed that the SLCAPM is a model of equilibrium expected returns.'
>
> 'We agree that the results of NERA (2015b) can be seen as counter intuitive relative to the description of equilibrium expected returns from the CAPM.'
>
> 'What this shows is that low beta shares have had realised returns that outperformed and high beta shares have had realised returns that underperformed relative to the CAPM equilibrium expected return benchmark.'

It is true that the SL CAPM is an equilibrium model of expected returns. It is one of very many such models. Testing whether the SL CAPM can provide unbiased estimates of expected returns, however, requires one examine data. That is, assessing whether the SL CAPM is a good or a bad model of expected returns requires one examine empirical evidence. One will not be able to determine whether the SL CAPM is a good or bad model solely by introspection.

### 5.1.2 Equilibrium irrelevance

The justification that Partington and Satchell use for setting aside the evidence of a low-beta bias is that the evidence may reflect disequilibrium in the capital markets over a long period of time.

Partington and Satchell state, for example, that: [105]

> 'So let us be absolutely clear that the purpose of asset pricing models is to determine the ex-ante return that investors require. When prices are in equilibrium this required return is equal to the expected return, but there is no guarantee that expectations will be realised, or that prices are always in equilibrium. If there were a guarantee that expectations would be realised then the asset would have no risk.'

It may be that on occasion markets are out of equilibrium, but whenever markets are out of equilibrium there will be strong forces propelling markets back towards equilibrium. If, for example, investors require a return on a risky asset of 10 per cent but the expected return on the asset is 15 per cent, then markets will be out of equilibrium. The gap between the expected return and the return that investors require will prompt Investors to increase their holdings of the asset, so bidding up its price. A higher price for the asset will lower the expected return that investors can expect to earn on the asset and may raise the return that investors require on the asset since investors will now be allocating a larger fraction of their wealth to the asset. Thus the adjustments that one would expect investors to quickly make should bring expected and required returns back together rapidly.

It is correct that asset pricing models make predictions about the returns that investors require and, since asset pricing models are typically equilibrium models, about expected (ex-ante) returns. It is also correct that for risky assets there is no guarantee that realised returns will match expected returns. It is unlikely, however, that the returns that investors require on assets will sit far below or far above the returns that investors can expect to earn on the assets for a prolonged period of time because, again, there are strong forces, should markets move away from equilibrium, which will propel markets back towards equilibrium.

[105] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, page 7.

Partington and Satchell's view that departures from equilibrium mean that past data provide a poor guide as to whether a pricing model will deliver unbiased estimates of the cost of equity is also made clear in the following passage: [106]

> 'We need to be clear what unbiased means. If it means that [the mean forecast errors associated with return forecasts in out-of-sample tests do not differ significantly from zero], then [the return forecasts] are generally unbiased, at least with respect to the beta sorted portfolios. However, this view of unbiasedness then gets translated into a view that the regulator who uses the SL CAPM is providing investors with approximately 4% per annum less compensation. This treats low beta ex-post returns as equilibrium returns. Here and elsewhere in the document we take the view that the low beta anomaly is indeed an anomaly. The correct regulatory return would be more sensibly based on subtracting the intercept term from returns [rather than] adjusting the slope.'

The part of the statement that says that tests for unbiasedness end up treating realised (ex-post) returns as equilibrium returns – and so expected returns – is, of course, untrue. Tests for unbiasedness treat each realised return as being the sum of an expected return and an unexpected return – which is tautologically correct – and average realised returns as estimates of expected returns. Tests for unbiasedness of the kind that we carry out in Table 1 take into account the fact that estimates of expected returns will differ from expected returns. The larger the variability of a series of forecast errors the bigger the gap that may exist between estimates of expected returns and the expected returns themselves and so, all else constant, the lower the p-value that we report. In other words, the larger the variability of a series of forecast errors, the less persuasive, all else constant, do we view the evidence.

The part of the statement that says that Partington and Satchell view the behaviour of the returns to low-beta portfolios as anomalous and are of the view that regulators should subtract the intercept term from returns (use the SL CAPM in computing an estimate of the cost of equity) reveals that they believe that the large mass of evidence against the SL CAPM should be set aside – regardless of its significance.

The justification that Partington and Satchell use for setting aside the evidence of a low-beta bias – that the evidence may reflect disequilibrium in the capital markets over a long period of time – is also made clear in the following statement: [107]

> 'It would be unwise to use the ability to forecast subsequent realised returns as the sole criterion for selecting an asset pricing model. Forecasting stock returns and determining equilibrium expected returns (asset pricing) are two different tasks.'

The second sentence of the above is clearly untrue. Asset pricing models are models, in which an equilibrium is in general assumed to exist, that make predictions about the cross-section of mean returns – that is, expected returns. An expectation is a forecast. [108] By evaluating whether the forecasts that a pricing model delivers are biased or unbiased one can assess whether estimates of the return on equity that the model delivers are likely to be biased or unbiased.

Regardless of whether markets are in equilibrium or disequilibrium the cost for a company of raising equity will be the return that the company expects that it must deliver to equity-holders, that is, the expected return to the equity. If the market expects to receive a return of 15 per cent, then that will be the cost that a company will face in raising equity – regardless of whether investors require only 10 per cent. There are strong forces that will prevent expected and required returns from diverging for very long and so in general one would expect that the return that the company expects to deliver to equity-holders will also be the return that investors require. It is, however, the return that the company expects to deliver that will determine the

[106] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, page 34.

[107] Partington, G. and S. Satchell, *Report to the AER: Cost of equity issues 2016 electricity and gas determinations*, April 2016, page 38.

[108] A forecast, on the other hand, need not be an expectation. One might use as a forecast of a random variable the median rather than the mean of the random variable's distribution.

cost that the company will face in raising equity and so it is far from clear that it matters whether the market is in equilibrium or disequilibrium.

One way that it might matter would be if the market is currently in equilibrium but has been out of equilibrium for the preceding 40 years. It would matter, for example, if the return that investors require on equity has been in the past persistently below the expected return on equity year after year. Relying on historical data then would lead an analyst to overestimate the expected return on equity going forward. It is not credible, however, that the return that investors require on equity has been persistently below the expected return on equity – that is, that the market has been out of equilibrium – for a period of 40 years.

### 5.1.3 Formula errors

Partington and Satchell argue that even were the SL CAPM to be true, one would expect to see evidence of a low-beta bias in past data because OLS estimators of the intercept and slope coefficient in a simple regression will be, by construction, negatively correlated with one another when the mean of the independent variable is positive. In particular, in their May 2016 report, they state about recent submissions and reports to the ERA that:[109]

> 'A considerable part of the submissions and reports that we are discussing are concerned with so called low beta bias … We address this issue in the general context of linear regression.
>
> For a linear regression, if we have $y = X\theta + V$ where $y$ is $(n \times 1)$, $X$ is $(n \times k)$, $\theta$ is $(k \times 1)$ and $V$ $(n \times 1)$ where $V \sim (0, \sigma^2 I_n)$. The above notation means that the estimators are distributed with mean vector 0 and covariance matrix $\sigma^2 I_n$ where $I_n$ is an $n$ by $n$ diagonal matrix with one's down the diagonal.
>
> Under classical assumptions, it is well-known that $\hat{\theta} \sim \left(\theta, \sigma^2 (X'X)^{-1}\right)$
>
> In particular, if $X = \begin{pmatrix} 1 & X_1 \\ 1 & X_n \end{pmatrix}$ $\theta = \begin{pmatrix} \alpha \\ \beta \end{pmatrix}$
>
> $$\hat{\theta} \sim \left( \begin{pmatrix} \alpha \\ \beta \end{pmatrix}, \begin{pmatrix} \sum X_i^2 & -n\bar{X} \\ -n\bar{X} & n \end{pmatrix} \right) \frac{1}{\sum \left(X_i - \bar{X}\right)^2} \text{ where } \bar{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$
>
> This tells us that $\text{cov}\left(\hat{\alpha}, \hat{\beta}\right) = \frac{-n\bar{X}}{\sum \left(X_i - \bar{X}\right)^2}$.
>
> In the context of the Sharpe Index Model, we note that $\bar{X} = \frac{\sum_{i=1}^{n} (R_i)}{n}$ that is, it is the mean excess return and so we find that $\hat{\alpha}$ and $\hat{\beta}$ are negatively correlated if excess returns are positive on average in the sample. We would expect the latter condition to hold on average, although there may be periods when it does not hold.
>
> If the SLCAPM holds we know … that $\alpha = 0$. However, from the foregoing analysis, firms with high estimated betas would be expected to have low (negative) estimated alphas and stocks with low estimated betas should have high (positive) estimated alphas. This will happen in time-series regression when the SLCAPM holds and when the true model is Sharpe's Market Model. This has absolutely nothing to do with a beta bias of any kind.'

[109] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, pages 17-18.

This analysis is incorrect. The formula that Partington derive for the covariance between the OLS estimator for the intercept $\alpha$ and the OLS estimator for the slope coefficient $\beta$ indicates that the covariance will tend in large samples to minus the ratio of the *MRP* to the variance of the excess return to the market – that is, the covariance will not tend to zero but, if the *MRP* is positive, to a positive constant. It is well known, however, that under the classical assumptions, the variance of each OLS estimator will approach zero as the sample size gets large – implying that the covariance between the two estimators will also approach zero. So Partington and Satchell's result cannot be correct.

Chapter 2 of Johnston's text, *Econometric Methods*, provides the correct formula for the covariance between the two estimators. This formula, using the notation of Partington and Satchell, is: [110]

$$\text{Cov}\left(\hat{\alpha},\hat{\beta}\right) = \frac{-\bar{X}\sigma^2}{\sum_{i=1}^{n}(X_i - \bar{X})^2} \qquad (28)$$

This formula differs from the formula that Partington and Satchell derive in two ways. First, the covariance depends, consistent with intuition, on $\sigma^2$, the variance of the disturbance from the regression – Partington and Satchell omit this term. Second, and more importantly, the formula that Johnston provides omits the term *n* – that is, the sample size – that Partington and Satchell incorrectly include. Omitting the term *n* guarantees that the covariance between the OLS estimator for the intercept $\alpha$ and the OLS estimator for the slope coefficient $\beta$ will tend in large samples to zero.

While the covariance between the OLS estimator for the intercept and the OLS estimator for the slope coefficient will tend in large samples to zero, the quantity will still be negative so long as the mean excess return to the market portfolio is positive over the sample. So one must still determine whether this negative relation between the two estimators could explain the low-beta bias that has been so well documented. Intuition suggests, however, that the finance profession will not have overlooked, over a period of nearly 50 years, the potential explanation for the low-beta bias that Partington and Satchell outline. Nevertheless, we investigate the matter.

We use data from January 1974 to December 2015 for the 10 portfolios that we form on the basis of past estimates of beta to estimate across the 10 portfolios the quantity:

$$\frac{\text{Cov}\left(\hat{\alpha}_j,\hat{\beta}_j\right)}{\text{Var}\left(\hat{\beta}_j\right)} \qquad (29)$$

under the null hypothesis that the SL CAPM is true. If the SL CAPM is true, the numerator of (29) will be given by (28). In other words, if the model is true, the only reason why a negative relation will arise across the 10 portfolios between the OLS estimator for $\alpha$ and the OLS estimator for $\beta$ will be because of estimation error. We estimate the ratio (29) using these data to be -0.0054 per cent per annum under the null hypothesis that the SL CAPM is true. [111] This implies that as one moves from an estimate of beta of one to an estimate of beta of 0.50, one would expect an estimate of alpha to fall by -0.0027 per cent per annum on average. This vanishingly small impact shows that the finance profession has been right to ignore the potential explanation for the low-beta bias that Partington and Satchell outline. For the sake of completeness, we also estimate the ratio (29) using the same data under the alternative hypothesis that the SL CAPM is false. We estimate the ratio under the alternative that the SL CAPM is false to be -12.0152 per

[110] Johnston, J., *Econometrics*, McGraw-Hill Korakusha, Tokyo, 1972, page 21.

[111] We use as an estimate of the variance of the disturbance from the regression, the average computed across the 10 portfolios.

cent per annum. This implies that as one moves from an estimate of beta of one to an estimate of beta of 0.50, one would expect an estimate of alpha to fall by around six per cent per annum on average. This analysis is, not surprisingly, consistent with the evidence that we provide in Table 1.

### 5.1.4 Many tongues

The ACT, again, in its 2016 PIAC and Ausgrid decision, states that: [112]

> 'It is, as the AER noted, correct that the three parameters for the SL CAPM – equity beta, risk free rate, and MRP – are recorded as giving a low beta bias for businesses with a beta (that is, the risk of the asset relative to the average asset) of less than 1.0, and that the Network Applicants are all within that group.'

Here and in past work we have endeavoured to use data to assess the severity of the low-beta bias. [113] Partington and Satchell state about HoustonKemp's work that: [114]

> 'HoustonKemp's answer is, let the data speak, but the data speaks in many tongues and does not provide one unambiguous answer, or even approximately similar answers … unless we resort to the underlying theory, how is judgement to be made?'

We do not agree with Partington and Satchell's idea that data cannot be used to assess the severity of the low-beta bias nor do we agree with the idea that a sole reliance on theory will provide a better way of assessing the severity of the bias. This is because, as we make clear in this report, theory does not provide unambiguous predictions as to the severity of the low-beta bias. The ACT, in its decision, does not proscribe the use of data in assessing the severity of the low-beta bias. So we believe that it makes sense that any adjustment, to offset the low-beta bias, which the AER proposes to make to the parameters of the SL CAPM, be examined to see whether it would have generated unbiased estimates of the cost of equity in past data.

We also note that a comparison of Satchell's published research with the reports that he has written for the AER and ERA suggests that he describes the answers that the data provide in his own research in a way that differs from the way in which he describes the answers in reports written for the two regulators.

As an example, in work co-authored with Muijsson and Fishwick, Satchell states that: [115]

> 'One of the observations over the cross-section of stocks is that the historical risk-return trade-off is flat or inverted: within the CAPM, we would expect that stocks with high systemic risk would outperform their low risk counterparts, but results have shown otherwise.'

In the literature review that Satchell, with Muijsson and Fishwick, provides, he does not qualify the statement by suggesting that an overall view of the evidence can be easily undermined by:

- an examination of exactly how the tests are conducted;
- an examination of differences between the large-sample and small-sample properties of the statistics on which the test rely;
- an examination of how the portfolios that the tests use are formed; or
- an examination of the distribution of an estimator for the zero-beta premium.

[112] Australian Competition Tribunal, *Applications by Public Interest Advocacy Centre Ltd and Ausgrid [2016] ACompT 1*, paragraph 731.

[113] HoustonKemp, *The cost of equity: Response to the AER's Draft Decisions for the Victorian Electricity Distributors, ActewAGL Distribution and Australian Gas Networks: A Report for ActewAGL Distribution, AusNet Services, Australian Gas Networks, CitiPower, Jemena Electricity Networks, Powercor and United Energy*, January 2016.

[114] Partington, G. and S. Satchell, *Report to the AER: Cost of equity issues 2016 electricity and gas determinations*, April 2016, page 42.

[115] Muijsson, C., E. Fishwick and S. Satchell, *The low-beta anomaly and interest rates*, in Risk-Based and Factor Investing, ed. J. Emmanuel, 2016, page 305.

Instead, he and his co-authors write that: [116]

> 'The anomaly has been recognized empirically in many applications (see, for instance, [BLA 72a, BLA 72b, FAM 92, HAU 75]). Baker and Wurgler [BAK 11] provide an extensive review in favor of the low beta anomaly. Also, see Ang *et al.* [ANG 06], who find that stocks with higher idiosyncratic risk earn lower returns in all cases considered.'

Here BLA 72b, FAM 92 and BAK 11 refer to: [117]

- Black, F., M.C. Jensen and M. Scholes, *The Capital Asset Pricing Model: Some empirical tests, in Studies in the Theory of Capital Markets*, M.C. Jensen, ed., Praeger, 1972.
- Fama, E. and K. French, *The cross-section of expected returns*, Journal of Finance 47, 1992, pages 427-465.
- Baker, M., B. Bradley, and J. Wurgler, 2011, *Benchmarks as limits to arbitrage: Understanding the low-volatility anomaly*, Financial Analysts Journal 67, pages 1-15.

These are papers to which we refer either directly or indirectly in our review of section 2 and that either show or suggest, without qualification, that a low-beta bias exists. The abstract of Baker and Wurgler states, for example, that:

> 'Contrary to basic finance principles, high-beta and high-volatility stocks have long underperformed low-beta and low-volatility stocks. This anomaly may be partly explained by the fact that the typical institutional investor's mandate to beat a fixed benchmark discourages arbitrage activity in both high-alpha, low-beta stocks and low-alpha, high-beta stocks.'

Further, we note that Fishwick, Satchell's co-author, provides an overview of his work with Muijsson and Satchell in a BlackRock presentation. The presentation, entitled *The Low-Beta Anomaly*, states that: [118]

> 'This presentation is based on the forthcoming paper:
>
> '*The Low Beta 'Anomaly' and Other Mysteries'*
>
> Cherry Muijsson, Ed Fishwick and Steve Satchell ~ Forthcoming 2014'

BlackRock is a fund manager and its web site states that: [119]

> 'BlackRock is trusted to manage more money than any other investment firm – $4.89 trillion assets under management as of 6/30/16'

Muijsson, Fishwick and Satchell state that: [120]

> 'We use long run industry level data to analyze beta effects. The source of the data is the monthly industry level Fama−French industry level returns from Kenneth French's Website. We use 43 industry groupings from 1953.01 to 2012.12 to calculate full sample betas. Some initial rolling calculations on the data found five industries that had betas less that 1 (defensive) and nine with betas greater than 1 (aggressive). The defensive industries are food products, tobacco, oil, utilities and telecoms. The aggressive industries are building materials, fun and entertainment, construction, steel, machinery, electrical equipment, chips, lab equipment and

[116] Muijsson, C., E. Fishwick and S. Satchell, *The low-beta anomaly and interest rates*, in Risk-Based and Factor Investing, ed. J. Emmanuel, 2016, page 307.

[117] Muijsson, C., E. Fishwick and S. Satchell, *The low-beta anomaly and interest rates*, in Risk-Based and Factor Investing, ed. J. Emmanuel, 2016, pages 326- 327.

[118] http://www.northinfo.com/documents/612.pdf

[119] https://www.blackrock.com/corporate/en-us/about-us

[120] Muijsson, C., E. Fishwick and S. Satchell, *The low-beta anomaly and interest rates*, in Risk-Based and Factor Investing, ed. J. Emmanuel, 2016, pages 312-313.

> financials. Then, we build market capitalization-weighted portfolios of the high beta and low beta industries.'
>
> 'We estimated the CAPM by regressing portfolio excess returns on an intercept and market excess returns, and present our results in the first panel of Table 13.2. We would expect the intercept to be zero if the CAPM holds; interestingly, the low beta portfolio has a positive intercept, while the high beta portfolio does not. This demonstration shows the returns to low risk portfolios based on a CAPM theory of risk. Investing in low beta portfolios gives us an extra 3.68% per annum relative to what the CAPM suggests.'

Fishwick provides the results referred to above in his presentation and we reproduce them in Table 5 below. By reproducing these results, exactly as they appear in his presentation and in Muijsson, Fishwick and Satchell's publication, we are not endorsing the empirical work – we are merely reproducing the results that they provide.

### Table 5: BlackRock CAPM Results Using Industry Portfolios

Sharpe's market model: $r_t = \alpha + \beta r_m + \upsilon_t$

| | $\alpha$ | $t(\alpha)$ | $\beta$ | $t(\beta)$ | $R^2$ |
|---|---|---|---|---|---|
| HIB | -0.007 | -0.102 | 1.274 | 81.138 | 0.902 |
| LOB | 0.307 | 4.096 | 0.696 | 40.857 | 0.699 |

*Notes: HIB and LOB refer to the high-beta and low-beta industry portfolios. The t-statistics provided are for tests of the null hypotheses that the intercept and slope coefficient are zero. Estimates of the intercept are in per cent per month.*

Table 5 illustrates the low-beta bias – or what Muijsson, Fishwick and Satchell term the low-beta anomaly. A low-beta portfolio of industry portfolios earns returns over the period 1953 to 2012 that cannot be explained by the SL CAPM.

Satchell, with Partington, has, on the other hand, argued in various reports for the AER and ERA that an overall view of the evidence on the SL CAPM can be easily undermined by:

- an examination of exactly how the tests are conducted;
- an examination of differences between the large-sample and small-sample properties of the statistics on which the test rely;
- an examination of how the portfolios that the tests use are formed; and
- an examination of the distribution of an estimator for the zero-beta premium.

Satchell, again, does not express these concerns in his work with Muijsson and Fishwick.

In addition, in his May 2016 report for the ERA, written again with Partington, Satchell states that: [121]

> 'Considering the use of the Black CAPM in practice, one of the authors of this report has been a quantitative consultant for over 25 years and has advised many scores of top level 'quant' teams in the finance industry. Whilst he has seen applications of both the SL CAPM and variants of the Fama and French model on many occasions, he has never seen a single application of the Black CAPM.'

The Black CAPM allows for a low-beta bias relative to the SL CAPM and so it is difficult to avoid drawing the conclusion from this statement that Satchell is suggesting that the finance industry has no interest in the low-

[121] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, page 21.

beta bias. Fishwick's BlackRock presentation suggests that it is untrue that the finance industry has no interest in the low-beta bias.

Finally, in his May 2016 report for the ERA, written again with Partington, Satchell states that: [122]

> 'the evidence for the viability of the SL CAPM as an appropriate model for time series regressions is supported, at the industry level, not just by the Australian results above, but also by results for the USA.'

The evidence that Satchell provides in his own work, co-authored with Muijsson and Fishwick, published in the same year as his report for the ERA, 2016, contradicts this statement.

### 5.1.5 Empirical evidence

High-beta portfolios will tend to outperform low-beta portfolios in up markets while low-beta portfolios will tend to outperform high-beta portfolios in down markets. This will be true regardless of whether the SL CAPM is true or false. A number of authors have tried – unsuccessfully – to portray the difference between the behaviour of high-beta and low-beta portfolios in up and down markets as providing support for the SL CAPM and Partington and Satchell refer to the work of one of these authors. Partington and Satchell state that: [123]

> 'When the equity market has negative returns, low beta stocks are expected to perform better than high beta stocks. Thus, ex-post a negative relation between beta and returns would be expected and vice versa when the equity market has positive returns. Indeed Isakov (1999) argues that tests of the CAPM should be conditioned on the sign of the excess return on the market and shows that when this is done beta is a highly significant predictor of returns with the signs of the coefficient as expected, positive when the excess return is positive and negative when the excess return is negative. Whereas, when there is no conditioning on the sign of the excess return on the market there is no relation between beta and expected returns. We are not arguing that conditioning on the sign of the excess return provides a good test of the CAPM, but merely that differences between expected and realised returns are a problem when testing asset pricing models.'

Isakov's work that uses eight years of Swiss data is based on the earlier work of Pettengill, Sundaram and Mathur (1995). [124] Pettengill, Sundaram and Mathur use 55 years of US data to test whether low-beta portfolios underperform high-beta portfolios in up markets and high-beta portfolios underperform low-beta portfolios in down markets. Not surprisingly, they find that they do – but this has nothing to do with whether the SL CAPM is true or false – the tests merely confirm that high-beta portfolios have high betas and low-beta portfolios have low betas. Pettengill, Sundaram and Mathur do not report estimates of the zero-beta premium in up and down markets and so they do not reveal whether their conditional tests support the SL CAPM. Pettengill, Sundaram and Mathur do, however, estimate the zero-beta rate to be, on average across both up and down markets, 9.10 per cent per annum from 1936 to 1990 with a standard error (that can be inferred from their Table 6, but that is surprisingly low) of 0.60. Shiller's web site indicates that the 10-year bond yield was, on average, 5.36 per cent per annum from 1936 to 1990. [125] Thus an estimate of the zero-beta premium relative to the 10-year bond yield, computed from the results of Pettengill, Sundaram and Mathur is 3.74 per cent per annum, and this estimate lies significantly above zero at conventional levels.

[122] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, page 21.

[123] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, page 8.

[124] Iaskov, D., *Is beta alive? Conclusive evidence from the Swiss stock market*, European Journal of Finance 5, 1999, pages 202-212.

Pettengill, G.N., S. Sundaram and I. Mathur, *The conditional relation between beta and returns*, Journal of Financial and Quantitative Analysis 30, 1995, pages 101-116.

[125] http://www.econ.yale.edu/~shiller/data.htm

While Pettengill, Sundaram and Mathur do not use their conditional framework to test the SL CAPM, Baker, Bradley and Wurgler (2011) – whom Muijsson, Fishwick and Satchell (2016) cite – do. [126] Baker, Bradley and Wurgler state that: [127]

> 'Finally, as if this puzzle [the low-beta anomaly] were not bad enough, other facts only compound it.
>
> • The low-risk portfolios' paths to their higher dollar values have been much smoother than those of the high-risk portfolios. They are as advertised: genuinely lower risk.
>
> • Motivated by the analysis of Pettengill, Sundaram, and Mathur (1995), we repeated the analysis separately for months in which market returns were above or below their median. Consistent with Pettengill et al. (1995), we found that high-beta stocks earned higher (lower) total returns than did low-beta stocks in up (down) markets, but on a capital asset pricing model (CAPM) market-adjusted basis, the low-beta anomaly was present in both environments. *That low beta is high alpha is a robust historical pattern*.'
>
> [the emphasis is ours]

Isakov also uses a conditional framework to test the SL CAPM. Not surprisingly, though, his tests, which use only eight years of data, have low power. His Table 2 reveals that the standard error attached to an estimate of the zero-beta premium that uses the framework is 7.87 per cent per annum in up markets and 12 per cent per annum in down markets.

It is not clear how Partington and Satchell intend to link the work of Isakov to their claim that differences between expected and realised returns are a problem when testing asset pricing models. It is certainly true that tests of pricing models that use short time series will lack power. There is a solution to this problem, however, and that is to use more data.

### 5.1.6 Rational expectations

In a 2014 submission to the ERA, DBP use the sample mean forecast error (11) to test whether forecasts of the return required on equity generated by the SL CAPM exhibit bias. DBP states about its use of (11) that: [128]

> 'the forecast of the market risk premium is replaced by the realisation of the return to the market in excess of the risk-free rate for the period being forecast. The interpretation is not that the [regulator] is clairvoyant, but rather that, whatever forecast it makes is rational. In other words, we assume that the ERA does not systematically overestimate or underestimate the MRP.'
>
> 'While our … tests do not presume that the ERA has perfect foresight, one way of interpreting our … results is that they show that, even if the ERA could use regulatory judgement to perfectly predict the excess return to the market, its use of the SL-CAPM would still lead to biased estimates of the return on equity.'

Partington and Satchell, however, state about the use of (11) that it: [129]

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[126] Baker, M., B. Bradley, and J. Wurgler, 2011, *Benchmarks as limits to arbitrage: Understanding the low-volatility anomaly*, Financial Analysts Journal 67, pages 1-15.

Muijsson, C., E. Fishwick and S. Satchell, *The low-beta anomaly and interest rates*, in Risk-Based and Factor Investing, ed. J. Emmanuel, 2016, page 307.

[127] Baker, M., B. Bradley, and J. Wurgler, 2011, *Benchmarks as limits to arbitrage: Understanding the low-volatility anomaly*, Financial Analysts Journal 67, page 4.

[128] DBP, *Proposed revisions DBNGP access arrangement 2016-2020 regulatory period rate of return supporting submission: 12*, December 2014, page 61.

DBP, *Proposed revisions DBNGP access arrangement 2016-2020 access arrangement period supporting submission: 56*, February 2016, page 39.

[129] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, page 20.

> 'assumes perfect foresight with respect to the realised excess return on the market. If investors could correctly forecast time varying excess returns on the market, then their behaviour would have been different. They would, for example, have avoided equity when the excess returns were forecast to be negative. In short equilibrium prices and hence actual returns would have been quite different from those actually observed.'

As section 3's analysis makes clear, the use of (11) does not presume that regulators or investors have perfect foresight. The use of (11) presumes only that regulators are rational. Thus the statement that Partington and Satchell make is untrue.

Partington and Satchell also state that a test that employs (11): [130]

> 'suffers from the use of ex-post information. Whereas tests of asset pricing models are generally careful to only use information observed ex-ante.'

This statement is also untrue. There are very few tests of pricing models that do not use ex-post information – that is, realised returns.

What is true is that tests of what are known as Euler conditions, that asset pricing models often impose, use only past information as *conditioning* information. The conditional version of the SL CAPM, for example, implies that:

$$\mathrm{E}_{t-1}\left(z_{jt} - \beta_{jt} z_{mt}\right) = 0 \qquad (30)$$

An in-sample test of the model will use realised excess returns to portfolio $j$ and the market portfolio $m$ from $t-1$ to $t$ (ex-post information) but only information known at time $t-1$ (ex-ante information) in forming expectations. It is common for the beta of the portfolio also to be expressed as a function of information know at time $t-1$.

## 5.2 Issues Raised by the AER

In its most recent decision, the AER states that: [131]

> 'Several service providers resubmitted an empirical test of the Sharpe-Lintner CAPM and the Black CAPM by NERA that was considered in the JGN final decision. We continue to 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 Sharpe-Lintner CAPM 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 market risk premium.'

The AER's statement that:

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

[130] Partington, G. and S. Satchell, *Report to the ERA: The cost of equity and asset pricing models*, May 2016, page 20.

[131] AER, *Draft decision AusNet Services transmission determination 2017-18 to 2021-22: Attachment 3 – Rate of return*, July 2016, pages 153-154.

cites as its sources page 92 of NERA's May 2014 report and page 3 of SFG's May 2014 report. [132] As we have made clear before, however, neither NERA's report nor SFG's report support the AER's statement. [133]

Page 92 of NERA's report states that: [134]

> '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.'

Elsewhere in its May 2014 report, NERA is even clearer that the absence of a relation between mean return and beta or even a negative relation between the two variables cannot be ruled out. On page 82 of its report, NERA states that: [135]

> 'While the Sharpe-Lintner CAPM predicts that the market portfolio of all risky assets must be mean-variance efficient the model makes no prediction about whether the market portfolio of stocks alone should be efficient. It follows that, even were the Sharpe-Lintner CAPM to be true, the relation between the mean return to an asset and the asset's beta computed relative to the market portfolio of stocks alone need be neither linear nor positive. Further, the Sharpe-Lintner CAPM does not imply that the mean return to an asset that has a zero beta relative to the market portfolio of stocks must equal the risk-free rate.'

Page 3 of SFG's report states that: [136]

> '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 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*. [137]

Both NERA and SFG make clear that the use of a portfolio of stocks as a proxy for the market portfolio of all risky assets may be responsible for the weak or negative relation between mean return and beta that one observes in the data. The work of Hong and Sraer (2016), however, shows that when investors do not share the same beliefs a weak or negative relation can appear in the data even in the absence of measurement problems. [138]

The intuition behind Hong and Sraer's result is as follows. Investors who are optimistic about the market will attempt to increase their holdings of high-beta assets relative to low-beta assets while investors who are pessimistic about the market will attempt to decrease their holdings of high-beta assets relative to low-beta assets. If investors face short-sale constraints, however, there will be a limit to the extent to which pessimistic investors can decrease their holdings of risky assets. Because of these constraints, optimistic investors will bid up the prices of high-beta assets relative to low-beta assets and so bid down the mean

[132] 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.

[133] NERA, *The cost of equity: Response to the AER's final decisions for the NSW and ACT electricity distributors, and for Jemena Gas Networks: A report for ActewAGL Distribution, AGN, APA, AusNet Services, CitiPower, Ergon Energy, Jemena Electricity Networks, Powercor, SA Power Networks and United Energy*, June 2015, page 18.

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

[135] NERA, *Return on Capital of a Regulated Electricity Network: A report for Ashurst*, May 2014, page 82.

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

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

[138] Hong, H. and D.A. Sraer, *Speculative betas*, Journal of Finance, 2016, pages 2095-2144.

returns on high-beta assets relative to low-beta assets. They will be able to do so even if arbitrageurs exist who have beliefs that are correct and who face no short-sale constraints. This is because the arbitrageurs will be discouraged from betting aggressively against high-beta assets by the idiosyncratic risk attached to positions in the assets.

Figure 9 below illustrates the predictions of Hong and Sraer's dynamic model.[139] The diamonds show the relation that will hold between mean return and beta when there is no disagreement. The stars show the relation that will hold when there is disagreement. The level of disagreement increases from Panel A through to Panel D. As intuition would suggest, when there is a lot of disagreement among investors about the prospects for the market, there can be a negative relation between mean return and beta. In other words, a negative relation between mean return and beta is not necessarily counterintuitive – even setting aside concerns about measurement error.

## 5.3 Issues Raised by the ERA

Again, in a 2014 submission to the ERA, DBP use the sample mean forecast error (11) to test whether forecasts of the return required on equity generated by the SL CAPM exhibit bias. The ERA states in its DBP final decision about this method that:[140]

> 'As a test of expected returns in equilibrium, [the method] suffers from the use of ex-post information in the setting of the MRP for the SL-CAPM input. This is contrary to standard tests of asset pricing models, which are generally careful to only use information available ex-ante. Furthermore, [the method] assumes perfect foresight with respect to the realised excess return on the market. But if investors could correctly forecast time varying excess returns on the market, then their behaviour would have been different. They would, for example, have avoided equity when the excess returns were forecast to be negative. In short, equilibrium prices and hence actual returns would have been quite different from those actually observed. [The method] is therefore spurious.'

We note in 5.1.6 that the assertion that the method assumes perfect foresight is untrue. We also explain in 5.1.6 above that the assertion that standard tests of asset pricing models only use information available ex-ante – that is, not realised returns – is untrue. We note here by way of illustration that O'Doherty, Savin and Tiwari (2012) also use realisations of the excess return to the market in evaluating forecasts generated by pricing models. They state that:[141]

> 'The joint predictive distribution of [the returns] and [the factors] can be thought of as the result of a two-stage prediction procedure where the first stage involves predicting the factor returns and the second stage predicts the asset returns conditional on the forecast of the factor returns. Indeed, this interpretation is often implicit in the specification of asset pricing models. As we show below, under the realistic assumption that a shared ancillary model … produces predictions of the various factor returns, the evaluation of the asset pricing models does not require the explicit specification of a prediction model for the factors. This is a desirable feature since the typical asset pricing model is silent about the prediction of the factors themselves.'

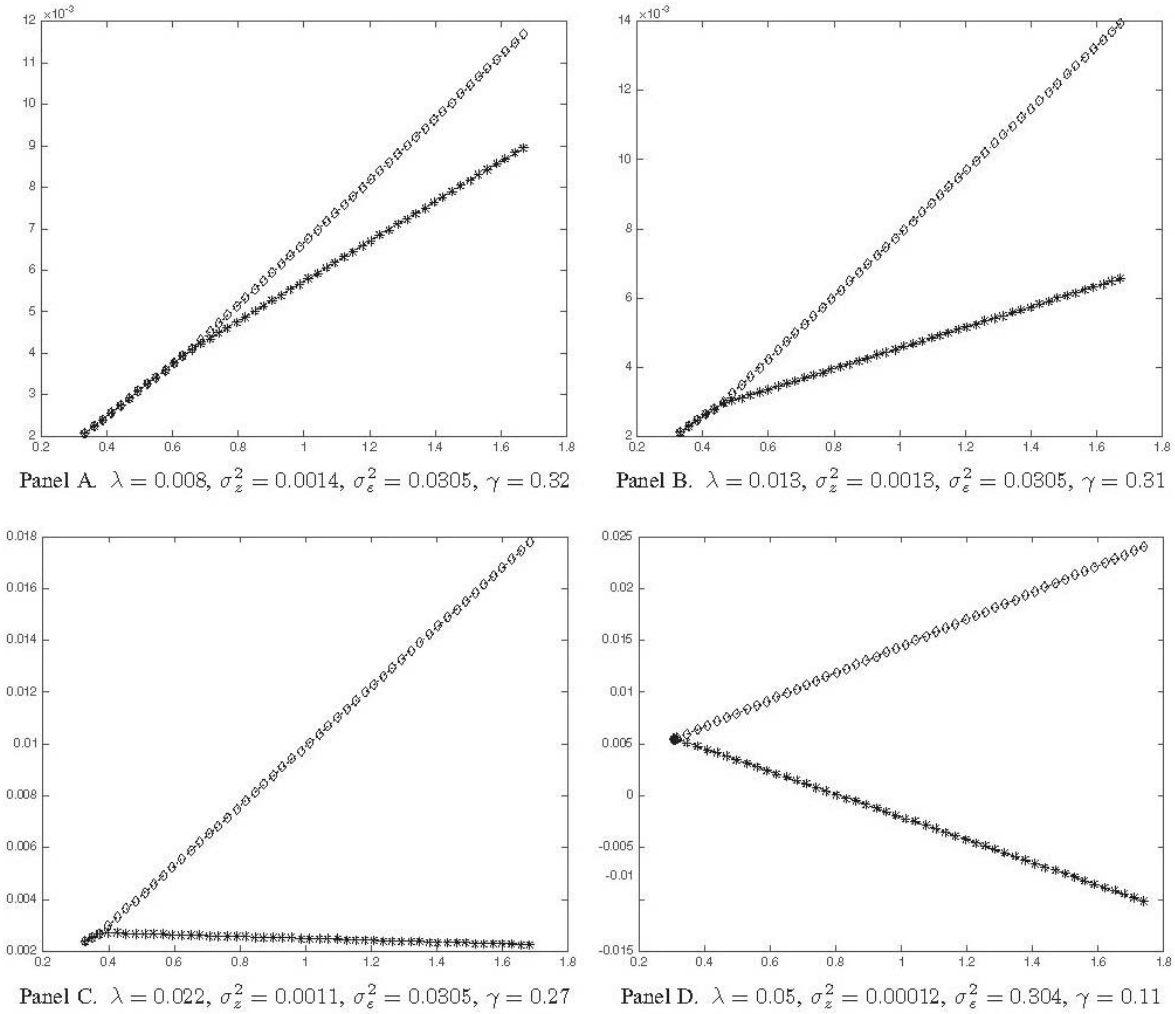
O'Doherty, Savin and Tiwari find that even though the SL CAPM produces biased forecasts of returns, it can still be optimal to place some weight on forecasts generated by the model.

[139] Note that Hong and Sraer mislabel their Figure 4 – our Figure 9. They state below the figure that the it 'plots the Security Market Line in the high-aggregate-disagreement state (diamonds) and in the low-aggregate-disagreement state (stars) obtained from the simulation of the dynamic model' but should state that the figure 'plots the Security Market Line in the low-aggregate-disagreement state (diamonds) and in the high-aggregate-disagreement state (stars) obtained from the simulation of the dynamic model'.

[140] ERA, *Final Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020 Submitted by DBNGP (WA) Transmission Pty Limited Appendix 4 Rate of Return*, June 2016, page 61.

[141] O'Doherty, M., N.E. Savin and A. Tiwari, *Modeling the cross-section of stock returns: A model pooling approach*, Journal of Financial and Quantitative Analysis 47, 2012, pages 1331-1360.

## Figure 9: Calibration of Hong and Sraer's Dynamic Model




*Note: Each panel plots mean return against beta. The diamonds show the relation that will hold between mean return and beta when there is little disagreement. The stars show the relation that will hold when there is a lot of disagreement. The level of disagreement increases from Panel A through to Panel D.*

*Source: Hong, H. and D.A. Sraer, Speculative betas, Journal of Finance, 2016, page 2116.*

Finally, the ERA states in paragraph 265 of its DBP Final Decision that: [142]

> 'When equity prices are in equilibrium in the market, this required return is equal to the expected return. However, crucially, there is no guarantee that expectations will be realised, or that prices are always in equilibrium. If there were a guarantee that expectations would be realised then the asset would have no risk. This view is well expressed by Davis:
>
> > The required returns are also referred to as expected returns by financial economists by relying on an assumption that asset prices equilibrate in efficient markets through supply and demand influences. If, given the current price of an asset, investors' expectations about future cash flows or future market value of that asset imply an expected return different to their required return,

[142] Davis, K., *Cost of equity issues: A report for the AER*, January 2011, page 3.

ERA, *Final Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020 Submitted by DBNGP (WA) Transmission Pty Limited Appendix 4 Rate of Return*, June 2016, pages 57-58.

> they will buy or sell that asset causing its price to adjust until it equates expected and required returns. Thus, the theories are simultaneously theories of equilibrium asset prices and *required* and *expected* returns. The theories do not purport to fully explain actual returns, since these can differ from expected returns due to a variety of factors including news about future cash flows which cause investors to reassess the appropriate price of an asset. If actual returns are a poor proxy for expected returns, the ability of a theory of *expected* returns to explain *actual* returns may be limited.'

and in paragraph 293 of the Final Decision that: [143]

> 'At the same time, the Authority is not convinced there is any empirical evidence at the current time to justify an adjustment to the SL-CAPM for *expected* alpha for the benchmark efficient entity. As noted above at paragraph 265, theory suggests that if such an expectation was widespread among investors, it would be bid away as part of a movement toward equilibrium asset pricing.'

Davis does not state, as the ERA alleges, that deviations from the SL CAPM will be bid away. In other words, he does not state that deviations of modelled returns from expected returns will be bid away. He states quite clearly – as do we – that deviations of expected returns from required returns will be bid away. In particular, he explains how deviations from equilibrium in the market for an asset will provide incentives for investors to trade in such a way as to return the market to equilibrium.

Davis also states on the very next page of his report about the assumptions made by the SL CAPM that: [144]

> 'It is clear that some of the core assumptions are invalid, and much subsequent research has been aimed at generalizing the model to allow for more realistic assumptions.'

The recent work of Hong and Sraer (2016) is just one example of research that examines the impact that relaxing the assumptions that underpin the SL CAPM can have on the predictions that the model makes. [145] Again, Hong and Sraer find that relaxing the assumptions that underpin the SL CAPM to allow for differences in beliefs and short-sale constraints can lead to a negative relation between mean return and beta for some assets.

[143] ERA, *Final Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020 Submitted by DBNGP (WA) Transmission Pty Limited Appendix 4 Rate of Return*, June 2016, page 64.

[144] Davis, K., *Cost of equity issues: A report for the AER*, January 2011, page 4.

[145] Hong, H. and D.A. Sraer, *Speculative betas*, Journal of Finance, 2016, pages 2095-2144.

# A1. Terms of Reference

## Expert Terms of Reference

## Multinet Cost of Equity Consultant Brief

## 2018-22 Mutlinet Access Arrangement 16 November 2016

In its *Guidelines*, the AER relied upon evidence from Henry which suggested, to the AER, a reasonable range for beta of 0.4 to 0.7, around a mean estimate of 0.52. The AER subsequently chose the top end of this range as being appropriate based, in part, on its consideration of the Black CAPM model, which highlights the downward bias of the SL-CAPM. The Tribunal subsequently endorsed this approach, specifically noting the importance of adjusting SL-CAPM results for this bias in its finding that PIAC was incorrect to call for no adjustment.

Subsequent to the *Guidelines*, beta has moved. Although recent evidence is mixed, with some evidence pointing to higher results, a conservative estimate of the mean beta for the BEE is now around 0.7; the top of the AER's former range. This means that a beta of 0.7 arguably no longer takes account of the downward bias of the SL-CAPM and suggests that, in order to follow the logic of the *Guidelines*, a new adjustment must be calculated. It is not clear whether this necessarily means adjusting beta per se, and the AER's advisors have recently suggested that it may be appropriate to instead focus upon the "alpha" or intercept in Henry's model, rather than beta, if adjustment is to be made.

Although the *Guidelines* describe in detail the evidence the AER considered to be valid and invalid, they do not describe the process of regulatory judgment by which the AER found that 0.7 was the right number to use for beta in such a way that someone independent of the AER could follow the same methodology, starting from a different range or a different mean beta estimate, and work out what the equivalent adjusted beta ought to be. This necessitates a need for Multinet to put forward its own adjustment process. For the purposes of transparency, we consider the most reliable approach is to make use of information from realised returns and, in particular, how well a given model is able to forecast realised returns over a long period of time to both motivate the relevant adjustments, and to subsequently test them.

To this end, we require two tasks be undertaken:

Firstly, considering the alpha, or intercept in Henry's SL-CAPM model, please examine the smallest portion of alpha which is consistent with the removal of the downward bias of the SL-CAPM.

Secondly, considering beta, please consider the smallest adjustment to the mean beta which can be made in order to remove the downward bias of the SL-CAPM.

In both cases, please clearly outline your empirical approach such that it can be followed by independent observers.

Additionally, in its recent *Final Decision* for DBP, the ERA has determined that "properly understood", there is no need to adjust for the downward bias of the SL-CAPM, given what it is that regulators are required to do under the NGR, and that evidence about bias is not conclusive. This is supported, in part, by advice from advisors who have also advised the AER, and have provided similar advice to the AER as underpinned the ERA's conclusions. Please examine the relevant literature and provide an expert view of whether, given the requirements of the NGR and the theoretical and empirical evidence, it is correct for regulators to make no adjustment for downward bias in the SL-CAPM.

Since it is possible that your expert report may be relied on in future proceedings before the Australian Competition Tribunal, we require that the work be undertaken in accordance with the *Federal Court Guidelines for Expert Witnesses* (attached). Further, your report should contain a declaration that you have been given and have read, understood and complied with *Practice Note CM7* issued by the Federal Court of Australia concerning guidelines for expert witnesses. It should also contain a declaration that you have made all the inquiries that you believe are desirable and appropriate and that no matters of significance that you regard as relevant have, to your knowledge, been withheld.

# A2. 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[146], 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**[147]

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.

**2. The Form of the Expert's Report**[148]

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

[146] 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].

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

[148] Rule 23.13.

(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[149]; 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[150].

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.

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[151].

**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

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

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

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

# A3. Curriculum Vitae

## Simon M. Wheatley

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## Overview

Simon is a special adviser to HoustonKemp and was until 2008 a Professor of Finance at the University of Melbourne. Since 2008, Simon has applied his expertise outside the university sector to solving problems in consulting and in fund management. Prior to joining the University of Melbourne, Simon taught finance at the Universities of British Columbia, Chicago, New South Wales, Rochester and Washington. Simon's interests and expertise are in how assets are priced.

## Employment

- Special Adviser, HoustonKemp, 2015-
- Affiliated Industry Expert, NERA Economic Consulting, 2014-2015
- 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

### HoustonKemp

- Evaluating Forecasts: Response to the ERA's Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: A Report for DBP, February 2016
- The Black CAPM: Response to the ERA's Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline 2016 – 2020: A Report for DBP, February 2016
- The Cost of Equity: Response to the AER's Draft Decisions for the Victorian Electricity Distributors, ActewAGL Distribution and Australian Gas Networks: A Report for ActewAGL Distribution, AusNet Services, Australian Gas Networks, CitiPower, Jemena Electricity Networks, Powercor and United Energy, January 2016
- Equity Beta for a Benchmark Australian Water Network Service Provider: A report for Sydney Water, June 2015 (with Greg Houston, Brendan Quach and Dale Yeats)

### NERA

- Estimating Distribution and Redemption Rates: Response to the AER's Final Decisions for the NSW and ACT Electricity Distributors, and for Jemena Gas Networks: A report for ActewAGL Distribution, AGN, APA, AusNet Services, CitiPower, Ergon Energy, Jemena Electricity Networks, Powercor, SA Power Networks and United Energy, June 2015
- Further Assessment of the Historical MRP: Response to the AER's Final Decisions for the NSW and ACT Electricity Distributors: A report for ActewAGL Distribution, AGN, APA, AusNet Services, CitiPower, Energex, Ergon Energy, Jemena Electricity Networks, Powercor, SA Power Networks and United Energy, June 2015
- The Cost of Equity: Response to the AER's Final Decisions for the NSW and ACT Electricity Distributors, and for Jemena Gas Networks: A report for ActewAGL Distribution, AGN, APA, AusNet Services, CitiPower, Ergon Energy, Jemena Electricity Networks, Powercor, SA Power Networks and United Energy, June 2015
- The Cost of Equity: A Critical Review of the Analysis of the AER and its Advisors: A report for DBP, June 2015
- Do Imputation Credits Lower the Cost of Equity? Cross-Sectional Tests: A report for United Energy, April 2015
- The Relation Between the Market Risk Premium and Risk-Free Rate: Evidence from Independent Expert Reports: A report for United Energy, April 2015
- 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
- Estimating Distribution and Redemption Rates from Taxation Statistics 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
- 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

- Historical estimates of the market risk premium: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, Ausgrid, AusNet Services, Australian Gas Networks, CitiPower, Endeavour Energy, Energex, Ergon, Essential Energy, Powercor, SA Power Networks and United Energy, February 2015
- Robust regression techniques: A report for DBP, December 2014
- Imputation Credits and Equity Returns: A report for the Energy Networks Association, October 2013 (with Brendan Quach)
- The Fama-French Three-Factor Model: A report for the Energy Networks Association, October 2013 (with Brendan Quach)
- The Market Risk Premium: Analysis in Response to the AER's Draft Rate of Return Guidelines: A report for the Energy Networks Association, October 2013 (with Brendan Quach)
- The Market, Size and Value Premiums: A report for the Energy Networks Association, June 2013 (with Brendan Quach)
- Estimates of the Zero-Beta Premium: A report for the Energy Networks Association, June 2013 (with Brendan Quach)
- The Payout Ratio: A report for the Energy Networks Association, June 2013 (with Brendan Quach)
- Review of Cost of Equity Models: A report for the Energy Networks Association, June 2013 (with Brendan Quach)
- The Cost of Equity for a Regulated Energy Utility: A Response to the QCA Discussion Paper on the Risk-Free Rate and the MRP: A report for United Energy and Multinet Gas, March 2013 (with Brendan Quach)
- The Cost of Equity for a Regulated Energy Utility: A report for Multinet, February 2013 (with Brendan Quach)
- The Black CAPM: A report for APA Group, Envestra, Multinet & SP AusNet, March 2012 (with Brendan Quach)
- Prevailing Conditions and the Market Risk Premium: A report for APA Group, Envestra, Multinet & SP AusNet, March 2012 (with Brendan Quach)
- The Market Risk Premium: A report for CitiPower, Jemena, Powercor, SP AusNet and United Energy, 20 February 2012 (with Brendan Quach)
- Cost of Equity in the ERA DBNGP Draft Decision: A report for DBNGP, 17 May 2011 (with Brendan Quach)
- The Market Risk Premium: A report for Multinet Gas and SP AusNet, 29 April 2011 (with Brendan Quach)
- Cost of Capital for Water Infrastructure Company Report for the Queensland Competition Authority, 28 March 2011 (with Brendan Quach)
- The Cost of Equity: A report for Orion, 2 September 2010 (with Greg Houston and Brendan Quach)
- New Gamma Issues Raised by AER Expert Consultants: A report for JGN, 17 May 2010 (with Brendan Quach)

- The Required Rate of Return on Equity for a Gas Transmission Pipeline: A Report for DBP, 31 March 2010 (with Brendan Quach)
- Jemena Access Arrangement Proposal for the NSW Gas Networks: AER Draft Decision: A report for Jemena, 19 March 2010 (with Greg Houston and Brendan Quach)
- Payout Ratio of Regulated Firms: A report for Gilbert + Tobin, 5 January 2010 (with Brendan Quach)
- Review of Da, Guo and Jagannathan Empirical Evidence on the CAPM: A report for Jemena Gas Networks, 21 December 2009 (with Greg Houston and Brendan Quach)
- The Value of Imputation Credits for a Regulated Gas Distribution Business: A report for WA Gas Networks, 18 August 2009 (with Greg Houston, Brendan Quach and Tara D'Souza)
- Cost of Equity - Fama-French Three-Factor Model Jemena Gas Networks (NSW), 12 August 2009 (with Jeff Balchin, Greg Houston and Brendan Quach)
- Estimates of the Cost of Equity: A report for WAGN, 22 April 2009 (with Brendan Quach)
- AER's Proposed WACC Statement – Gamma: A report for the Joint Industry Associations, 30 January 2009 (with Greg Houston and Brendan Quach)
- The Value of Imputation Credits: A report for the ENA, Grid Australia and APIA, 11 September 2008 (with Greg Houston and Brendan Quach)

## Consulting Experience

- HoustonKemp, 2015 -
- NERA, 2008 - 2015
- 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, LaTex, Matlab, R, Visual Basic. Familiar with the SIRCA SPPR, 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

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