

# Jemena Electricity Networks (Vic) Ltd

## 2016-20 Electricity Distribution Price Review Regulatory Proposal

Attachment 9-10

NERA literature review on the Sharpe-Lintner CAPM,  
Black CAPM, and Fama-French three factor model

Public

30 April 2015



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# **Review of the Literature in Support of the Sharpe-Lintner CAPM, the Black CAPM and the Fama-French Three-Factor Model**

A report for Jemena Gas Networks, Jemena Electricity Networks, AusNet Services, Australian Gas Networks, CitiPower, Ergon Energy, Powercor, SA PowerNetworks, and United Energy

March 2015

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## Executive Summary

This report has been prepared for Jemena Gas Networks (JGN), Jemena Electricity Networks, AusNet Services, Australian Gas Networks, CitiPower, Ergon Energy, Powercor, SA PowerNetworks, and United Energy (the networks) by NERA Economic Consulting (NERA). The networks have asked NERA to review the theoretical and empirical literature on relevant financial models which may be used to estimate the return on equity component of the rate of return, in a way that complies with the requirements of the National Gas Law and Rules and National Electricity Law and Rules. The networks have also asked NERA to respond to matters raised by the Australian Energy Regulator (AER) in its recently published *Draft decision Jemena Gas Networks (NSW) Ltd Access arrangement 2015-20*, in other recent AER decisions and by the AER's advisors.<sup>1</sup>

In particular, the networks have asked NERA to review the theoretical and empirical literature on three asset pricing models:

- the Sharpe-Lintner (SL) CAPM;
- the Black CAPM; and
- the Fama-French three-factor model.

## Importance of Measuring the Cost of Equity Accurately

Regulated and unregulated firms use asset pricing models to construct estimates of the cost of equity. The costs of choosing a model, however, that delivers a poor estimate of the cost of equity will in general be greater for a regulated firm than for an unregulated firm. As Grout (1995) makes clear:<sup>2, 3</sup>

‘For non-regulated activity prices are not directly dependent o(n) the cost of capital. Firms aim to maximize profit and the precise value of the cost of capital, since it is used as a hurdle rate, will only affect the marginal projects. If the cost of capital is mistakenly set too high then some marginal projects that are good are rejected and if it is too low then some bad projects are accepted. However, almost all will be

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<sup>1</sup> AER, *Draft decision Jemena Gas Networks (NSW) Ltd Access arrangement 2015–20 Attachment 3 –Rate of return*, November 2014.

<sup>2</sup> Grout, P., *The cost of capital in regulated industries*, in M. Bishop, J. Kay and C. Mayer (eds.), *The regulatory challenge*, Oxford University Press, 1995, pages 386-407.

<sup>3</sup> It is obvious that here Grout intends a ‘precise estimate’ to be an accurate estimate rather than solely an estimate to which is attached a low standard error.

The Oxford Dictionary definition of precision is:

‘accuracy or exactness.’

In statistics the precision of a random variable is the reciprocal of its variance. So in statistics a precise estimator can be exact but inaccurate.

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

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

unaffected by the exact value that is attached to the cost of capital. In contrast, for regulated activities almost all regulated prices will be affected by the cost of capital. If the cost of capital is over-estimated then the price of all these activities will be set too high, and if it is under-estimated then all prices will be too low. Obviously, the relationship will be stronger and more direct for rate of return regulation than for price cap regulation, but the general principle holds good. *The economic implications of errors in the cost of capital are far greater in the regulated sector than in the private non-regulated sector and, not surprisingly, the pressure to provide precise estimates is greater both from the regulators and those within the regulated industries than in the private non-regulated sector.*<sup>7</sup>

[The emphasis is ours]

Thus while no model is perfect and all models make assumptions, the costs of using a model that provides inaccurate estimates of the cost of equity will be far greater for a regulated firm than for a unregulated firm.

## Roll Critique

We emphasise in this report that both the SL CAPM and the Black CAPM make assumptions that are unrealistic, and that departures from these assumptions may render the predictions of the two models poor. We also emphasise, however, that we may never know whether the predictions of the models are poor because the predictions concern the behaviour of the return to the market portfolio of *all* risky assets and, as Roll (1977) makes clear, one cannot observe the return.<sup>4</sup>

The AER uses difficulties in testing the predictions that the SL CAPM makes about the behaviour of the return to the market portfolio of *all* risky assets to shield the version of the model that it employs from scrutiny. The version of the model that the AER employs uses the market portfolio of stocks alone as a proxy for the market portfolio of *all* risky assets. The AER, for example, states in the *Appendices* to its *Rate of Return Guidelines* that:<sup>5</sup>

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

We emphasise throughout this report that the AER does not employ a version of the SL CAPM that uses the return to the market portfolio of *all* risky assets. Thus whether the model works when one employs the return to the market portfolio of *all* risky assets is irrelevant to the issue of how the AER should set the return on equity for a regulated energy utility. The AER employs, like almost all practitioners who use the model, a version of the SL CAPM

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

<sup>5</sup> AER, *Better Regulation Explanatory Statement Rate of Return Guideline (Appendices)*, December 2013, pages 11-12.

that uses the market portfolio of stocks as a proxy for the market portfolio of *all* risky assets. Thus, what is relevant to the issue of how the AER should set the return on equity for a regulated energy utility is whether the version of the SL CAPM that the regulator employs works. In particular, we are interested in whether the empirical version of the model that the AER uses allows the AER to generate unbiased estimates of the return required by a regulated energy utility. Fortunately, the empirical version of the SL CAPM that the AER employs resembles the empirical version of the model that the academic literature tests. So a review of the empirical literature that tests an empirical version of the SL CAPM is relevant to determining whether estimates provided by the empirical version of the SL CAPM that the AER employs meet Rule 87 of the National Gas Rules and clauses 6A.6.2 (for electricity transmission) and 6.5.2 (for electricity distribution) of the National Electricity Rules.

In what follows, unless otherwise stated, all references to tests of the SL CAPM or Black CAPM will be to tests of empirical versions of the models that use the return to a portfolio of stocks as a proxy for the market portfolio of all risky assets.

## SL CAPM

It has been known for well over 40 years that empirical versions of the SL CAPM tend to underestimate the returns to low-beta assets and overestimate the returns to high-beta assets. Mehrling (2005), for example, reports that:<sup>6</sup>

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

These early results have been confirmed in many, more recent studies. These studies have also shown that the SL CAPM tends to underestimate the returns to value stocks and low-cap stocks.<sup>7</sup> Thus Campbell and Vuolteenah (2005) summarise the empirical evidence in the following way:<sup>8</sup>

‘It is well known that the CAPM fails to describe average realized stock returns since the early 1960s, if a value-weighted equity index is used as a proxy for the market portfolio. In particular, small stocks and value stocks have delivered higher average returns than their betas can justify. Adding insult to injury, stocks with high past betas have had average returns no higher than stocks of the same size with low past betas.’

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<sup>6</sup> Mehrling, Perry, *Fischer Black and the revolutionary idea of finance*, Wiley, 2005, pages 104-105.

<sup>7</sup> A value stock is a stock that has a high book value relative to its market value or, identically, a low market value relative to its book value.

<sup>8</sup> Campbell, J. and T. Vuolteenaho, *Bad beta, good beta*, American Economic Review 94, page 1249.

Similarly, Da, Guo and Jagannathan (2012) state that:<sup>9</sup>

‘A variety of managed portfolios constructed using various firm characteristics earn very different returns on average from those predicted by the CAPM.’

‘Fama and French make a convincing case that the CAPM fails to describe the cross section of stock returns (Fama and French, 1992, 1996, 1997, 1999, 2004, and 2006).’

Fama and French (2004) themselves state that:

‘The attraction of the CAPM is that it offers powerful and intuitively pleasing predictions about how to measure risk and the relation between expected return and risk. Unfortunately, the empirical record of the model is poor – poor enough to invalidate the way it is used in applications. The CAPM’s empirical problems may reflect theoretical failings, the result of many simplifying assumptions. But they may also be caused by difficulties in implementing valid tests of the model. For example, the CAPM says that the risk of a stock should be measured relative to a comprehensive "market portfolio" that in principle can include not just traded financial assets, but also consumer durables, real estate and human capital. Even if we take a narrow view of the model and limit its purview to traded financial assets, is it legitimate to limit further the market portfolio to U.S. common stocks (a typical choice), or should the market be expanded to include bonds, and other financial assets, perhaps around the world? In the end, we argue that whether the model’s problems reflect weaknesses in the theory or in its empirical implementation, the failure of the CAPM in empirical tests implies that most applications of the model are invalid.’

We review in some detail recent evidence on the ability of the SL CAPM to accurately estimate the returns required on assets focusing, in particular, on evidence that the AER’s advisors have discussed in recent reports. Some of this evidence comes from the recent work of Lewellen, Nagel and Shanken (2010) that examines the ability of a number of pricing models to explain the mean returns to a large cross-section of portfolios.<sup>10</sup> We note that while Davis (2011), Handley (2014) and McKenzie and Partington (2014), in reports written for the AER, endorse the use of the SL CAPM and review, favourably, the work of Lewellen, Nagel and Shanken, the evidence that Lewellen, Nagel and Shanken provide indicates that the SL CAPM does not generate unbiased estimates of the cost of equity.<sup>11</sup>

Lewellen, Nagel and Shanken (2010) use, in their empirical work, quarterly data from 1963 to 2004 on the returns to 25 portfolios formed on the basis of size and book-to-market and 30

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<sup>9</sup> Da, Z., R-J. Guo and R. Jagannathan, *CAPM for estimating the cost of equity capital: Interpreting the empirical evidence*, Journal of Financial Economics, 2012, pages 204-206.

<sup>10</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

<sup>11</sup> Davis, K., *Cost of Equity Issues: A Report for the AER*, University of Melbourne, January 2011.

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

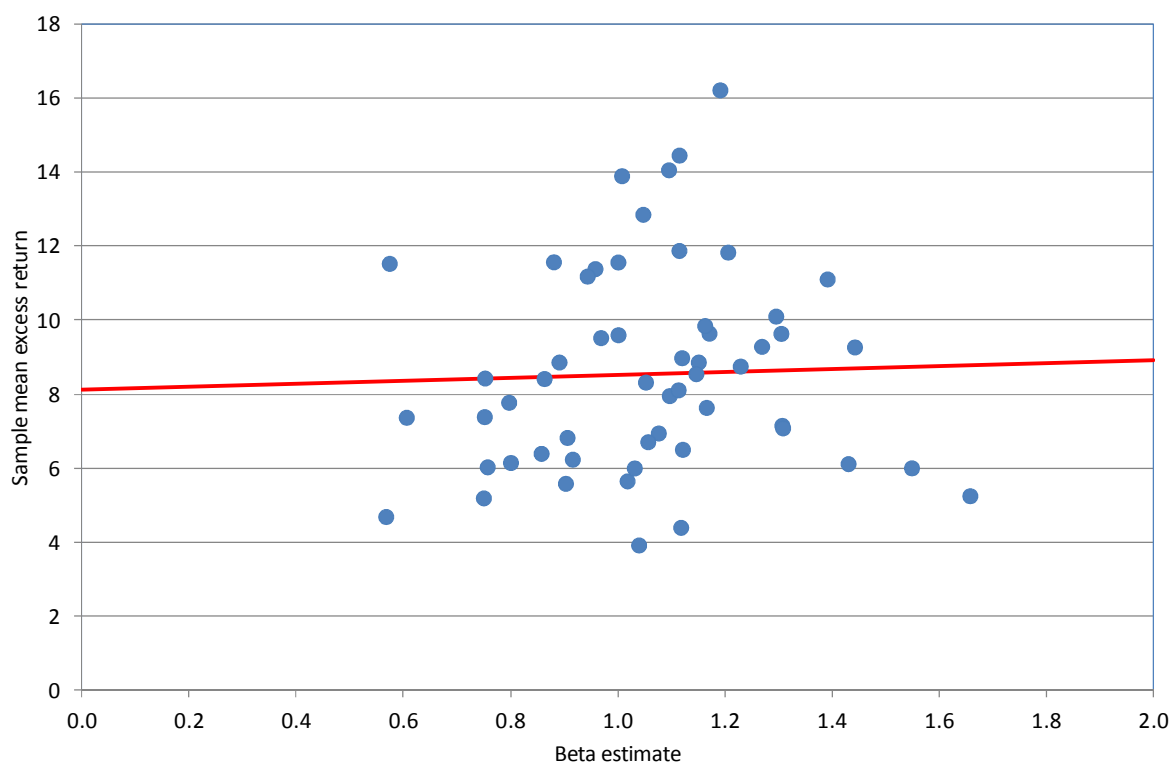
Handley, J., *Advice on the return on equity*, University of Melbourne, October 2014.

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

industry portfolios.<sup>12</sup> Figure 1 below plots the sample mean returns in excess of the risk-free rate on these 55 portfolios against estimates of their betas, indicated by the 55 blue markers, together with the relation that Lewellen, Nagel and Shanken estimate exists between mean excess return and beta for the portfolios, indicated by the red line.<sup>13</sup> The figure indicates that there is little relation between the sample mean return to a portfolio and an estimate of its beta.

**Figure 1**

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



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

*Sources: [http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data\\_library.html](http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html)*

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

<sup>12</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

<sup>13</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

The AER uses the SL CAPM as its ‘foundation’ model and so places this model at the centre of its determination of the cost of equity.<sup>14</sup> We emphasise, however, that the model is based on assumptions about investor preferences and their ability to borrow and lend at the risk-free rate rather than on the principle that there should not be any arbitrage opportunities available to market participants.<sup>15</sup> So deviations from an empirical version of the model found in the data should not be treated with the suspicion with which one would treat deviations from a no-arbitrage condition. Deviations from an empirical version of the model merely mean an empirical version of the model does not work – they do not indicate that there are unexploited arbitrage opportunities.

## **Black CAPM**

The Black CAPM is a more general model than the SL CAPM since it does not constrain the mean return to a zero-beta portfolio to match the risk-free rate. Thus, not surprisingly, there is less evidence against the model than there is against the SL CAPM. By construction, the Black CAPM eliminates the tendency of the SL CAPM to underestimate the returns to low-beta assets and overestimate the returns to high-beta assets. Both the SL CAPM and the Black CAPM, however, predict that variation in the mean returns to a cross-section of assets should be entirely explained by variation in their betas and there is evidence against this prediction of the model. The evidence indicates that the Black CAPM does not eliminate the tendency of the SL CAPM to underestimate the returns to value stocks and, in the US and some other countries, low-cap stocks.

## **Fama-French Three-Factor Model**

The Fama-French three-factor model, in its original form, is not a more general model than the SL CAPM but there is, nevertheless, less evidence against the model than against the SL CAPM. The model, unlike the SL CAPM and Black CAPM, does not tend to underestimate the returns to value stocks and low-cap stocks.

One way of looking at the results that Lewellen, Nagel and Shanken (2010) provide on the empirical performance of the Fama-French model is to follow Cochrane (2001) and plot the sample mean excess return to each portfolio against the mean excess return that the Fama-French three-factor model predicts the portfolio should earn.<sup>16</sup> Figure 2 provides the results of this exercise for the 25 portfolios formed on the basis of size and book-to-market that Lewellen, Nagel and Shanken employ together with the 30 industry portfolios that they use. The figure uses the quarterly data that Lewellen, Nagel and Shanken employ from 1963 to 2004. The figure shows that the Fama-French three-factor model provides better predictions of the mean excess returns to the portfolios than does the SL CAPM in Figure 1, which use the same data.

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<sup>14</sup> AER, *Better Regulation Rate of Return Guideline*, December 2013, page 4.

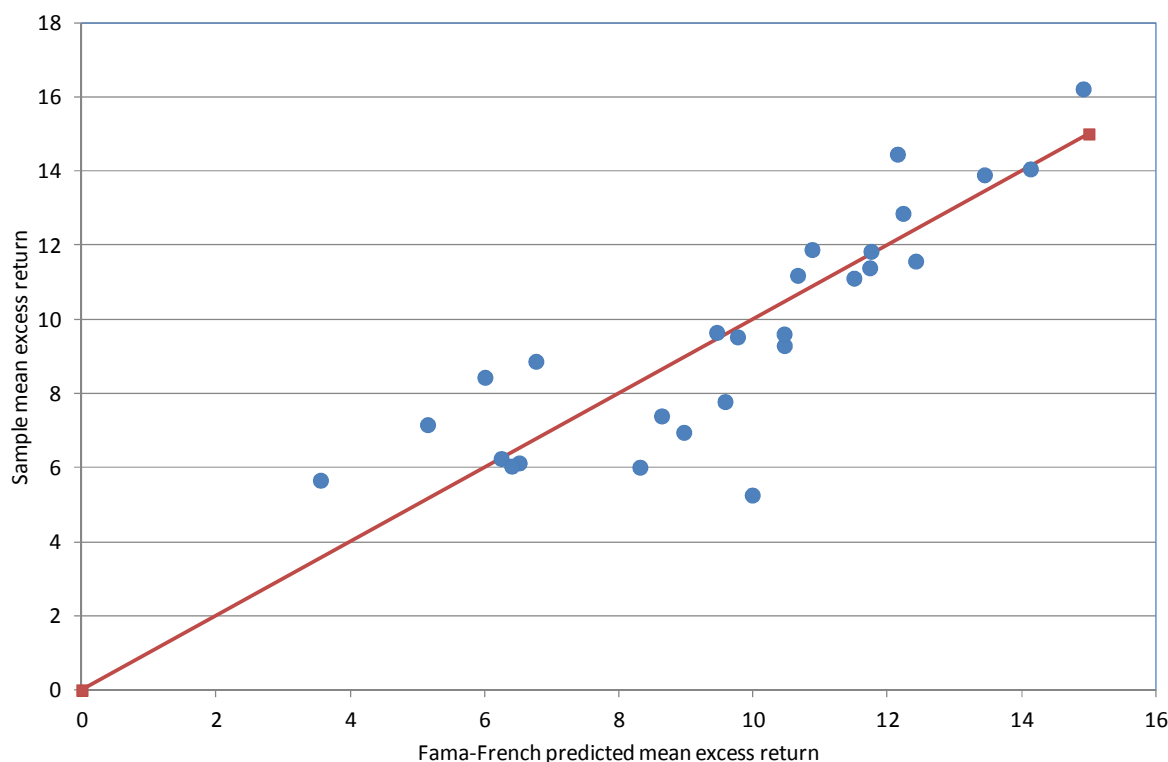
<sup>15</sup> Deviations from no-arbitrage conditions that cannot be explained by taxes or transaction costs are rare and so surprising if found.

<sup>16</sup> Cochrane, J., *Asset pricing*, Princeton University Press, 2001, chapter 20.

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

**Figure 2**

**Sample mean excess return against Fama-French prediction for 25 US portfolios formed on the basis of size and book-to-market and 30 US industry portfolios: Quarterly data from 1963 to 2004**



*Notes: Data are from Ken French's web site and are those used by Lewellen, Nagel and Shanken (2010). The red line plots a line with slope one that passes through the origin. Sample mean excess returns and the Fama-French predictions have been annualised by multiplying the quarterly returns by four and are in per cent per annum.*

*Sources: [http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data\\_library.html](http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html)*

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

While the evidence that Figure 2 presents provides support for the hypothesis that the Fama-French three-factor model generates estimates of the cost of equity that are unbiased, other evidence that Fama and French (2000) and Lewellen, Nagel and Shanken (2010) provide indicates that the model, like the SL CAPM, has a tendency to underestimate the returns required on low-beta assets.<sup>17</sup>

<sup>17</sup> Davis, James, Eugene Fama and Kenneth French, *Characteristics, covariances, and average returns: 1929 to 1997*, Journal of Finance 55, 2000, pages 389-406.

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

## 1. Introduction

This report has been prepared for Jemena Gas Networks (JGN), Jemena Electricity Networks, AusNet Services, Australian Gas Networks, CitiPower, Ergon Energy, Powercor, SA PowerNetworks, and United Energy (the networks) by NERA Economic Consulting (NERA). The networks have asked NERA to review the theoretical and empirical literature on relevant financial models which may be used to estimate the return on equity component of the rate of return, in a way that complies with the requirements of the National Gas Law and Rules and National Electricity Law and Rules. The networks have also asked NERA to respond to matters raised by the Australian Energy Regulator (AER) in its recently published *Draft decision Jemena Gas Networks (NSW) Ltd Access arrangement 2015-20*, in other recent AER decisions and by the AER's advisors.<sup>18</sup>

In particular, the networks have asked NERA to review the theoretical and empirical literature on three asset pricing models:

- the Sharpe-Lintner (SL) CAPM;
- the Black CAPM; and
- the Fama-French three-factor model.

The remainder of this report is structured as follows:

- section 2 describes the theory underlying the three pricing models; and
- section 3 reviews the existing evidence on whether the models can generate unbiased estimates of the cost of equity.

In addition:

- Appendix A provides the terms of reference for this report;
- Appendix B provides a copy of the Federal Court of Australia's *Guidelines for Expert Witnesses in Proceeding in the Federal Court of Australia*; and
- Appendix C provides the curriculum vitae of the author of the report.

### Statement of Credentials

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

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

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<sup>18</sup> AER, *Draft decision Jemena Gas Networks (NSW) Ltd Access arrangement 2015-20 Attachment 3 –Rate of return*, November 2014.



Melbourne, Simon taught finance at the Universities of British Columbia, Chicago, New South Wales, Rochester and Washington.

In preparing this report, the author (herein after referred to as ‘I’ or ‘my’ or ‘me’) confirms that I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld from this report. I acknowledge that I have read, understood and complied with the Federal Court of Australia’s *Practice Note CM 7, Expert Witnesses in Proceedings in the Federal Court of Australia*. I have been provided with a copy of the Federal Court of Australia’s *Practice Note CM 7, Expert Witnesses in Proceedings in the Federal Court of Australia*, dated 4 June 2013, and my report has been prepared in accordance with those guidelines.

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

## 2. Theory

In its Rate of Return Guideline, and again in its Draft Decision for JGN, the AER identifies three asset pricing models that it considers are relevant to the task of estimating the return on equity:<sup>19</sup>

- the SL CAPM;
- the Black CAPM; and
- the Fama-French three-factor model.

In this section, we describe the theory underlying each of these models.

We emphasise that both the SL CAPM and the Black CAPM make assumptions that are unrealistic, and that departures from these assumptions may render the predictions of the two models poor. We also emphasise, however, that we may never know whether the predictions of the models are poor because the predictions concern the behaviour of the return to the market portfolio of *all* risky assets and, as Roll (1977) makes clear, one cannot observe the return.<sup>20</sup>

The AER uses difficulties in testing the predictions that the SL CAPM makes about the behaviour of the return to the market portfolio of *all* risky assets to shield the version of the model that it employs from scrutiny. The version of the model that the AER employs uses the market portfolio of stocks alone as a proxy for the market portfolio of *all* risky assets. The AER, for example, states in the *Appendices* to its *Rate of Return Guidelines* that:<sup>21</sup>

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

We emphasise throughout this report that the AER does not employ a version of the SL CAPM that uses the return to the market portfolio of *all* risky assets. Thus whether the model works when one employs the return to the market portfolio of *all* risky assets is irrelevant to the issue of how the AER should set the return on equity for a regulated energy utility. The AER employs, like almost all practitioners who use the model, a version of the SL CAPM that uses the market portfolio of stocks as a proxy for the market portfolio of *all* risky assets.

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<sup>19</sup> AER, *Better Regulation Rate of Return Guideline*, December 2013, page 13.

AER, *Draft decision Jemena Gas Networks (NSW) Ltd Access arrangement 2015–20 Attachment 3 – Rate of return*, November 2014, page 35.

<sup>20</sup> Roll, R., *A critique of the asset pricing theory's tests: Part I*, *Journal of Financial Economics* 4, 1977, pages 129-176.

<sup>21</sup> AER, *Better Regulation Explanatory Statement Rate of Return Guideline (Appendices)*, December 2013, pages 11-12.

Thus, what is relevant to the issue of how the AER should set the return on equity for a regulated energy utility is whether the version of the SL CAPM that the regulator employs works.

The AER uses the SL CAPM as its ‘foundation’ model and so places this model at the centre of its determination of the cost of equity.<sup>22</sup> We emphasise below, however, that the model is based on a number of assumptions – including assumptions about investor preferences and their ability to borrow and lend at the risk-free rate. The model is not based on the principle that there should not be any arbitrage opportunities available to market participants.<sup>23</sup> So deviations from an empirical version of the model found in the data should not be treated with the suspicion with which one would treat deviations from a no-arbitrage condition. Deviations from an empirical version of the model merely mean an empirical version of the model does not work – they do not indicate that there are unexploited arbitrage opportunities.

In contrast, as we will show, the Fama-French three-factor model can be viewed as being based on the principle that in an efficient market there should be no arbitrage opportunities.

We begin by describing the theory underlying the SL CAPM.

## 2.1. SL CAPM

It is generally accepted that modern portfolio theory originated with the work of Markowitz (1952).<sup>24</sup> It has long been known that it does not pay to put all of one’s eggs in one basket. Markowitz examined how one should distribute the eggs one has across baskets. In particular, Markowitz examined how a risk-averse investor who cares only about the mean and variance of her future wealth should select a portfolio. His insight was that the risk of a portfolio depends largely on how the returns to the assets that make up the portfolio covary with one another and not on how variable the returns are. He emphasized, for example, that a large portfolio of risky assets whose returns are uncorrelated with one another will be virtually risk-free, despite the fact that if any one of the assets were held alone, it would be risky.

In subsequent work, Sharpe (1964) and Lintner (1965) examined how the prices of assets will be determined if all investors choose portfolios that are mean-variance efficient.<sup>25</sup> 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.

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<sup>22</sup> AER, *Better Regulation Rate of Return Guideline*, December 2013, page 4.

<sup>23</sup> Deviations from no-arbitrage conditions that cannot be explained by taxes or transaction costs are rare and so surprising if found.

<sup>24</sup> Markowitz, Harry, *Portfolio selection*, Journal of Finance 7, 1952, pages 77-91.

Markowitz won the Nobel Prize in Economics in 1990 for his work on portfolio theory.

<sup>25</sup> 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.

Sharpe won the Nobel Prize in Economics in 1990 for his work on how assets are priced.

Sharpe and Lintner's insight was that the return that investors will require on an individual asset will be determined not by how risky the asset would be if held alone, but by how the asset contributes to the risk of the market portfolio. A rational risk-averse investor will never invest solely in one single risky asset. In other words, a rational investor will never place all of her eggs in one basket. Instead, she will diversify. So in the SL CAPM an investor will care not about how risky an individual asset would be if held alone, but by how the asset contributes to the risk of the portfolio that she holds – which, in the SL CAPM, is a combination of risk-free borrowing or lending and a share of the market portfolio.

In the SL CAPM, 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.

These assumptions are, of course, unrealistic. Investors almost surely look more than a single period ahead in making their investment decisions. Investors do not share the same beliefs. Investors face taxes and transaction costs and investors face lending rates and borrowing rates that differ. As these assumptions are unrealistic, we examine, later, the impact of departures from the assumptions on the predictions of the model.

In the SL CAPM, all investors hold a portfolio that is mean-variance efficient and a portfolio that is mean-variance efficient is a portfolio that has the highest possible Sharpe ratio. A portfolio's Sharpe ratio is the ratio of the mean return to the portfolio in excess of the risk-free rate to the portfolio's risk, measured by the standard deviation of return.<sup>26</sup> It is the ratio of what is good about a portfolio to what is bad about the portfolio and is a widely used measure of portfolio performance.

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

Figure 2.1 illustrates this idea. In the figure, the hyperbola shows where portfolios of risky assets plot that have the least risk for given mean return. The risk-free asset has no risk and so plots on the vertical axis. Combinations of the risk-free asset and a risky portfolio will plot along a straight line linking the risk-free asset to the portfolio in question. Investor I lends at the risk-free rate and invests the remainder of her wealth in portfolio *M*. This position, *S*, is preferable to a position with the same expected return that contains only risky assets because *S* is less risky. Investor II borrows at the risk-free rate and invests the

<sup>26</sup> The standard deviation of the return to a portfolio is the square root of the variance of the return to the portfolio.

proceeds in portfolio  $M$ . This position,  $P$ , is preferable to a position with the same standard deviation of return that contains only risky assets (and, therefore, incorporates no borrowing at the risk-free rate) because  $P$  offers a higher mean return. The only portfolio of risky assets that investors will hold is portfolio  $M$  and so if all risky assets are to be held,  $M$  must be the market portfolio. In other words, in the SL model the market portfolio must be mean-variance efficient.

In Figure 2.1, the slope of the line  $r_f M$  is the Sharpe ratio of the market portfolio.

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

$$r_j - r_f = \alpha_j + \beta_j[r_p - r_f] + \varepsilon_j, \quad (1)$$

where

$r_j$  = the return to asset  $j$ ;

$r_f$  = the risk-free rate;

$\alpha_j$  = the intercept of the regression;

$\beta_j$  = the slope coefficient of the regression;

$r_p$  = the return to portfolio  $p$ ; and

$\varepsilon_j$  = a zero-mean disturbance that is uncorrelated with  $r_p$ ;

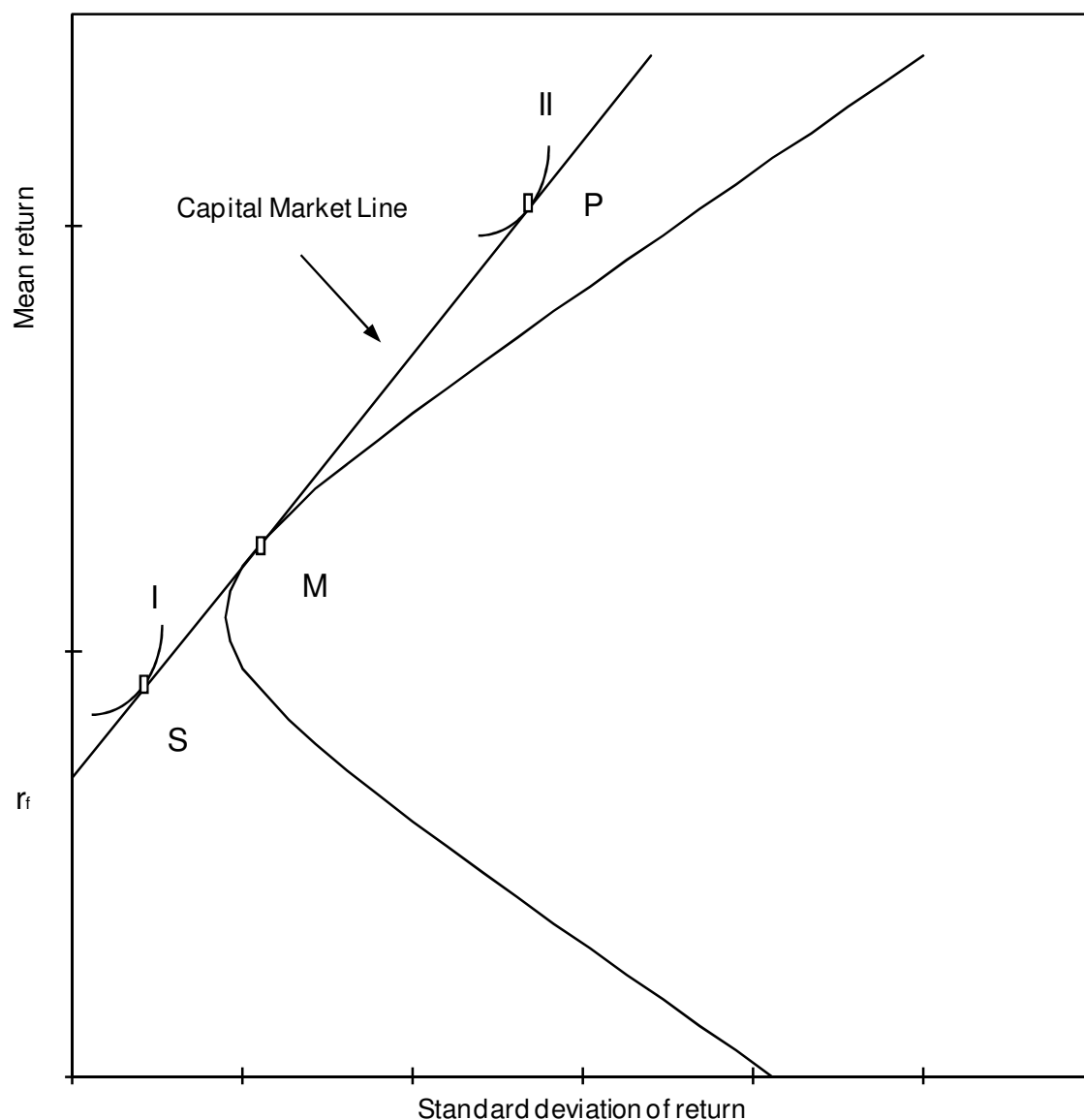
The regression parameters  $\alpha_j$  and  $\beta_j$  can be given economic interpretations.  $\alpha_j$  measures whether adding a small position in asset  $j$  to portfolio  $p$  will create a new portfolio that has a higher Sharpe ratio than  $p$ . If  $\alpha_j > 0$  ( $\alpha_j < 0$ ), then adding a small position in asset  $j$  to portfolio  $p$  will create a new portfolio with a higher (lower) Sharpe ratio.<sup>27</sup>

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

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<sup>27</sup> An asset's alpha is another widely used measure of performance. An asset's alpha can be a sensible measure of performance if one intends to add the asset to a portfolio. It will not be a sensible measure of performance if one intends to hold the asset alone. In contrast, an asset's Sharpe ratio can be a sensible measure of performance if one intends to hold the asset alone. An asset's Sharpe ratio will not be a sensible measure of performance if one intends to add the asset to another portfolio.

**Figure 2.1**  
**Position of the market portfolio in mean return-standard deviation of return space**  
**when the SL CAPM is true**



*Notes: M is the market portfolio. Investor I holds the portfolio S that is a combination of the market portfolio and risk-free lending. Investor II holds the portfolio P that is a combination of the market portfolio and risk-free borrowing. The slope of the line  $r_f M$  is the Sharpe ratio of the market portfolio.*

If the market portfolio of risky assets has the highest Sharpe ratio, then one cannot add a position in an asset to the portfolio to create a new portfolio with a higher Sharpe ratio. If one could do so, then the market portfolio would not have the highest Sharpe ratio.

So for every asset it must be true that the asset's alpha computed relative to the market portfolio is zero and that:

$$E(r_j) = r_f + \beta_j[E(r_m) - r_f], \quad (2)$$

where:

$E(r_j)$  = the mean return to asset  $j$ ; and

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

Equation (2) is the SL CAPM. In the model, the return that an investor requires on an asset in excess of the risk-free rate, is a function only of the asset's beta, and the market price of risk or market risk premium.

So the SL CAPM predicts that:

- there should be a positive linear relation between risk, measured by beta, and return;
- the price of risk should be the market risk premium; and
- the return required on a zero-beta asset should be the risk-free rate.

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 by how the asset contributes to the risk of the market portfolio. Beta measures this contribution.

The analysis above indicates that only if the market portfolio is mean-variance efficient will the simple relation (2) arise. If the market portfolio is inefficient, then the relation between the mean return to an asset and its beta need not be linear and need not be positive. In addition, if the market portfolio is inefficient, the return required on a zero-beta asset need not match the risk-free rate.

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.<sup>28</sup> The empirical version of the model that the AER and others use measures the risk of an asset relative to a portfolio of stocks alone. Stocks have readily available and transparent prices relative to other risky assets such as debt, property and human capital. Stocks, though, make up a relatively small fraction of all risky assets, so the return to a portfolio of stocks need not track closely the return to the market portfolio of *all* risky assets.<sup>29</sup> Thus the empirical version of the SL CAPM that the AER and most

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<sup>28</sup> Roll, R., *A critique of the asset pricing theory's tests: Part I*, Journal of Financial Economics 4, 1977, pages 129-176.

<sup>29</sup> The mean value of an Australian household's direct investment in stocks in 2010 was \$37,505 and the mean value of the household's superannuation account – part of which would have been invested in stocks – was \$142,429. The mean net wealth of a household in 2010 was \$683,805. Thus the average Australian household in 2010 invested no more than  $100 \times (37,505 + 142,429)/683,805 = 26$  per cent of its net non-human wealth in stocks. Baxter and Jermann (1997), however, estimate that human capital for a nation as a whole represents around 60 per cent of total wealth. Thus an estimate of the proportion of total wealth that is invested in stocks will be no more than  $(1 - 0.6) \times 26 = 10.4$  per cent.

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

practitioners who use the model actually employ differs from the theoretical model proposed by Sharpe and Lintner. The empirical version of the model that the AER employs does closely resemble, though, the version that academic work tests.<sup>30</sup>

Roll (1977) points out that difficulties in measuring the return to the market portfolio of *all* risky assets mean that it is not possible to test the SL CAPM.<sup>31</sup> One may be able to reject an empirical version of the model that uses the market portfolio of stocks as a proxy for the market portfolio of all risky assets, but this rejection will not imply that the theoretical model itself is wrong. The issue that concerns us, though, is not whether the theoretical SL CAPM is correct, but whether the empirical version of the SL CAPM applied by the AER and practitioners who use the model works. In other words, we are interested in whether the empirical version of the model that is generally employed by those who use the model will generate unbiased estimates of the return required by a regulated energy utility.

In what follows all references to the empirical performances of the SL CAPM and the Black CAPM, unless otherwise stated, are to the empirical performances of versions of the models that use the market portfolio of stocks as a proxy for the market portfolio of *all* risky assets.

As we emphasise in section 3, the empirical performance of the SL CAPM is poor. The model tends to underestimate the mean returns to low-beta assets, value stocks and, in the US and some other countries, low-cap stocks.<sup>32</sup> A value stock is a stock that has a high book value relative to its market value or, identically, a low market value relative to its book value. A growth stock is a stock that has a low book value relative to its market value or, identically, a high market value relative to its book value.

An interesting question is why the performance of the SL CAPM is so poor. There are two possible explanations:

- the model is right but the proxies typically used for the market portfolio are poor; and
- the model is wrong.

In what follows, we examine how departures from the assumptions made by the SL CAPM may lead to departures from the simple pricing relation (2) linking an asset's mean return to its beta.

Melbourne Institute, *A statistical report on waves 1 to 10 of the Household, Income and Labour Dynamics in Australia Survey*, 2013, page 83.

<sup>30</sup> The only differences between the version of the model that the AER employs and the version that academic work typically tests are that (i) academic work typically employs a one-month bill rate as a measure of the risk-free rate whereas the AER uses a 10-year bond yield and (ii) academic work typically assigns no value to imputation credits whereas the AER assigns a value to imputation credits distributed. An exception to this rule is a paper by Lajbcygier and Wheatley (2012) that tests the model that the AER uses and finds evidence against the proposition that the market places a value on credits distributed and against the hypothesis that a zero-beta portfolio earns the risk-free rate.

Lajbcygier, P. and S.M. Wheatley, *Imputation credits and equity returns*, Economic Record, 2012, page 487.

<sup>31</sup> Roll, R., *A critique of the asset pricing theory's tests: Part I*, Journal of Financial Economics 4, 1977, pages 129-176.

<sup>32</sup> A value stock is a stock that has a high book value relative to its market value or, identically, a low market value relative to its book value. A growth stock is a stock that has a low book value relative to its market value or, identically, a high market value relative to its book value.



### 2.1.1. Investors care only about mean and variance

The first assumption that Sharpe and Lintner make is that investors are risk averse, choose between portfolios on the basis of the mean and variance of their returns and plan only for a single period ahead.

It is generally accepted that for all intents and purposes investors are risk averse. On the other hand, even casual observation indicates that investors plan more than a single period ahead. If investors plan more than a single period ahead, then, in general, they will not choose between portfolios on the basis of solely the mean and variance of the returns to the portfolios.<sup>33</sup>

If investors do plan only a single period ahead, then they will choose between portfolios on the basis of the mean and variance of the return to each portfolio if:

- investors display quadratic utility; or
- the returns to individual risky assets are multivariate normal.

The assumption that investors display quadratic utility implies that they will care only about the mean and variance of the return to a portfolio but also implies that they will display increasing absolute risk aversion.<sup>34</sup> In a world in which a single risk-free asset and a single risky asset exist, investors who display increasing absolute risk aversion will choose to hold less of the risky asset as their wealth rises.<sup>35</sup> This is not the kind of behaviour one would expect to see. So the more commonly adopted justification for the assumption that investors choose between portfolios on the basis of the mean and variance of their returns in a single-period framework is that the returns to individual risky assets are multivariate normal.<sup>36</sup> If the returns to individual risky assets are multivariate normal, then the return to a portfolio of the assets will be normally distributed and the distribution of the return to the portfolio will be completely characterised by its mean and variance.

Harvey and Siddique (2000) provide evidence against the hypothesis that the returns to risky assets are multivariate normal.<sup>37</sup> They, like Kraus and Litznberger (1976), show that if investors do not display quadratic utility and returns are not multivariate normal, then, in general, the predictions of the SL CAPM will not hold. Instead, the mean return to an asset will depend not solely on the asset's beta but on its co-skewness – the covariance of the return to the asset with the square of the return to the market portfolio.<sup>38</sup>

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<sup>33</sup> Merton, R.C., *An intertemporal capital asset pricing model*, *Econometrica* 41, 1973, pages 867-887.

<sup>34</sup> Ingersoll, J., *Theory of financial decision making*, Rowman and Littlefield, New York, 1987, page 96.

<sup>35</sup> If there is a single risky asset, then the asset will constitute the market portfolio of risky assets.

<sup>36</sup> Ingersoll, J., *Theory of financial decision making*, Rowman and Littlefield, New York, 1987, page 96.

<sup>37</sup> Harvey, C. and A. Siddique, *Conditional skewness in asset pricing tests*, *Journal of Finance*, 2000, pages 1263-1295.

<sup>38</sup> Kraus, A. and R. Litznberger, *Skewness preference and the valuation of risk assets*, *Journal of Finance*, 1976, pages 1085-1100.

The assumption that investors plan only for a single period ahead implies that investors will not attempt to hedge against changes in the investment opportunities that are available to them. Merton (1973) shows that in general if investors plan more than a single period ahead and can hedge against changes in the investment opportunity set, then they will do so and, as a result, the predictions of the SL CAPM will not hold.<sup>39</sup> Intuitively, investors may view assets that pay off well when future investment opportunities are attractive as more valuable than assets that pay off badly because they will be better able to take advantage of the opportunities. So, all else constant, investors may be willing to accept a lower return on these assets. As Merton shows, this means that, in general, risks other than just the risk of an asset relative to the market, the asset's beta, will be priced.

### **2.1.2. Investors share the same beliefs**

The second assumption that Sharpe and Lintner make is that investors share the same beliefs about the distribution of returns.

The dispersion in analyst forecasts for stock prices strongly suggests that even informed investors do not share the same beliefs about the distribution of returns.

Recent analyses of what impact heterogeneous beliefs will have on the way in which assets are priced typically use multi-period frameworks in which the investment opportunity set can shift through time. Fama (1976), however, examines the impact of heterogeneous beliefs on the way in which assets are priced in a single-period mean-variance framework.<sup>40</sup> With heterogeneous beliefs, investors will typically disagree about the identity of portfolios that are efficient. So what may represent an efficient portfolio for one investor need not represent an efficient portfolio for another investor who has a different set of beliefs. As a result, the simple relation linking the mean return on an asset to its beta, given by (2), will no longer hold.

### **2.1.3. No taxes**

The third assumption that Sharpe and Lintner make is that investors either face no taxes or the same taxes on all forms of income.

Investors do not in general face the same taxes on all forms of income.

Long (1977) assumes that investors face different rates of tax on capital gains and dividends but that all investors face the same rate of tax on capital gains and that all investors face the same rate of tax on dividends.<sup>41</sup> With these assumptions, he provides a necessary and sufficient condition under which portfolios that are mean-variance efficient on a before-tax basis are also efficient on an after-tax basis and vice versa. He concludes that the condition is unlikely to be satisfied. Thus, if the market portfolio is efficient on an after-tax basis, it is

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<sup>39</sup> Merton, R.C., *An intertemporal capital asset pricing model*, *Econometrica* 41, 1973, pages 867-887.

<sup>40</sup> Fama, E.F., *Foundations of finance*, Basic Books, New York, 1976, pages 314-319.

<sup>41</sup> Long, J.B., *Efficient portfolio choice with differential taxation of dividends and capital gains*, *Journal of Financial Economics*, 1977, pages 25-53.

unlikely that it will be efficient on a before-tax basis and the simple relation linking the mean before-tax return on an asset to its beta, given by (2), is unlikely to hold. In other words, under the assumptions that Long makes about taxes, which better reflect reality, the relation linking the mean before-tax return on an asset to its beta, given by (2), is unlikely to hold.

#### 2.1.4. Investors can borrow and lend at a single risk-free rate

The fourth assumption that Sharpe and Lintner make is that investors can borrow and lend unlimited amounts at a single risk-free rate of interest.

As a practical matter borrowing rates exceed lending rates and the extent to which an investor can borrow will depend on the investor's credit worthiness.

Markowitz (2005) suggests that the assumption that investors can borrow or lend unlimited amounts at a single risk-free rate is unrealistic.<sup>42</sup> Markowitz examines the impact of relaxing the assumption that investors can borrow or lend unlimited amounts at a single risk-free rate while retaining an assumption that investors cannot short sell. He shows that if one relaxes the assumption that investors can borrow or lend unlimited amounts, the SL CAPM will no longer hold. In particular, Markowitz states that:<sup>43</sup>

'The assumption that the investor can borrow without limit is crucial to the Sharpe-Lintner model's conclusions. As illustrated later in this article, if we accept the other three CAPM assumptions but assume limited (or no) borrowing, the Sharpe-Lintner conclusions no longer follow.'

'(If) we assume the first three premises of the Sharpe-Lintner CAPM but take into account the fact that investors have limited borrowing capacity, then it no longer follows that the market portfolio is efficient. As this article will illustrate, this inefficiency of the market portfolio could be substantial and it would not be arbitrated away even if some investors could borrow without limit.'

'(T)he original CAPM, with unlimited borrowing ... (implies) that the expected return of a stock depends in a simple (linear) way on its beta, and only on its beta. This conclusion has been used for estimating expected returns, but it has lost favor for this use because of poor predictive results. It is still used routinely in "risk adjustment," however, for valuing assets and analyzing investment strategies on a "risk-adjusted basis." I will show here that the conclusion that expected returns are linear functions of beta does not hold when real-world limits on permitted portfolio holdings are introduced into the CAPM. This discussion will call into question the frequent use of beta in risk adjustment.'

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<sup>42</sup> Markowitz, H.M., *Market efficiency: A theoretical distinction and so what?* Financial Analysts Journal 61, 2005, pages 17-30.

<sup>43</sup> Markowitz, H.M., *Market efficiency: A theoretical distinction and so what?* Financial Analysts Journal 61, 2005, pages 17-18.

Also, Markowitz makes clear that he believes that the problems associated with empirical versions of the SL CAPM would *not* disappear were one to be provided with a series of returns to the market portfolio of *all* assets. For example, Markowitz states that:<sup>44</sup>

‘A frequent explanation of why observed expected returns do not appear to be linearly related to betas is that the measures of market return used in the tests do not measure the true, universal market portfolio that appears in the CAPM. The conclusion is that to test the CAPM, we need to measure returns on a cap-weighted world portfolio. The preceding discussion implies, however, that before spending vast resources on ever finer approximations to returns on this cap-weighted universal portfolio, we should note that CAPM Conclusion 2 (that expected returns are linearly related to betas) is not likely to be true if real-world constraints are substituted for (the assumption that the Sharpe-Lintner CAPM makes of unlimited borrowing opportunities).’

While the SL CAPM is an attractively simple theory, it has been known for well over 40 years that empirical versions of the model tend to underestimate the returns to low-beta assets and overestimate the returns to high-beta assets. Mehrling (2005), for example, reports that:<sup>45</sup>

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

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.<sup>46</sup>

## 2.2. Black CAPM

Black (1972) examines a world in which investors face no short-sale restrictions but cannot borrow or lend, Vasicek (1971) examines a world in which investors face no short-sale constraints but cannot borrow and Brennan (1971) examines a world in which investors face no short-sale restrictions and can borrow and lend at risk-free rates that differ from one another.<sup>47</sup> In addition, Black summarises the results that Vasicek produces. All three models

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<sup>44</sup> Markowitz, H.M., *Market efficiency: A theoretical distinction and so what?* Financial Analysts Journal 61, 2005, pages 28.

<sup>45</sup> Mehrling, Perry, *Fischer Black and the revolutionary idea of finance*, Wiley, 2005, pages 104-105.

<sup>46</sup> 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.

<sup>47</sup> Black, Fischer, *Capital market equilibrium with restricted borrowing*, Journal of Business 45, 1972, pages 444-454.

predict that the market portfolio of risky assets will be mean-variance efficient relative to portfolios constructed solely from risky assets.

If the market portfolio of risky assets is mean-variance efficient relative to portfolios constructed solely from risky assets, then:

$$E(r_j) = E(r_z) + \beta_j [E(r_m) - E(r_z)], \quad (3)$$

where:

$E(r_z)$  = the mean return on a zero-beta portfolio.

Although three authors contributed to the development of (3), the model is generally known simply as the ‘Black CAPM’ and, unless otherwise stated, we will follow the tradition here.<sup>48</sup>

While each of the models that Black (1972), Vasicek (1971) and Brennan (1971) derive predicts that the cross-section of mean returns to risky assets will be described by (3), the models place different restrictions on the mean return to a zero-beta portfolio:<sup>49</sup>

- Black’s model places no restriction on the zero-beta rate other than it must lie below the mean return to the market portfolio;
- Vasicek’s model places the additional restriction on the zero-beta rate that it must lie above the risk-free lending rate; and
- Brennan’s model places the additional restriction on the zero-beta rate that it must lie below the risk-free borrowing rate.

Note, however, of the three models, Brennan’s model is the most general – Black’s model and Vasicek’s model are special cases of Brennan’s model. In Brennan’s model, all risk-free borrowing will cease when the borrowing rate is set sufficiently high. In other words, if the borrowing rate is set sufficiently high, Brennan’s model will collapse to the simpler model that Vasicek examines. Similarly, in Brennan’s model, both risk-free borrowing and lending will cease when the borrowing rate is set sufficiently high and the lending rate is set sufficiently low.<sup>50</sup> In other words, if the borrowing rate is set sufficiently high and the

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.

<sup>48</sup> See, for example:

Bodie, Z., A. Kane and A.J. Marcus, *Investments*, McGraw-Hill Irwin, New York, 2002, page 277.

Ingersoll, *Theory of financial decision making*, Rowman and Littlefield, Maryland, 1987, chapter 4.

<sup>49</sup> 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.

<sup>50</sup> An example of a low lending rate would be minus 90 per cent per day.

lending rate is set sufficiently low, Brennan's model will collapse to the simpler model that Black examines – and the constraint that the zero-beta rate lie between the borrowing and lending rates will not bind. If, on the other hand, in Brennan's model, the borrowing and lending rates converge on one another, then the model collapses to the SL CAPM. Thus Brennan's model is a more general model than Sharpe and Lintner's model.

It is important to recognise that 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 be mean-variance efficient.<sup>51</sup> The Black CAPM states that the risk of an asset should be measured relative to the market portfolio of all risky assets whereas empirical versions of the model measure the risk of an asset relative to a portfolio of stocks alone. It follows that one should *not* expect the zero-beta rate in an empirical version of the model to necessarily lie between the risk-free borrowing and lending rates. This is because the Black CAPM does not impose the restriction that the mean return to a portfolio that has a zero beta relative to the market portfolio of *stocks* must lie between the risk-free borrowing and lending rates.

Again, the idea that poor proxies are responsible for any evidence against the model will be of little assistance because it is these proxies that one will have to use in employing the model.

By construction, the Black CAPM eliminates the tendency of the SL CAPM to underestimate the returns to low-beta assets and overestimate the returns to high-beta assets. The model does not, though, eliminate the tendency of the SL CAPM to underestimate the returns to value stocks and, in the US and some other countries, low-cap stocks.

As with the SL CAPM, there are two possible explanations for why the performance of an empirical version of the Black CAPM appears to be poor:<sup>52</sup>

- the model is right but the proxies employed for the market portfolio are poor; and
- the model is wrong.

Departures from the assumptions that the Black CAPM makes can lead to the model being wrong. The Black CAPM replaces the fourth assumption that the SL CAPM makes, that investors can borrow and lend unlimited amounts at a single risk-free rate of interest, with the assumption that there are no restrictions on short sales. As a practical matter there are restrictions on short sales. A short sale is the sale of shares that the seller does not own but is committed to repurchasing at some date in the future.

### 2.2.1. No restrictions on short sales

To sell short, one must pay a fee and there also legal and institutional constraints that inhibit investors from selling short (see, for example, Jones and Lamont (2002)).<sup>53</sup>

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<sup>51</sup> Roll, Richard, *A critique of the asset pricing theory's tests: Part I*, Journal of Financial Economics 4, 1977, pages 129-176.

<sup>52</sup> The poor performance to which we refer here is the difficulty that the Black CAPM has in pricing value stocks and low-cap stocks. The SL CAPM also has difficulty in pricing value stocks and low-cap stocks.

Markowitz (2005) suggests that the assumption that there are no constraints on short sales is unrealistic and that the Black CAPM – what he labels an alternate version of the CAPM – is likely to be wrong.<sup>54</sup> For example, Markowitz states that:<sup>55</sup>

‘An alternate version of the CAPM speaks of investors holding short as well as long positions. But the portfolios this alternate CAPM permits are as unrealistic as those of the Sharpe-Lintner CAPM with unlimited borrowing.’

Markowitz also makes clear that he believes that the problems associated with empirical versions of the Black CAPM would *not* disappear were one to be provided with a series of returns to the market portfolio of *all* assets. Thus Markowitz believes that the assumptions that both the SL CAPM and Black CAPM make are unrealistic and that replacing these assumptions by more realistic assumptions would remove the implication of both models that there should be a positive linear relation between risk, measured by beta, and return.

Ross (1976) provides a no-arbitrage framework that is an alternative to the mean-variance framework of Sharpe, Lintner and Black.<sup>56</sup> While Sharpe and Lintner assume that no investor faces borrowing constraints and Black assumes that no investor faces short-sale constraints, Ross assumes only that at least one investor faces no borrowing or short-sale constraints. In the Arbitrage Pricing Theory (APT) of Ross investors are rewarded for risks that are pervasive and that they cannot diversify away but are not 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. An arbitrage opportunity offers a positive return with no investment or risk undertaken. The no-arbitrage principle is a cornerstone of modern finance and applications of the principle to corporate finance and to the pricing of derivatives have led to Nobel Prizes for Miller, Merton and Scholes.<sup>57</sup>

A stock’s price will depend on the cash flows that the stock is expected to provide and on the rate at which the market will discount the cash flows. So the cross-section of stock prices should contain useful information about the cross-section of mean returns to stocks. A stock whose price is low is, all else constant, a stock whose mean return is likely to be high. A stock whose price is high is, all else constant, a stock whose mean return is likely to be low. A stock’s price, however, will also depend on factors like the number of shares of the stock that are outstanding. A stock’s price, for example, will fall by approximately one half when a two-for-one stock split is executed. For this reason, financial ratios in which price sits either in the denominator or numerator are more likely to track variation across stocks in mean returns than are prices that have not been scaled in some way.

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<sup>53</sup> Jones, C.M. and O.A. Lamont, *Short-sale constraints and stock returns*, Journal of Financial Economics, 2002, pages 207-239.

<sup>54</sup> Markowitz, H.M., *Market efficiency: A theoretical distinction and so what?* Financial Analysts Journal 61, 2005, pages 17-30.

<sup>55</sup> Markowitz, H.M., *Market efficiency: A theoretical distinction and so what?* Financial Analysts Journal 61, 2005, page 18.

<sup>56</sup> Ross, Stephen, *The arbitrage theory of capital asset pricing*, Journal of Economic Theory 13, 1976, pages 341-360.

<sup>57</sup> [http://www.nobelprize.org/nobel\\_prizes/economic-sciences/laureates/](http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/)

Ball (1978) emphasises that financial ratios may provide information about the cross-section of mean returns to stocks not provided by estimates of beta.<sup>58</sup> Similarly, Berk (1995) emphasises that the market value of a firm's equity may provide information about the cross-section of returns to stocks not provided by estimates of beta.<sup>59</sup> Fama and French (1992) show that the market value of a firm's equity and the ratio of the book value of the equity to its market value do not just provide information about the equity's return not provided by an estimate of the equity's beta, but they provide information whereas the estimate of the equity's beta does not.<sup>60</sup> Fama and French (1993) argue that if assets are priced rationally, then variables, like the market value of a firm's equity and the ratio of the book value of equity to its market value, which can explain the cross-section of mean returns *must* be proxies for risks that cannot be diversified away.<sup>61</sup>

### 2.3. Fama-French Three-Factor Model

Fama and French (1993) suggest that:<sup>62</sup>

- (a) the excess return to the market portfolio;
- (b) 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
- (c) the difference between the return to a portfolio of small-cap stocks and the return to a portfolio of large-cap stocks (*SMB*)

are proxies for shared and thus undiversifiable risk factors. If the following conditions are true:

- (i) there are no arbitrage opportunities;
- (ii) a risk-free asset exists; and
- (iii) the excess return to the market, *HML* and *SMB* fully capture any pervasive sources of risk,

then:

$$E(r_j) = r_f + b_j[E(r_m) - r_f] + h_jE(HML) + s_jE(SMB), \quad (4)$$

where:

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<sup>58</sup> Ball, R., *Anomalies in relationships between securities' yields and yield surrogates*, Journal of Financial Economics, 1978, pages 103-126.

<sup>59</sup> Berk, J., *A critique of size-related anomalies*, Review of Financial Studies, 1995, pages 275-286.

<sup>60</sup> Fama, Eugene and Kenneth French, *The cross-section of expected returns*, Journal of Finance 47, 1992, pages 427-465.

<sup>61</sup> Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

<sup>62</sup> Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.



$b_j, h_j$  and  $s_j$  are the slope coefficients from a multivariate regression of  $r_j$  on  $r_m$ ,  $HML$  and  $SMB$ , and  $E(HML)$  and  $E(SMB)$  are the  $HML$  and  $SMB$  premiums.

We explain below whether assumption (i) is likely to hold and whether Fama and French provide evidence to support (iii). We also explain why assumptions (i) to (iii) imply that the pricing relation (4) should hold, at least approximately, in the data that Fama and French use.

### 2.3.1. No arbitrage opportunities

An arbitrage opportunity offers a positive return with no investment or risk undertaken. If there is anything about which economists can agree, it is that arbitrage opportunities in the market place should be difficult to identify.

Of course, for an investor to be able to take full advantage of an arbitrage opportunity requires that the investor face either no borrowing constraints or no short sale constraints.<sup>63</sup> Again, however, whereas the Black CAPM requires *all* investors face no short-sale constraints, for there to be no arbitrage opportunities it is only necessary that *at least one* investor face no short-sale constraints. Thus the assumption necessary for there to be no arbitrage opportunities is less restrictive than the assumption of no short-sale constraints necessary for the Black CAPM to hold.

### 2.3.2. HML and SMB capture pervasive sources of risk

Fama and French (1993) form 25 portfolios on the basis of the book-to-market ratios and market capitalisations of US stocks. Using data from July 1963 to December 1991 they regress the returns to these portfolios in excess of the one month risk-free rate on the three Fama-French factors.

The  $R^2$  values attached to these time series regressions range from 0.83 to 0.97.<sup>64</sup>  $R^2$ , known as the coefficient of determination, represents the fraction of the variation in a dependent variable explained by variation in a set of independent variables. Thus a regression that has an  $R^2$  that is close to one is a regression in which the set of independent variables comes close to fully explaining variation in the dependent variable. It follows that the high  $R^2$  values that Fama and French report indicate that one could almost replicate the returns to the 25 portfolios using the three Fama-French factors. If the  $R^2$  values were all equal to 1.00, one would be able to replicate the returns to the portfolios exactly.

Estimates of the Fama-French betas of the 25 portfolios relative to the excess return to the market range from 0.91 to 1.18. Thus the portfolios all have Fama-French betas relative to the market factor that are around one. In contrast, estimates of the betas of the 25 portfolios relative to the  $HML$  factor range from -0.52 to 0.76 and estimates of the betas relative to the

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<sup>63</sup> This is because to take full advantage of an arbitrage opportunity, an investor will need to go long one asset or portfolio and short another.

<sup>64</sup> Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

*SMB* factor range from -0.23 to 1.46. Thus the 25 portfolios that Fama and French construct have a variety of exposures to the *HML* and *SMB* factors.

Together these pieces of evidence indicate that one can form up portfolios of US stocks with different exposures to the *HML* and *SMB* factors in which virtually all but an exposure to the three Fama-French factors is diversified away. In other words, the evidence that Fama and French provide suggests that the *HML* and *SMB* factors capture pervasive sources of risk – at least in US data.

It may be, on the other hand, that the excess return to the market portfolio, *HML* and *SMB* do not fully capture all pervasive sources of risk. As Fama and French (2004) point out, another pervasive source of risk may be linked to momentum in stock returns.<sup>65</sup> They emphasise, however, that since momentum is short-lived, it is largely irrelevant for constructing estimates of the cost of capital.

### 2.3.3. Implications

The mean excess returns to the 25 portfolios, that Fama and French form, range from 4.68 per cent per annum to 12.60 per cent per annum while estimates of their SL betas range from 0.84 to 1.40. So the evidence that Fama and French provide suggests that an empirical version of the SL CAPM cannot describe the data that they assemble. Instead, as Cochrane (2001) points out, the evidence that Fama and French provide suggests that, to rule out near-arbitrage opportunities, their three-factor model must be approximately true. Cochrane states that:<sup>66</sup>

‘extremely high Sharpe ratios for the residuals would have to be invoked for the [Fama-French] model *not* to fit well. Equivalently, 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.’

[The emphasis is Cochrane’s]

The Sharpe ratio, again, is the ratio of the mean return to a portfolio in excess of the risk-free rate to the risk, measured by standard deviation of return, which one must bear in holding the portfolio.

To illustrate the point that Cochrane makes, we use a numerical example drawn from the results that Fama and French provide. In particular, we use various statistics for the small/high (low market capitalisation and high book-to-market) portfolio and the three factors, that Fama and French supply. These statistics appear in Table 2.1 below.

The argument that Cochrane makes is that if the Fama-French model were not to hold for the 25 portfolios that Fama and French construct, but instead the mean returns to the portfolios

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<sup>65</sup> Fama, E. and K. French, *The Capital Asset Pricing Model: Theory and evidence*, Journal of Economic Perspectives, 2004 pages 25-46.

<sup>66</sup> Cochrane, John H., *Asset pricing*, Princeton University Press, 2001, page 442.

were to be determined by the SL CAPM, there would be near-arbitrage opportunities. To see that this would be the case, consider an arbitrage strategy that is:

- short a zero-investment position that is long the small/high portfolio and short the risk-free asset;<sup>67</sup> and
- long a synthetic version of the zero-investment position constructed from the three Fama-French factors.<sup>68</sup>

The return to the arbitrage strategy will be:

$$\left[ b_j(r_m - r_f) + h_j HML + s_j SMB \right] - \left[ r_j - r_f \right] \quad (5)$$

The second term in brackets is the return to the zero-investment position that is long the small/high portfolio and short the risk-free asset. The first term is the return to a synthetic version of the zero-investment position constructed from the three Fama-French factors.

The results that Fama and French provide, summarised in Table 2.1, indicate that the mean return to the strategy, were the mean return to the small/high portfolio to be determined by the SL CAPM, would be in per cent per annum:

$$\begin{aligned} & \left[ b_j E(r_m - r_f) + h_j E(HML) + s_j E(SMB) \right] - \left[ \beta_j E(r_m - r_f) \right] \\ & = \left[ 0.96 \times 5.16 + 0.62 \times 4.80 + 1.23 \times 3.24 \right] - \left[ 1.08 \times 5.16 \right] = 6.34 \end{aligned} \quad (6)$$

The standard deviation of the return to the strategy will be, in per cent per annum, again using the results that appear in Table 2.1:

$$\sigma(\eta_j) = \sigma(r_j) \times \sqrt{1 - R_j^2} = 21.72 \times \sqrt{1 - 0.96} = 4.34 \quad (7)$$

where:

- $\sigma(\eta_j)$  = the standard deviation of the disturbance from a regression of the excess return to portfolio  $j$  on the three Fama-French factors;
- $\sigma(r_j)$  = the standard deviation of the return to portfolio  $j$ ; and
- $R_j^2$  = the  $R^2$  from a regression of the excess return to portfolio  $j$  on the three Fama-French factors.

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<sup>67</sup> A zero-investment position involves no investment. An example of a zero-investment position would be a purchase of \$100 of stock financed entirely by borrowing \$100 from a bank. If after a year the position in the stock were to have delivered a higher return than the cost of borrowing \$100 from the bank, then the zero-investment position would have delivered a positive return.

<sup>68</sup> A synthetic version of a position is one constructed from other assets that mimics as closely as possible the return to the position.

Thus, if the mean return to the small/high portfolio were to be determined by the SL CAPM, the strategy would have a Sharpe ratio attached to it of  $6.34 \div 4.34 = 1.46$  – a high enough Sharpe ratio for the strategy to be described as a near-arbitrage opportunity. Other strategies that involve combining positions in a number of the 25 portfolios that Fama and French form may generate even larger Sharpe ratios. The Sharpe ratio for the market, in contrast, is, from Table 2.1, just 0.33, for the *HML* factor, 0.55, and for the *SMB* factor 0.32.

If, of course, the mean return to the small/high portfolio were to be determined by the Fama-French model, the near-arbitrage opportunity that we describe would vanish.

**Table 2.1**  
**Statistics for the small/high portfolio and the three factors drawn from the results that Fama and French (1993) provide: US data from 1963 to 1991**

Statistic	Excess returns		Factors	
	Small/High	Market	<i>HML</i>	<i>SMB</i>
Mean	12.12	5.16	4.80	3.24
Std. dev.	21.72	15.73	8.80	10.01
Sharpe ratio	0.56	0.33	0.55	0.32
$\beta_j$	1.08			
$b_j$	0.96			
$h_j$	0.62			
$s_j$	1.23			
Fama-French R <sup>2</sup>	0.96			

*Notes: Means are in per cent per annum and have been computed by multiplying the monthly data that Fama and French (1993) provide by 12. Standard deviations are also in per cent per annum and have been computed by multiplying the monthly data that Fama and French (1993) provide by  $\sqrt{12}$ .*

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

### 3. Evidence

Regulated and unregulated firms use asset pricing models to construct estimates of the cost of equity. The costs of choosing a model, however, that delivers a poor estimate of the cost of equity will in general be greater for a regulated firm than for an unregulated firm. As Grout (1995) makes clear:<sup>69, 70</sup>

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

[The emphasis is ours]

In this section we examine the existing literature on the empirical performance of the three models:

- the SL CAPM;
- the Black CAPM; and
- the Fama-French three-factor model.

In particular, we examine whether the existing literature indicates that estimates of the cost of equity that the three models produce are unbiased.

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<sup>69</sup> Grout, P., *The cost of capital in regulated industries*, in M. Bishop, J. Kay and C. Mayer (eds.), *The regulatory challenge*, Oxford University Press, 1995, pages 386-407.

<sup>70</sup> It is obvious that here Grout intends a ‘precise estimate’ to be an accurate estimate rather than solely an estimate to which is attached a low standard error.

The Oxford Dictionary definition of precision is:

‘accuracy or exactness.’

In statistics the precision of a random variable is the reciprocal of its variance. So in statistics a precise estimator can be exact but inaccurate.

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

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

Determining whether a model delivers estimates of the cost of equity that are biased or unbiased is important if the prices of the services that regulated utilities provide are to be set appropriately. Evidence that a model delivers estimates of the cost of equity that are upwardly biased will indicate that use of the model would tend to lead to prices being set too high. Evidence that a model delivers estimates of the cost of equity that are downwardly biased will indicate that use of the model would tend to lead to prices being set too low.

Of course, realised returns will, in general, differ from expected or required returns. Tests of asset pricing models, however, if correctly executed, take this fact into account. In the same way, one can conduct tests of the null hypothesis that a die is fair that take into account the fact that, under the null, each throw of the die results in an outcome that is random.

The SL CAPM and the Fama-French three-factor model restrict the zero-beta rate to be the risk-free rate. Equivalently, they restrict the zero-beta premium – defined to be the difference between the zero-beta rate and risk-free rate – to be zero. Our review of the evidence indicates that there is overwhelming evidence against the restriction that the zero-beta premium is zero both in Australian data and in US data. The evidence indicates that for both the SL CAPM and the Fama-French three-factor model, the zero-beta premium is positive – that is, the zero-beta rate exceeds the risk-free rate. Since the equity of a regulated energy utility has a low SL beta and a low Fama-French market beta this evidence indicates that both models will tend to underestimate the cost of equity for a regulated energy utility.

The SL CAPM and the Black CAPM restrict the relation between mean return and beta to be linear. In other words, both models imply that no variable other than beta should be able to explain the cross-section of mean returns. Our review of the evidence indicates that there is also overwhelming evidence against this restriction both in Australian data and in US data. Both the Australian evidence and the US evidence indicate that book-to-market explains variation in the mean returns to stocks unexplained by variation in beta. In particular, the evidence indicates that both the SL CAPM and the Black CAPM tend to underestimate the returns required on value stocks. Since the equity of a regulated energy utility has a positive exposure to an Australian *HML* factor, this evidence indicates that both models will tend to underestimate the cost of equity for the utility. The US evidence also indicates that size explains variation in the mean returns to stocks unexplained by variation in beta.

Several references have been made by the AER and its advisors to the work of Roll (1977). The argument that appears to have been made is that:

- because one cannot observe the return to the market portfolio of *all* risky assets; and
- because the results of tests of the CAPM can be sensitive to the choice of a proxy for the market portfolio of all assets,

one can dismiss the overwhelming evidence against an empirical version of the model and use the empirical version of the model anyway. For example, the AER states in its 2011

*Envestra Final Decision* that:<sup>71</sup>

‘The AER considers that there is no reasonable basis to conclude that the standard CAPM implemented by the AER results in a bias. The AER acknowledges that the classical tests of the CAPM (following the 1972 Black, Jensen and Scholes paradigm) find that the realised return on shares with equity betas less than (more than) one is higher (lower) than that predicted by the CAPM. However, any interpretation of this result must first have regard to the problems with testing the CAPM in this manner, including reliance on invalid proxies and inappropriate statistical procedures. The AER considers that the empirical finding of ‘low beta bias’ plausibly arises from the flaws in this type of testing, rather than any deficiency in the CAPM.’

‘The AER considers that the CAPM remains the pre-eminent asset pricing model, and that it provides a reasonable basis from which to estimate the cost of equity, as is required by r. 74(2) of the NGR.’

‘The seminal 1977 paper by Roll supports the position that the ‘low beta bias’ empirical finding results from a problem with the test (a mis-specified market portfolio) not a problem with the underlying CAPM.’

As another example, the AER states in its 2013 *Rate of Return Consultation Paper* that:<sup>72</sup>

‘Empirical findings of a low-beta bias in the Sharpe-Lintner CAPM, for example, plausibly arose from flaws in testing methods (rather than any deficiencies in the model itself). These flaws included relying on invalid proxies.’

‘We have used the Sharpe-Lintner CAPM to determine the return on equity in each of our access arrangements and determinations to date.’

As we note in section 2, the empirical version of the SL CAPM that the AER and most practitioners who use the model employ measures the risk of an asset relative to a portfolio of stocks. So the empirical version of the SL CAPM that the AER actually employs differs from the theoretical model proposed by Sharpe and Lintner. Thus the issue that concerns us is not whether the theoretical SL CAPM is correct, but whether the empirical version of the SL CAPM applied by the AER works. In particular, we are interested in whether the empirical version of the model that the AER uses allows the AER to generate unbiased estimates of the return required by a regulated energy utility. Fortunately, the empirical version of the SL CAPM that the AER employs resembles the empirical version of the model that the academic literature tests. So a review of the empirical literature that tests an empirical version of the SL CAPM is relevant to determining whether estimates provided by the empirical version of the SL CAPM that the AER employs meet Rule 87 of the National Gas Rules and clauses 6A.6.2 (for electricity transmission) and 6.5.2 (for electricity distribution) of the National Electricity Rules.

Again, in what follows all references to the empirical performances of the SL CAPM and the Black CAPM, unless otherwise stated, will be to the empirical performances of versions of

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<sup>71</sup> AER, *Final decision Envestra Ltd: Access arrangement proposal for the SA gas network 1 July 2011 – 30 June 2016*, June 2011, pages 45, 46 and 169.

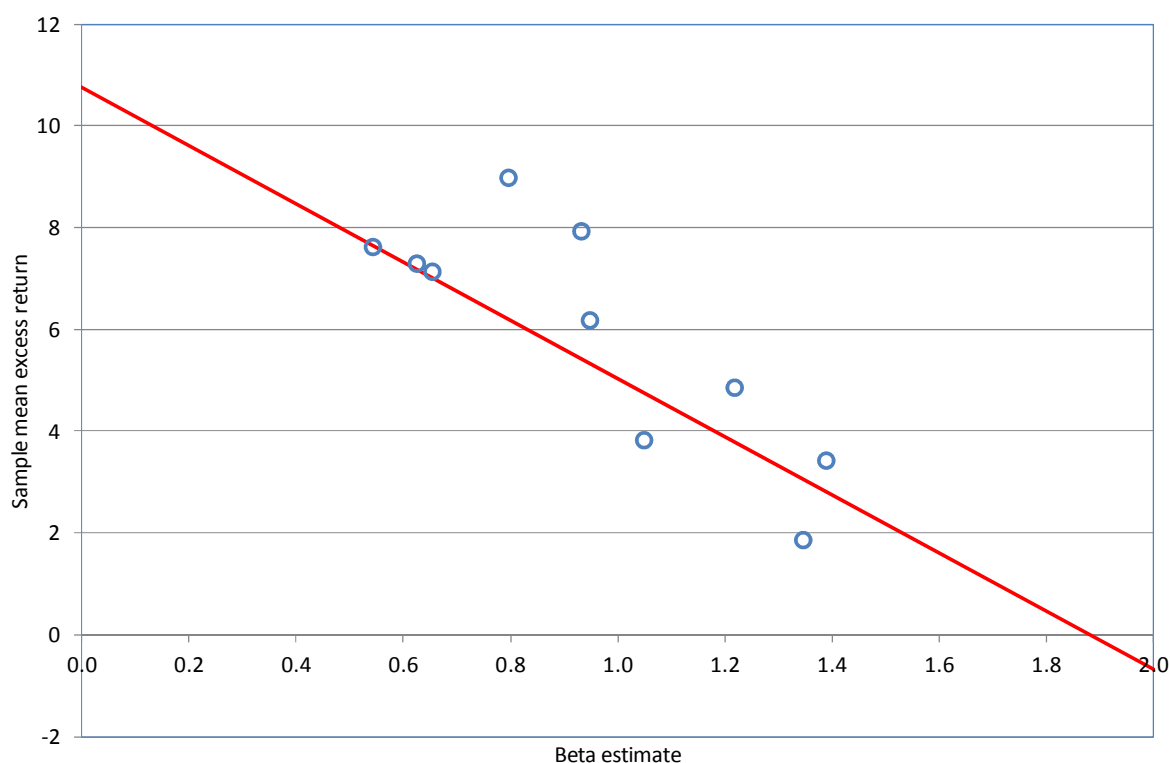
<sup>72</sup> AER, *Consultation paper: Rate of return guidelines*, May 2013, pages 90-91.

the models that use the market portfolio of stocks as a proxy for the market portfolio of *all* risky assets.

### 3.1. CAPM

In a recent report, NERA (2015) provides tests of the SL CAPM that use Australian data.<sup>73</sup> NERA finds that there is little relation between mean return and beta and that estimates of the zero-beta premium are large, and both economically and statistically significant. NERA uses 10 portfolios formed on the basis of past estimates of beta. Figure 3.1 plots the sample mean returns on these 10 portfolios in excess of the risk-free rate against estimates of their betas, indicated by the 10 blue markers. The red line in Figure 3.1 plots the relation that NERA estimates exists between mean excess return and beta for the portfolios.<sup>74</sup>

**Figure 3.1**  
Sample mean excess return against beta estimate for 10 Australian portfolios formed on the basis of past estimates of beta: Monthly data from 1974 to 2013



Source: NERA, *Empirical performance of Sharpe-Lintner and Black CAPMs*, February 2015.

<sup>73</sup> NERA, *Empirical performance of Sharpe-Lintner and Black CAPMs*, February 2015.

<sup>74</sup> Note that NERA does not estimate the relation from an ordinary least squares (OLS) regression of sample mean excess returns on estimates of beta. So one should not expect the red line to sit between the blue markers in the same way as one would expect an OLS estimate of a regression line to sit between a scatter plot of points.



Four advisors to the AER, Davis (2011), Handley (2014) and McKenzie and Partington (2014), refer to the work of Lewellen, Nagel and Shanken (2010) and, later, we address the issues that they raise in some detail.<sup>75</sup> Lewellen, Nagel and Shanken find that there is little relation between mean return and beta and that estimates of the zero-beta premium are large and both economically and statistically significant. Lewellen, Nagel and Shanken use two sets of portfolios to test a range of models.

The first set of portfolios are the 25 portfolios that Ken French provides on his web site that are formed on the basis of size (market capitalisation) and book-to-market. Figure 3.2 plots the sample mean returns on these 25 portfolios in excess of the risk-free rate against estimates of their betas, indicated by the 25 blue markers, together with the relation that Lewellen, Nagel and Shanken (2010) estimate exists between mean excess return and beta for the portfolios, indicated by the red line.<sup>76</sup>

The second set of portfolios are the 25 portfolios that Ken French provides on his web site that are formed on the basis of size and book-to-market together with the 30 industry portfolios whose returns he provides. Figure 3.3 plots the sample mean returns on these 55 portfolios in excess of the risk-free rate against estimates of their betas, indicated by the 55 blue markers, together with the relation that Lewellen, Nagel and Shanken (2010) estimate exists between mean excess return and beta for the portfolios, indicated by the red line.<sup>77</sup>

Figures 3.2 and 3.3 indicate that there is little relation between the sample mean returns to the 55 portfolios and estimates of their betas and that estimates of the zero-beta premium are correspondingly large (the zero beta premium is recorded where the red line intersects the vertical axis). Lewellen, Nagel and Shanken (2010) report that a two-tailed test of the hypothesis that the zero-beta premium is zero can be rejected at the one per cent level or lower.<sup>78</sup>

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<sup>75</sup> Davis, K., *Cost of Equity Issues: A Report for the AER*, University of Melbourne, January 2011.

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

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

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

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

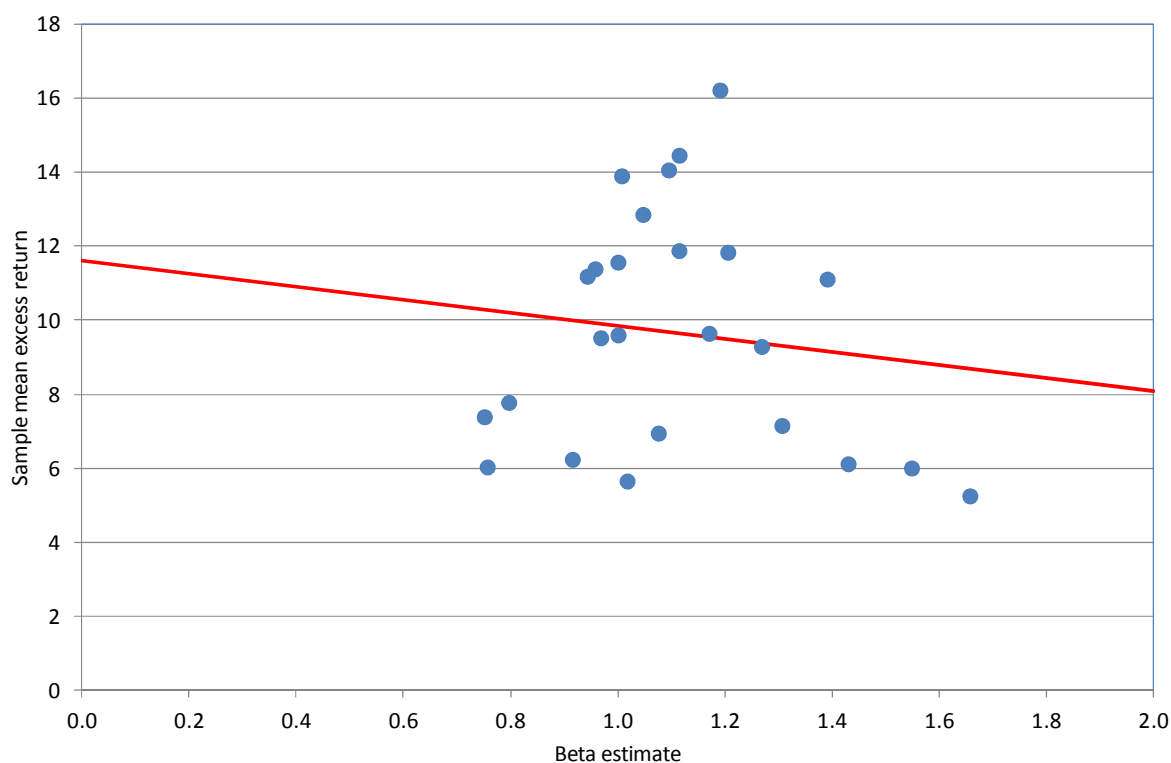
<sup>76</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

<sup>77</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

<sup>78</sup> The t-test statistics attached to the estimates of the zero-beta premium that Lewellen, Nagel and Shanken provide are 3.18 for Figure 1 and 2.57 for Figure 2.

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

**Figure 3.2**  
**Sample mean excess return against beta estimate for 25 US portfolios formed on the basis of size and book-to-market: Quarterly data from 1963 to 2004**



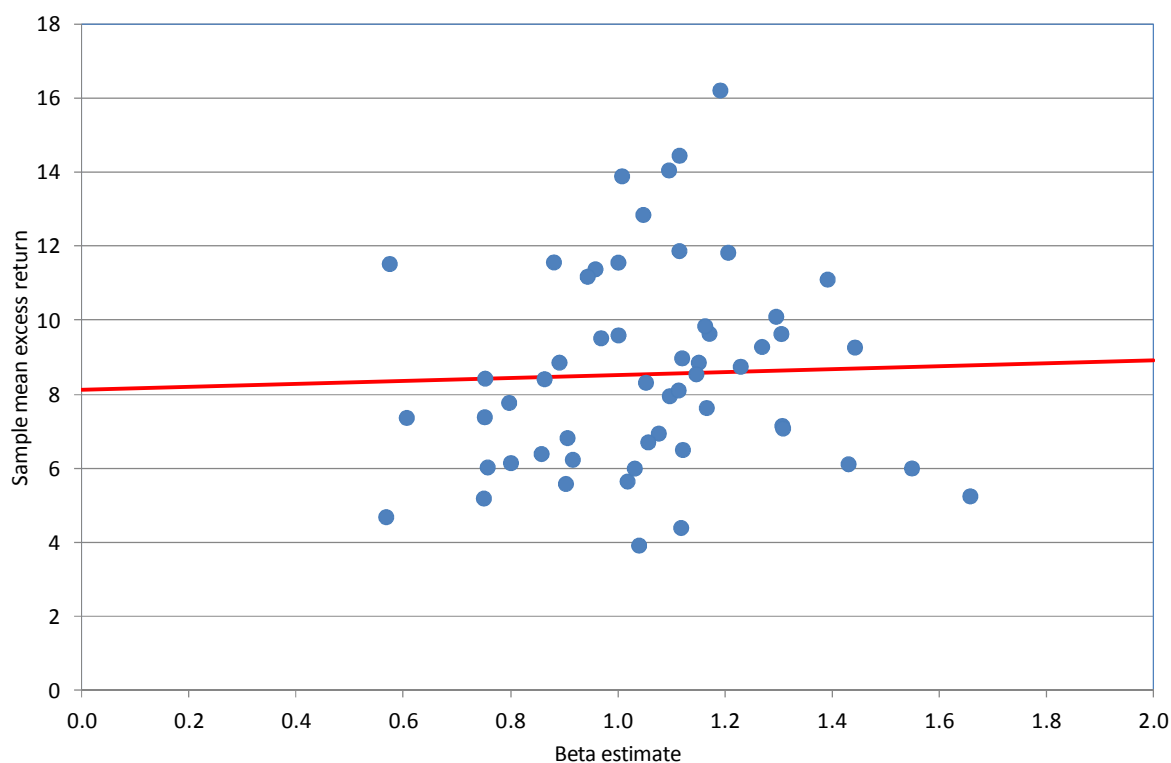
*Notes: Data are from Ken French's web site and are those used by Lewellen, Nagel and Shanken (2010). The red line plots Lewellen, Nagel and Shanken's estimate of the relation between mean excess return and beta constructed from the 25 portfolios formed on the basis of size and book-to-market. Sample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

*Sources: [http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data\\_library.html](http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html)*

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

The evidence that Figures 3.1 to 3.3 provide indicates that the SL CAPM does not work well. The evidence also indicates that a version of the Black CAPM that constrains the zero-beta rate to sit close to the risk-free rate will not work well. Figures 3.1 to 3.3, however, use data from 1963 onwards. Tests of the SL CAPM that use earlier data also provide evidence against the model but the evidence against the model is weaker. Table 3.1 below summarises the results of tests that use earlier US data.

**Figure 3.3**  
**Sample mean excess return against beta estimate for 25 US size and book-to-market sorted portfolios and 30 US industry portfolios: Quarterly data from 1963 to 2004**



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

*Sources: [http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data\\_library.html](http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html)*

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

Using 20 portfolios formed on the basis of past estimates of beta and data from 1935 to 1968, Fama and MacBeth (1973) reject the hypothesis that the zero-beta premium is zero at conventional levels using a two-tailed test.<sup>79</sup> Campbell and Vuolteenaho (2004), on the other hand, using 25 portfolios formed on the basis of book-to-market and size and 20 portfolios formed on the basis of past estimates of beta and data from 1929 to 1963, are unable to reject the hypothesis that the zero-beta premium is zero.<sup>80</sup> While they are unable to reject the hypothesis that the zero-beta premium is zero from 1929 to 1963, however, they are able to

<sup>79</sup> Fama, E and J. MacBeth, *Risk, return, and equilibrium: Empirical tests*, Journal of Political Economy 71, pages 607-636.

<sup>80</sup> Campbell, J. and T. Vuolteenaho, *Bad beta, good beta*, American Economic Review 94, pages 1249-1275.

reject the hypothesis at conventional levels from 1963 to 2001, and aggregating their results over the two periods reveals that they are able to reject the hypothesis from 1929 to 2001.<sup>81</sup>

While Fama and MacBeth (1973) are able to reject the hypothesis that the zero-beta rate matches the risk-free rate, they are also able to reject the hypothesis that the price of risk is zero at conventional levels.<sup>82</sup> On the other hand, Campbell and Vuolteenaho (2004) are unable to reject the hypothesis that the price of risk is zero using data either from 1929 to 1963 or from 1963 to 2001.<sup>83</sup> Aggregating their results over the two periods reveals that they are also unable to reject the hypothesis from 1929 to 2001.<sup>84</sup>

**Table 3.1**  
**Earlier evidence on the CAPM**

Study	Period	Zero-beta premium	Empirical price of risk
Fama and MacBeth (1973) 20 beta-sorted portfolios	1935-1968	5.76 (2.26)	10.20 (3.95)
Campbell and Vuolteenaho (2004) 25 book-to-market- & size & 20 beta-sorted portfolios	1929-1963	2.76 (3.36)	6.12 (5.52)
Campbell and Vuolteenaho (2004) 25 book-to-market- & size & 20 beta-sorted portfolios	1963-2001	8.28 (3.12)	-0.84 (4.08)

*Notes: Annualised estimates of the zero-beta premium and the empirical price of risk in per cent are produced by multiplying the monthly estimates provided by Table 3 of Fama and MacBeth, Tables 6 and 7 of Campbell and Vuolteenaho by 12. Standard errors are in parentheses.*

*Sources: Campbell, J. and T. Vuolteenaho, Bad beta, good beta, American Economic Review 94, pages 1249-1275.*

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

There is additional evidence against the SL CAPM which can also be viewed as evidence against the Black CAPM. Both the SL CAPM and Black CAPM imply that no variable other than beta should be able to explain the cross-section of mean returns but both the Australian

<sup>81</sup> There are 414 months in the first period that Campbell and Vuolteenaho examine and 462 months in the second period and so an estimate of the zero-beta premium from 1929 to 2001 is  $(414 \times 2.76 + 462 \times 8.28)/(414 + 462) = 5.67$  per cent per annum. The standard error of the estimate, in per cent per annum is:

$$(414 + 462)^{-1} \sqrt{414^2 \times 3.36^2 + 462^2 \times 3.12^2} = 2.29$$

<sup>82</sup> Fama, E and J. MacBeth, *Risk, return, and equilibrium: Empirical tests*, Journal of Political Economy 71, pages 607-636.

<sup>83</sup> Campbell, J. and T. Vuolteenaho, *Bad beta, good beta*, American Economic Review 94, pages 1249-1275.

<sup>84</sup> An estimate of the price of risk from 1929 to 2001 computed using the results of Campbell and Vuolteenaho is  $(414 \times 6.12 - 462 \times 0.84)/(414 + 462) = 2.45$  per cent per annum. The standard error of the estimate, in per cent per annum is:

$$(414 + 462)^{-1} \sqrt{414^2 \times 5.52^2 + 462^2 \times 4.08^2} = 3.38$$

evidence and the US evidence indicate that the ratio of book values to market values explains variation in the mean returns to stocks not explained by variation in beta. The US evidence also indicates that size explains variation in the mean returns to stocks not explained by variation in beta.

As an example, Figure 3.4 summarises evidence that Brailsford, Gaunt and O'Brien (2012) provide using Australian data.<sup>85</sup> The figure plots SL CAPM alphas against book-to-market and size for 25 Australian portfolios formed on the basis of book-to-market and size. Again, an asset's alpha is a measure of the error with which the model prices the asset. It is the difference between the mean return to the asset and the return that the model predicts that the asset should, on average, earn. If an asset has a positive alpha, then the model underestimates the return that the market requires the asset to earn. If an asset has a negative alpha, then the model overestimates the return that the market requires on the asset.

Figure 3.4 shows that value stocks – that is, high book-to-market stocks – have positive alphas and growth stocks – that is, low book-to-market stocks – have negative alphas. In other words, value stocks tend to earn higher returns than the SL CAPM predicts should be the case and growth stocks tend to earn less than the SL CAPM predicts should be the case. The evidence that Brailsford, Gaunt and O'Brien (2012) provide indicates that the SL CAPM underestimates the returns required on value stocks and overestimates the returns to growth stocks. Tests that Brailsford, Gaunt and O'Brien conduct of the hypothesis that the SL CAPM alphas attached to the 25 portfolios are simultaneously zero reject the null at conventional significance levels.

As another example, Figure 3.5 updates the evidence that Fama and French (1993) provide using US data from Ken French's web site.<sup>86</sup> The figure, like Figure 3.4, plots SL CAPM alphas against book-to-market and size for 25 portfolios formed on the basis of book-to-market and size. Figure 3.5 shows that US value stocks – that is, high book-to-market stocks – also have positive alphas. In other words, value stocks tend to earn higher returns than the SL CAPM predicts should be the case. Figure 3.5, in addition, shows that small value stocks have particularly large and positive alphas and small growth stocks have particularly large and negative alphas.

To summarise, there is little evidence in recent data of a relation between mean return and beta, the evidence from recent data and from earlier data indicates that the zero-beta rate exceeds the risk-free rate by a substantial margin and there is evidence in recent and earlier data that other variables besides beta can explain variation across stocks in their mean returns.

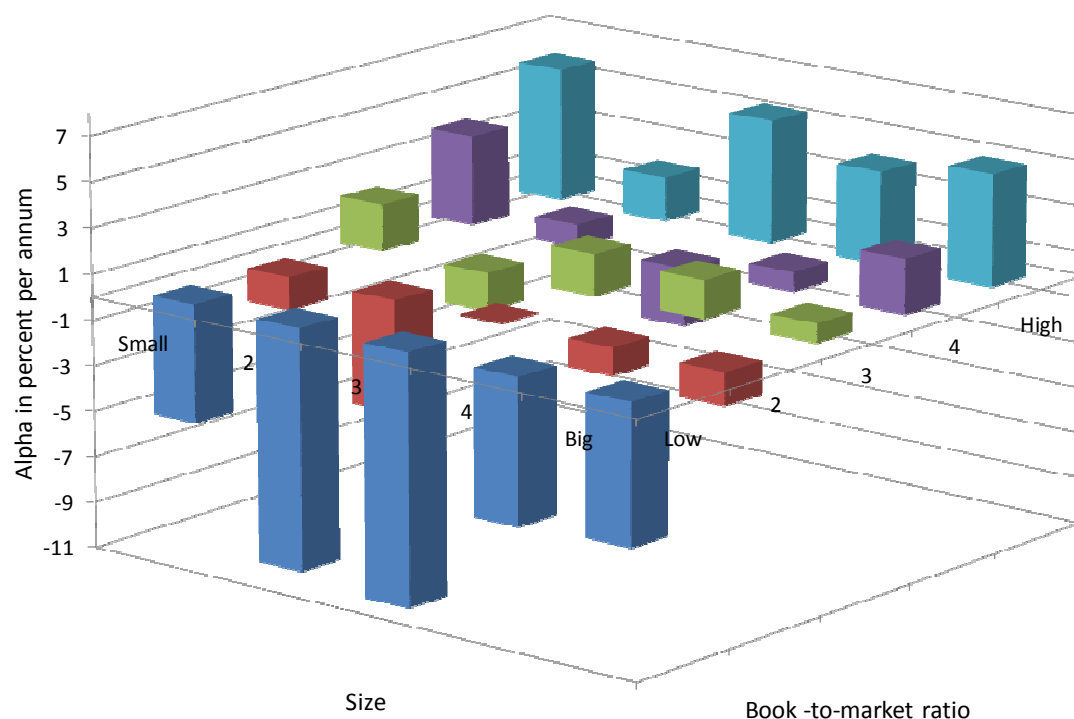
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<sup>85</sup> Brailsford, T., C. Gaunt and M. O'Brien, *Size and book-to-market factors in Australia*, Australian Journal of Management, 2012, pages 261-281.

<sup>86</sup> Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

[http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data\\_library.html](http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html)

**Figure 3.4**  
**SL CAPM alpha against book-to-market and size: Australian data from 1982 to 2006**



Source: Table 4 of Brailsford, Gaunt and O'Brien (2012).

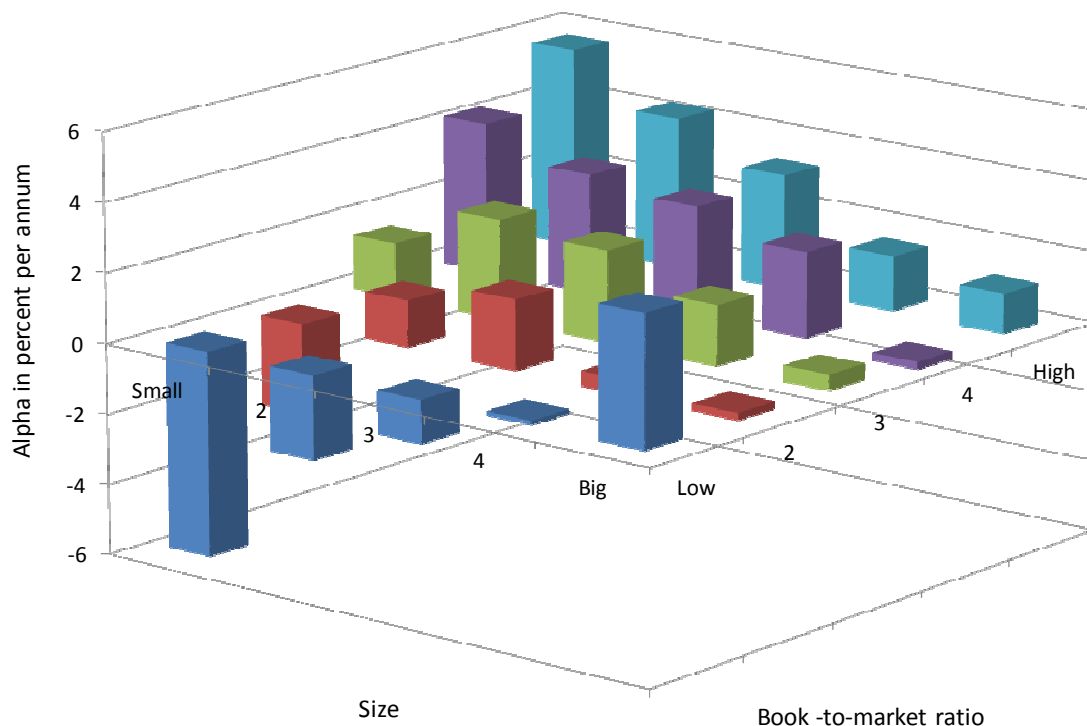
Brailsford, T., C. Gaunt and M. O'Brien, Size and book-to-market factors in Australia, *Australian Journal of Management*, 2012, pages 261-281.

The SL CAPM is an attractively simple model. So the evidence that the model does not work has been subject to some scrutiny. This scrutiny has included determining:

- whether the model works when tests use measures of mean returns provided by an auxiliary model rather than realisations of returns;
- whether the model works when one constructs estimates of beta in a different way;
- whether the model works when a different proxy for the market portfolio of risky assets is chosen;
- whether the model works when restrictions are placed on the portfolios whose mean returns one wishes to explain; and
- whether the evidence against the model is overstated.

In what follows we review a number of papers that have subjected existing tests of the SL CAPM to scrutiny in one of these ways.

**Figure 3.5**  
**SL CAPM alpha against book-to-market and size: US data from 1927 to 2014**



Notes: Data are from Ken French's web site.<sup>87</sup>

### 3.1.1. Mean returns

Campello, Chen and Zhang (2008) test the SL CAPM and Black CAPM using mean returns implied by an auxiliary model, bond prices and default rates.<sup>88</sup> They report evidence against both the SL CAPM and the Black CAPM. In particular, they reject the hypothesis at conventional levels that no variable other than beta explains the cross-section of mean returns. Using the method of Fama and MacBeth (1973), they find that there is a positive relation between a stock's mean return and the exposure of the stock to the *HML* factor and the exposure of the stock to the *SMB* factor.<sup>89</sup> Thus they report evidence that provides some support for the Fama-French three-factor model. Surprisingly, though, they do not use the method of Fama and MacBeth to test whether the mean returns that they construct provide unbiased predictors of realised returns. In other words, they do not test whether the mean returns that they construct can track variation across stocks in realised returns.

<sup>87</sup> [http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data\\_library.html](http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html)

<sup>88</sup> Campello, M., L. Chen, and L. Zhang, *Expected returns, yield spreads, and asset pricing tests*, Review of Financial Studies, 2008, pages 1298-1338.

<sup>89</sup> Fama, E and J. MacBeth, *Risk, return, and equilibrium: Empirical tests*, Journal of Political Economy 71, pages 607-636.

Davis (2011) notes that:<sup>90</sup>

‘Campello, Chen and Zhang (2008) argue that the use of realized returns as a proxy for expected returns creates problems for asset pricing tests, referring to simulation evidence demonstrating that wrong inferences can be drawn due to non-convergence of actual to expected returns except over very long horizon windows, and empirical observation of long periods during which relative stock and bond returns do not conform to theoretical predictions.’

The simulations to which Campello, Chen and Zhang (2010) refer appear in the work of Lundblad (2005) and Pastor, Sinha, and Swaminathan (2007) and are not simulations that examine the properties of tests of restrictions imposed on the mean returns on a cross-section of assets.<sup>91</sup> They are instead simulations that examine the properties of time-series tests for a link between the market risk premium and the risk of the market portfolio which is an interesting but separate issue.

### 3.1.2. Beta estimates

A number of papers have examined whether the SL CAPM works when beta is estimated in a different way.

Davis (2011) notes that:<sup>92</sup>

‘Cohen, Polk and Vuolteenaho (2009) adopt a long-horizon approach (involving 5 years or more) to examining the CAPM, in contrast to most other studies which examine returns measured over short time horizons.’

‘Their approach focuses on explaining asset prices rather than returns, since over a long horizon prices are the dominant determinant of returns. It also involves an alternative, fundamental, method of estimating beta, using the covariance between longer term cash flows of the firm and the market.’

They find that their cash-flow (fundamental) CAPM betas are able to explain a substantial proportion of differential returns on value and growth portfolios. However, their empirical results do involve estimates of the market risk premium which are somewhat high relative to the observed historical values.

While these results are interesting, the AER does not compute cash flow betas using horizons of five years or more and, given the short time series of accounting data for Australian regulated energy utilities that exists, it would have a great deal of difficulty in computing precise estimates of cash flow betas. The evidence that Cohen, Polk and Vuolteenaho (2009)

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<sup>90</sup> Davis, K., *Cost of Equity Issues: A Report for the AER*, University of Melbourne, January 2011, page 6.

<sup>91</sup> Campello, M., L. Chen, and L. Zhang, *Expected returns, yield spreads, and asset pricing tests*, Review of Financial Studies, 2008, pages 1298-1338.

Lundblad, C., *The risk-return tradeoff in the long run: 1836-2003*, Journal of Financial Economics, 2007, pages 123-150.

Pastor, L., M. Sinha, and B. Swaminathan, *Estimating the intertemporal risk-return tradeoff using the implied cost of capital*, Journal of Finance, 2007, pages 2859-2897.

<sup>92</sup> Davis, K., *Cost of Equity Issues: A Report for the AER*, University of Melbourne, January 2011, pages 5 and 6.



provide is, therefore, not relevant to assessing estimates of the cost of equity provided by the empirical version of the SL CAPM that the AER employs.

In recent work, Da, Guo and Jagannathan (2012) argue that growth options that firms possess may be largely responsible for the weak relation between return and beta.<sup>93</sup> McKenzie and Partington (2014) state that:<sup>94</sup>

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

What McKenzie and Partington do not explain is that Da, Guo and Jagannathan do not suggest that the SL CAPM be used in the same way that the AER has been using the model. To construct estimates of beta that can be used in project evaluation, unadjusted common or garden estimates of beta have to be adjusted. Da, Guo and Jagannathan (2012) state that:<sup>95</sup>

‘In general, both the equity risk premium and the equity beta of a firm are complex functions of the firm’s project beta and real option characteristics. If we project them on a set of variables capturing the features of real options using linear regressions, the residual risk premium and the residual beta are option-adjusted and more closely resemble the underlying project risk premium and project beta.’

Since beta is a relative measure of risk, an adjustment must be made even to the betas of firms that have no growth options. Da, Guo and Jagannathan construct option-adjusted betas as the residuals from a cross-sectional regression, without an intercept, of unadjusted betas on book-to-market, idiosyncratic volatility and the return on assets where the three regressors are measured relative to averages for the market. Neither the AER nor its advisers construct estimates of beta in this way. Thus the evidence that Da, Guo and Jagannathan provide is not relevant to assessing estimates of the cost of equity provided by the empirical version of the SL CAPM that the AER employs.

While Da, Guo and Jagannathan provide some interesting results, there are some obvious practical problems that would arise in trying to use their procedure. First, their data suggest that, in the cross-sectional regression used to adjust betas, the coefficient on book-to-market will be negative, the coefficient on idiosyncratic volatility will be positive and the coefficient on return on assets will be negative. It follows that an option-adjusted beta for a risk-free

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<sup>93</sup> Da, Z., R-J. Guo and R. Jagannathan, *CAPM for estimating the cost of equity capital: Interpreting the empirical evidence*, Journal of Financial Economics, 2012, pages 204-220.

<sup>94</sup> McKenzie, M. and G. Partington, *Report to the AER Part A: Return on equity*, SIRCA, October 2014, pages 9-10.

<sup>95</sup> Da, Z., R-J. Guo and R. Jagannathan, *CAPM for estimating the cost of equity capital: Interpreting the empirical evidence*, Journal of Financial Economics, 2012, pages 204-220.

asset will likely be positive because its idiosyncratic volatility will be zero in absolute terms and negative relative to the average for the market. This implies that for some firms there may be a negative rather than a positive relation between the adjusted equity beta of the firm and leverage. Second, as the idiosyncratic volatility of two firms that merge can be expected, all else constant, to fall below the idiosyncratic volatilities of the unmerged firms, one can expect the adjusted betas of merged firms to be higher than a weighted average of the adjusted betas of the unmerged firms. The idiosyncratic volatility of two firms that merge will be likely to fall below the idiosyncratic volatilities of the unmerged firms if the idiosyncratic returns to the two firms are less than perfectly positively correlated.

### 3.1.3. Market proxies

Sharpe (1964) and Lintner (1965) argue, given the assumptions that the SL CAPM makes, that the tangency portfolio  $M$  in Figure 2.1 must be the market portfolio.<sup>96</sup> Regardless of whether the assumptions underlying the SL CAPM are true, however, there will always be a tangency portfolio and regardless of whether the model is true a condition like (2) will always hold for the portfolio. It will also be true that there will, in general, be many portfolios for which a condition like (2) will not hold. Indeed for many of these portfolios there will be no relation between mean return and beta. Roll and Ross (1994) show that depending on the method used to estimate the relation between mean return and beta such portfolios may plot close to the sample tangency position or far from the position. For this reason, Roll and Ross state about the evidence that there is little relation between the return to a stock and an estimate of its beta, that:<sup>97</sup>

‘An alternative interpretation of (the) results is that the SLB Model may be of little use in explaining cross-sectional returns no matter how close the index is to the efficient frontier unless it is exactly on the frontier. Since such exactitude can never be verified empirically, we would endorse (again, as we have in the past when we first asserted the proposition; see, e.g., Roll (1977), and Chen, Roll, and Ross (1986)), that the SLB is of little practical use in explaining stock returns.’

That is, Roll and Ross argue that the SL CAPM is of little practical use in determining the cost of equity for a firm.

### 3.1.4. Portfolio selection

Commonsense dictates that there may be a choice of portfolios whose mean returns one wishes to explain, for which deviations from the SL CAPM will be hidden from view. Fama and French (1992, 1996) and Kothari, Shanken and Sloan (1995) show that in US data the SL CAPM can explain the cross-section of mean returns to portfolios formed on the basis of

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<sup>96</sup> 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.

<sup>97</sup> SLB stands for Sharpe-Lintner-Black.

Roll, R. and S. Ross, *On the cross-sectional relation between expected returns and betas*, Journal of Finance, 1994, page 111.

size alone.<sup>98</sup> However, the same authors show that when each size portfolio is further sorted into a set of portfolios on the basis of past estimates of beta, the deviations from the model that exist are revealed. Fama and French (1993) and Cochrane (2001) similarly show that when each size portfolio is further sorted into a set of portfolios on the basis of book-to-market, the deviations from the model that exist are revealed.<sup>99</sup> Figure 3.2 which uses data that Lewellen, Nagel and Shanken (2010) employ on the returns to portfolios formed on the basis of size and book-to-market illustrates these deviations.<sup>100</sup>

### 3.1.5. Statistical inference

In a recent paper, Ray, Savin and Tiwari (2009) show that the finite-sample distribution of the Wald statistic for a test of the SL CAPM need not conform closely to its theoretical asymptotic distribution.<sup>101</sup> A Wald statistic uses unrestricted parameter estimates and an estimate of the covariance matrix of the unrestricted parameter estimates to test whether a set of restrictions are true.<sup>102</sup> The finite-sample distribution refers to the distribution in samples that are not very, very large while the asymptotic distribution refers to the distribution in very, very large samples. Asymptotic results are ones that are strictly true only in the limit as the sample size tends to infinity.<sup>103</sup>

As a result of the differences that can occur between the finite-sample and asymptotic distributions of the Wald statistics used to test the SL CAPM, Ray, Savin and Tiwari note that tests of pricing models that rely on the asymptotic distributions of the statistics can reject more frequently than the stated sizes (significance levels) of the tests would suggest. Using portfolios formed on the basis of size, they find that tests in which inference is based on asymptotic theory reject the SL CAPM but tests that take into account differences between the finite-sample and asymptotic distributions of test statistics do not reject the model.

Our discussion in section 3.1.4. of the sensitivity of the results of tests to how the test portfolios are formed indicates that one should expect to find little evidence against the SL CAPM in portfolios formed on the basis of size but that these results will not survive when the size portfolios are themselves broken up into portfolios on the basis of, for example, past estimates of beta. Ray, Savin and Tiwari do not investigate the impact of sorting on the basis

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<sup>98</sup> Fama, Eugene and Kenneth French, *The cross-section of expected returns*, Journal of Finance 47, 1992, pages 427-465.

Fama, Eugene and Kenneth French, *The CAPM is wanted, dead or alive*, Journal of Finance 51, 1996, pages 1947-1958.

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.

<sup>99</sup> Cochrane, J., *Asset pricing*, Princeton University Press, 2001, chapter 20.

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

<sup>100</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

<sup>101</sup> Ray, S., N.E. Savin and A. Tiwari, *Testing the CAPM revisited*, Journal of Empirical Finance, 2009, pages 721-733.

<sup>102</sup> Davidson, R. and J.G. MacKinnon, *Estimation and inference in econometrics*, Oxford University Press, 1993, page 89.

<sup>103</sup> Davidson, R. and J.G. MacKinnon, *Estimation and inference in econometrics*, Oxford University Press, 1993, page 42.

of past estimates of beta but do find more evidence against the model when they sort stocks into portfolios on the basis of both size and book-to-market.

### 3.2. Fama-French Three-Factor Model

Davis, Fama and French (2000) show that the Fama-French three-factor model, like the SL CAPM, tends to under-estimate the mean returns to low-beta assets and over-estimate the returns to high-beta assets.<sup>104</sup> Equivalently, Lewellen, Nagel and Shanken (2010) show that estimates of the mean excess return to a portfolio that has zero betas relative to the three Fama-French factors are large, positive and significant at conventional levels.<sup>105</sup> These results mean that the Fama-French three-factor model will be likely to *underestimate* the return required on the equity of a regulated energy utility because a regulated energy utility has a low market equity beta.

Lewellen, Nagel and Shanken (2010) make a number of important contributions to the asset pricing literature and a number of the AER's advisors have made references to the paper and so we examine the paper in some detail.<sup>106</sup>

#### 3.2.1. Lewellen, Nagel and Shanken (2010)

First, Lewellen, Nagel and Shanken (2010) note that Fama and French (1993) effectively test a two-factor model since the 25 book-to-market and size portfolios that they use all have betas relative to the market of around one.<sup>107</sup> Thus the tests that Fama and French conduct effectively examine the behaviour of the returns to the 25 portfolios in excess of the market return. The two factors to which we refer are the *HML* and *SMB* factors.

Second, Lewellen, Nagel and Shanken (2010) note that the factors that Fama and French (1993) construct are not unique in being able to explain the cross-section of mean returns to the 25 book-to-market and size portfolios.<sup>108</sup> There are other sets of factors that will also be able to explain the cross-section of mean returns. Quite obviously, there will be linear combinations of the Fama-French factors – but there will also be other sets of factors that will work. Thus it should not be surprising that a number of multifactor pricing models besides

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<sup>104</sup> Davis, James, Eugene Fama and Kenneth French, *Characteristics, covariances, and average returns: 1929 to 1997*, Journal of Finance 55, 2000, pages 389-406.

<sup>105</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

<sup>106</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

<sup>107</sup> Fama, E.F. and K.R. French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, page 177.

<sup>108</sup> Fama, E.F. and K.R. French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 3-56.

Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, page 179.

the Fama-French three-factor model can explain the cross-section of mean returns to the 25 book-to-market and size portfolios that Fama and French assemble.

Third, Lewellen, Nagel and Shanken (2010) note that tests often do not examine all of the restrictions that a pricing model imposes.<sup>109</sup> For example, tests often do not examine whether the zero-beta rate matches the risk-free rate.

Handley (2014) states that:<sup>110</sup>

‘The empirical evidence supporting the Fama-French model (and a number of other asset pricing models for that matter) has recently been called into question by Lewellen, Nagel and Shanken (2010).’

Keyword searches of Lewellen, Nagel and Shanken’s (2010) paper for the expressions ‘Fama’ and ‘FF’ paper do not uncover a statement to that effect.<sup>111</sup> A close look at the paper does, however, uncover the following statements. First, Lewellen, Nagel and Shanken state that:<sup>112</sup>

‘Fig. 6 illustrates the confidence-interval approach for testing the unconditional CAPM. The test is based on FF’s 25 size-B/M portfolios from 1963 to 2004, and our market proxy is the Center for Research in Security Prices (CRSP) value-weighted index. The size and B/M effects are strong during this sample (the average absolute quarterly alpha is 0.96% across the 25 portfolios), and the GRS F statistic, 3.49, strongly rejects the CAPM with a p-value of 0.000. The graph shows, moreover, that we can reject that the squared Sharpe ratio on the market is within 0.21 of the squared Sharpe ratio of the tangency portfolio: a 90% confidence interval for (the difference between the squared Sharpe ratio of the tangency portfolio and the squared Sharpe ratio on the market) is [0.21, 0.61]. Interpreted differently, following MacKinlay (1995), there exists a zero-beta portfolio that, with 90% confidence, has a quarterly Sharpe ratio between 0.46 (=0.211/2) and 0.78 (=0.611/2). This compares with a quarterly Sharpe ratio for the market portfolio of 0.18 during this period. The confidence interval provides a good summary measure of just how poorly the CAPM works.’

In other words, Lewellen, Nagel and Shanken (2010) note that there is strong evidence against the SL CAPM.<sup>113, 114</sup>

<sup>109</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, page 176.

<sup>110</sup> Handley, J., *Report prepared for the Australian Energy Regulator: Advice on the return on equity*, University of Melbourne, October 2014, page 7.

<sup>111</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

<sup>112</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 186-187.

<sup>113</sup> Again, a portfolio’s Sharpe ratio is the ratio of the mean return to the portfolio in excess of the risk-free rate divided by the standard deviation of the return to the portfolio.

<sup>114</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

Second, Lewellen, Nagel and Shanken (2010) find – consistent with the argument that they make that the Fama-French factors are not unique in their ability to correctly price the 25 Fama-French book-to-market and size portfolios – that 10 per cent of two-factor models and 30 per cent of three-factor models that use factors constructed by forming at random zero-investment portfolios from the 25 portfolios explain more cross-sectional variation than the Fama-French factors.<sup>115</sup> They go on, however, to state that:<sup>116</sup>

‘These facts in no way represent an indictment of Fama and French (1993) since one of their main points was precisely that returns on the size-B/M portfolios could be summarized by a small number of factors. Our simulations just indicate that the factors they constructed are far from unique in their ability to explain cross-section variation in expected returns on the size-B/M portfolios.’

Handley (2014) goes on to note that:<sup>117</sup>

‘Further, they argue that once you take into account the cross sectional dependence in returns using Generalized Least Squares (GLS) rather than Ordinary Least Squares (OLS) then the explanatory power of the model is substantially reduced:

*“The third key result is that none of the models provides much improvement over the simple or consumption CAPM when performance is measured by the GLS  $R^2$  or  $q$  .... The average GLS  $R^2$  is only 0.08 across the five models using size-B/M portfolios and 0.02 using the full set of 55 portfolios.”*

In regards to the Fama-French model in particular, Lewellen, Nagel and Shanken (2010) show that using Fama and French’s 25 size-B/M portfolios as test assets results in an apparently impressive OLS  $R^2$  of 0.78 but when the set of test assets is expanded to include 30 industry portfolios, then the more relevant resultant GLS  $R^2$  is only 0.06.’

A close inspection of Lewellen, Nagel and Shanken’s (2010) Table 1, the relevant portion of which we reproduce below, reveals that the expression ‘none of the models’ refers to the set of five alternatives to the Fama-French three-factor model and not to a set of models that includes the Fama-French three-factor model.<sup>118</sup> The GLS  $R^2$  is a measure of the fit of a model and a larger  $R^2$  represents a better fit than a lower  $R^2$ . The results indicate that of the models that Lewellen, Nagel and Shanken examine, the Fama-French three-factor model has the highest GLS  $R^2$  when their preferred combination of 25 book-to-market and size portfolios and 30 industry portfolios is employed. Thus Handley has misrepresented the results that Lewellen, Nagel and Shanken provide.

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<sup>115</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

<sup>116</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, page 179.

<sup>117</sup> Handley, J., *Report prepared for the Australian Energy Regulator: Advice on the return on equity*, University of Melbourne, October 2014, page 8.

<sup>118</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.

**Table 3.2**  
**OLS and GLS R<sup>2</sup> for asset pricing models, 1963-2004**

Model	OLS R <sup>2</sup>		GLS R <sup>2</sup>	
	FF 25	FF 25 + 30 ind.	FF 25	FF 25 + 30 ind.
1 LL (2001)	0.58	0.00	0.05	0.01
2 LVN (2004)	0.57	0.09	0.02	0.00
3 SV (2006)	0.27	0.08	0.02	0.02
4 LVX (2006)	0.80	0.42	0.26	0.04
5 Yogo (2006)	0.18	0.02	0.04	0.05
6 CAPM	-0.03	-0.02	0.01	0.00
7 Cons. CAPM	0.05	-0.02	0.01	0.00
8 Fama-French	0.78	0.31	0.19	0.06
Average of models 1-5	0.48	0.12	0.08	0.02
Average of models 1-5 & 8	0.53	0.15	0.10	0.03

*Notes: Models 1 through 5 are the multifactor models that are alternatives to the Fama-French three-factor model. The CAPM and the consumption-based CAPM (cons. CAPM) are single-factor models. FF25 refers to the 25 Fama-French book-to-market and size portfolios while 30 ind. refers to 30 industry portfolios that Fama and French have assembled.*

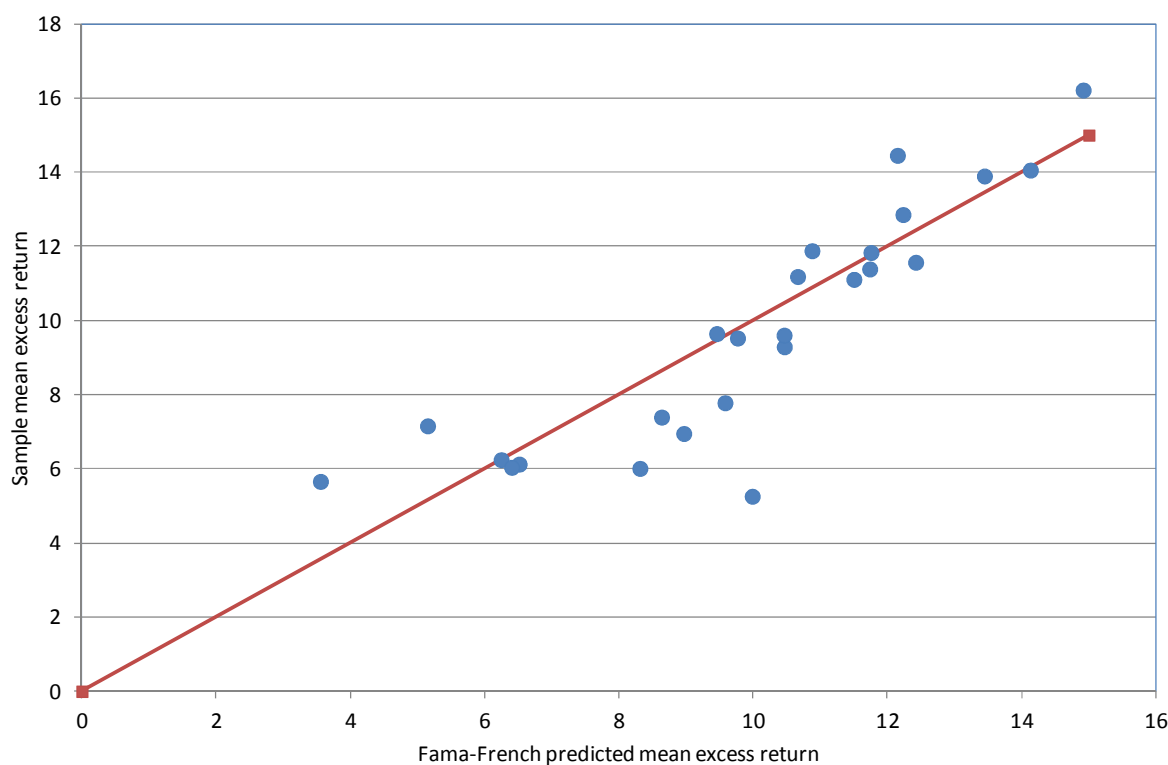
*Source: Lewellen, J., S. Nagel and J. Shanken, A skeptical appraisal of asset pricing tests, Journal of Financial Economics, 2010, page 188.*

Another way of looking at the results that Lewellen, Nagel and Shanken (2010) provide is to follow Cochrane (2001) and plot the sample mean excess return to each portfolio against the mean excess return that the Fama-French three-factor model predicts the portfolio should earn.<sup>119</sup> Figure 3.6 provides the results of this exercise for the 25 portfolios formed on the basis of size and book-to-market while Figure 3.7 provides the results for the 25 portfolios formed on the basis of size and book-to-market together with the 30 industry portfolios. These figures use the quarterly data that Lewellen, Nagel and Shanken employ from 1963 to 2004. Consistent with the results of Table 3.2, which are taken from Lewellen, Nagel and Shanken's paper, the figures show that the Fama-French three-factor model provides better predictions of the mean excess returns to the portfolios than does the SL CAPM in Figure 3.2 and 3.3, which use the same data.

<sup>119</sup> Cochrane, J., *Asset pricing*, Princeton University Press, 2001, chapter 20.

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

**Figure 3.6**  
**Sample mean excess return against Fama-French prediction for 25 US portfolios**  
**formed on the basis of size and book-to-market: Quarterly data from 1963 to 2004**



*Notes: Data are from Ken French's web site and are those used by Lewellen, Nagel and Shanken (2010). The red line plots a line with slope one that passes through the origin. Sample mean excess returns and the Fama-French predictions have been annualised by multiplying the quarterly returns by four and are in per cent per annum.*

*Sources: [http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data\\_library.html](http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html)*

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

Finally, we note that, despite the evidence provided by Figure 3.6 and Figure 3.7, Lewellen, Nagel and Shanken (2010) state that they find that across all eight models they examine – one of which is the SL CAPM – that:<sup>120</sup>

‘annualized, the zero-beta rates range from 7.8% to 14.3% above the risk-free rate. These estimates cannot reasonably be attributed to differences in lending versus borrowing costs.’

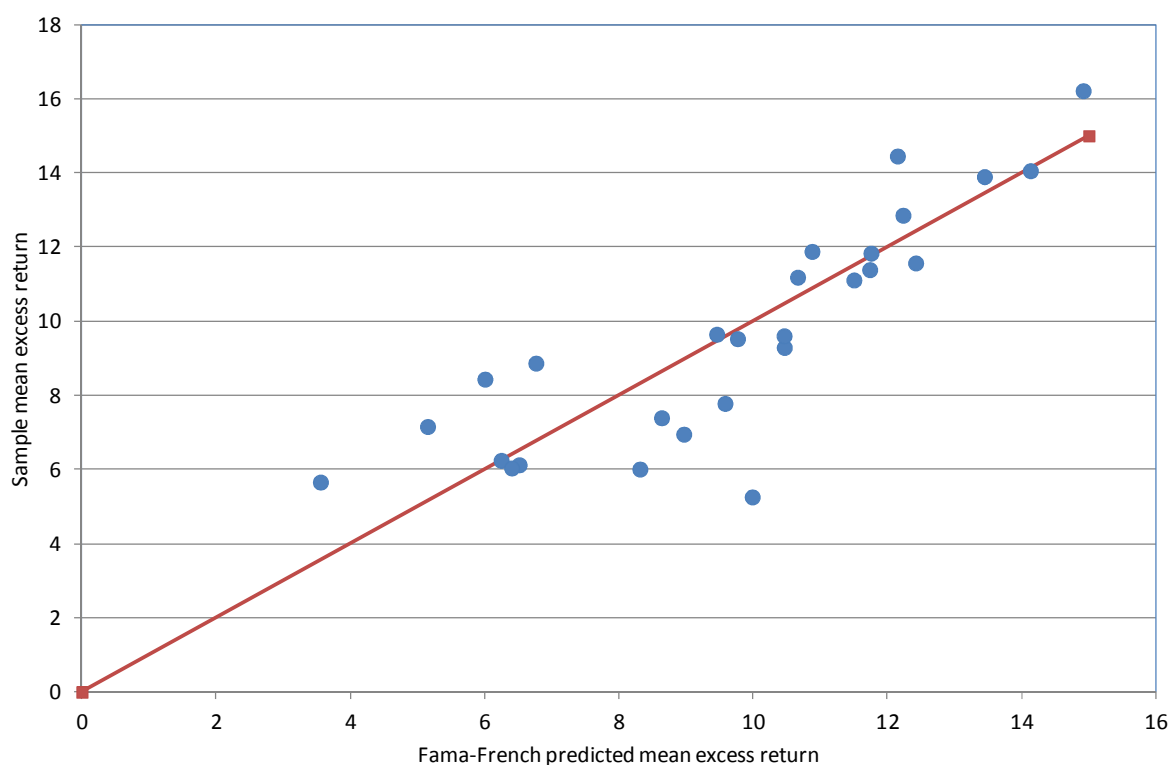
In other words, they find that both the SL CAPM and Fama-French three-factor model tend to underestimate the returns required on low-beta equities. Lewellen, Nagel and Shanken, on

<sup>120</sup> Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2010, pages 175-194.



the other hand, provide only weak evidence of variation across portfolios in their mean returns that can be explained by the pricing models that they examine. Of the 38 estimates of premiums for bearing risk that they provide, only six differ significantly from zero at conventional levels. In contrast, of the 16 estimates of the zero-beta premium that they provide for various models, all are positive and only one does not sit significantly above zero at conventional levels.

**Figure 3.7**  
**Sample mean excess return against Fama-French prediction for 25 US portfolios**  
**formed on the basis of size and book-to-market and 30 US industry portfolios:**  
**Quarterly data from 1963 to 2004**



*Notes: Data are from Ken French's web site and are those used by Lewellen, Nagel and Shanken (2010). The red line plots a line with slope one that passes through the origin. Sample mean excess returns and the Fama-French predictions have been annualised by multiplying the quarterly returns by four and are in per cent per annum.*

*Sources: [http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data\\_library.html](http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html)*

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

### 3.2.2. Fama and French (2014)

In recent work Fama and French (2014) examine a five-factor pricing model.<sup>121</sup> Handley summarises their results in the following way:<sup>122</sup>

‘Fama and French (2014) present a five factor asset pricing model which adds a profitability factor (RMW – for robust minus weak profitability) and an investment factor (CMA – for conservative minus aggressive investment) to the existing market, size and value factors of the Fama-French model and find that their value factor (HML – for high minus low B/M) becomes redundant for describing average returns – a result which they describe as “*so striking we caution the reader that it may be specific to this sample*” Their reservation is not surprising given they have previously argued that the value factor “*does the heavy lifting in the improvements to the CAPM*”.’

[The emphasis is Handley’s]

Similarly, McKenzie and Partington (2014) state that:<sup>123</sup>

‘Even Fama and French (2014) themselves have moved on from the three factor model ...

the main discussion of this section of our report highlights the nascent literature suggesting that the use of the Fama and French model is no longer optimal, and may indeed lead to invalid, incorrect or misleading inference. Even the originators of this model, Fama and French (2014) themselves, have contributed to this literature. It would seem unusual to adopt a model 21 years after its publication, when its weaknesses are becoming more evident and contemporary research is just beginning to understand the possible causes and potential solutions.’

The implicit suggestion that Handley and McKenzie and Partington are making is that Fama and French have abandoned their three-factor model and are ready to accept the use of the SL CAPM. This is not the case. What Fama and French (2014) find is that one can improve upon their three-factor model – by replacing the *HML* factor with a *CMA* factor and a *RMW* factor – not by using the SL CAPM in its place.<sup>124</sup> Fama and French are not abandoning their long-held position that the Fama-French three-factor model provides a better description of the cross-section of mean returns than the SL CAPM. They are suggesting that there may be a four or five-factor model that performs better than their three-factor model.

This point is made particularly clear by Fama and French in December 2014 in their online Fama/French Forum. They state that:<sup>125</sup>

<sup>121</sup> Fama, E.F. and K.R. French, *A five-factor asset pricing model*, University of Chicago, IL, March 2014.

<sup>122</sup> Handley, J., *Report prepared for the Australian Energy Regulator: Advice on the return on equity*, University of Melbourne, October 2014, page 8.

<sup>123</sup> McKenzie, M. and G. Partington, *Report to the AER Part A: Return on equity*, SIRCA, October 2014, pages 16-18.

<sup>124</sup> Fama, E.F. and K.R. French, *A five-factor asset pricing model*, University of Chicago, IL, March 2014.

<sup>125</sup> <http://www.dimensional.com/famafrench/questions-answers/qa-what-does-it-mean-to-say-hml-is-redundant.aspx>

‘There is some confusion about the interpretation of the evidence in Fama and French (2014, “A Five-Factor Model of Expected Returns”) that *HML* is redundant for explaining average U.S. stock returns for 1963-2013.

It doesn’t imply that there is no value premium. When *HML* is defined in the usual way (2×3 sorts on *Size* and *B/M*), its average value for 1963-2013 is a hefty 5.21% per year with a standard deviation of 13.70% and a *t*-statistic of 2.72. This is similar to the market premium in excess of the bill rate, 6.74% per year with a standard deviation of 17.97% and a *t*-statistic of 2.68. The *t*-statistics tell us that the underlying expected premiums are reliably greater than zero.’

As another illustration of the fact that Fama and French (2014) are not abandoning their previously held position, we note that they state that:<sup>126</sup>

‘Empirical tests of the CAPM, from Black, Jensen, and Scholes (1972) and Fama and MacBeth (1973) to Fama and French (1992) and Frazzini and Pedersen (2013), find that the premium for market beta is much smaller than predicted by the version of the CAPM in which there is unrestricted riskfree borrowing and lending. Davis, Fama, and French (2000) document a similar result for the multivariate beta in the Fama-French three-factor model. These results suggest that the predictions of models (like those examined here) that include a standard market factor,  $R_{Mt} - R_{Ft}$ , are too high for assets with market betas greater than 1.0 and too low for assets with betas less than 1.0.

Fortunately, although the market betas for the LHS assets examined here show some dispersion, they are never far from 1.0. In applications in which betas differ a lot from 1.0, however, misspecification of the market premium may be an important issue. We have examined a simple approximate cure. Specifically, assume all market betas are 1.0, drop the market premium from the RHS of the asset pricing regression, and use asset returns measured net of the market return as LHS variables.’

This suggestion, if it were to be applied to the SL CAPM would amount to setting beta to one for every stock and portfolio.

### 3.2.3. Mispricing and the value premium

It has been known for well over 25 years that the SL CAPM misprices value stocks.<sup>127</sup> There is, however, no consensus among academics about whether these deviations from the SL CAPM represent compensation for risks not priced by the SL CAPM or mispricing by the market. Thus Handley states that:<sup>128</sup>

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<sup>126</sup> Fama, E.F. and K.R. French, *A five-factor asset pricing model*, University of Chicago, IL, March 2014.

<sup>127</sup> See, for example, the references that Fama and French (2004) provide.

Fama, E.F. and K.R. French, *The Capital Asset Pricing Model: Theory and evidence*, Journal of Economic Perspectives, 2004, page 36.

<sup>128</sup> Handley, J., *Report prepared for the Australian Energy Regulator: Advice on the return on equity*, University of Melbourne, October 2014, page 8.

‘Lakonishok, Shleifer and Vishny (1994) argue that the value factor instead proxies for mispricing. Daniel and Titman (1997) also suggest that the return premia on small stocks and value stocks cannot be viewed as compensation for risk.’

Unfortunately, as Fama and French (2004) explain:

‘When tests reject the CAPM, one cannot say whether the problem is its assumption that prices are rational (the behavioral view) or violations of other assumptions that are also necessary to produce the CAPM (our position).’

Nevertheless, as Fama and French (2004) go on to explain:

‘Fortunately, for some applications, the way one uses the three-factor model does not depend on one's view about whether its average return premiums are the rational result of underlying state variable risks, the result of irrational investor behavior or sample specific results of chance. For example, when measuring the response of stock prices to new information or when evaluating the performance of managed portfolios, one wants to account for known patterns in returns and average returns for the period examined, whatever their source. Similarly, when estimating the cost of equity capital, one might be unconcerned with whether expected return premiums are rational or irrational since they are in either case part of the opportunity cost of equity capital (Stein, 1996).’

In other words, a belief that deviations from the SL CAPM represent compensation for risks not priced by the SL CAPM – even if false – need not lead one to mismeasure the cost of equity in using the Fama-French three-factor model. If investors irrationally require higher returns on value stocks, then the cost of capital for firms whose stock can be so classified will be higher as a result.

## Appendix A. Terms of Reference

### Expert Terms of Reference

#### Review of literature in support of the Sharpe-Lintner CAPM, the Black CAPM and the Fama-French three factor model

#### Jemena Gas Networks 2015-20 Access Arrangement Review

AA15-570-0069

12 March 2015

### 1. Background

Jemena Gas Networks (**JGN**) is the major gas distribution service provider in New South Wales (**NSW**). JGN owns more than 25,000 kilometres of natural gas distribution system, delivering approximately 100 petajoules of natural gas to over one million homes, businesses and large industrial consumers across NSW.

JGN submitted its revised Access Arrangement proposal (**proposal**) with supporting information for the consideration of the Australian Energy Regulator (**AER**) on 30 June 2014. The revised access arrangement will cover the period 1 July 2015 to 30 June 2020 (July to June financial years). The AER published its draft decision on this proposal on 27 November 2014. JGN must submit any additions or other amendments to its proposal by 27 February 2015.

As with all of its economic regulatory functions and powers, when assessing JGN's revised Access Arrangement under the National Gas Rules and the National Gas Law, the AER is required to do so in a manner that will or is likely to contribute to the achievement of the National Gas Objective, which is:

“to promote efficient investment in, and efficient operation and use of, natural gas services for the long term interests of consumers of natural gas with respect to price, quality, safety, reliability and security of supply of natural gas.”

For electricity networks, the AER must assess regulatory proposals under the National Electricity Rules and the National Electricity Law in a manner that will or is likely to achieve the National Electricity Objective, as stated in section 7 of the National Electricity Law.

Where there are two or more possible decisions in relation to JGN's revised Access Arrangement that will or are likely to contribute to the achievement of the National Gas Objective, the AER is required to make the decision that the AER is satisfied will or is likely to contribute to the achievement of the National Gas Objective to the greatest degree.

The AER must also take into account the revenue and pricing principles in section 24 of the National Gas Law and section 7A of the National Electricity Law, when exercising a discretion related to reference tariffs. The revenue and pricing principles include the following:

“(2) A service provider should be provided with a reasonable opportunity to recover at least the efficient costs the service provider incurs in—

- (a) providing reference services; and
  - (b) complying with a regulatory obligation or requirement or making a regulatory payment.
- (3) A service provider should be provided with effective incentives in order to promote economic efficiency with respect to reference services the service provider provides. The economic efficiency that should be promoted includes—
- (a) efficient investment in, or in connection with, a pipeline with which the service provider provides reference services...
- [...]
- (5) A reference tariff should allow for a return commensurate with the regulatory and commercial risks involved in providing the reference service to which that tariff relates.
- (6) Regard should be had to the economic costs and risks of the potential for under and over investment by a service provider in a pipeline with which the service provider provides pipeline services.”

Some of the key rules that are relevant to an access arrangement and its assessment are set out below.

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

- (1) Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.
- (2) A forecast or estimate:
  - (a) must be arrived at on a reasonable basis; and
  - (b) must represent the best forecast or estimate possible in the circumstances.

Rule 87 of the National Gas Rules, relating to the allowed rate of return, states:

- (1) Subject to rule 82(3), the return on the projected capital base for each regulatory year of the access arrangement period is to be calculated by applying a rate of return that is determined in accordance with this rule 87 (the allowed rate of return).
- (2) The allowed rate of return is to be determined such that it achieves the allowed rate of return objective.
- (3) The allowed rate of return objective is that the rate of return for a service provider is to be commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to the service provider in respect of the provision of reference services (the allowed rate of return objective).
- (4) Subject to subrule (2), the allowed rate of return for a regulatory year is to be:

- (a) a weighted average of the return on equity for the access arrangement period in which that regulatory year occurs (as estimated under subrule (6)) and the return on debt for that regulatory year (as estimated under subrule (8)); and
  - (b) determined on a nominal vanilla basis that is consistent with the estimate of the value of imputation credits referred to in rule 87A.
- (5) In determining the allowed rate of return, regard must be had to:
- (a) relevant estimation methods, financial models, market data and other evidence;
  - (b) the desirability of using an approach that leads to the consistent application of any estimates of financial parameters that are relevant to the estimates of, and that are common to, the return on equity and the return on debt; and
  - (c) any interrelationships between estimates of financial parameters that are relevant to the estimates of the return on equity and the return on debt.

#### *Return on equity*

- (6) The return on equity for an access arrangement period is to be estimated such that it contributes to the achievement of the allowed rate of return objective.
- (7) In estimating the return on equity under subrule (6), regard must be had to the prevailing conditions in the market for equity funds.

[Subrules (8)–(19) omitted].

The equivalent National Electricity Rules are in clauses 6A.6.2 (for electricity transmission) and 6.5.2 (for electricity distribution).

In this context, JGN seeks a report from NERA, as a suitable qualified independent expert (**Expert**), in relation to relevant financial models which may be used to estimate the return on equity component of the rate of return, in a way that complies with the requirements of the National Gas Law and Rules and National Electricity Law and Rules, including as highlighted above. JGN seeks this report on behalf of itself, Jemena Electricity Networks, AusNet Services, Australian Gas Networks, CitiPower, Ergon Energy, Powercor, SA PowerNetworks, and United Energy.

## **2. Scope of Work**

In its Rate of Return Guideline (and again in its Draft Decision for JGN), the AER identifies three asset pricing models that it considers relevant to estimating the return on equity:

- Sharpe-Lintner CAPM;
- Black CAPM; and
- Fama-French three factor model.

The AER states in the Draft Decision for JGN that it considers the Sharpe-Lintner CAPM to be superior to the others, and therefore decides to use it as the ‘foundation model’ for determining the

return on equity. The AER also considers that there is no compelling evidence that the return on equity estimate from this model will be downward biased, given the AER's selection of input parameters.

Having regard to the AER's position on relevant return on equity models, as set out in the Rate of Return Guideline and the Draft Decision for JGN, the Expert will provide an opinion report that:

1. Reviews the relevant economic literature in relation to the three asset pricing models referred to by the AER, insofar as it addresses:
  - (a) any theoretical or empirical limitations of the models;
  - (b) any empirical evidence of bias in the application of the models; and
  - (c) whether there is empirical evidence that companies with different risks have different average returns.
2. Provides an expert opinion on whether the empirical evidence referred to by the AER supports its approach to estimating the return on equity in the Draft Decision.

In preparing the report, the Expert will:

- A. consider different approaches to applying each of the financial models, including any theoretical restrictions on empirical estimates;
- B. consider the theoretical and empirical support for each of the financial models; and
- C. consider any comments raised by the AER, its experts and other regulators, including on (but not limited) to (a) whether each of the financial models applies in Australia; (b) the statistical reliability of the parameter estimates produced by those models; and (c) evidence of bias in the return on equity estimates produced by any of these models.

### **3. Information to be Considered**

The Expert is also expected to consider the following additional information:

- such information that, in Expert's opinion, should be taken into account to address the questions outlined above;
- relevant literature on the rate of return;
- the AER's rate of return guideline, including explanatory statements and supporting expert material;
- material submitted to the AER as part of its consultation on the rate of return guideline; and
- previous decisions of the AER, other relevant regulators and the Australian Competition Tribunal on the rate of return and any supporting expert material, including the recent draft decisions for JGN and electricity networks in ACT, NSW and Tasmania.



## 4. Deliverables

At the completion of its review the Expert will provide an independent expert report which:

- is of a professional standard capable of being submitted to the AER;
- is prepared in accordance with the Federal Court Practice Note on Expert Witnesses in Proceedings in the Federal Court of Australia (CM 7) set out in Attachment 1, and includes an acknowledgement that the Expert has read the guidelines<sup>129</sup>;
- contains a section summarising the Expert's experience and qualifications, and attaches the Expert's curriculum vitae (preferably in a schedule or annexure);
- identifies any person and their qualifications, who assists the Expert in preparing the report or in carrying out any research or test for the purposes of the report;
- summarises JGN's instructions and attaches these term of reference;
- includes an executive summary which highlights key aspects of the Expert's work and conclusions; and
- (without limiting the points above) carefully sets out the facts that the Expert has assumed in putting together his or her report, as well as identifying any other assumptions made, and the basis for those assumptions.

The Expert's report will include the findings for each of the items defined in the scope of works (Section 2).

## 5. Timetable

The Expert will deliver the final report to Jemena Regulation by **27 March 2015**.

## 6. Terms of Engagement

The terms on which the Expert will be engaged to provide the requested advice shall be:

- as provided in accordance with the Jemena Regulatory Consultancy Services Panel arrangements applicable to the Expert.

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<sup>129</sup> Available at: <http://www.federalcourt.gov.au/law-and-practice/practice-documents/practice-notes/cm7>.

## Appendix B. Federal Court Guidelines

### FEDERAL COURT OF AUSTRALIA

#### Practice Note CM 7

### EXPERT WITNESSES IN PROCEEDINGS IN THE FEDERAL COURT OF AUSTRALIA

#### Commencement

1. This Practice Note commences on 4 June 2013.

#### Introduction

2. Rule 23.12 of the Federal Court Rules 2011 requires a party to give a copy of the following guidelines to any witness they propose to retain for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based on the specialised knowledge of the witness (see **Part 3.3 - Opinion** of the *Evidence Act 1995* (Cth)).
3. The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence<sup>130</sup>, and to assist experts to understand in general terms what the Court expects of them. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.

#### Guidelines

##### 1. General Duty to the Court<sup>131</sup>

- 1.1 An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise.
- 1.2 An expert witness is not an advocate for a party even when giving testimony that is necessarily evaluative rather than inferential.
- 1.3 An expert witness's paramount duty is to the Court and not to the person retaining the expert.

##### 2. The Form of the Expert's Report<sup>132</sup>

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

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<sup>130</sup> 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].

<sup>131</sup> The "*Ikarian Reefer*" (1993) 20 FSR 563 at 565-566.

<sup>132</sup> Rule 23.13.

- (a) be signed by the expert who prepared the report; and
  - (b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and
  - (c) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge; and
  - (d) identify the questions that the expert was asked to address; and
  - (e) set out separately each of the factual findings or assumptions on which the expert's opinion is based; and
  - (f) set out separately from the factual findings or assumptions each of the expert's opinions; and
  - (g) set out the reasons for each of the expert's opinions; and
  - (ga) contain an acknowledgment that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c) above<sup>133</sup>; and
  - (h) comply with the Practice Note.
- 2.2 At the end of the report the expert should declare that “[the expert] has *made all the inquiries that [the expert] believes are desirable and appropriate and that no matters of significance that [the expert] regards as relevant have, to [the expert's] knowledge, been withheld from the Court.*”
- 2.3 There should be included in or attached to the report the documents and other materials that the expert has been instructed to consider.
- 2.4 If, after exchange of reports or at any other stage, an expert witness changes the expert's opinion, having read another expert's report or for any other reason, the change should be communicated as soon as practicable (through the party's lawyers) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court<sup>134</sup>.
- 2.5 If an expert's opinion is not fully researched because the expert considers that insufficient data are available, or for any other reason, this must be stated with an indication that the opinion is no more than a provisional one. Where an expert witness who has prepared a report believes that it may be incomplete or inaccurate without some qualification, that qualification must be stated in the report.
- 2.6 The expert should make it clear if a particular question or issue falls outside the relevant field of expertise.
- 2.7 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports<sup>135</sup>.

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<sup>133</sup> See also *Dasreef Pty Limited v Nawaf Hawchar* [2011] HCA 21.

<sup>134</sup> The “*Ikarian Reefer*” [1993] 20 FSR 563 at 565

<sup>135</sup> The “*Ikarian Reefer*” [1993] 20 FSR 563 at 565-566. See also Ormrod “*Scientific Evidence in Court*” [1968] Crim LR 240

**3. Experts' Conference**

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

J L B ALLSOP  
Chief Justice  
4 June 2013

## Appendix C. Curriculum Vitae

### Simon M. Wheatley

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#### Overview

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

#### Personal

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

#### Employment

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

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

## Education

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

## Publicly Available Reports

Empirical Performance of Sharpe-Lintner and Black CAPMs: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, AusNet Services, CitiPower, Energex, Ergon Energy, Powercor, SA Power Networks, and United Energy, February 2015, <http://jemena.com.au/Gas/Jemena/media/jemenagasnetworksmedia/community-engagement-document/our-revised-regulatory-proposal/Appendix%2007.08%20NERA%20Empirical%20performance%20of%20the%20Sharpe-Lintner%20and%20Black%20CAPMs%20-%2026%20Feb%2015.pdf>

Historical Estimates of the Market Risk Premium: A report for Jemena Gas Networks, Jemena Electricity Networks, ActewAGL, Ausgrid, AusNet Services, Australian Gas Networks, CitiPower, Endeavour Energy, Energex, Ergon, Essential Energy, Powercor, SA Power Networks and United Energy, February 2015, <http://jemena.com.au/Gas/Jemena/media/jemenagasnetworksmedia/community-engagement-document/our-revised-regulatory-proposal/Appendix%2007.07%20NERA%20Historical%20estimates%20of%20the%20MRP%20-%2013%20Feb%2015.pdf>

Robust Regression Techniques: A report for DBP, December 2014, <https://www.erawa.com.au/cproot/13287/2/Submission%2012%20-%20Appendix%20F%20-%20Robust%20Regression.PDF>

Imputation Credits and Equity Returns: A report for the Energy Networks Association, October 2013, <http://www.aer.gov.au/sites/default/files/ENA,%20Attachment%204%20-%20NERA%20Report%20-%20Imputation%20Credits%20and%20Equity%20Prices,%20Submission%20to%20draft%20AER%20rate%20of%20return%20guideline%20-%2011%20Oct%202013.pdf>

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

The Market Risk Premium: Analysis in Response to the AER's Draft Rate of Return Guidelines: A report for the Energy Networks Association, October 2013, <http://www.aer.gov.au/sites/default/files/ENA,%20Attachment%203%20-%20NERA%20Report%20-%20>

[The Market, Size and Value Premiums: A report for the Energy Networks Association, June 2013, http://www.aer.gov.au/sites/default/files/Report%2015%20-%20ENAMRPRReport28062013%20Final.pdf](http://www.aer.gov.au/sites/default/files/Report%2015%20-%20ENAMRPRReport28062013%20Final.pdf)

[Estimates of the Zero-Beta Premium: A report for the Energy Networks Association, June 2013, http://www.aer.gov.au/sites/default/files/Report%202%20-%20Black%20CAPM%20Zero%20Beta%20Estimate%20\(Final\)%20-%2027%20June.pdf](http://www.aer.gov.au/sites/default/files/Report%202%20-%20Black%20CAPM%20Zero%20Beta%20Estimate%20(Final)%20-%2027%20June.pdf)

[The Payout Ratio: A report for the Energy Networks Association, June 2013, http://www.aer.gov.au/sites/default/files/Report%2012%20-%20Payout%20Ratio%20\(Final\)%20-%20June%202013.pdf](http://www.aer.gov.au/sites/default/files/Report%2012%20-%20Payout%20Ratio%20(Final)%20-%20June%202013.pdf)

[Review of Cost of Equity Models: A report for the Energy Networks Association, June 2013, http://www.aer.gov.au/sites/default/files/Report%201%20-%20Alternative%20Cost%20of%20Equity%20Models%20\(Final\)%20-%2026%20June.pdf](http://www.aer.gov.au/sites/default/files/Report%201%20-%20Alternative%20Cost%20of%20Equity%20Models%20(Final)%20-%2026%20June.pdf)

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[The Cost of Equity for a Regulated Energy Utility: A report for Multinet, February 2013, http://www.erawa.com.au/cproot/11197/2/20130312%20-%20D103642%20-%20Guidelines%20for%20the%20Rate%20of%20Return%20for%20Gas%20Transmission%20and%20Distribution%20Networks%20-%20United%20Energy%20and%20Multinet%20Gas.pdf](http://www.erawa.com.au/cproot/11197/2/20130312%20-%20D103642%20-%20Guidelines%20for%20the%20Rate%20of%20Return%20for%20Gas%20Transmission%20and%20Distribution%20Networks%20-%20United%20Energy%20and%20Multinet%20Gas.pdf)

[The Black CAPM: A report for APA Group, Envestra, Multinet & SP AusNet, March 2012, http://www.aer.gov.au/sites/default/files/Attachment%209.6%20NERA%20-%20Black%20CAPM%20Report%20March%202012.pdf](http://www.aer.gov.au/sites/default/files/Attachment%209.6%20NERA%20-%20Black%20CAPM%20Report%20March%202012.pdf)

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[5%20NERA%20%20Prevailing%20Conditions%20and%20the%20Market%20Risk%20Premium%20March%202012.pdf](http://www.aer.gov.au/content/item.phtml?itemId=752660&nodeId=fe0280e7e2113c467dfc4b3b076e1623&fn=Vic%20DNSPs%20(NERA)%20-%2020%20February%202012.pdf)

[The Market Risk Premium: A report for CitiPower, Jemena, Powercor, SP AusNet and United Energy, 20 February 2012, http://www.aer.gov.au/content/item.phtml?itemId=752660&nodeId=fe0280e7e2113c467dfc4b3b076e1623&fn=Vic%20DNSPs%20\(NERA\)%20-%2020%20February%202012.pdf](http://www.aer.gov.au/content/item.phtml?itemId=752660&nodeId=fe0280e7e2113c467dfc4b3b076e1623&fn=Vic%20DNSPs%20(NERA)%20-%2020%20February%202012.pdf)

Cost of Equity in the ERA DBNGP Draft Decision: A report for DBNGP, 17 May 2011,  
[http://www.erawa.com.au/cproot/9669/2/20110620%20-%20DBNGP%20\(WA\)%20-%20Sub%2055%20-%20Att%207%20-%20NERA%20Economic%20Consulting%20Cost%20of%20equity%20in%20the%20draft%20decision.pdf](http://www.erawa.com.au/cproot/9669/2/20110620%20-%20DBNGP%20(WA)%20-%20Sub%2055%20-%20Att%207%20-%20NERA%20Economic%20Consulting%20Cost%20of%20equity%20in%20the%20draft%20decision.pdf)

The Market Risk Premium: A report for Multinet Gas and SP AusNet, 29 April 2011,  
<http://www.aer.gov.au/content/index.phtml/itemId/745782>

Cost of Capital for Water Infrastructure Company Report for the Queensland Competition Authority, 28 March 2011,  
<http://www.qca.org.au/files/W-NERA-EconomicConsulting-FinalReport-WACC-0411.pdf>

The Cost of Equity: A report for Orion, 2 September 2010,  
<http://www.comcom.govt.nz/assets/Pan-Industry/Input-Methodologies/Draft-Reasons-Papers/Draft-Reasons-EDBs/Draft-Determination-X-Sub/Orion-Cross-Submission-Attachment-on-EDBs-and-GPBs-Input-Methodologies-Draft-Determination-and-Reasons-Paper-NERA-Report-2-September-2010.pdf>

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[http://www.aer.gov.au/content/item.phtml?itemId=736652&nodeId=dea014515519350384275dccc6b56018&fn=JGN%20further%20submission%20on%20gamma%20\(18%20May%202010\).pdf](http://www.aer.gov.au/content/item.phtml?itemId=736652&nodeId=dea014515519350384275dccc6b56018&fn=JGN%20further%20submission%20on%20gamma%20(18%20May%202010).pdf)

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Payout Ratio of Regulated Firms: A report for Gilbert + Tobin, 5 January 2010,  
[http://www.aer.gov.au/content/item.phtml?itemId=735236&nodeId=10e87413b13d1da23cd55faf20a6918d&fn=Appendix%206.3D%20-%20NERA%20\(4%20Jan%202010,%20ETSA\)%20Payout%20ratio%20of%20regulated%20firms.pdf](http://www.aer.gov.au/content/item.phtml?itemId=735236&nodeId=10e87413b13d1da23cd55faf20a6918d&fn=Appendix%206.3D%20-%20NERA%20(4%20Jan%202010,%20ETSA)%20Payout%20ratio%20of%20regulated%20firms.pdf)

Review of Da, Guo and Jagannathan Empirical Evidence on the CAPM: A report for Jemena Gas Networks, 21 December 2009,  
<http://www.ipart.nsw.gov.au/files/Submission%20-%20Alternative%20approaches%20to%20the%20determination%20of%20the%20cost%20of%20equity.pdf>



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The Value of Imputation Credits for a Regulated Gas Distribution Business: A report for WA Gas Networks, 18 August 2009, summarized in:

<http://www.erawa.com.au/cproot/8357/2/20100215%20WAGN%20-%20Proposed%20Revisions%20to%20the%20AA%20for%20the%20WAGN%20Gas%20Distribution%20Systems%20Submission%20-%20Public%20Version.pdf>

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<http://www.aer.gov.au/content/item.phtml?itemId=730699&nodeId=4fcc57398775fe84685434e0b749d76a&fn=Appendix%209.1%20-%20NERA%20-%20Cost%20of%20equity%20-%20Fama-French%20Model.pdf>

Estimates of the Cost of Equity: A report for WAGN, 22 April 2009, summarized in:

<http://www.erawa.com.au/cproot/8357/2/20100215%20WAGN%20-%20Proposed%20Revisions%20to%20the%20AA%20for%20the%20WAGN%20Gas%20Distribution%20Systems%20Submission%20-%20Public%20Version.pdf>

AER's Proposed WACC Statement – Gamma: A report for the Joint Industry Associations, 30 January 2009,

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

## Consulting Experience

NERA, 2008-present

Lumina Foundation, Indianapolis, 2009

Industry Funds Management, 2010

## Academic Publications

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

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

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

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

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

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

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

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

## **Working Papers**

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

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

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

Evaluating asset pricing models, 1998.

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

Testing asset pricing models with infrequently measured factors, 1989.

## **Refereeing Experience**

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

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

## **Teaching Experience**

International Finance, Melbourne Business School, 2008

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

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

Investments, University of Chicago, 1993-1994

Investments, University of British Columbia, 1986

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

Investments, Macroeconomics, Statistics, University of Rochester, 1982

Accounting, 1981, Australian Graduate School of Management, 1981

## **Teaching Awards**

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

## **Computing Skills**

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

## **Board Membership**

Anglican Funds Committee, Melbourne, 2008-2011

## **Honours**

Elected a member of Beta Gamma Sigma, June 1986.

## **Fellowships**

Earhart Foundation Award, 1982-1983

University of Rochester Fellowship, 1979-1984

Simon Fraser University Fellowship, 1979

Inner London Education Authority Award, 1973-1977

## **Report qualifications/assumptions and limiting conditions**

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