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Cost of Equity in the ERA-DBNGP Draft Decision

A report for DBNGP

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Executive Summary

DBNGP (WA) Transmission, the operator of the Dampier to Bunbury Natural Gas Pipeline, is required to submit a revised access arrangement proposal for its transmission network for the period 2011 through 2015. DBNGP has engaged NERA Economic Consulting (NERA) to examine a number of issues that arise from the recently published *Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline*, provided by the Economic Regulation Authority (ERA), the independent economic regulator for Western Australia.

In particular, DBNGP has asked NERA to assess:

- whether the four pricing models that we use in our March 2010 report have theoretical bases;
- whether the four pricing models are used by academics or practitioners;
- whether the methodological issues raised by the ERA have merit;
- whether the Sharpe-Lintner CAPM (SL CAPM) provides the best estimate of the cost of equity; or
- whether alternative pricing models offer an improvement over the SL CAPM; and
- whether the asset pricing models that we use are consistent with the framework that SFG uses in its submission on behalf of DBNGP.

We document that:

- each of the pricing models that we use in our March 2010 report have theoretical bases;
- the SL CAPM is used by practitioners but has been little used by academics in empirical work for almost 40 years;
- the Black CAPM, while not used explicitly by practitioners, is used implicitly by practitioners but has been little used by academics in empirical work for over 20 years;
- the Fama-French Three-Factor Model (FFM) is used by practitioners and is widely used by academics in empirical work; and
- a zero-beta version of the FFM, while it offers an improvement over the FFM, is not used by practitioners and is not yet in widespread use by academics.

We also document that:

- the ERA displays a misunderstanding of how the FFM determines the cost of equity;
- the way in which we relever betas does not distort the data;
- the way in which we relever betas does not assume that there are no taxes; and that
- the problems that one encounters in estimating the Fama-French risk premiums are also encountered in estimating the market risk premium (*MRP*).

Finally, we document that:

- there is substantial evidence against the unconditional SL CAPM and at least one of the advisors of the Australian Energy Regulator (AER) acknowledges this to be true;
- the conditional CAPM cannot explain the premium that value stocks have historically commanded over growth stocks;
- the existing evidence indicates that the FFM does a better job of explaining the cross-section of returns than the SL CAPM; and that
- the asset pricing models that we use are consistent with the framework that SFG uses.

1 Introduction

This is the third report we have prepared for DBNGP (WA) Transmission regarding the cost of equity for the Dampier to Bunbury Natural Gas Pipeline.[1] DBNGP has asked us to examine a number of issues that arise from the recently published *Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline*, provided by the Economic Regulation Authority (ERA), the independent economic regulator for Western Australia.

In particular, DBNGP has asked NERA to assess:

- whether the four pricing models that we use in our March 2010 report have theoretical bases;
- whether the four pricing models are used by academics or practitioners;
- whether the methodological issues raised by the ERA have merit;
- whether the Sharpe-Lintner Capital Asset Pricing Model (SL CAPM) provides the best estimate of the cost of equity; or
- whether alternative pricing models offer an improvement over the SL CAPM; and
- whether the asset pricing models that we use are consistent with the framework that SFG uses in its report for DBNGP.

The remainder of this report is structured as follows:

- Section 2 – examines the theoretical bases for and uses of the four pricing models that we employ to compute estimates of the cost of equity for DBNGP;
- Section 3 – shows that the methodological issues raised by the ERA are without merit;
- Section 4 – examines whether the SL CAPM provides the best estimate of the cost of equity or whether alternative models offer an improvement over the SL CAPM.

Appendix A provides information about the ability of a conditional version of the SL CAPM to correctly price assets.

[1] Our first report was entitled, *The Required rate of return on equity for a gas transmission pipeline: A report for DBP*, 31 March 2010.

The second report was entitled *Estimating the required rate of return on equity for a gas transmission pipeline: An update for DBNGP*, April 2011.

1.1 Statement of Credentials

This report has been jointly prepared by **Simon Wheatley** and **Brendan Quach**.[2]

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

Brendan Quach is a Senior Consultant at NERA with ten years experience as an economist, specialising in network economics and competition policy in Australia, New Zealand and Asia Pacific. Since joining NERA in 2001, Brendan has advised a wide range of clients on regulatory finance matters, including approaches to estimating the cost of capital for regulated infrastructure businesses.

We have read the Guidelines for Expert Witnesses in Proceedings of the Federal Court of Australia. A copy of these guidelines is attached at Annexure B to this report. We confirm that all inquiries that we believe are desirable have been made and no matters of significance which we regard as relevant have, to the best of our knowledge, been withheld.

[2] If requested a complete curriculum vitae can be provided for each of the authors.

2 Asset Pricing Theory and Model Use

There are a range of financial models available to estimate the cost of equity that measure the risk of owning equity in a variety of ways. In our March 2010 report for DBNGP, we use four different pricing models to estimate the cost of equity. The four models are: [3]

- the Sharpe-Lintner Capital Asset Pricing Model (SL CAPM);
- the Black CAPM;
- the Fama-French Three-Factor Model (FFM); and
- a zero-beta version of the FFM.

As we make clear in our report, while each of the models is well accepted, there is either evidence against or concerns about each model. Thus we acknowledge that no model is perfect and that it makes sense to produce a number of estimates of the cost of equity generated by a variety of models.

This is the strategy recommended by Professor Franks of the London Business School and Professor Myers of the Massachusetts Institute of Technology in their advice provided to the New Zealand Commerce Commission. The Commission states that:[4]

> 'At present, the Commission exclusively uses a version of the Capital Asset Pricing Model (CAPM) to estimate firms' cost of equity, a major input into the estimation of the WACC. Professors Myers and Franks point out that, although the CAPM is very useful, it does suffer from several limitations. ... The CAPM does not explain differences in returns averaged over stocks and long periods of time.'
>
> 'Professors Myers and Franks recommend the Commission employ other methods as cross-checks on CAPM estimates, provided that adequate data are available. Crosschecks should be done unless there are good reasons to the contrary. The most natural models to use as cross-checks are the Discounted Cash Flow (DCF) model for equity valuation and Arbitrage Pricing Theory (APT) models, the most common of which is the Fama-French three-factor model.'

A strategy of examining estimates of the cost of equity generated by a number of different models is also the strategy adopted by many US regulators. The California Public Utilities Commission, for example, in a recent decision, states that:[5]

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[3] The SL CAPM and Black CAPM predict that the market portfolio will be mean-variance efficient, that is, that the portfolio should have the highest mean return for a given level of risk, measured by variance of return. Theory suggests that the market portfolio should consist of all assets, not just stocks. Measuring the returns to assets other than stocks, though, can be difficult. For these reasons, most academic work and most practitioners use the return to an index of stocks as a proxy for the return to the market portfolio. While the use of a stock index as a proxy for the market portfolio is almost uniform, Roll (1977) emphasises that the CAPM does not imply that a stock index should be mean-variance efficient. For simplicity, however, in what follows references to the SL CAPM and Black CAPM will be to empirical versions of the models unless the context requires that we make a distinction.

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

[4] Franks, J, M. Lally, S. Myers, *Recommendations to the New Zealand Commerce Commission on an Appropriate Cost of Capital*, 18 December 2008, page 7.

[5] California Public Utilities Commission, *Decision 09-05-019*, May 2009, pages 15 and 25-26.

> 'The financial models commonly used in water utility cost of capital proceedings are the Discounted Cash Flow Analysis and Capital Asset Pricing Model. Various other models and measures of risk premium analysis have also been proposed by the parties. None of the models are independently reliable ... therefore, the Commission has historically reviewed an array of models with varied assumptions before exercising its judgment in adopting a return on equity.'
>
> 'In the final analysis, it is the application of informed judgment, not the precision of financial models, which is the key to selecting a specific ROE estimate. We affirmed this view in D.89-10-031, noting that all these models have their flaws and, as we have routinely stated in past decisions, the models should not be used rigidly or as definitive proxies for the determination of the investor-required return on equity.'

In spite of the advice provided by eminent financial economists and the approach adopted by international regulators, the ERA argues that the return on equity for DBNGP should be set solely by reference to estimates generated by the SL CAPM since this is the only model that is both:[6]

> 'based on a theory;'

and

> 'widely used by practitioners.'

In this section we examine whether these statements are true.

2.1 The Sharpe-Lintner CAPM

Sharpe (1964) and Lintner (1965) show that if risk-averse investors:

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

(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 there are no transaction costs; and

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

then the market portfolio of risky assets must be mean-variance efficient.[7] A portfolio that is mean-variance efficient is a portfolio that has the highest mean return for a given level of risk, measured by variance of return.

If the market portfolio is mean-variance efficient, the following condition will hold:

$$\mathrm{E}(R_j) = R_f + \beta_j[\mathrm{E}(R_m) - R_f], \qquad (1)$$

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[6] ERA, *Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline*, March 2011, page 115.

[7] Sharpe, William F., *Capital asset prices: A theory of market equilibrium under conditions of risk*, Journal of Finance 19, 1964, pages 425-442.

Lintner, John, *The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets*, Review of Economics and Statistics 47, 1965, pages 13-37.

where

$E(R_j)$ = is the mean return on asset j;

R_f = is the risk-free rate;

β_j = asset j's beta, which measures the contribution of the asset to the risk, measured by standard deviation of return, of the market portfolio; and

$E(R_m)$ = the mean return to the market portfolio of risky assets.

In the SL CAPM, a risk-averse investor will never invest solely in a single risky asset but rather will hold a share of the market portfolio. So, in the model, an investor cares not about how risky an individual asset would be if held alone, but about how the asset contributes to the risk of the market portfolio.

2.1.1 Theoretical basis

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.[8] The empirical version of the model that the ERA uses 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. So while it is true that the SL CAPM is based on a theory, it is *misleading* to say that the empirical version of the SL CAPM that the ERA uses is based on a theory.

2.1.2 Use by practitioners

We accept that the empirical version of the SL CAPM that the ERA uses is also widely used by practitioners. We contend, though, that because practitioners often use Blume-adjusted estimates of beta without a clear rationale for doing so, practitioners are often in effect using a combination of the SL CAPM and Black CAPM. A Blume-adjusted estimate of beta is a weighted average of a least squares estimate and one. In section 2.2.2, we will show that were the ERA to use the SL CAPM and Black CAPM together, it could generate a cost of equity identical to the one on which it relies.

While the SL CAPM is widely used, it has been known for well over 40 years that the model tends to underestimate the returns to low-beta assets and overestimate the returns to high-beta assets. Mehrling (2005), for example, reports that: [9]

> '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

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

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

> 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.'

This empirical regularity prompted Black (1972), Vasicek (1971) and Brennan (1971) to examine whether relaxing the assumption that investors can borrow or lend freely at a single rate can produce a model that better fits the data.[10]

2.2 The Black CAPM

Brennan (1971) shows that if one replaces assumption (iv) with:

(i) investors can borrow at a risk-free rate R_b and lend at a risk-free rate $R_l < R_b$,

then

$$\mathrm{E}(R_j) - \mathrm{E}(R_z) = \beta_j[\mathrm{E}(R_m) - \mathrm{E}(R_z)], \qquad R_l < \mathrm{E}(R_z) < R_b \tag{2}$$

where

$\mathrm{E}(R_z)$ = the mean return to a zero-beta portfolio.

Although three authors contributed to the development of the model, the model is generally known simply as the Black CAPM. In estimating the Black CAPM, we follow Velu and Zhou (1999) and assume that the difference between the zero-beta and risk-free rates, what we label the zero-beta premium, is a constant through time.[11] Thus we examine the model:

$$\mathrm{E}(R_j) - R_f - z = \beta_j[\mathrm{E}(R_m) - R_f - \mathrm{z}], \tag{3}$$

where

z = the zero-beta premium.

If $z = 0$, the model collapses to the SL CAPM, illustrating the fact that the Black CAPM is a more general model than the SL CAPM. If $z > 0$, as empirically is the case, then the SL CAPM will underestimate the mean returns to low-beta assets. The Black CAPM, by construction, will neither underestimate the returns to low-beta assets nor overestimate the returns to high-beta assets.

2.2.1 Theoretical basis

The Black CAPM, like 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

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

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

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

[11] Velu, Raja and Guofu Zhou, *Testing multi-beta asset pricing models*, Journal of Empirical Finance 6, 1999, pages 219-241.

be mean-variance efficient.[12] So while it is true that the Black CAPM is based on a theory, it would again be *misleading* to say that the empirical version of the Black CAPM – that we will argue that many practitioners implicitly use – is based on a theory. The Black CAPM states that the risk of an asset should be measured relative to the market portfolio of all risky assets whereas the empirical version of the model that practitioners implicitly use measures the risk of an asset relative to a portfolio of stocks alone.

2.2.2 Use by practitioners

The tendency of the SL CAPM to underestimate the returns to low-beta assets and overestimate the returns to high-beta assets meant that the more general Black CAPM became the most widely accepted pricing model among academics for much of the 1970s and 1980s. On the other hand, it is less clear that the model has ever gained widespread *explicit* acceptance among practitioners. There has been and is, however, a widespread *implicit* acceptance of the model by practitioners. This is because many practitioners use Blume-adjusted estimates of beta – either explicitly or implicitly – when there is no clear rationale for doing so other than to move estimates of the cost of equity generated by the SL CAPM closer to estimates that would be generated by the Black CAPM.

A Blume-adjusted estimate of beta is given by:

$$\tilde{\beta}_j = w_j \hat{\beta}_j + (1 - w_j), \qquad 0 < w_j < 1 \tag{4}$$

where

w_j = a weight;

$\tilde{\beta}_j$ = the Blume-adjusted estimate; and

$\hat{\beta}_j$ = the least-squares estimate.

Thus a Blume-adjusted estimate of beta is a weighted average of a least squares estimate and one. Bloomberg chooses the weight w_j to be one third.

There are two rationales for using Blume-adjusted estimates of beta:

- the true betas of firms tend to regress towards the mean of all betas of one over time as the risks of the activities undertaken by firms change; and
- Blume-adjusted estimates of betas can be more precise than unadjusted least squares estimates because they take into account prior beliefs about the cross-sectional distribution of betas.

A market-capitalisation weighted average of all betas must be one. So the beta of a randomly selected firm will tend to regress towards one over time if the activities that it undertakes change. If, on the other hand, the activities that the firm undertakes do not change, there will

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

be no reason to suspect that the beta of the firm will change. There is, for example, no evidence that the activities undertaken by the AER control firms have changed or will change in the immediate future in such a way as to suggest that the beta of a portfolio of the firms will regress towards one over time.

The other rationale for using Blume-adjusted betas is to take into account prior beliefs about the cross-sectional distribution of betas. Koller, Goedhart and Wessels (2010) note that if a practitioner has such prior beliefs, the Blume weight should be:[13]

$$w_j = \frac{\sigma_\beta^2}{\sigma_\beta^2 + \sigma_{\varepsilon_j}^2}, \qquad (5)$$

where

σ_β = the cross-sectional standard deviation of betas; and

σ_{ε_j} = the standard error of the least squares estimate of the beta of asset j.

This formula says that less weight will be attached to the least squares estimate and more weight will be attached to the mean of the prior distribution of one the higher the standard error of the estimate, that is, the less precise the least squares estimate. Importantly, the weight attached to the least squares estimate will not be the same for all estimates.

To illustrate how prior beliefs about the cross-sectional distribution of betas can be taken into account by a practitioner we will consider a simple example that uses the nine AER control firms. Suppose there is a belief that the cross-sectional distribution of betas has a mean of one and a standard deviation of 0.05. In other words, suppose the prior belief is that the cross-sectional dispersion of betas is very low. Suppose also that a least squares estimate of beta is 0.6 with a standard error of 0.05, as we find the average least squares estimate of the beta of one of the nine AER control firms and its standard error to be.[14]

It follows, using equation (5), that the weight that the practitioner will place on the average least squares estimate will be: [15]

$$w = \frac{0.05^2}{0.05^2 + 0.05^2} = 0.5 \qquad (6)$$

Thus, using equation (4), the practitioner's estimate of the beta of the equity of one of the nine AER control firms will be:

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[13] Koller, T.; Goedhart, M.; Wessels, D. *Valuation: Measuring and Managing the Value of Companies*, John Wiley & Sons, 2010, page 253.

[14] NERA, *Estimating the required rate of return on equity for a gas transmission pipeline: An update for DBNGP*, April 2011, page 13.

[15] NERA, *Estimating the required rate of return on equity for a gas transmission pipeline: An update for DBNGP*, April 2011, page 13.

$$\tilde{\beta}_j = 0.5 \times 0.6 + (1 - 0.5) = 0.8 \quad (7)$$

This estimate is, coincidentally, the estimate that both the AER and ERA use. Thus if a practitioner were to go through an exercise of combining an empirical estimate of the beta of the equity of one of the nine AER control forms with a strong prior belief about the cross-sectional distribution of betas, they would arrive at the same cost of equity that the AER and ERA choose.[16] We do not believe that the exercise makes much sense, because the exercise requires the practitioner to have an unreasonably strong prior belief. With a more reasonable set of prior beliefs, the weight placed on the average least squares estimate would be much closer to one reflecting the precision of our least squares estimates that use weekly data. There is an alternative way, however, by which a practitioner could arrive at the same result that does not require that he or she hold a strong prior belief about the cross-sectional dispersion of betas.

We note that recent estimates of the zero-beta premium are sufficiently high that an empirical version of the Black CAPM predicts that the mean returns to all equities are identical.[17] An outcome where the returns required on all equities are identical will also be generated if one uses the SL CAPM and a beta of one for all equities. So another way by which the practitioner could arrive at the same result would be for he or she to place a weight of 0.5 on an estimate of the cost of equity delivered by the SL CAPM and the empirical estimate of the beta of the equity of an energy utility of 0.6 and a weight of 0.5 on an estimate delivered by the Black CAPM.

Thus a practitioner will arrive at the same result whether they:

- use the SL CAPM, an empirical estimate of beta of 0.6 and strong prior beliefs about the cross-sectional distribution of betas; or
- average an estimate of the cost of equity delivered by the SL CAPM and the empirical estimate of the beta of the equity of an energy utility of 0.6 and an estimate delivered by the Black CAPM.

Since the use of weekly data generally allows one to estimate the beta of a portfolio relatively precisely and the activities that many firms undertake do not change substantially through time, we believe that the use by practitioners of Blume-adjusted estimates – either explicitly or implicitly – often represents an implicit use of the Black CAPM.

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[16] Similar results are generated by using one of the other estimates that we provide.

[17] CEG, *Estimation of, and correction for, biases inherent in the Sharpe CAPM formula: A report for the Energy Networks Association Grid Australia and APIA*, September 2008.

Lajbcygier P. And S. M. Wheatley, *An evaluation of some alternative models for pricing Australian stocks*, Working Paper , Monash University, 2009.

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

2.3 The Fama-French Three-Factor Model

Fama and French (1992) show that, contrary to the predictions of both the SL CAPM and Black CAPM, the market value of a firm's equity and the ratio of the book value of the equity to its market value are better predictors of the equity's return than is the equity's beta.[20, 21] Fama and French (1993) argue that if assets are priced rationally, variables that can explain the cross-section of mean returns must be proxies for risks that cannot be diversified away.[22]

To explain the patterns in mean returns that one observes, Fama and French (1993) suggest that investors care about the exposure of each asset to: [23]

(i) the excess return to the market portfolio;

(ii) the difference between the return to a portfolio of high book-to-market stocks and the return to a portfolio of low book-to-market stocks (*HML*); and

(iii) the difference between the return to a portfolio of small cap stocks and the return to a portfolio of large cap stocks (*SMB*).

If investors care only about the exposure of an asset to these three factors and a risk-free asset exists, then:

$$\mathrm{E}(R_j) - R_f = b_j[\mathrm{E}(R_m) - R_f] + h_j HMLP + s_j SMBP, \qquad (8)$$

where

b_j, h_j and s_j are the slope coefficients from a multivariate regression of R_j on R_m, *HML* and *SMB* and *HMLP* and *SMBP* are the *HML* and *SMB* premiums.

The FFM is designed to explain the returns to small firms and value firms correctly.

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[21] The ERA states that:

'the Authority notes that the 2005 Kothari, Shanken, and Sloan study concludes that ... the book-to-market premia could be a result of survivorship bias.'

The 1995 (not 2005) study of Kothari, Shanken, and Sloan suggests that selective backfilling by Compustat may provide the appearance of a stronger value effect than actually exists. Chan, Jegadeesh and Lakonishok (1995), however, show that selection bias contributes negligibly to the value effect in Compustat data and Davis (1994) shows that a value effect exists in pre-Compustat data that are free from any survivorship bias.

Chan, Louis K. C., Narasimhan Jegadeesh, and Josef Lakonishok, *Evaluating the performance of value versus glamour stocks: The impact of selection bias*, Journal of Financial Economics, 1995, pages 269–296.

Davis, James L., *The cross-section of realized stock returns: The pre-Compustat evidence*, Journal of Finance, 1994, pages 1579–1593.

ERA, *Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline*, March 2011, page 116.

Kothari, S.P., Jay Shanken, and Richard G. Sloan, *Another look at the cross-section of expected stock returns*, Journal of Finance, 1995, pages 185–224.

[22] Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

[23] Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

2.3.1 Theoretical basis

As Fama and French (1993) make clear, if there are factors besides the return to the market portfolio that are pervasive, then the Arbitrage Pricing Theory (APT) of Ross (1976) predicts that the additional risks associated with the factors should be priced.[24] To be precise, if the factors are pervasive, the mean return to each asset should be determined by its exposure to the factors. The intuition behind the APT is that investors will be rewarded for risks that are pervasive and they cannot diversify away but will not be rewarded for risks that are idiosyncratic and that they can diversify away. If investors were not rewarded for bearing pervasive risks, arbitrage opportunities would arise.

The R^2 values attached to the time series regressions of the returns to the 25 US portfolios on the three factors that Fama and French (1993) report range from 0.83 to 0.97.[25] This means that one could almost replicate the returns to the 25 portfolios using the three Fama-French factors. Thus, as Cochrane (2001) points out, the three-factor model must be approximately true to avoid near arbitrage opportunities. He states that:[26]

> 'given the average returns and the failure of the CAPM to explain those returns, there would be near-arbitrage opportunities if value and small stocks did not move together in the way described by the Fama-French model.'

If the R^2 values were all equal to 1.00, the three-factor model would have to hold *exactly* to rule out arbitrage opportunities. The idea that prices should be set so as to rule out arbitrage opportunities is one of the most basic and oldest in Finance. Rubinstein notes that Fisher used a no-arbitrage argument as early as 1907.[27]

2.3.2 Use by practitioners

The use of pricing models by practitioners typically lags the use of pricing models by academics. For example, while Sharpe's paper introducing the CAPM was published in 1964, Gitman and Mercurio (1982) find that only 30 per cent of respondents to their survey used the model.[28] Graham and Harvey (2001), on the other hand, find, nearly 20 years later, that 73 per cent of respondents to their survey used the SL CAPM.[29] Ironically, as we point out, it was already known by 1969 – at least by academics with access to the necessary data – that the SL CAPM underestimates the returns required on low-beta assets and overestimates

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[24] Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

Ross, Stephen, *The arbitrage theory of capital asset pricing*, Journal of Economic Theory 13, pages 341-360.

[25] Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

[26] Cochrane, John H., *Asset pricing*, Princeton University Press, 2001, page 442.

[27] Rubinstein, M., *A history of the theory of investments*, Wiley, 2006, page 7.

[28] Sharpe, William F., *Capital asset prices: A theory of market equilibrium under conditions of risk*, Journal of Finance 19, 1964, pages 425-442.

Gitman, L.J. and V. Mercurio, *Cost of capital techniques used by major U.S. firms: survey and analysis of Fortune's 1000*, Financial Management 14, 1982, pages 21-29.

[29] Graham, J. and C. Harvey, (2001), *The theory and practice of corporate finance: Evidence from the field*, Journal of Financial Economics 60, pages 187-243.

the returns required on high-beta assets. So adoption by many practitioners of the SL CAPM may have come well after problems with the model had been identified.

Graham and Harvey (2001) also find that there is some use by US managers of size and value factors when computing an equity cost of capital. Their evidence, though, is based on a survey conducted in February 1999, less than six years after the publication of the paper by Fama and French (1993) introducing the FFM. [30] So the managers that they surveyed may not have had sufficient time to learn about the benefits of using an alternative framework for estimating the cost of equity. More direct evidence that some practitioners use the FFM is provided by the fact that Morningstar, a leading provider of independent investment research, sells Fama-French betas in the US.[31]

While there is evidence that the FFM is used by practitioners, there is no question that the SL CAPM is currently more widely used by practitioners than the FFM. On the other hand, there is also no question that the FFM is currently more widely used by academics as a benchmark for computing required returns than is the SL CAPM.

For example, Koller, Goedhart and Wessels (2005) state that: [32]

> 'Fama and French significantly damaged the credibility of the CAPM and beta. Today, most academics rely on three-factor models to measure historical risk and return.'

As another example, Morgan Stanley's web site indicates that Eugene Fama was awarded in 2005 the inaugural Morgan Stanley – American Finance Association (AFA) Prize in Financial Economics in part for producing:[33, 34]

> 'a model that has replaced the Capital Asset Pricing Model in applied and empirical work.'

The quote is from a joint statement by Morgan Stanley and AFA but the AFA is *solely* responsible for the selection of the Award Recipient.[35]

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30 Graham, J. and C. Harvey, (2001), *The theory and practice of corporate finance: Evidence from the field*, Journal of Financial Economics 60, pages 187-243.

31 http://corporate.morningstar.com/IB/asp/subject.aspx?xmlfile=5532.xml

32 Koller, T.; Goedhart, M.; Wessels, D. *Valuation: Measuring and Managing the Value of Companies*, John Wiley & Sons, 2005, page 323.

33 http://www.morganstanley.com/about/press/articles/5558.html

34 Morgan Stanley is a leading global financial services firm providing a wide range of investment banking, securities, investment management and wealth management services. The firm's employees serve clients worldwide including corporations, governments, institutions and individuals from more than 600 offices in 32 countries.

35 To select a recipient, the AFA uses the following criteria:

At its annual meeting the Executive Committee of the AFA will nominate and the AFA Board will approve a selection committee, to be chaired by the outgoing President. The committee will evaluate candidates for the award based on the impact of the candidates' research along several dimensions.

Fundamental Impact. Fundamental research opens new areas to inquiry, changes scholars', practitioners', and regulators' thinking about basic problems, or develops new tools that make academic and practical research progress possible.

Sustained Impact. The candidates' activities should have a cumulative impact through the course of a career, and continuing influence on current research.

As a third example, Da, Guo and Jagannathan (2009) state that[36]

> 'the Fama and French (1993) three-factor model ... has become the standard model for computing risk adjusted returns in the empirical finance literature'

Despite the widespread acceptance of the FFM by the academic community, recent evidence indicates that a zero-beta version of the FFM better fits the data than does the FFM. So we also examine a zero-beta version of the model.

2.4 The Zero-Beta Fama-French Three-Factor Model

A zero-beta version of the FFM can be generated by relaxing the assumption, inherent in the FFM, that investors can borrow or lend as much as they like at a single risk-free rate. Again, we follow Velu and Zhou (1999) and assume that the difference between the zero-beta and risk-free rates, the zero-beta premium, is a constant through time.[37] Thus we examine the following model

$$\mathrm{E}(R_j) - R_f = z + b_j[\mathrm{E}(R_m) - R_f - z] + h_j HMLP + s_j SMBP, \qquad (9)$$

where

z = the zero-beta premium.

If $z = 0$, the model collapses to the FFM. Thus the zero-beta model is a more general model than the FFM. If $z > 0$, as empirically is found, then the FFM will underestimate the mean returns to low-beta assets. The zero-beta version of the model, by construction, will neither underestimate nor overestimate the returns.

2.4.1 Theoretical basis

The theoretical basis for the zero-beta version of the FFM is almost identical to the theoretical basis for the FFM itself. If there are factors besides the return to the market portfolio that are pervasive, then the Arbitrage Pricing Theory (APT) of Ross (1976) predicts that the additional risks associated with the factors should be priced.[38] If, however, there are borrowing and lending constraints, then the return required on a zero-beta portfolio should lie between the lending and borrowing rates but need not equal either.

Broad Impact. The most important research contributions are likely to be widely understood and appreciated across multiple subfields, to influence subsequent research, practice, and pedagogy, and to alter the course of empirical and theoretical inquiry.

http://www.afajof.org/association/morganstanley.asp

[36] Da Z., R. Guo and R. Jagannathan, *CAPM for Estimating the Cost of Equity Capital: Interpreting the Empirical Evidence*, National Bureau of Economic Research Working Paper 14889, April 2009.

[37] Velu, Raja and Guofu Zhou, *Testing multi-beta asset pricing models*, Journal of Empirical Finance 6, 1999, pages 219-241.

[38] Ross, Stephen, *The arbitrage theory of capital asset pricing*, Journal of Economic Theory 13, pages 341-360.

2.4.2 Use by practitioners

There is currently little use of a zero-beta version of the FFM by practitioners and little use by academics because it has only recently become known through the work of Lewellen, Nagel and Shanken (2010) that the FFM has, like the SL CAPM, a tendency to underestimate the returns required on low-beta assets and a tendency to overestimate the returns required on high-beta assets.[39]

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

3 Methodological Issues

The ERA raises a number of methodological issues that the AER also raised in its *Jemena Gas Networks Access Arrangement Proposal for the NSW Gas Networks: Draft Decision* of February 2010. Some of these issues represent a misunderstanding of the way in which the FFM works and we were careful to point this out in our response to the AER on behalf of Jemena in 2010.[40] So much of what follows is necessarily a repetition of arguments we made in that response. However, besides repeating the arguments we made on behalf of Jemena, we also note where the AER disagreed with our response and where it did not disagree in its *Jemena Gas Networks Access Arrangement Proposal for the NSW Gas Networks: Final Decision* of June 2010. Where the AER disagreed with our response, we provide additional analysis.

3.1 Characteristics and Exposures

The evidence that Fama and French (1992) provide shows that, contrary to the predictions of the SL CAPM, size and book-to-market are better predictors of return than beta.[41] Size and book-to-market are *characteristics*. Beta measures the *exposure* of an asset to market risk. To correct these problems with the SL CAPM, Fama and French (1993) introduce a pricing model that does not link the cost of equity to a set of characteristics but instead links it to the exposure of equity to three sources of risk: market risk; *HML* risk; and *SMB* risk.[42]

The *HML* factor is the return to a zero-investment position that is long a portfolio of high book-to-market (value) stocks and short a portfolio of low book-to-market (growth) stocks. In other words, it is the return to a position that finances an investment in value stocks by shorting growth stocks. The *SMB* factor is the return to a zero-investment position that is long a portfolio of low market-capitalisation (small) stocks and short a portfolio of high market-capitalisation (big) stocks. In other words, it is the return to a position that finances an investment in small stocks by shorting big stocks.

The predictions of a characteristics-based model and an exposure-based model can differ substantially. For example, absent synergies or tax effects, the FFM predicts that the merger of two identical unlevered companies will not affect the return required on each company. A characteristics-based model in which the cost of equity is negatively related to size, on the other hand, will predict that the return required on each company will fall. While an exposure-based model can be given a theoretical rationale consistent with the idea that investors behave rationally, a theoretical rationale for a characteristics-based model will in general require that some investors do not behave rationally.[43]

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[40] NERA, *Jemena access arrangement proposal for the NSW Gas Networks, AER draft decision: A report for Jemena*, March 2010.

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

[42] Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

[43] Daniel, K. And S. Titman, *Evidence on the characteristics of cross sectional variation in stock returns*, Journal of Finance 52, 1997, pages 1-33.

The ERA's *Draft Decision* contains a fundamental misunderstanding of how the FFM determines the required return on a stock or portfolio of stocks. The ERA states that: [44]

> 'NERA's empirical study on the FFM uses individual stock data of the nine Australian regulated businesses. The FFM is used to adjust for business specific risks, including the firm size and the book-to-market ratio of businesses in the sample. The regulatory framework for assessment is relative to a *benchmark* exposure to risks, with the benchmark characteristics reflecting the circumstances of an efficient firm providing regulated businesses.'
>
> [ERA's e*mphasis*]

Similarly, the AER states that:[45]

> 'The FFM seeks to adjust for business specific risks, but the regulatory framework for assessment is a benchmark exposure to risks. That is, the FFM posits that a business' return should be based on its specific *characteristics*—the business size and book-to-market ratio'
>
> 'in order to derive a cost of capital for a regulated business, the NERA report on the FFM either aggregates data before estimation or averages the outcome for individual firms. However, all the firms have different sizes and variations in the book-to-market valuations which would lead one to expect, under the FFM, that they should exhibit different costs of capital. By using an average estimate the NERA report on the FFM's implementation of the FFM dilutes the variation in returns that the FFM seeks to explain and model.'
>
> [*Emphasis added*]

The ERA's concern and the AER's concern is that if the FFM were a *characteristics-based* model – and it is not – then it would not be appropriate to use the model to estimate the cost of equity for a benchmark energy business. This is because the cost of equity for a benchmark energy business would depend, in what would understandably be seen as an arbitrary fashion, on the characteristics of the companies used to define the benchmark. A merger of some of the companies would produce a benchmark business with different characteristics and so, under a characteristics-based model, a different cost of equity.

The FFM states that the return required on an asset should be explained by its *exposure* to the three factors, that is, its factor betas, irrespective of the asset's *characteristics*. As Davis, Fama and French (2000) point out, for example, the FFM:[46]

> 'says expected returns compensate risk loadings *irrespective* of the BE /ME characteristic,'

where risk loadings refer to exposures or factor betas and BE/ME denotes book-to-market. In other words, the required return on an asset depends on its exposures to the three factors *irrespective* of the asset's characteristics. Firms with large *HML* betas may be firms with high book-to-market ratios but they need not be. A firm, for example, may have a large *HML* beta but have a low book-to-market ratio. Similarly firms with high *SMB* betas may be small

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[44] ERA, *Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline*, March 2011, page 126.

[45] AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, pages 109 and 119-120.

[46] Davis, James, Eugene Fama and Kenneth French, *Characteristics, covariances, and average returns: 1929-1997*, Journal of Finance 55, 2000, pages 389-406.

firms but they need not be. A small firm, for example, may have a low *SMB* beta. As Koller, Goedhart and Wessels (2005) point out, in the FFM: [47]

> 'a company does not receive a premium for being small. Instead, the company receives a risk premium if its stock returns are correlated with those of small stocks or high book-to-market companies.'

We emphasise, therefore, that the FFM does *not* use size and book-to-market as inputs in determining the cost of equity for a gas transmitter.

The ERA also states that it is: [48]

> 'of the view that it is inappropriate for all nine regulated utilities to be pooled together to estimate the HML and SMB risk premia and their betas.'

Similarly, the AER states that the FFM can only be used to determine the return required on an individual asset and not on a portfolio. For example the AER states that:[49]

> 'the approach in the NERA report on the FFM to manipulating data prior to parameter estimation represents a distortion of the original FFM by ... the pooling of firms of disparate sizes,'

and that:[50]

> 'in order to derive a cost of capital for a regulated business, the NERA report on the FFM either aggregates data before estimation or averages the outcome for individual firms. However, all the firms have different sizes and variations in the book-to-market valuations which would lead one to expect, under the FFM, that they should exhibit different costs of capital. By using an average estimate the NERA report on the FFM's implementation of the FFM dilutes the variation in returns that the FFM seeks to explain and model. As outlined previously, the NERA report on the FFM's specification of the FFM does not represent a standard application of the FFM.'

The ERA's argument and the AER's argument that the FFM can only be used to determine the return required on an individual asset and not on a portfolio is wrong. In the FFM, the factor beta of a portfolio is a weighted average of the factor betas of the assets in the portfolio, where the weights are the weights of the assets in the portfolio. In exactly the same way, in the SL CAPM, the beta of a portfolio is simply a weighted average of the betas of the assets that make up the portfolio, where the weights are, again, the weights of the assets in the portfolio.[51]

Since the return required on a portfolio is a weighted average of the returns required on the assets in the portfolio, it follows that the FFM, like the SL CAPM, can be used to calculate both the returns required on *individual assets* and the returns required on *portfolios*. Indeed,

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47 Koller, Tim, Marc Goedhart and David Wessels, *Valuation: Measuring and managing the value of companies*, 2005, McKinsey.

48 ERA, *Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline*, March 2011, page 126.

49 AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, page 110.

50 AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, page 119-120.

51 Fama, Eugene, *Foundations of Finance*, Basic Books, New York, 1976, page 75.

a large number of studies use the FFM to determine the returns required on a range of portfolios. One such study is the study by Da, Guo and Jagannathan (2009) that the AER cites.[52] This study forms portfolios on the basis of a number of characteristics and measures the returns required on these portfolios using the SL CAPM and FFM.

To recap, the FFM is *not* a characteristics-based model and so the ERA's concern and the AER's concern that the model is an inappropriate one to use in estimating the required return on equity for a benchmark energy business is misplaced. The FFM, like the SL CAPM, is a model in which the return required on an asset is a linear function of a number of factor betas. So the FFM can be used to calculate both the returns required on *individual assets* and the returns required on *portfolios*.

The AER in its *Final Decision* on Jemena did not disagree with the arguments we provide here about characteristics and exposures.[53]

To compute estimates of the three Fama-French betas of the equity of a benchmark energy business, one must take into account that the leverage of each of the sample of nine energy businesses that the AER uses does not match the leverage of 60 per cent that the ERA and AER accept that an efficient energy business will have.[54] We define leverage here to be the ratio of the value of the firm's debt to the value of the firm. Taking this fact into account in computing estimates of the Fama-French betas requires one first delever and then relever the estimates.

3.2 Characteristics and Relevering

To compute the Fama-French betas of a benchmark business we delever and then relever the estimates from the nine businesses in *exactly* the same way as if one were to use the SL CAPM. Relevering is necessary because the capital structures of the comparable companies differ from the assumed capital structure of the benchmark business.

The ERA, however, believes that relevering returns creates a distortion. It states that: [55]

> 'the Authority also notes that the data used in NERA's study is not the data provided by DFA or MSCI. The data has been manipulated for the purpose of the estimates. For example, NERA has made the adjustment of returns for gearing by multiplying the return to the equity of each regulated utility by $(1 - L_j)/(1 - 0.6)$ where L_j is the average net debt-to-value ratio over the period for which data is available for the nine regulated energy businesses to reflect the widely adopted level of gearing of 60 per cent by Australian regulators.'

Similarly, the AER states that:[56]

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[52] The AER introduces Da, Guo and Jagannathan (2009) into the debate on page 63 of AER, *ActewAGL Access arrangement proposal for the ACT, Queanbeyan and Palerang gas distribution network: 1 July 2010 – 30 June 2015,* 2009.

[53] AER, *Jemena Gas Networks Access arrangement proposal for the NSW gas networks: Final Decision,* June 2010.

[54] ERA, *Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline,* March 2011, page 196.

AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision,* February 2010, page xvi.

[55] ERA, *Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline,* March 2011, page 126.

> 'in addition, the approach in the NERA report on the FFM to manipulating data prior to parameter estimation represents a distortion of the original FFM by the adjustment of returns for gearing.'

and that:[57]

> 'the ... returns have been altered such that they do not reflect the actual firms' circumstances ... the gearing change would alter other business fundamentals (for instance, changes in interest costs, business distress risks and the book-to-market ratio).'

The ERA's concerns and the AER's concerns are misplaced since both the SL CAPM and FFM are linear financial models in which the return required on an asset depends on its exposure to a number of factors and not on a set of characteristics. One can apply standard delevering and relevering techniques in exactly the same way with the FFM as one can with the SL CAPM.

Suppose that a levered firm that has default-free debt outstanding maintains a constant leverage through time. Then the relation between the return to the firm's equity and the return to an equivalent unlevered firm is:[58]

$$R_e = R_a\left(1+\frac{D}{E}\right)-R_f\,\frac{D}{E}, \qquad (10)$$

where R_e is the return to the levered firm's equity, R_a is the return to an equivalent unlevered firm, R_f is the risk-free rate and D and E are the values of the levered firm's debt and equity. As we emphasise later, this relation will hold even in the presence of corporate and personal taxes – so long as the levered firm issues or retires debt to maintain a constant leverage.

It follows from equation (10) that the beta of the levered firm and the beta of an equivalent unlevered firm are related in the following way:

$$\beta_e = \beta_a\left(1+\frac{D}{E}\right) \qquad (11)$$

where β_e is the beta of the levered firm's equity and β_a is the beta of an equivalent unlevered firm. Equation (11) is the relation that AER advisor Henry (2009) uses and the AER endorses.[59]

To illustrate how one can use (11) to delever and relever betas, we consider a simple example. Consider a levered firm whose equity has a beta of one. If the firm's debt-to-equity ratio is one, then, from (11), the beta of the equity of an equivalent unlevered firm must be 0.5. The beta of the equity of an equivalent unlevered firm is the delevered beta. Also, from (11), the

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56 AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, page 109.

57 AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, page 119.

58 Dempsey, M., *The Fama and French three-factor model and leverage: Compatibility with the Modigliani and Miller propositions*, Investment Management and Financial Innovations 6, 2009, pages 48-53.

59 Olan T. Henry, *Estimating β: Report for the Australian Energy Regulator*, 23 April 2009.

beta of the equity of an otherwise identical firm that has a debt-to-equity ratio of 1.5 must be 1.25. This is a relevered beta.

In *exactly* the same way the Fama-French factor betas for a levered firm and for an equivalent unlevered firm are related in the following way: [60]

$$b_e = b_a\left(1+\frac{D}{E}\right), \quad h_e = h_a\left(1+\frac{D}{E}\right) \quad \text{and} \quad s_e = s_a\left(1+\frac{D}{E}\right), \tag{12}$$

where b_e, h_e and s_e are the market, *HML* and *SMB* betas for the levered firm and b_a, h_a and s_a are the corresponding betas for an unlevered firm.

To summarise, the process of delevering and relevering Fama-French betas is identical to the process of delevering and relevering Sharpe-Lintner betas. So the concerns expressed by the ERA and the AER about estimating the parameters of the FFM using relevered returns are *misplaced*.

The AER in its *Final Decision* on Jemena did not disagree with the arguments we provide here about characteristics and relevering.[61]

While the AER in its *Draft Decision* on Jemena states that the relevering formula that we use assumes no taxes, the ERA makes no such a statement in its *Draft Decision*. To ensure, however, that the ERA is aware of the fact that the AER statement is *incorrect*, we reproduce our explanation of why it is incorrect from our response to the AER on behalf of Jemena.

3.3 Taxes and Relevering

In our report for DBNGP and in our report for Jemena we adjust the Fama-French betas to reflect an assumption that a regulated business has 60 per cent debt and 40 per cent equity. Our report for Jemena states that:[62]

> 'none of the nine utilities has a debt-to-value ratio of 0.6, ie, the ratio that the AER assumes a benchmark utility should have. We have therefore adjusted (relevered) all of our beta estimates to reflect this benchmark assumption. More specifically, we have followed Henry (2009) and multiplied each return by $(1 – L_j)/(1 – 0.6)$, where L_j is the average net debt-to-value ratio over the period for which net debt and market capitalisation data are available for the utility. If the utility follows a strategy of issuing or retiring debt to ensure its leverage is constant through time, then relevering in this way is appropriate.'

However, the AER's *Draft Decision* states that:[63]

> 'the leverage transformation used in the NERA report on the FFM assumes no tax (or that gamma is equal to one'

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60 Dempsey, M., The Fama and French three-factor model and leverage: Compatibility with the Modigliani and Miller propositions, Investment Management and Financial Innovations 6, 2009, pages 48-53.

61 AER, *Jemena Gas Networks Access arrangement proposal for the NSW gas networks: Final Decision*, June 2010.

62 NERA, *Cost Of Equity – Fama-French Three-Factor Model: Report for Jemena Gas Networks (NSW)*, August 2009.

63 AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, page 119.

and that:[64]

> 'the gearing transformation is inconsistent with Jemena's access arrangement proposal, since it assumes no tax (or that gamma is one) but elsewhere taxation adjustments to returns are proposed to be based on a gamma of 0.2.'

This concern we found puzzling since we use the leveraging formula endorsed by the AER in its *Explanatory Statement* for its *Review of the WACC Parameters*. The *Review* states that:[65]

> 'the AER notes that the ACG prefers a simplified de-levering and re-levering formula (the Brealey and Myers formula with a debt beta of zero), and has adopted this approach in recent reports. This approach has also been adopted by Associate Professor Henry.
>
> The de-levering and re-levering formula under the approach preferred by the ACG and adopted by Associate Professor Henry is:
>
> $$\beta_e = \beta_a\left(1+\frac{D}{E}\right)$$
>
> where each of the parameters are as defined above.
>
> The AER notes that it is generally accepted that the choice of de-levering and re-levering formula, in general, does not make a significant difference to the resultant estimates, so long as the same formula is adopted for both de-levering and re-levering. The AER also notes that the use of the same formula across the ACG's current and recent reports, and Associate Professor Henry's report, also allows for ease of comparison across the various reports.
>
> To implement this approach, the ACG and Associate Professor Henry, have multiplied the raw equity beta estimates by the following factor (omega):
>
> $$\omega = \left(\frac{1-G}{1-0.6}\right) \quad , \quad G = \frac{D}{D+E} \quad ,$$
>
> where D = the book value of debt and E = the market value of equity.
>
> While the market value of equity can be observed continuously, the book value of debt can only be observed in reports from the businesses, which are published semi-annually. Associate Professor Henry has utilised these published book values of debt and market values of equity at the time of publication of the book values of debt. The data was sourced from Bloomberg and provided by the AER. The ACG has adopted the same approach, however has interpolated monthly book values of debt for the periods in between publication. The AER considers both methods are acceptable and should make little difference to the resultant estimates.'

These quotes demonstrate that the delevering and relevering procedure that NERA uses is identical to the delevering and relevering procedure that the AER endorses.

Delevering and relevering betas requires one make an assumption about the debt policy each firm pursues. One policy a firm might pursue is to maintain a constant leverage through time. A policy of maintaining a constant leverage through time requires a firm to continually issue

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64 AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, page 120.

65 AER, *Explanatory Statement: Electricity transmission and distribution network service providers Review of the weighted average cost of capital (WACC) parameters*, December 2008, page 202.

or retire debt (a Miles-Ezzell framework).[66] A second, policy a firm might pursue is to maintain a constant dollar amount of debt outstanding through time. A third policy might be to issue some new debt when the value of the firm rises and retire some debt when the value of the firm falls but to allow the leverage of the firm to fall as the value of the firm rises and rise as the value of the firm falls. In delevering and relevering betas, one must also make an assumption about whether a firm will ever default on its debt.

Taggart (1991) shows that delevering and relevering is particularly simple if one assumes that a firm follows a strategy of continually maintaining a constant leverage through time and that it never defaults on its debt.[67] It is particularly simple because one can ignore corporate and personal taxes – and so imputation credits, which are nothing more than negative personal taxes. In contrast, if one assumes that a firm follows a strategy of maintaining a constant dollar amount of debt outstanding through time, then one cannot ignore corporate and personal taxes. It is, perhaps, for this reason that Henry (2009) assumes that a firm follows a strategy of continually maintaining a constant leverage through time and never defaults on its debt in his report for the AER.[68] It may also be that Henry recognises that the AER view that an efficient regulated energy business should have a gearing of 0.6 *requires* that the business maintain a constant leverage through time.[69]

We reiterate that NERA has followed methodology endorsed by the AER, *precisely*.

The AER in its *Final Decision* on Jemena did not disagree with the arguments we provide here about taxes and relevering.[70]

3.4 Fama-French Risk Premiums

3.4.1 Variability

Both the ERA and the AER express concerns about the sensitivity of estimates of the *HML* and *SMB* risk premiums to:

- the time period used; and
- the way in which the premiums are computed.

For example, the ERA in its *Draft Decision* states that:

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66 Miles, James and John Ezzell, *The weighted average cost of capital, perfect capital markets, and project life: A clarification*, Journal of Financial and Quantitative Analysis, 1980, pages 719-730.

Miles, James and John Ezzell, *Reformulating tax shield valuation: A note*, Journal of Finance, 1985, pages 1485-1492.

67 Taggart, Robert, *Consistent valuation and cost of capital expressions with corporate and personal taxes*, Financial Management, 1991, page 14.

68 Olan T. Henry, *Estimating β: Report for the Australian Energy Regulator*, 23 April 2009.

69 An analysis of the third, hybrid policy that we describe is substantially more complicated. For an analysis, see

Grinblatt, Mark and Jun Liu, *Debt policy, corporate taxes, and discount rates*, UCLA working paper, 2002.

70 AER, *Jemena Gas Networks Access arrangement proposal for the NSW gas networks: Final Decision*, June 2010.

> 'Table 29 shows that the ranges of the HML risk premia, from 14.6 per cent to 6 per cent, and of SMB risk premia, from 17.2 per cent to -9 per cent, can be considered too large to confirm the presence of the risk factors when using the FFM in Australia.'

Similarly, the AER in its *Draft Decision* states that:[71]

> 'The HML premiums shown in Table 5.4 vary from 14.6 per cent to 6 per cent, a range that is considered too large to be able to confirm its presence as a risk factor in Australia. The SMB premiums are even more of a problem, since they range from 17.2 per cent to negative 9 per cent, a result that is completely at odds with the original FFM.'

To illustrate the fact that estimates of risk premiums are bound to vary when they are estimated over relatively short but different periods, in our response to the AER, we augmented Table 5.4 from the AER's *Draft Decision* with data on the *MRP* taken from Ken French's web site and the Reserve Bank of Australia.[72] The augmented table showed that there was almost as much variation in estimates of the *MRP* across the studies as there was in estimates of the *HML* premium.

The AER in its *Final Decision* responded by stating that: [73]

> 'The AER does not consider that this is a relevant consideration for establishing that premiums underlying the FFM can be systematically observed. This is because:
>
> - the response in the second NERA report on the FFM omits any mention of variation in the SMB risk premium and focuses only on the HML risk premium. The variation in SMB is more than four times the variation in the MRP
>
> - the MRP estimates presented in the second NERA report on the FFM are not appropriately generated.
>
> The second NERA report on the FFM relies on MRP estimates sourced from the Ken French data library. It compares these MRP estimates to HML and SMB estimates generated from the eight academic papers. The AER considers that this is not a consistent basis for comparison. A more appropriate comparison is to use the MRP estimates from each paper. The AER has calculated the relevant MRP estimates for the purposes of this comparison and presents them with the NERA figures for comparison in table 5.2.'

We reproduce the AER's Table 5.2 below. The table shows what appears to be substantially less variation in estimates of the *MRP* across the studies than in estimates of the *HML* premium. On a closer inspection of the eight papers from which the estimates that the AER provides are drawn, however, we have discovered that the AER has incorrectly collected or computed several of the estimates. We provide a corrected version of the table as Table 3.1 below.

The corrected version:

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71 AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, page 115.

72 NERA, *Jemena access arrangement proposal for the NSW Gas Networks, AER draft decision: A report for Jemena*, March 2010.

73 AER, *Jemena Gas Networks Access arrangement proposal for the NSW gas networks: Final Decision*, June 2010, pages 139-140.

- uses the sample means of the factors when they are reported directly; and
- extracts the sample means from other results that are reported when the sample means are not reported directly.

Where necessary, we extract the sample means of the Fama-French factors in the following way. Define

$$\omega_j = \overline{(R_j - R_f)} - \hat{a}_j - \hat{b}_j \overline{(R_m - R_f)} - \hat{h}_j \overline{HML} - \hat{s}_j \overline{SMB}\,, \qquad (13)$$

where

a bar denotes the sample mean of a random variable, a hat denotes a least squares estimate and a_j is the intercept from a multivariate regression of R_j on $R_m - R_f$, *HML* and *SMB*.

Table 5.2: Variability in risk premiums HML, SMB and MRP

Authors	Period	HML	SMB	NERA MRP	Paper MRP
Fama and French, 1998	1975–1995	12.3	na	7.2	8.9
Halliwell et al, 1999	1980–1991	14.6	6.0	3.2	5.3
Faff, 2001	1991–1999	14.0	–6.0*	9.6	5.5
Faff, 2004	1996–1999	6.0	–6.5	9.3	9.1
Gaunt, 2004	1993–2001	8.5	10.0	8.6	6.9
Gharghori, Chan and Faff, 2007	1996–2004	10.4	17.2	6.0	5.6
O'Brien et al, 2008	1982–2006	9.4	4.3	6.2	4.7
Kassimatis, 2008	1993–2005	12.6	11.5	8.3	
Standard deviation		**2.7**	**8.9**	**2.1**	**1.7**

Source: NERA, response to the DD, p. 44 (table 44); Source papers for each academic reference; AER analysis.
Note: Faff 2001 SMB estimate has been scaled back (composition different)
Sample standard deviation presented (the NERA report presents the standard deviation of the sample, this is biased estimate for small sample)
Gaunt 04 has been adjusted to use GMM estimates.

Each ω_j should be zero but is invariably not precisely zero because of rounding error. We choose the sample means of $R_m - R_f$, *HML* and *SMB*, when they are not reported elsewhere in a paper, to minimise:[74]

[74] With the paper of Kassimatis (2008), we augment (13) with a momentum factor.

$$\sum_{j=1}^{J} \omega_j^2 \ , \qquad (14)$$

where

J is the number of portfolios – typically 25.

The major differences between the corrected table and the table that the AER provides arise because:

- The AER mistakenly uses an *MRP* from Fama and French (1998) that is the average US dollar return on the market portfolio of Australian stocks in excess of the one-month US bill rate. There should be little difference between the average *HML* premium computed in Australian dollar terms and the average *HML* premium computed in US dollar terms because the exchange rate adjustments for the high book-to-market and low book-to-market portfolios should offset each other. There will be a difference, though, between the average US dollar return on the market portfolio of Australian stocks in excess of the one-month US bill rate and the average Australian dollar return to the portfolio in excess of the one-month Australian bill rate because uncovered interest-rate parity does not hold. So in the corrected table we retain an estimate of the *MRP* computed using data from Ken French's web site and the Reserve Bank of Australia;
- the AER incorrectly collects the *MRP* from Halliwell, Heaney and Sawicki (1999). Halliwell, Heaney and Sawicki state that: [75]

  'the monthly market risk premium (Rm – Rf) is very close to zero on average'

- the AER reports estimates of the three premiums from Faff (2001) that are not sample means but are estimates drawn from a system estimated under the restriction that the FFM is true. As we point out, the FFM, like the SL CAPM, tends to underestimate the returns required on low-beta assets and overestimate the returns required on high-beta assets. So these restricted estimates will not be unbiased because the restrictions imposed are unlikely to be true. In contrast, the sample means, which the paper provides, will provide unbiased estimates of the three risk premiums whether or not the FFM is true;
- the AER incorrectly computes the three risk premiums from Gaunt's (2004) empirical results; and
- the AER uses our estimate of the *MRP* computed using data from Ken French's web site and the Reserve Bank when an estimate extracted from the empirical results of Kassimatis (2008) is much higher.

When these corrections and other minor corrections are made, there is not a substantial difference between the variability of estimates of the *MRP* and the variability of estimates of the *HML* premium. There is, however, a substantial amount of variability in both sets of estimates because the eight papers estimate the premiums over *short* time periods. There is

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Kassimatis, K., *Size, book-to-market and momentum effects in the Australian stock market,* Australian Journal of Management, 2008, pages 145-168.

[75] Halliwell, J., R. Heaney and J. Sawicki, *Size and book to market effects in Australian share markets: a time series analysis,* Accounting Research Journal 12, 1999, page 129.

also a substantially higher variation in the *SMB* premium than in either the *MRP* or *HML* premium.

Table 3.1
Corrected version of AER's Table 5.2

					Data source	
Authors	Period	*HML*	*SMB*	*MRP*	Page(s)	Table(s)
Fama and French, 1998	1975-1995	12.3		7.2	1980	III
Halliwell et al., 1999	1980-1991	14.6	6.0	0.0	129	
Faff, 2001	1991-1999	5.5	-3.8	8.1	9	1
Faff, 2004	1996-1999	6.2	-6.4	9.6	88	2
Gaunt, 2004	1993-2001	12.7	0.0	7.5	36, 39	2, 4
Ghargori, Chan and Faff, 2007	1996-2004	10.4	17.2	5.6	233	1
O'Brien et al., 2008	1982-2006	9.0	4.2	4.7		3
Kassimatis, 2008	1993-2005	12.6	11.5	14.7	150-156	1, 2, 3
Standard deviation		3.1	7.7	3.9		

Note: All returns are in per cent per annum. Faff (2001, 2004) uses continuously compounded returns. The data are from Ken French's web site, the Reserve Bank of Australia and

Fama, Eugene and Kenneth French, Value versus growth: The international evidence, Journal of Finance. 53, 1998, pages 975-999.

Halliwell, J., R. Heaney and J. Sawicki, Size and book to market effects in Australian share markets: a time series analysis, Accounting Research Journal 12, 1999, pages 122–137.

Faff, R., An examination of the Fama and French three-factor model using commercially available factors, Australian Journal of Management 26, 2001, pages 1–17.

Faff, A simple test of the Fama and French model using daily data: Australian evidence, Applied Financial Economics 14, 2004, pages 83–92.

Gaunt, C., Size and book-to-market effects and the Fama–French three factor asset pricing model: Evidence from the Australian stock market, Accounting and Finance 44, 2004, pages 27-44.

Gharghori, P., H. Chan and R. Faff, Are the Fama–French factors proxying default risk?, Australian Journal of Management 32, 2007, pages 223–249.

O'Brien, Brailsford and Gaunt (2008) O'Brien, Brailsford, and Gaunt, Size and book-to-market factors in Australia, University of Queensland working paper, 2008.

Kassimatis, K., Size, book-to-market and momentum effects in the Australian stock market, Australian Journal of Management, 2008, pages 145-168.

The estimates of the three risk premiums vary, though, not just because they are computed over short time periods, but also because different authors construct the Fama-French factors in different ways. For example, Faff (2001) uses data from Frank Russell to compute the factors, Fama and French (1998) use data from Morgan Stanley, while O'Brien, Brailsford and Gaunt (2008) use data from the ASX and company accounts. As another example,

Faff (2001) constructs the Fama-French factors using only stocks that are part of the All Ordinaries Index and so are among the top 500 stocks by market capitalisation while Ghargori, Chan and Faff (2007) do not impose a screen of this kind. As a result, Ghargori, Chan and Faff report that the average market capitalisation of a stock that is in the one third of the stocks that they use with the lowest market capitalisations is less than 10 million dollars.[78] Thus they include in their analysis the stocks of many companies that are very, very small relative to the stocks that make up the All Ordinaries. The market capitalisation of BHP as of 6 May 2011, for example, was 224 billion dollars.[79]

There are also many ways of constructing a proxy for the market portfolio. While it may well be convention to compute the beta of a stock relative to the All Ordinaries, the SL CAPM certainly does not dictate that the beta of a stock should be computed in this way. As Roll (1977) points out, there may be no ambiguity about how, *in theory*, to measure the return to the market portfolio but there is ambiguity about how, *in practice*, to measure the return.[80]

As Stambaugh (1982) shows, though, a lack of consensus about how to measure the return to the market portfolio need not imply that different authors will measure the return required on an asset to be different.[81] Similarly, a lack of consensus about how to measure the Fama-French factors need not imply that different authors will measure the return required on an asset to be different. In other words, the use of an alternative set of factors need not imply that one will measure the return required on an asset differently.

To illustrate how ambiguity about how to measure the return to the market portfolio can create substantial variation across estimates of the mean return to the market portfolio, we use data from Stambaugh. Table 3.2 provides estimates of the mean real return to the US market portfolio in per cent per annum across four different time periods using the four measures of the market that Stambaugh employs. As the table makes clear, the estimates are sensitive to the way the market proxy is constructed. Nevertheless, Stambaugh finds that tests of the SL CAPM and Black CAPM are not sensitive to the use of a proxy. His tests *reject* the SL CAPM but find little evidence against the Black CAPM.

To summarise, there are two reasons why estimates of the Fama-French factor premiums that different authors produce may vary:

- the estimates may be drawn from different periods; and
- different authors may compute the premiums using different sets of data.

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[78] See their Table 2. There is an obvious typographical error in the table. The market capitalisations are in millions of dollars and not in billions of dollars.

Gharghori, P., H. Chan and R. Faff, Are the Fama–French factors proxying default risk?, Australian Journal of Management 32, 2007, pages 223–249.

[79] http://www.bloomberg.com/apps/quote?ticker=BHP:AU

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

[81] Stambaugh, R., *On the exclusion of assets from tests of the two-parameter model: A sensitivity analysis*, Journal of Financial Economics 10, pages 237-268.

In *exactly* the same way:

- estimates of the *MRP* drawn from different periods will differ; and in exactly the same way,
- estimates of the *MRP* are sensitive to what one defines to be the market portfolio.

Importantly, the fact that estimates of the *MRP* that various authors produce may differ does not imply that these authors will produce different estimates using the SL CAPM of the cost of equity – at least if they are consistent in their use of a proxy for the market portfolio. Similarly, the fact that estimates of the Fama-French factor premiums that various authors produce may differ does not imply that these authors will produce different estimates of the cost of equity – if they are consistent in their use of the factors that they construct.

Table 3.2
Estimates of the mean real return to the market portfolio: US evidence from 1953 to 1976

	Market proxy			
Period	1	2	3	4
1953-1959	15.74	7.25	2.75	0.98
1959-1965	9.95	6.85	3.12	1.39
1965-1971	1.87	0.38	-0.02	-0.64
1971-1976	0.50	0.43	-0.11	-0.14
1953-1976	7.02	3.73	1.43	0.40

Note: Market proxy no. 1 is a value-weighted portfolio of NYSE common stocks; market proxy no. 2 is no. 1 plus corporate bonds and government bonds and Treasury bills; market proxy no. 3 is no. 2 plus real estate, housefurnishings and automobiles; market proxy no 4 is the same as no. 3 but with NYSE stocks given a 10 per cent weight. All returns are in per cent per annum.

Source: Stambaugh, R., On the exclusion of assets from tests of the two-parameter model: A sensitivity analysis, Journal of Financial Economics 10, pages 237-268.

3.4.2 Precision

The ERA and AER rely on the work of Handley (2011) who uses a long time series of returns to a portfolio of stocks to compute a relatively precise estimate of the *MRP*.[82] We use much shorter time series to compute estimates of the *HML* and *SMB* premiums that relative to the estimate of the *MRP* on which the ERA and AER rely are imprecise. Possibly as a result, our point estimate of the *SMB* premium is negative, although a standard confidence interval for the parameter includes, as well as a range of negative values, a range of positive values.[83]

[82] Handley, J., *An estimate of the historical equity risk premium for the period 1883 to 2010*, January 2011.

[83] Even though our estimate of the *SMB* premium is negative, we nevertheless use the estimate. We do not consider dropping the *SMB* factor because we wish to use the FFM in its original form.

The precision associated with the estimate of the *MRP* on which the ERA and AER rely derives:

- in part from the length of the time series that Handley uses; and
- in part from the fact that the volatility of the return to the portfolio of stocks that he uses is very much lower before 1958 than after, as Kearns and Pagan (1993) clearly document.[84]

Figure 3.1 below updates Figure 1 from Kearns and Pagan's paper. We follow Kearns and Pagan and for each half decade use monthly without-dividend returns to estimate the variance of the monthly return to the Australian market portfolio of stocks.[85] We use their estimates for the five years ending in December 1882 to the five years ending in December 1987 and update the series using estimates computed in an identical fashion for the five years ending December 1992 through to the five years ending in December 2007. Finally, we add an estimate of the monthly variance computed using the three years and three months from January 2008 through March 2011 to complete the series.[86] Figure 3.1 makes clear that the earlier data have properties that differ substantially from those of the later data.

An estimate of the variance of the monthly return to the market computed by averaging the Kearns and Pagan five-year estimates from 1887 through 1957 is:[87]

$$\frac{1}{15}\sum_{j=1}^{15}\hat{\sigma}^2_{1887+5(j-1)} = 0.62\times10^{-3}$$

where

$\hat{\sigma}^2_k$ = the variance of the monthly return to the market portfolio estimated over the five-year period ending in December of year *k*.

The corresponding estimate computed using data from 1962 through 2011 is:

$$\frac{1}{10\times(60-1)+(39-1)}\left[(60-1)\sum_{j=1}^{10}\hat{\sigma}^2_{1962+5(j-1)} + (39-1)\tilde{\sigma}^2_{2011}\right] = 1.88\times10^{-3}$$

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84 Kearns, P. and A. Pagan, *Australian stock market volatility: 1875-1987*. Economic Record, 1993, pages 163-178.

85 Thus if r_t denotes the without-dividend return to the Australian market portfolio from the end of month *t*-1 to the end of month *t*, the five-year variance at the end of month *t* is:

$$\frac{1}{59}\sum_{j=1}^{60}(r_{t+1-j}-\bar{r})^2 \qquad \text{where} \qquad \bar{r} = \frac{1}{60}\sum_{j=1}^{60} r_{t+1-j}$$

86 The series that we draw from Kearns and Pagan and our updates to their series appear in Table A.1 in Appendix A of:

NERA, *The Market Risk Premium: A report for Multinet Gas and SP AusNet*, April 2011.

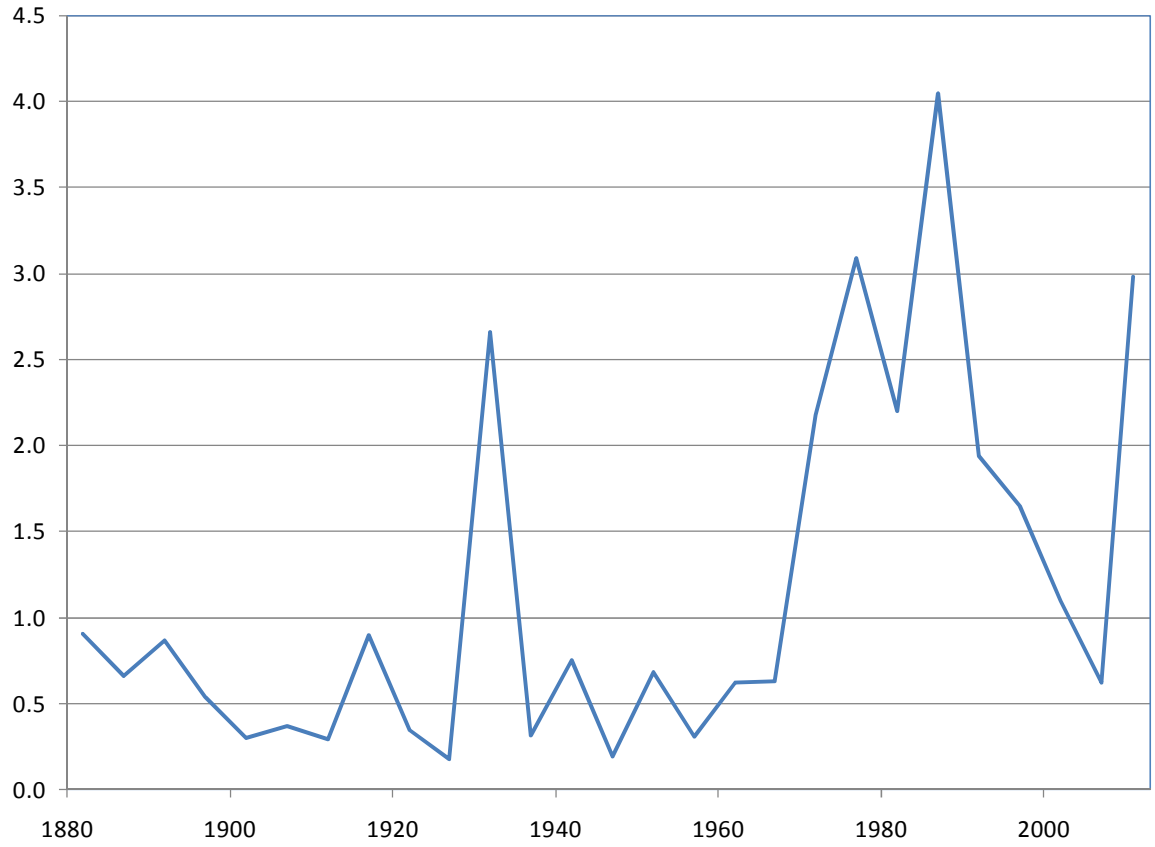
87 Handley (2011) uses data from 1883 (= 1887 – 5 + 1) to construct estimates of the *MRP*.

Handley, J., *An estimate of the historical equity risk premium for the period 1883 to 2010*, January 2011.

where

$\tilde{\sigma}^2_{2011}$ = the variance of the monthly return to the market portfolio estimated over the 39 months ending in March 2011.

Figure 3.1
Stock market variance by half decade



Note: Variance is multiplied by 10^3. Data are from Kearns and Pagan (1993) before 1992 and are computed from the All Ordinaries Price Index thereafter.

Thus an estimate of the variance of the return to the market portfolio after 1957 is three times an estimate of the variance of the return to the market portfolio before 1958. While we do not have the complete time series of monthly returns used to generate Figure 3.1, a test that uses the data from Kearns and Pagan (1993) and our updates to their data rejects the null hypothesis that the variance of the return to the market portfolio after 1957 is equal to the variance of the return to the market portfolio before 1958 at all conventional levels of significance.[89] So the difference between the risks of the market portfolio before 1958 and after is both economically and statistically significant.

[89] NERA, *The Market Risk Premium: A report for Multinet Gas and SP AusNet*, April 2011, page 7.

Thus part of the additional precision that Handley produces is *illusory* and comes about because he is mixing two sets of data that have very different properties. As Davis (2011) makes clear in his advice to the AER:[90]

> 'a higher level of market volatility is likely to be associated with an increase in risk which translates into a higher *MRP*.'

Thus to use the longer time series Handley, on whom the ERA and AER rely, should employ some upwards adjustment to the *MRP* from 1883 through 1957 to reflect the lower risk of the Australian market portfolio over that period.[91] Davis, however, notes that: [92]

> 'the strength of the relationship [between risk and the MRP] is difficult to assess.'

Thus it may be that there will not be uniform agreement about what adjustment to make. Since there is no evidence that the behaviour of the series that we use has changed in a similar manner over the relatively short period that we examine, we do not have to face these problems.

3.4.3 Summary

Estimates of *all three* Fama-French risk premiums: the *MRP*, the *HML* premium and the *SMB* risk premium are sensitive to:

- the time period used; and
- the way in which the premiums are computed.

Handley (2011) reports an estimate of the *MRP* unadjusted for imputation credits over the period 1883 through 1957 of 6.1 per cent per annum that is identical to an estimate computed over the period 1958 through 2010. [93] Thus it may appear that estimates of the *MRP* are not sensitive to the time period used. As we point out, though, the variance of the return to the market portfolio is three times smaller in the earlier period than in the later period. Thus it is not clear that Handley's estimates computed using the earlier data are estimates of the same parameter as his estimates computed using the later data.

The SL CAPM does not dictate that one should use the return to a portfolio of stocks to estimate the *MRP*. We note that estimates of the *MRP* can be very sensitive to whether one uses as a proxy for the market portfolio a portfolio of stocks or a portfolio of stocks and other assets.

The problems that one encounters in estimating the *MRP* are not unique. The same problems are encountered in estimating the *HML* and *SMB* risk premiums. To address these problems we use:

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90 Davis, K.., *Cost of equity issues: A Report for the AER*, January 2011, page 20.

91 Unless one can provide reliable evidence that the aversion to risk of a representative investor has fallen.

92 Davis, K.., *Cost of equity issues: A Report for the AER*, January 2011, page 20.

93 Handley, J., *An estimate of the historical equity risk premium for the period 1883 to 2010*, January 2011, page 5.

- the longest time series available of reliable data, sourced from DFA, a fund manager with whom Fama and French are affiliated; and
- an alternative source for data to determine whether an estimate of the cost of equity is sensitive to the use of a different data source.

The estimates of the *HML* and *SMB* premiums that we compute from 1975 through 2010 and from 1980 through 2010 are no less precise than the estimate of the *MRP* that Handley computes using data from 1958 through 2010. The standard errors attached to our estimates are 2.9 and 2.2 per cent per annum while the standard error attached to Handley's estimate is, regardless of the assumption that one makes about the value attached to imputation credits by the market, 3.1 per cent per annum.[94] Nevertheless, any estimate that has attached to it a standard error of this magnitude may by chance turn out to be not significantly different from zero and may even be negative. This is precisely what we find to be true of our estimate of the *SMB* risk premium.

[94] NERA, *The Market Risk Premium: A report for Multinet Gas and SP AusNet*, April 2011, page 15.

Handley, J., *An estimate of the historical equity risk premium for the period 1883 to 2010*, January 2011, pages 5-8.

4 Does the CAPM Provide the Best Estimate?

In this section we examine whether the SL CAPM delivers the best estimate of the cost of equity. In his recent review for the AER, Davis (2011) states that: [95]

> '(a) it is my opinion that (i) the theoretical assumptions of the Sharpe CAPM do not necessarily lead to a downward bias estimate of the required rate of return for low beta firms (ii) the empirical evidence does not clearly demonstrate such a bias (iii) there is general agreement that the CAPM needs to be viewed in a conditional form – but that the precise determinants and size of that conditionality (and hence variations over time in beta, MRP etc) are not well agreed. The AER's approach of revisiting the CAPM parameters at each regulatory review is consistent with a conditional approach, although it does not involve any specific formulation of how such conditionality is reflected in current values or future changes in asset parameters. That approach could, perhaps, be referred to as an "implicit conditional CAPM".'
>
> '(b) It is my opinion that (i) the Black CAPM does not resolve the problems of the Sharpe CAPM; (ii) is not better supported than the Sharpe CAPM by available empirical evidence; (iii) its implementation is problematic because of problems in reliably estimating the zero beta return.'

Since Davis draws a distinction between the SL CAPM in its unconditional form and the SL CAPM in its conditional form, we examine first the evidence on whether the SL CAPM holds unconditionally and we then discuss whether the evidence indicates that the SL CAPM can hold conditionally and whether the ERA and AER use a version of the conditional CAPM that could match the behaviour of returns that one observes.

4.1. The Unconditional CAPM

4.1.1 Evidence

CEG working with Professor Grundy of the University of Melbourne (2008) use Australian data from 1964 through 2007 to test the SL CAPM. They use the longest time series of any empirical test of the SL CAPM that has been conducted with Australian data of which we are aware. They follow Fama and MacBeth (1973) and conduct tests in the following way:[96]

> 'For each month, *t*, from January 1974 to December 2007, betas for each stock *i* are estimated separately over the months *t-120* to *t-61* and *t-60* to *t-1*. That is, for a stock in January 1974, two betas are estimated using data from January 1964 to December 1969 and January 1970 to December 1974. Each pair of beta estimates is retained only if it is based on at least 40 observations in each of the five-year sample periods, and the stock has a valid observed return in month *t*. This creates a pair of betas in each month between January 1974 and December 2007 inclusive for each stock that satisfies these conditions in that particular month.'
>
> 'For each time period *t*, ten portfolios of stocks are created by ranking the betas estimated over the time periods from *t-120* to *t-61*. The stocks with the bottom 10 per cent of betas are allocated to portfolio 1, the next 10 per cent of betas are allocated to portfolio 2, and so on. We then estimate the following regression:

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[95] Davis, K.., *Cost of equity issues: A Report for the AER,* January 2011, page 21.

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

CEG, *Estimation of, and correction for, biases inherent in the Sharpe CAPM formula: A report for the Energy Networks Association Grid Australia and APIA,* September 2008.

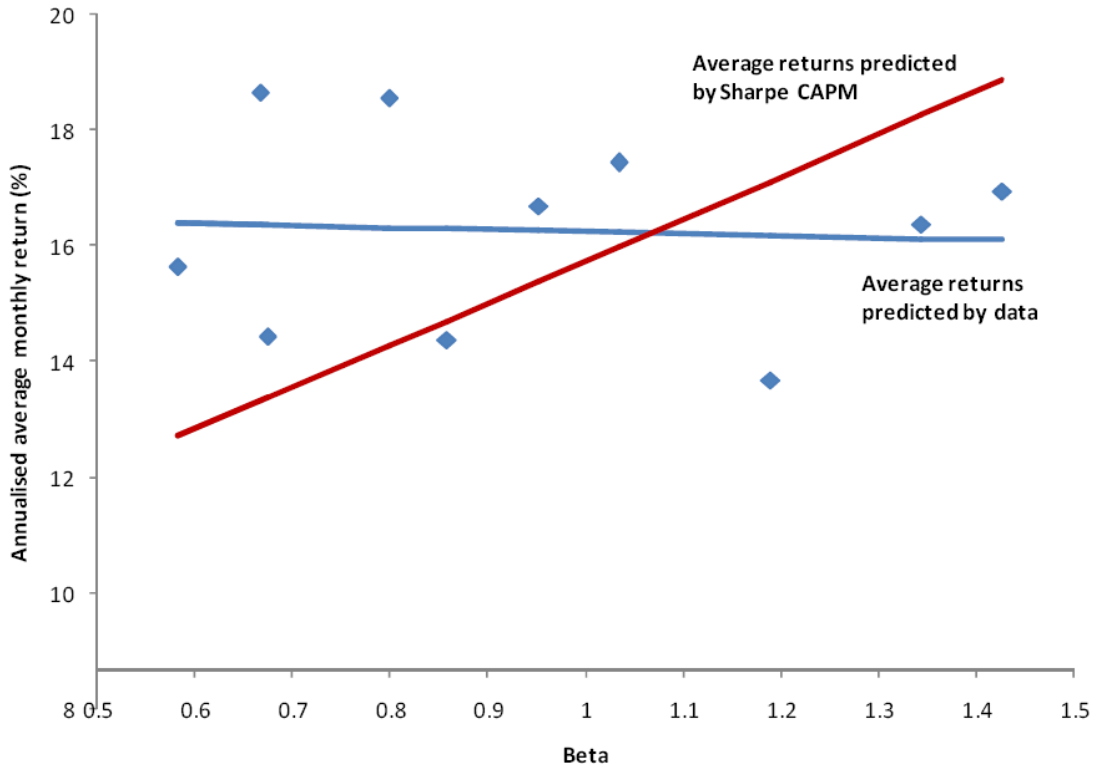
$$r_{pt} - r_{ft} = \lambda_{0t} + \lambda_{1t}\beta_{pt} + \varepsilon_{pt}, \qquad p = 1,2,...,10$$

where: r_{pt} is the average return of stocks in portfolio p at time t; β_{pt} is the average betas of stocks in portfolio p at time t, where the beta is calculated over the period t-60 to t-1. Estimating equation (3) at each time t gives us a time series of 408 estimates for λ_{0t} and λ_{1t}. The simplest way to conduct inference on these values is to take the mean and standard error of the mean and test against the null hypotheses that:

i. $\lambda_0 = 0$. That is, that the average excess return on a stock with a beta of zero is also zero; and
ii. $\lambda_1 > 0$. That is, average returns increase as a stock's beta increases.'

CEG and Grundy find, like Fama and French (1992), that there is little relation between mean return and beta and that, as a result, an estimate of the zero-beta rate is about as high as the mean return on the market.[97] Figure 1 from their report is reproduced below as Figure 4.1. This figure plots the mean returns on 10 value-weighted portfolios formed in the manner described above against their betas. The SL CAPM predicts that there should be a positive relation between mean return and beta. In particular, the slope of the line relating the mean return on a portfolio to its beta should be the *MRP* and the intercept should be the risk-free rate. Thus the points in the graph should scatter around the red line. Instead, the points scatter around the blue line – a line that is negatively sloped.

Figure 4.1
Mean return against beta for 10 portfolios sorted on beta

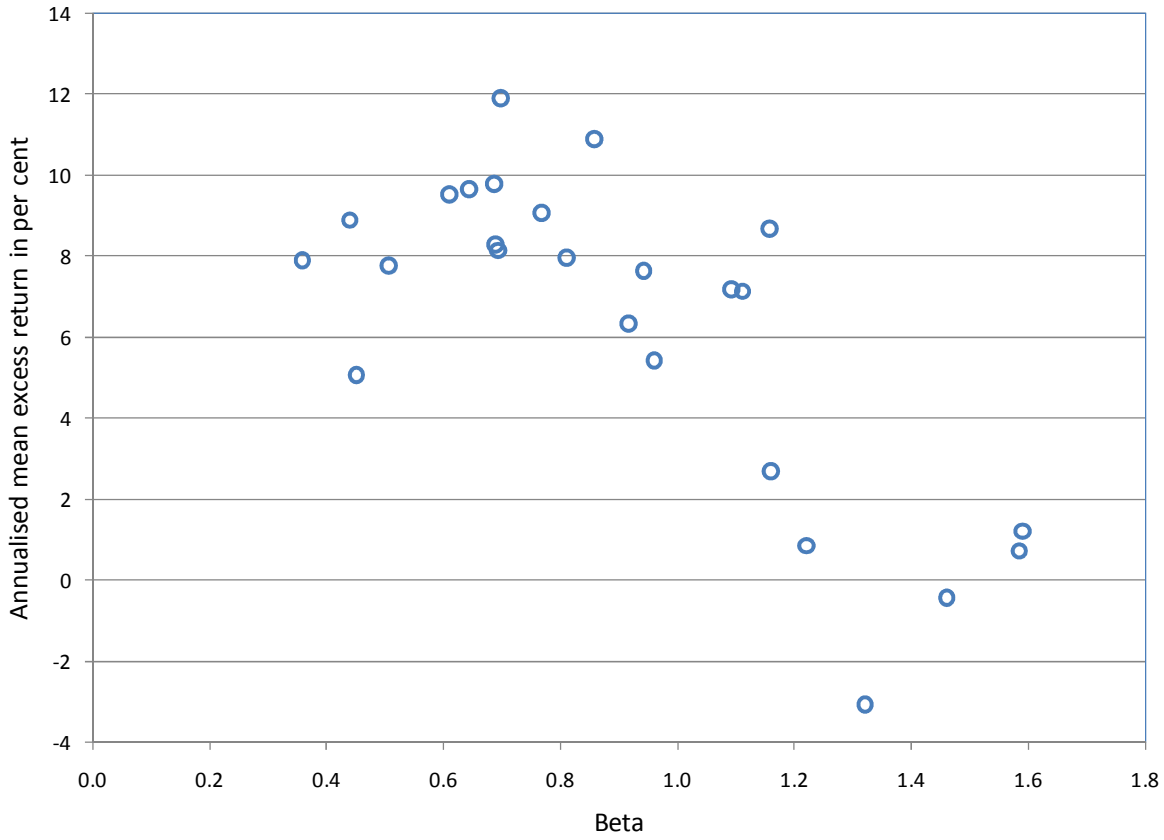


Source: CEG, Estimation of, and correction for, biases inherent in the Sharpe CAPM formula: A report for the Energy Networks Association Grid Australia and APIA, September 2008.

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

In a similar exercise, Lajbcygier and Wheatley (2009) form 25 portfolios on the basis of past estimates of betas and past dividend yields. Instead of using the method of Fama and MacBeth (1973), they use the method of Gibbons (1982) to estimate the zero-beta premium and the market price of risk.[98] Figure 4.2 below plots mean return in excess of the risk-free rate against beta for the 25 portfolios. As CEG find, the evidence does not support the SL CAPM – or at least an empirical version of the model.

Figure 4.2
Mean excess return against beta for 25 portfolios sorted on beta and yield



Source: Lajbcygier P. And S. M. Wheatley, An evaluation of some alternative models for pricing Australian stocks, Working Paper , Monash University, 2009.

Table 4.1 provides estimates of the zero-beta premium and market price of risk from CEG's report and Lajbcygier and Wheatley. The results, as one would expect, are similar. Both CEG and Lajbcygier and Wheatley reject the SL CAPM in favour of the Black CAPM. Both sets of authors find that the zero-beta premium is of a similar magnitude and that the market price of risk is insignificantly different from zero. Also included in the table are the results

[98] Gibbons, Michael, 1982, *Multivariate tests of financial models: A new approach*, Journal of Financial Economics 10, 3-27.

Lajbcygier P. And S. M. Wheatley, *An evaluation of some alternative models for pricing Australian stocks*, Working Paper , Monash University, 2009.

from Lewellen, Nagel and Shanken (2010), a paper that we cite in our 2010 report to the ERA on behalf of DBNGP and that Davis (2011) cites in his advice to the AER. [99, 100]

Table 4.1
Estimates of the zero-beta rate and market price of risk

Study	Period	Zero-beta premium	Price of risk
	US evidence		
Lewellen, Nagel and Shanken (2008)	1963-2004	11.60	-1.76
		(3.65)	(4.51)
	Australian evidence		
CEG (2008)	1964-2007	7.92	-0.38
		(3.09)	(4.00)
Lajbcygier and Wheatley (2009)	1979-2007	9.96	-2.64
		(2.04)	(3.72)

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

CEG, Estimation of, and correction for, biases inherent in the Sharpe CAPM formula: A report for the Energy Networks Association Grid Australia and APIA, September 2008.

Lajbcygier P. and S. M. Wheatley, An evaluation of some alternative models for pricing Australian stocks, Working Paper , Monash University, 2009.

4.1.2 Interpretation

Davis (2011) does not dispute the empirical evidence that we provide above. In fact Davis makes a specific reference to the paper by Lewellen, Nagel and Shanken (2010), which we cited in our report for DBNGP, that provides estimates of the zero-beta rate and market price of risk using US data that are comparable to the Australian estimates that CEG and Lajbcygier and Wheatley report.

His interpretation of the results, however, differs from our own. Our interpretation of the results is straightforward. The results show that an empirical version of the SL CAPM tends to substantially underestimate the returns to low-beta assets and that an empirical version of the Black CAPM would eliminate this tendency. This is the same conclusion drawn by CEG and Professor Grundy.

In contrast, Davis (2011) argues that:[101]

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

100 Davis, K.., *Cost of equity issues: A Report for the AER*, January 2011, page 11.

> 'With borrowing and lending opportunities available, the zero beta expected return will lie within the range given by those borrowing and lending rates. While it will be above the risk-free interest rate, it will not lie above the available borrowing rate.'
>
> 'This observation is relevant for assessing the implications of early CAPM studies which found that the relationship between security returns and beta was flatter and with higher intercept than consistent with the Sharpe CAPM. One interpretation of that result is that it is consistent with the Black CAPM – for which the intercept is the zero beta expected return which is higher than the risk-free interest rate. There are, however, other interpretations. One is that the market portfolio used in the tests is not mean-variance efficient. If so, the intercept of the estimated equation will not be an unbiased estimator of the zero-beta expected return. Another interpretation (along the lines suggested by Lewellyn, Nagle and Shanken, 2010) is that the estimated zero-beta expected returns are so different to the risk free interest rate as to not be credible, implying that the Black CAPM is not supported.'
>
> 'One problem in implementing the Black CAPM is that the expected return on the zero beta portfolio is not *ex ante* observable, unlike the risk free interest rate. It is tempting to infer the zero beta return from the intercept of a cross sectional regression of individual security (or portfolio) returns on betas of those securities (portfolios). However, this is subject to the criticisms made above (ie that the results simply demonstrate use of a market portfolio which is not mean-variance efficient) and thus that the intercept term may be a biased estimate of the zero-beta rate even if the Black CAPM applies.'

There are a number of problems with this analysis.

First, it is important to realise that the SL CAPM is a special case of the Black CAPM. In other words, the Black CAPM is a more *general* model than the SL CAPM. So, one cannot conclude that the evidence does not support the Black CAPM but does support the SL CAPM. If the evidence leads one to reject the Black CAPM, that same evidence must lead one to also reject the SL CAPM.

Second, while we agree that in the Black CAPM the zero-beta rate should in theory lie between the lending and borrowing rates, we note that the tests whose results we report in Table 4.1 are not tests of the SL CAPM or Black CAPM but of empirical versions of the models. Theory does not imply that the zero-beta rate associated with a proxy for the market portfolio that includes only stocks should lie between the lending and borrowing rates. It is also unclear what empirically the borrowing rate should be. Nevertheless, we are sympathetic to the idea that a model that states that the mean returns to all stocks are identical is too simple a model. The high estimates of the zero-beta premium reported in Table 4.1, though, are evidence that an empirical version of the SL CAPM does not work well and that an empirical version of the Black CAPM does a *better* job of describing the data – even if it is a simple model.

Third, while we agree that there is plenty of evidence to indicate that the market portfolio of stocks is not mean-variance efficient – and this motivates our use of alternative models – if the market portfolio of stocks is not efficient, empirical versions of the SL CAPM and Black CAPM cannot be true. Thus while an argument that the market portfolio of stocks is not efficient does not support the use of an empirical version of the Black CAPM, it also does *not* support the continued use of the SL CAPM by the ERA and AER.

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[101] Davis, K.., *Cost of equity issues: A Report for the AER*, January 2011, page 11.

There are also two technical errors contained in the discussion that Davis provides.

First, a portfolio that is not mean-variance efficient need not have a unique zero-beta rate associated with it. So it makes no sense to talk about 'the' zero-beta rate associated with an inefficient proxy for the market portfolio. There may be *many* zero-beta rates associated with the portfolio.

Second, Fama (1976) shows that in a Fama-MacBeth regression the intercept to which Davis refers will *by construction* be the realised return on 'a' zero-beta portfolio regardless of whether the proxy one uses for the market portfolio is efficient.[102] So it makes no sense to say that: [103]

> 'the intercept of the estimated equation will not be an unbiased estimator of the zero-beta expected return.'

In a peer review, commissioned by the AER, of the report written by Davis (2011), Handley (2011) disputes whether a low-beta bias exists. [104] He states that: [105]

> 'whilst a number of possible explanations have been proposed for the low-beta bias, it is important to keep in mind that there is at least one very influential explanation by Roll (1977) which seriously questions whether the low-beta bias even exists.'
>
> 'Accordingly, CEG is incorrect to suggest that:
>
> *"The existence of bias in the AER implementation of the CAPM can reasonably be regarded as being universally accepted by those who have examined the empirical data. ... This is one of the few areas of consensus amongst finance experts"'*

Handley has misinterpreted what Roll (1977) has to say. [106] Roll emphasises that:

- the SL CAPM predicts that the market portfolio of *all* assets should be mean-variance efficient and not that the market portfolio of stocks should be efficient; and so
- a test of the mean-variance efficiency of a portfolio of stocks should not be viewed as a test of the SL CAPM.

Roll's entire discussion of how one should interpret tests of an empirical version of the SL CAPM, however, takes as a given that an empirical version of the SL CAPM that uses the market portfolio of stocks as a proxy for the market portfolio will tend to underestimate the mean returns to low-beta assets and overestimate the returns to high-beta assets. The issue that concerns Roll is whether this evidence can be used to infer whether the SL CAPM *itself* is true or false. The issue that concerns us, on the other hand, is whether an *empirical* version of the SL CAPM produces accurate estimates of required returns.

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[102] Fama, E., *Foundations of Finance*, 1976, pages 329-330.

[103] Davis, K.., *Cost of equity issues: A Report for the AER*, January 2011, page 11.

[104] Handley, J., *Peer review of draft report by Davis on the cost of equity*, January 2011.

[105] Handley, J., *Peer review of draft report by Davis on the cost of equity*, January 2011, page 4.

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

We agree with Roll that a test of the efficiency of the market portfolio of stocks cannot be viewed as a test of the SL CAPM *itself*. Discovering whether the model is really true, though, is not an issue that concerns us. What concerns us, again, is whether the *empirical* version of the SL CAPM that the ERA and AER use has a tendency to underestimate the returns required on low-beta assets. The evidence, as we note, is that it does.

4.2. The Conditional CAPM

When explicit recognition is given to the idea that the *MRP* and an asset's beta may change over time, the model is typically referred to as the *conditional* CAPM. Importantly, the conditional CAPM can hold period by period even when the unconditional CAPM does not hold.

The following sections:

- explain how the *MRP* and the betas of value stocks must evolve through time for the conditional CAPM to correctly price value stocks;
- assess whether empirically the *MRP* and the betas of value stocks evolve in such a way – that is, so that the conditional CAPM will correctly price value stocks; and
- assess whether the AER and ERA use a conditional version of the CAPM that is likely to correctly price value stocks.

4.1.1 Theory

The conditional version of the SL CAPM implies that:

$$E_{t-1}(R_{jt}) = \beta_{jt} E_{t-1}(R_{mt}), \quad (15)$$

where

$E_{t-1}(R_{jt})$ = the expected return from time t-1 to time t on asset j in excess of the risk-free rate, conditional on what is known at time t-1;

β_{jt} = asset j's time t beta, conditional on what is known at time t-1; and

$E_{t-1}(R_{mt})$ = the expected return from time t-1 to time t on the market portfolio of risky assets in excess of the risk-free rate, conditional on what is known at time t-1.

A casual analysis might suggest that if the conditional CAPM were to hold period by period, then the unconditional CAPM would also have to be true. However, this is not the case. The unconditional CAPM will be true only if β_{jt} and $E_{t-1}(R_{mt})$ do not covary with one another. This is because the expectation of the product of two random variables will only equal the product of the expectations of the two variables if the two variables are uncorrelated with one another. If instead β_{jt} and $E_{t-1}(R_{mt})$ covary positively (negatively) with one another, the unconditional CAPM will underestimate (overestimate) the unconditional mean return on

asset *j*. So the error with which the unconditional CAPM measures the mean return on an asset, that is, the asset's unconditional alpha, will be, approximately:[107]

$$\alpha_j^U = \mathrm{Cov}(\beta_{jt}, \mathrm{E}_{t-1}(R_{mt})) \quad (16)$$

It is known that the unconditional CAPM underestimates the returns required on value stocks. So, for the conditional CAPM to price these stocks correctly period by period, it must be the case that the betas of value stocks covary positively with the *MRP*.

4.1.2 Evidence

Lewellen and Nagel (2006) examine the magnitude of the pricing errors produced by an array of combinations of variation in beta, variation in the *MRP* and covariation between the two.[108] They conclude that variation through time in the betas of value and growth stocks and in the *MRP* cannot explain the value premium because the variation needed to explain the premium is *implausibly large*.

The approximation for the error with which the unconditional CAPM measures the required return to an asset (16) can be rewritten as:[109]

$$\alpha_j^U = \mathrm{Cov}(\beta_{jt}, \mathrm{E}_{t-1}(R_{mt})) = \rho\sigma_\beta\sigma_\gamma, \quad (17)$$

where

ρ = is the correlation between β_{jt} and $\mathrm{E}_{t-1}(R_{mt})$ across time;

σ_β = the standard deviation of β_{jt} across time; and

σ_γ = the standard deviation of $\mathrm{E}_{t-1}(R_{mt})$ across time.

Thus the error with which the unconditional CAPM measures the mean return on an asset will be higher, all else constant, the higher the correlation between the beta of the asset β_{jt} and the market risk premium $\mathrm{E}_{t-1}(R_{mt})$ across time, the higher the standard deviation of β_{jt} across time and the higher the standard deviation of $\mathrm{E}_{t-1}(R_{mt})$ across time. Note that, all else constant, a value for the correlation coefficient ρ of one provides an *upper bound* on the error with which the unconditional CAPM measures the required return to an asset.

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[107] Jagannathan, R., and Z. Wang, *The conditional CAPM and the cross-section of expected returns*, Journal of Finance 51, 1996, 3–53.

Lewellen, J. and S. Nagel, *The conditional CAPM does not explain asset-pricing anomalies*, Journal of Financial Economics 82, 2006, 289-314.

[108] Appendix A reproduces their analysis in more detail.

[109] The asset may be a zero-investment portfolio. For example, the asset may be a portfolio that is long a portfolio of value stocks and short a portfolio of growth stocks.

Lewellen and Nagel estimate that the error with which the unconditional CAPM measures the return to a long-short value strategy is, with US data, 0.59 per cent per month. A long-short value strategy is a zero-investment position that is long a portfolio of value stocks and short a portfolio of growth stocks and so is identical to the *HML* factor of the FFM. From our April 2011 update for DBNGP, an estimate of the annual *HML* risk premium computed using Australian data from 1975 through 2010 is 5.90 per cent per annum.[110] As the beta of the *HML* factor relative to the market over this period is almost precisely zero, an estimate of the error with which the unconditional CAPM measures the return to a long-short value strategy is, with Australian data, around 0.49 per cent per month. This error is similar in magnitude to its US counterpart.

Again, a value for the correlation coefficient ρ of one provides an upper bound on the error with which the unconditional CAPM measures the required return to an asset. Even with a correlation coefficient of one, though, a *substantial* variation in the beta of a value strategy and the *MRP* is required to explain the extent to which the unconditional CAPM misprices a value strategy. An unconditional alpha of 0.49 per cent per month can be generated, for example, by choosing σ_β and σ_γ both to be 0.7 but this would produce an implausibly large amount of variation in the beta of a value strategy and the *MRP*.

To see this, note that if the mean of the distribution of betas across time were to be zero, then a value for the standard deviation of 0.7 would imply that approximately 50 per cent of the time beta would lie outside of the range – 0.5 and 0.5. If the mean of the distribution of the *MRP* across time were to be 0.5 per cent per month (6 per cent per annum), then a value for the standard deviation of 0.7 would imply that approximately 50 per cent of the time the *MRP* would lie outside of the range 0.0 per cent per month (0.3 per cent per annum) and 1.0 per cent per month (11.7 per cent per annum). Thus choosing σ_β and σ_γ both to be 0.7 would produce an *implausibly large* amount of variation in the beta of a value strategy and the *MRP*.

Since the variation in beta needed to explain the value premium that one observes is so large, one would think that one would be able to document it. Lewellen and Nagel use daily data and short-window regressions to estimate time series of conditional betas for value and growth portfolios. They find from these short-window regressions evidence of variation through time in the beta of a long-short value strategy. Their estimates of the covariance across time between the *MRP* and the beta of a long-short value strategy, though, range between 0.04 and 0.11. These estimates are far below their estimate of the error with which the unconditional CAPM measures the return to a long-short value strategy of 0.59 per cent per month. Thus they conclude that the conditional CAPM performs about as *poorly* as the unconditional CAPM in pricing value and growth stocks.

4.1.3 Practice

Aside from the essentially academic issue of whether a conditional version of the SL CAPM can explain the pricing errors that an unconditional version makes, from a practical standpoint, it is unclear how the ERA or AER could *implement* a conditional version of the model. This is because to implement a conditional version of the SL CAPM requires the beta

[110] NERA, *Estimating the required rate of return on equity for a gas transmission pipeline: An update for DBNGP*, April 2011.

of a regulated firm and the *MRP* to be continually updated while regulatory reviews are typically only carried out once every five years.

Nevertheless, the AER and ERA make occasional marginal adjustments to the betas of regulated firms and the *MRP*. For example, Table 7.1 of the AER's *WACC Review Final Decision* summarises seven decisions all of which set a value of 6 per cent per annum for the *MRP*.[111] The *Decision* itself chooses 6.5 per cent and the AER in its *Envestra Draft Decision* has since reduced the *MRP* back to 6 per cent. [112, 113] While this shows that Australian regulators do make adjustments to the *MRP*, the adjustments to the *MRP* are an order of magnitude *below* the adjustments to the *MRP* that Lewellen and Nagel identify as necessary to explain the inability of the unconditional SL CAPM to correctly price value stocks. Thus the comment in the advice that Davis (2011) provides to the AER that: [114]

> '[the AER's] approach could, perhaps, be referred to as an "implicit conditional CAPM"'

is very misleading.

Since both the SL CAPM and Black CAPM underestimate the returns to value stocks, we estimate the return on equity for a regulated gas pipeline business using a number of alternative models. In particular we use two versions of the FFM.

4.3. Alternative Models

The FFM is designed to price value and growth stocks correctly. In our report for Jemena to the AER, we carefully examined an array of evidence that indicates that the FFM does a better job of explaining the cross-section of returns to Australian stocks than does the SL CAPM.

The ERA reproduces a table that the AER had previously produced in its *Draft Decision* on Jemena that reviews the evidence provided by eight papers on the ability of Australian versions of the FFM to correctly measure the cost of equity. We focus our attention on these papers as we have done previously in our response to the AER on behalf of Jemena. All of the papers form portfolios based on some set of characteristics and test whether the FFM (or, in one paper, an augmented version of the model) correctly measures the returns required on the portfolios. Some of the papers also test whether the SL CAPM correctly measures the returns required on the portfolios.

The ERA's review of the eight papers involves counting the number of portfolios for which the FFM can and cannot be rejected. There are two problems with relying on counts of this kind. First, our interest is not just in whether the FFM is true but in whether it is *better* to use the FFM than the SL CAPM. Thus it is essential that the evidence on whether the SL CAPM

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111 AER, *Electricity transmission and distribution network service providers: Review of the weighted average cost of capital (WACC) parameters, Final Decision*, March 2009, page 176.

112 AER, *Electricity transmission and distribution network service providers: Review of the weighted average cost of capital (WACC) parameters, Final Decision*, March 2009, page 238.

113 AER, *Draft Decision. Envestra Ltd. Access Arrangement proposal for the SA gas network, 1 July 2011 – 30 June 2016*, February 2011.

114 Davis, K.., *Cost of equity issues: A Report for the AER*, January 2011, page 21.

can correctly measure the returns required on the portfolios also be examined. Second, the returns to the portfolios are not independent and so counting the number of portfolios for which the FFM can and cannot be rejected can provide a *misleading* guide as to whether or not the model is true. There are multivariate tests that take into account the fact that the returns to portfolios typically covary with one another and some of the papers report the results of such tests.

Of the eight papers that the AER reviews, only one, a working paper by O'Brien, Brailsford and Gaunt (2008) sponsored by an Australian Research Council grant, uses more than 13 years' worth of data.[115] Since it is difficult to draw reliable inferences about pricing models from short time series we focus much of our attention on the results provided by their work.

O'Brien, Brailsford and Gaunt (2008) form 25 portfolios, like Fama and French (1993), on the basis of size and book-to-market and examine the performance of the SL CAPM and FFM in measuring the returns required on the portfolios over the 25-year period from 1982 through 2006.[116] Table 4.2 summarises their results. The table provides estimates of the alphas associated with each model and each portfolio in per cent per annum. The alpha associated with an asset is the error with which a model measures the return required on the asset. Thus a model that produces large alphas is a model that will provide poor estimates of the cost of equity. Table 4.2 contains two panels. Panel A provides estimates of the alphas associated with an Australian version of the SL CAPM while Panel B provides estimates of the alphas associated with an Australian version of the FFM.

Table 4.2 shows that on average the absolute values of the alpha estimates associated with the FFM are 22 per cent smaller than their Sharpe-Lintner counterparts. The mean absolute value of the FFM alpha estimates is 6.69 per cent per annum while the mean absolute value of the Sharpe-Lintner alpha estimates is 8.58 per cent. While the individual alpha estimates are illustrative of a pricing model's ability or inability to correctly price assets, a multivariate test, as we have already emphasised, provides a better picture of whether a pricing model can correctly price assets.

Despite the lower FFM alpha estimates, O'Brien, Brailsford and Gaunt are still able to reject the hypothesis that all of the FFM alphas are simultaneously zero. The evidence they provide against the FFM, though, is *less* than the evidence that they provide against the SL CAPM. For example, the Newey-West D-statistic (a multivariate test statistic) for a test that all of the FFM alphas are zero is 148.27 while the corresponding statistic for a test that all of the Sharpe-Lintner alphas are zero is 245.13. A larger value for the statistic means that there is more evidence against the hypothesis that all of the alphas are zero.

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[115] O'Brien, Brailsford, and Gaunt, *Size and book-to-market factors in Australia*, University of Queensland, 2008.

[116] Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 36-37.

O'Brien, Brailsford, and Gaunt, *Size and book-to-market factors in Australia*, University of Queensland, 2008.

Table 4.2
The SL CAPM and FFM: Australian evidence from 1982 to 2006

Size	Portfolio alpha					Mean absolute alpha
	Low BM	2	3	4	High BM	
			Panel A: SL CAPM			
Small	21.36	19.80	26.64	21.60	27.84	23.45
2	-2.04	8.76	3.24	6.48	7.08	5.52
3	-19.56	-4.20	-0.60	2.52	4.32	6.24
4	-10.32	-2.52	-1.44	-0.12	4.44	3.77
Big	-5.64	-2.76	1.08	2.88	7.20	3.91
Mean absolute alpha	11.78	7.61	6.60	6.72	10.18	8.58
			Panel B: FFM			
Small	14.64	13.20	16.92	12.96	16.92	14.93
2	-5.52	3.24	-3.72	-1.92	-3.48	3.58
3	-22.08	-7.92	-5.28	-2.76	-3.60	8.33
4	-11.52	-6.00	-4.56	-3.24	-2.16	5.50
Big	-0.96	-1.56	0.60	-1.80	-0.60	1.10
Mean absolute alpha	10.94	6.38	6.22	4.54	5.35	6.69

Notes: Alpha estimates are in per cent per annum. Stocks are allocated to one of 25 portfolios on the basis of market capitalisation and book-to-market (BM).

Source: O'Brien, Brailsford, and Gaunt, Size and book-to-market factors in Australia, University of Queensland, 2008.

Since O'Brien, Brailsford and Gaunt provide more evidence against the hypothesis that the SL CAPM correctly measures the cost of equity than against the hypothesis that the FFM correctly measures the cost of equity, they conclude that:[117]

> 'the three-factor model is found to be consistently superior to the CAPM.'

The ERA, on the other hand, states that:

> 'when both overestimates and underestimates (measured by alphas in the regressions) are taken into consideration, the Sharpe-Lintner CAPM has the mean value of alphas of -0.06 per cent, whereas the FFM has the mean value of alphas of -4.24 per cent. A lower alpha indicates that

[117] O'Brien, Brailsford, and Gaunt, *Size and book-to-market factors in Australia*, University of Queensland, 2008.

> the Sharpe-Lintner CAPM produces a lower error when this model is used to price the portfolio returns.'

This statement is incorrect. The average SL alpha is 4.64 per cent while the average FFM alpha is – 0.41. More importantly, however, it makes no sense to compare average alphas. A value-weighted average of all SL alphas must be zero *by construction* whether or not the SL CAPM is true. In other words, even if the SL CAPM were incorrect, the value-weighted average of all SL alphas would still be zero. Some of the alphas would, of course, be large and positive while some of the alphas would be large and negative. A value-weighted average of the alphas, though, would be precisely zero.

The ERA also states that:

> 'In the study by O'Brien et al, the mean value of the small-minus-big (SMB) risk premium is 0.35 per cent per month, with a t-statistic of 1.12. As such, the Authority notes that the SMB risk premium in this study is not significant (i.e. the difference between small and large firms is not statistically different from zero). In addition, the Authority also notes that the high-minus-low (HML) risk premium is not significant in 9 of 25 portfolios used in the study.'

As we make clear in Section 3, even over a relatively long period, an estimate of one of the three Fama-French risk premiums may turn out to be not significantly different from zero because it is difficult to measure the risk premiums precisely. In fact, O'Brien, Brailsford and Gaunt similarly report that an estimate of the *MRP* is 0.39 per cent per month with a t-statistic of 1.38. [118] Thus O'Brien, Brailsford and Gaunt are *also* unable to reject the hypothesis that the *MRP* is zero at conventional levels of significance. In contrast, the authors report that an estimate of the *HML* premium is 0.75 per cent per month with a t-statistic of 3.90. [119] Thus they easily reject the hypothesis that the *HML* premium is zero at conventional levels.

The FFM does *not* place a restriction on the exposure of a portfolio to each Fama-French factor. The FFM, for example, does not imply that the exposure of a portfolio must differ from the value-weighted averages across all assets of one, for the market, and zero, for the *HML* and *SMB* factors. Similarly, the SL CAPM does not place a restriction on the beta of a portfolio. The SL CAPM, for example, does not imply that the beta of a portfolio must differ from the value-weighted average across all assets of one.

Thus the fact that 9 of 25 portfolios have exposures (not risk premiums, as the ERA describes them) to the *HML* factor that do not differ significantly from zero is *perfectly* consistent with the FFM. Similarly, the fact that 11 of 25 portfolios have betas that do not differ significantly from one is not inconsistent with the SL CAPM.[120]

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[118] O'Brien, Brailsford, and Gaunt, *Size and book-to-market factors in Australia*, University of Queensland, 2008, Table 3.

[119] O'Brien, Brailsford, and Gaunt, *Size and book-to-market factors in Australia*, University of Queensland, 2008, Table 3.

[120] Table 4 of O'Brien, Brailsford and Gaunt provides beta estimates and t-statistics for tests that each beta is zero. t-statistics for tests that each beta is one can be uncovered from these data.

O'Brien, Brailsford, and Gaunt, *Size and book-to-market factors in Australia*, University of Queensland, 2008.

As the AER notes, Gharghori, Lee and Veeraraghavan (2009) provide perhaps the most recent published evidence on the performance of the FFM in the Australian market.[121,122] In a private communication from one of the authors, though, we have been informed that serious computational errors were made in the paper and that therefore one cannot rely upon the paper's results.

The AER also introduces the recent evidence that Kassimatis (2008) provides.[123] Kassimatis forms 25 portfolios, like Fama and French, on the basis of size and book-to-market. He uses Australian data from 1993 to 2005 to conduct tests of the SL CAPM and the FFM augmented with a momentum factor and concludes that:[124]

> 'For space considerations we do not report the regressions for the CAPM. Similar regressions have been reported by several researchers and our results confirm the existing evidence. The static CAPM is rejected for the Australian stock market because the intercept for most regressions is statistically significant (see, Gaunt 2004). The four factor model does a much better job at explaining realised returns.'

His inclusion of a fourth momentum factor is unnecessary because the portfolios he forms are passively managed. He finds, for example, that only five of 25 momentum betas differ significantly from zero and estimates of the betas are small. In contrast, he finds that 11 of the 25 *HML* betas differ significantly from zero and 20 of the 25 *SMB* betas differ significantly from zero.

Kassimatis also follows Fama and French (2006) and conducts tests of the SL CAPM and the FFM augmented with a momentum factor over rolling 12-month periods. There is an important difference, though, between the work of Fama and French and Kassimatis. Fama and French compute betas using 12 months of data at a time but do not compute estimates of the factor risk premiums using 12 months of data. 12 monthly observations are insufficient data with which to measure the means of the Fama-French factors with any precision. To give an idea as to how poor will estimates be of the cost of equity produced from 12 monthly observations, consider the following simple example. Let us assume that the SL CAPM is true, that the beta of a portfolio is known to be one and that the monthly excess return to the market in per cent is distributed N(0.5, 5). Then, approximately, an estimator of the annual excess return to the portfolio computed using 12 months of data will be distributed N(6, 17). In other words, if the standard deviation of the estimator were known, a 95 per cent confidence interval for the annual mean excess return will have a width that exceeds 60 per cent! If, for example, an estimate of the mean excess return were 6 per cent per annum, then a 95 per cent confidence interval for the true mean would range from – 28 per cent per annum to 40 per cent per annum.

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121 AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, page 114.

122 Gharghori, P., R. Lee and M. Veeraraghavan, *Anomalies and stock returns: Australian evidence*, Accounting and Finance 49, 2009, pages 555–576.

123 Kassimatis, K., *Size, book-to-market and momentum effects in the Australian stock market*, Australian Journal of Management, 2008, pages 145-168.

124 Kassimatis, K., *Size, book-to-market and momentum effects in the Australian stock market*, Australian Journal of Management, 2008, page 154.

Not surprisingly, Kassimatis finds that the rolling forecasts he produces using both models are poor. As a result, he is unable to find any evidence against the SL CAPM. There is too much variation in his forecasts to be able to conclude at conventional significance levels that they are biased. On the other hand, Kassimatis claims that there is evidence from his rolling regressions against the FFM. The observation that he views as evidence against the FFM is the observation that the p-values associated with univariate tests that each FFM alpha is zero – none of which indicate a rejection of the model – are not uniformly distributed across the portfolios he examines. There is no requirement, though, that under the FFM these p-values be uniformly distributed across the portfolios. So one cannot interpret the observation that the p-values are not uniformly distributed as evidence against the FFM.

Rather than describe in detail the results of the remaining five papers reviewed by the ERA in its *Draft Decision*, we list below a number quotes drawn from these papers in which the authors of the papers summarise their own results.

Halliwell, Heaney and Sawicki (1999) use Australian data from 1980 to 1991 to test the SL CAPM and FFM. They conclude that:[125]

> 'The results of the analysis are similar to those reported in Fama and French (1993). The market risk premium does not appear to be the sole explanatory variable for Australian equity returns over the period 1981 to 1991.'

Faff (2001) provides tests of the FFM using Australian data from 1991 through 1999 and concludes that:[126]

> 'the evidence seems to quite strongly support the three-factor Fama and French model'

while Faff (2004) uses daily data from 1996 through 1999 to test the FFM and concludes:[127]

> 'In general, evidence obtained is quite favourable to the model based on formal asset pricing tests. However, when one takes into account the estimated risk premia, support for the Fama French model is less persuasive. In particular, a negative size premium is uncovered that adds to the recent findings questioning its continued existence over recent years.'

Neither study compares the FFM to the SL CAPM.

Gaunt (2004) uses Australian data from 1993 through 2001 to test the FFM and the SL CAPM and concludes that:[128]

> 'Overall, the present study indicates that the three factor model provides a better explanation of observed Australian stock returns than the CAPM.'

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[125] Halliwell, J., R. Heaney and J. Sawicki, *Size and book to market effects in Australian share markets: a time series analysis*, Accounting Research Journal 12, 1999, pages 122–137.

[126] Faff, R., *An examination of the Fama and French three-factor model using commercially available factors*, Australian Journal of Management 26, 2001, pages 1–17.

[127] Faff, *A simple test of the Fama and French model using daily data: Australian evidence*, Applied Financial Economics 14, 2004, pages 83–92.

[128] Gaunt, C., *Size and book-to-market effects and the Fama–French three factor asset pricing model: Evidence from the Australian stock market*, Accounting and Finance 44, 2004, pages 27-44.

Finally, Gharghori, Chan and Faff (2007) use Australian data to examine whether the Fama-French factors are proxying for default risk. They find that the Fama-French factors are not proxying for default risk but conclude that:[129]

> 'our findings suggest that the Fama-French model is vastly superior to the CAPM in explaining returns.'

To summarise, we review the results of seven papers that provide evidence on the ability of Australian versions of the FFM and SL CAPM to correctly measure the cost of equity.[130] The two studies that restrict their attention to the FFM find evidence in support of the model while the four papers that compare the FFM and SL CAPM all conclude that the FFM provides better estimates of the cost of equity than does the SL CAPM.[131,132]

4.4. DCF Analysis

SFG uses, as an alternative method of estimating the cost of equity for DBNGP, discounted cash flow (DCF) analysis.[133] The use of DCF analysis is complimentary to the analysis that we provide. This is because DCF analysis does not require that one choose a pricing model. So if one of the pricing models that we use is correct and the DCF analysis is carried out appropriately, estimates produced using the particular pricing model and estimates delivered by DCF analysis should on average over time be identical. The fact that the estimate that SFG produces for the cost of equity using DCF analysis falls within the range of estimates that we produce suggests that the DCF estimate is not an unreasonable one.

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129 Gharghori, P., H. Chan and R. Faff, *Are the Fama–French factors proxying default risk?*, Australian Journal of Management 32, 2007, pages 223–249.

130 We note that of the eight papers reviewed in this section six were first introduced into the debate by the AER.

131 The two studies that restrict their attention to the FFM are:

Faff, R., *An examination of the Fama and French three-factor model using commercially available factors*, Australian Journal of Management 26, 2001, pages 1–17.

Faff, *A simple test of the Fama and French model using daily data: Australian evidence*, Applied Financial Economics 14, 2004, pages 83–92.

The four studies that compare the performance of the FFM and SL CAPM are:

Halliwell, J., R. Heaney and J. Sawicki, *Size and book to market effects in Australian share markets: a time series analysis*, Accounting Research Journal 12, 1999, pages 122–137.

Gaunt, C., *Size and book-to-market effects and the Fama–French three factor asset pricing model: Evidence from the Australian stock market*, Accounting and Finance 44, 2004, pages 27-44.

Gharghori, P., H. Chan and R. Faff, *Are the Fama–French factors proxying default risk?*, Australian Journal of Management 32, 2007, pages 223–249.

O'Brien, Brailsford and Gaunt (2008) O'Brien, Brailsford, and Gaunt, *Size and book-to-market factors in Australia*, University of Queensland working paper, 2008.

132 As we have already outlined, Kassimatis (2008) uses an augmented version of the FFM rather than the original version of the FFM and provides inconclusive results.

Kassimatis, K., *Size, book-to-market and momentum effects in the Australian stock market*, Australian Journal of Management, 2008, pages 145-168.

133 SFG, *The required return on equity commensurate with current conditions in the market for funds*, March 2010.

5 Conclusions

The work of Markowitz (1952), Sharpe (1964) and Lintner (1965) in developing modern portfolio theory and the SL CAPM represents one of the most significant advances in Finance.[134] Markowitz emphasised that a rational investor will not hold a single risky asset alone but will instead diversify. Sharpe and Lintner showed that, in a world in which investors are rational and diversify, the return that an investor will require on an asset will be determined not by the risk of the asset if held alone but by how the asset *contributes* to the risk of the portfolio that the investor holds, that is, by the asset's beta. These lessons continue to be taught to tens of thousands of business school students around the world each year.

Almost as soon as Sharpe and Lintner had created the SL CAPM, however, it became obvious that the data did *not* match the theory. It was found that the model underestimates the returns required on low-beta assets and overestimates the returns required on high-beta assets. Once it became apparent that there were empirical problems with the SL CAPM, academics began to create different pricing models – importantly, building on the work of Sharpe and Lintner, rather than entirely jettisoning their approach – in an attempt to create a model that is both theoretically appealing and practical.

The first of these more advanced models was the Black CAPM, a model that relaxes the assumption made by the SL CAPM that investors can freely borrow and lend at a single risk-free rate. [135] The initial evidence on this version of the CAPM proved to be more encouraging. As a result, the Black CAPM became the pricing model *most* widely used by academics in empirical work for much of the 1970s and 1980s.

By the early 1980s, however, it had become clear that there were stocks that the Black CAPM also systematically mispriced. The Black CAPM tends to underestimate the returns to *low-market-capitalisation* stocks and the returns to *value* stocks. Fama and French (1993) noted that the Arbitrage Pricing Theory of Ross (1976) predicts that risks that are pervasive must be priced.[136] Thus they theorised that the premiums earned by low-market-capitalisation stocks and value stocks must represent compensation for risks not captured by either the SL CAPM or Black CAPM.

To build a model that could correctly price low-market-capitalisation stocks and value stocks, Fama and French augmented the SL CAPM with two additional factors – a size factor and a value factor. In their augmented three-factor model, the required return on a stock depends

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134 Markowtiz, Harry, *Portfolio selection*, Journal of Finance 7, 1952, pages 77-91.

Sharpe, William F., *Capital asset prices: A theory of market equilibrium under conditions of risk*, Journal of Finance 19, 1964, pages 425-442.

Lintner, John, *The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets*, Review of Economics and Statistics 47, 1965, pages 13-37.

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

136 Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

Ross, Stephen, *The arbitrage theory of capital asset pricing*, Journal of Economic Theory 13, pages 341-360.

on its exposure to a market factor, a size factor and a value factor. A large number of studies find that there is substantially *less* evidence against their model than against the SL CAPM.

More recent evidence, however, finds that the Fama-French three-factor model, like the SL CAPM underestimates the returns required on low-beta assets and overestimates the returns required on high-beta assets. A zero-beta version of the model does *not* suffer from this problem.

In our report for DBNGP we use the SL CAPM, the Black CAPM, the FFM and a zero-beta version of the FFM to estimate the cost of equity for a regulated energy utility. The ERA raises a number of issues in its *Draft Decision* about the way in which we use the FFM that suggest that it does not fully understand how the model works. In this response, we carefully examine the issues that the ERA raises. In particular, we document that:

- the FFM does *not* link the cost of equity to characteristics like size and the ratio of the book value of a firm's equity to its market value but instead links the cost of equity to the exposure of equity to the three Fama-French factors;
- the way in which we relever betas does not distort the data;
- the way in which we relever betas does not assume that there are no taxes; and
- the problems that one encounters in estimating the Fama-French risk premiums are *also* encountered in estimating the *MRP*.

We also review the evidence that exists *against* the SL CAPM and document that the evidence indicates that the FFM does a better job of explaining the cross-section of returns than does the SL CAPM.

Two independent studies that use long time series of Australian data find, contrary to the predictions that the SL CAPM makes, that there is no significant relation between the mean returns to portfolios of stocks and the betas of the portfolios.[137] Thus, empirically, the SL CAPM *underestimates* the returns required on low-beta assets.

We review the results of seven papers that provide evidence on the ability of Australian versions of the FFM and SL CAPM to correctly measure the cost of equity. The two studies that restrict their attention to the FFM find evidence in support of the model and the four papers that compare the FFM and SL CAPM all conclude that the FFM provides *better* estimates of the cost of equity than does the SL CAPM.[138]

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[137] CEG, *Estimation of, and correction for, biases inherent in the Sharpe CAPM formula: A report for the Energy Networks Association Grid Australia and APIA*, September 2008.

Lajbcygier P. and S. M. Wheatley, *An evaluation of some alternative models for pricing Australian stocks*, Working Paper , Monash University, 2009.

[138] The two studies that restrict their attention to the FFM are:

Faff, R., *An examination of the Fama and French three-factor model using commercially available factors*, Australian Journal of Management 26, 2001, pages 1–17.

Faff, *A simple test of the Fama and French model using daily data: Australian evidence*, Applied Financial Economics 14, 2004, pages 83–92.

The empirical evidence indicates that it would be misguided to rely solely on the SL CAPM as a model with which to estimate the cost of equity for a regulated energy utility. Thus Professor Franks of the London Business School and Professor Myers of the Massachusetts Institute of Technology advised the New Zealand Commerce Commission in 2008 to use the FFM and DCF analysis in addition to the SL CAPM.[139] Similarly, the California Public Utilities Commission explained in a 2009 decision that it does not view any single model as being reliable and so as a matter of policy it reviews estimates provided by an array of models before deciding upon a cost of equity for a regulated utility. [140]

For this reason, we examined the following four models to estimate the cost of equity for a regulated energy utility:[141]

- the SL CAPM;
- the Black CAPM;
- the FFM; and
- a zero-beta version of the FFM.

These models indicate a range for the cost of equity in excess of the risk-free rate of between 3.45 per cent per annum (using the SL CAPM) to 8.85 per cent per annum (using the zero-beta version of the FFM). With a risk-free rate determined using the AER methodology and CGS mid-rates for the 20 trading days of February 2011 of 5.71 per cent per annum,[143] this generates a range for the cost of equity of between 9.16 per cent per annum and 14.56 per cent per annum.

The four studies that compare the performance of the FFM and SL CAPM are:

Halliwell, J., R. Heaney and J. Sawicki, *Size and book to market effects in Australian share markets: a time series analysis*, Accounting Research Journal 12, 1999, pages 122–137.

Gaunt, C., *Size and book-to-market effects and the Fama–French three factor asset pricing model: Evidence from the Australian stock market*, Accounting and Finance 44, 2004, pages 27-44.

Gharghori, P., H. Chan and R. Faff, *Are the Fama–French factors proxying default risk?*, Australian Journal of Management 32, 2007, pages 223–249.

O'Brien, Brailsford and Gaunt (2008) O'Brien, Brailsford, and Gaunt, *Size and book-to-market factors in Australia*, University of Queensland working paper, 2008.

One study uses an augmented version of the FFM rather than the original version of the FFM and provides inconclusive results.

Kassimatis, K., *Size, book-to-market and momentum effects in the Australian stock market*, Australian Journal of Management, 2008, pages 145-168.

139 Franks, J, M. Lally, S. Myers, *Recommendations to the New Zealand Commerce Commission on an Appropriate Cost of Capital*, 18 December 2008, page 7.

140 California Public Utilities Commission, *Decision 09-05-019*, May 2009, pages 15 and 25-26.

141 NERA, *Estimating the required rate of return on equity for a gas transmission pipeline: An update for DBNGP*, April 2011.

143 AER, *Electricity transmission and distribution network service providers: Review of the weighted average cost of capital (WACC) parameters, Final Decision*, May 2009, pages 129-131 and pages 168-169.

Appendix A. The Conditional CAPM

This appendix reproduces the analysis of Lewellen and Nagel (2006) who examine the magnitude of the pricing errors produced by the unconditional CAPM and an array of combinations of variation in beta, variation in the *MRP* and covariation between the two when the conditional CAPM is true.

Again, the approximation for the error with which the unconditional CAPM measures the required return to an asset can be rewritten as:[144]

$$\alpha_j^U = \text{Cov}(\beta_{jt}, \text{E}_{t-1}(R_{mt})) = \rho\sigma_\beta\sigma_\gamma, \qquad (17)$$

where

ρ = is the correlation between β_{jt} and $\text{E}_{t-1}(R_{mt})$ across time;

σ_β = the standard deviation of β_{jt} across time; and

σ_γ = the standard deviation of $\text{E}_{t-1}(R_{mt})$ across time.

Lewellen and Nagel compute the approximate error with which the unconditional CAPM will price an asset for an array of values for these parameters.

They consider two values for the correlation between the beta of the asset β_{jt} and the market risk premium $\text{E}_{t-1}(R_{mt})$:

$$\rho = 0.6 \text{ and } \rho = 1.0.$$

They consider three values for the standard deviation of β_{jt} across time:

$$\sigma_\beta = 0.3, \sigma_\beta = 0.5 \text{ and } \sigma_\beta = 0.7.$$

Finally, they consider five values for the standard deviation of $\text{E}_{t-1}(R_{mt})$ across time:

$$\sigma_\gamma = 0.1, \sigma_\gamma = 0.2, \sigma_\gamma = 0.3, \sigma_\gamma = 0.4 \text{ and } \sigma_\gamma = 0.5.$$

Table A.1 shows the error with which the unconditional CAPM measures the monthly return required on an asset under the assumption that the conditional CAPM holds each period for various combinations of the parameters. The table shows that even with the most extreme combination of parameters, the error with which the unconditional CAPM measures the return required on an asset does not exceed 0.35 per cent per month.

[144] The asset may be a zero-investment portfolio. For example, the asset may be a portfolio that is long a portfolio of value stocks and short a portfolio of growth stocks.

Table A.1
Unconditional alpha per month for an array of values for ρ, σ_β and σ_γ

$\rho = 0.6$	σ_β			$\rho = 1.0$	σ_β		
	0.30	0.50	0.70		0.30	0.50	0.70
	Unconditional alpha in per cent				Unconditional alpha in per cent		
$\sigma_\gamma = 0.1$	0.02	0.03	0.04	$\sigma_\gamma = 0.1$	0.03	0.05	0.07
0.2	0.04	0.06	0.08	0.2	0.06	0.10	0.14
0.3	0.05	0.09	0.13	0.3	0.09	0.15	0.21
0.4	0.07	0.12	0.17	0.4	0.12	0.20	0.28
0.5	0.09	0.15	0.21	0.5	0.15	0.25	0.35

Source: Lewellen, J. and S. Nagel, The conditional CAPM does not explain asset-pricing anomalies, Journal of Financial Economics 82, 2006, 289-314.

Appendix B. Expert Witness Guidelines

Guidelines for Expert Witnesses in Proceedings in the

Federal Court of Australia

Practice Direction

This replaces the Practice Direction on Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia issued on 6 June 2007.

Practitioners should 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)).

M.E.J. BLACK

Chief Justice

5 May 2008

Explanatory Memorandum

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 (footnote #1), 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.

Ways by which an expert witness giving opinion evidence may avoid criticism of partiality include ensuring that the report, or other statement of evidence:

(a) is clearly expressed and not argumentative in tone;

(b) is centrally concerned to express an opinion, upon a clearly defined question or questions, based on the expert's specialised knowledge;

(c) identifies with precision the factual premises upon which the opinion is based;

(d) explains the process of reasoning by which the expert reached the opinion expressed in the report;

(e) is confined to the area or areas of the expert's specialised knowledge; and

(f) identifies any pre-existing relationship (such as that of treating medical practitioner or a firm's accountant) between the author of the report, or his or her firm, company etc, and a party to the litigation.

An expert is not disqualified from giving evidence by reason only of a pre-existing relationship with the party that proffers the expert as a witness, but the nature of the pre-existing relationship should be disclosed.

The expert should make it clear whether, and to what extent, the opinion is based on the personal knowledge of the expert (the factual basis for which might be required to be established by admissible evidence of the expert or another witness) derived from the ongoing relationship rather than on factual premises or assumptions provided to the expert by way of instructions.

All experts need to be aware that if they participate to a significant degree in the process of formulating and preparing the case of a party, they may find it difficult to maintain objectivity.

An expert witness does not compromise objectivity by defending, forcefully if necessary, an opinion based on the expert's specialised knowledge which is genuinely held but may do so if the expert is, for example, unwilling to give consideration to alternative factual premises or is unwilling, where appropriate, to acknowledge recognised differences of opinion or approach between experts in the relevant discipline.

Some expert evidence is necessarily evaluative in character and, to an extent, argumentative. Some evidence by economists about the definition of the relevant market in competition law cases and evidence by anthropologists about the identification of a traditional society for the purposes of native title applications may be of such a character. The Court has a discretion to treat essentially argumentative evidence as submission, see Order 10 paragraph 1(2)(j).

The guidelines are, as their title indicates, no more than guidelines. Attempts to apply them literally in every case may prove unhelpful. In some areas of specialised knowledge and in some circumstances (eg some aspects of economic evidence in competition law cases) their literal interpretation may prove unworkable.

The Court expects legal practitioners and experts to work together to ensure that the guidelines are implemented in a practically sensible way which ensures that they achieve their intended purpose.

Nothing in the guidelines is intended to require the retention of more than one expert on the same subject matter – one to assist and one to give evidence. In most cases this would be wasteful. It is not required by the Guidelines. Expert assistance may be required in the early identification of the real issues in dispute.

Guidelines

1. General Duty to the Court (footnote #2)

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 (footnote #3).

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 Evidence (footnote #4)

2.1 An expert's written report must give details of the expert's qualifications and of the literature or other material used in making the report.

2.2 All assumptions of fact made by the expert should be clearly and fully stated.

2.3 The report should identify and state the qualifications of each person who carried out any tests or experiments upon which the expert relied in compiling the report.

2.4 Where several opinions are provided in the report, the expert should summarise them.

2.5 The expert should give the reasons for each opinion.

2.6 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*."

2.7 There should be included in or attached to the report; (i) a statement of the questions or issues that the expert was asked to address; (ii) the factual premises upon which the report proceeds; and (iii) the documents and other materials that the expert has been instructed to consider.

2.8 If, after exchange of reports or at any other stage, an expert witness changes a material opinion, having read another expert's report or for any other reason, the change should be communicated in a timely manner (through legal representatives) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court (footnote #5).

2.9 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 (footnote #5).

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

2.11 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 (footnote #6).

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.

footnote #1

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].

footnote #2

See rule 35.3 Civil Procedure Rules (UK); see also Lord Woolf "Medics, Lawyers and the Courts" [1997] 16 CJQ 302 at 313.

footnote #3

See *Sampi v State of Western Australia* [2005] FCA 777 at [792]-[793], and *ACCC v Liquorland and Woolworths* [2006] FCA 826 at [836]-[842]

footnote #4

See rule 35.10 Civil Procedure Rules (UK) and Practice Direction 35 – Experts and Assessors (UK); *HG v the Queen* (1999) 197 CLR 414 per Gleeson CJ at [39]-[43]; *Ocean Marine Mutual Insurance Association (Europe) OV v Jetopay Pty Ltd* [2000] FCA 1463 (FC) at [17]-[23]

footnote #5

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

footnote #6

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

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