31 March 2010

The Required Rate of Return on Equity for a Gas Transmission Pipeline

A Report for DBP

NERA
Economic Consulting

Project Team

Simon Wheatley

Brendan Quach

NERA Economic Consulting
Darling Park Tower 3
201 Sussex Street
Sydney NSW 2000
Tel: +61 2 8864 6500
Fax: +61 2 8864 6549
www.nera.com

Contents

List of Tables

Executive Summary

DBP Transmission (DBP), the owner of the Dampier to Bunbury Natural Gas Pipeline, is required to submit a revised access arrangement proposal for its transmission network for the period 2011 through 2015. A critical element in determining the total revenues during the access period is the return allowed on equity. DBP has engaged NERA Economic Consulting (NERA) to estimate the current cost of equity for a gas transmission business applying well accepted financial models.

The National Gas Law, as amended and implemented in Western Australia, (NGL(WA)) and National Gas Rules (NGR) create a regulatory framework that allows a business to recover its efficient costs including a benchmark cost of equity. This benchmark cost must reflect the risks of owning equity in a gas transmission business.

There are a range of financial models available to estimate the cost of equity that measure the risk of owning equity in a variety of different ways. We use four different pricing models to estimate the cost of equity. The model that has traditionally been employed by Australian regulators to estimate the cost of equity is the Sharpe-Lintner (SL) Capital Asset Pricing Model (CAPM) and is the first model considered.

The SL CAPM states that an asset's risk should be measured by its beta and that an asset with a zero beta should earn the risk-free rate. Although the SL CAPM is an attractively simple model, there is a large body of evidence against it to the effect that it does not properly estimate the cost of equity for a gas transmission business. For example, Fama and French (2004) state that:[1]

> 'the empirical record of the model is poor – poor enough to invalidate the way it is used in applications.'

Empirically, the SL CAPM underestimates the returns to low-beta stocks, value stocks and low-market-capitalisation stocks. Since the equity of a gas transmission business has both a low beta and value characteristics, it follows that one can expect the SL CAPM to *underestimate* the return required on the equity.

A more general version of the CAPM, the Black version, states that while an asset's risk should be measured by its beta, an asset with a zero beta need not earn the risk-free rate. This is the second model used to estimate the required return on equity for a gas transmission business. There is less evidence against the Black version of the CAPM than against the Sharpe-Lintner version. Empirically, the Black CAPM does not underestimate the returns to low-beta assets. In fact, a zero-beta rate is chosen, essentially, to ensure that this is so. The Black CAPM, though, like the SL CAPM underestimates the returns to value stocks and low-market-capitalisation stocks. Therefore one can expect the Black CAPM, like the SL CAPM, to *underestimate* the return required on the equity of a gas transmission business.

The third model is the Fama-French three-factor model (FFM). This model is designed to correctly price value stocks and the equities of small firms. The ability of the Fama- French

1 Fama, E. And K. French, *The Capital Asset Pricing Model: Theory and Evidence,* Journal of Economic Perspectives, Summer 2004, pages 25-46.

three-factor model to correctly price the equities of small firms and value stocks has meant that it has become the standard model for estimating required returns in the academic finance literature. However, recent evidence indicates that the FFM, like the SL CAPM, underestimates the returns to low-beta stocks. Thus one can expect the FFM, like the Black CAPM and SL CAPM, to *underestimate* the return required on the equity of a gas transmission business.

So the fourth model considered is a zero-beta version of the FFM.

The NGR does not require that the Economic Regulation Authority of Western Australia (ERA) continue to use the CAPM to determine the return on capital. Rather, the NGR allow a transmission business to propose a financial model so long as it complies with the requirements of the NGR and the NGL(WA). In our opinion, the NGR and NGL(WA) impose two different types of requirements with respect to the derivation of the rate of return:

§ the outcome of the estimation process be as accurate as possible (but not less than) an estimate of the cost of capital associated with the relevant activity (Rule 87(1), Rule 74(2)(b) and Sections 24(2) and (5) of the NGL(WA)); and

§ the financial model that is used to estimate the rate of return be 'well accepted' (Rule 87(2)) and any forecast or estimate be 'arrived at on a reasonable basis' (Rule 74(2)(a)).

In our opinion, the four models that we use are all well accepted. In the academic world the SL CAPM is widely used as a teaching device. For example, Fama and French (2004) state that the model:[2]

> 'is the centerpiece of MBA investment courses. Indeed, it is often the only asset pricing model taught in these courses.'

They go on to point out, though, that:

> 'we ... warn students that despite its seductive simplicity, the CAPM's empirical problems probably invalidate its use in applications.'

The FFM is designed to explain the returns required on (and so to price) the equities of small firms and value firms correctly. The model is widely used in the academic world in research. So, for example, in a recent working paper, Da, Guo and Jagannathan (2009) note that:

> '(t)he Fama and French (1993) three-factor model ... has become the standard model for computing risk adjusted returns in the empirical finance literature'.[3]

The recent evidence that we review on the performance of the four models that we use indicates that among the four the zero-beta version of the FFM best fits the data. An enthusiasm for this model, though, should be tempered by the fact that empirical estimates of

---

2 Fama, E. And K. French, *The Capital Asset Pricing Model: Theory and Evidence*, Journal of Economic Perspectives, Summer 2004, pages 25-46.

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

the difference between the zero-beta and risk-free rates are higher than perhaps theory might lead one to expect. Empirical estimates from the last 40 years or so of Australian and US data are no less than 6.50 percent per annum while theory suggests that the difference should not exceed the difference between the rates at which investors can borrow and lend.

Consistent with the existing approach of the ERA and the Australian Energy Regulator (AER), estimates of the cost of equity for a gas transmission business have been computed using domestic versions of the four models. Where appropriate, the models have been populated with the same data and parameters as those employed by the ERA in its *Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power*.[4] Also, we use the same delevering and relevering scheme that the AER endorses in its review of the *WACC* parameters for electricity lines businesses. [5]

To estimate parameters not shared with the SL CAPM, we primarily use data provided by Dimensional Fund Advisors Australia Ltd (DFA), an investment group affiliated with Fama and French.

Table 1, sets out our estimates of the parameters and required return on equity for each of the financial models considered by NERA.

Table 1
Estimates of the return required on an Australian utility stock computed using weekly DFA data

			Beta			Risk Premium			
Model	Risk-Free Rate*	Zero-Beta Premium	Market	*HML*	*SMB*	Market	*HML*	*SMB*	Return On Equity
Sharpe-Lintner CAPM	5.51		0.51			6.50			8.85
Black CAPM	5.51	6.50	0.51			0.00			12.01
Fama-French	5.51		0.57	0.41	0.28	6.50	6.12	-0.45	11.59
Zero-Beta Fama-French	5.51	6.50	0.57	0.41	0.28	0.00	6.12	-0.45	14.40

* *The risk-free rate and market risk premium are from the Economic Regulation Authority's 'Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power'.*

The four financial models provide a plausible range for the return on equity required by an Australian regulated gas transmission business of between 8.85 per cent and 14.40 per cent.

---

4 ERA, *Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power*, 2009.

The ERA in adopting a *WACC* of 7.98 per cent used the *WACC* parameters outlined by the Australian Energy Regulator's *Final Decision on Electricity transmission and distribution network service providers: Review of the weighted average cost of capital (WACC) parameters*, May 2009.

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

1. Introduction

This report has been prepared for DBP by NERA Economic Consulting (NERA). DBP operates the Dampier to Bunbury Natural Gas Pipeline in Western Australia (DBNGP). DBP is required to submit an access arrangement proposal to the Economic Regulation Authority of Western Australia (ERA) in early 2010. The revised access arrangement will cover the period January 2011 through December 2015.

DBP has asked NERA to provide a report that examines a number of financial models to estimate a plausible range for the return on equity required by an Australian regulated gas transmission business by apply a number of well accepted financial models.

Specifically, DBP has requested that we provide an expert opinion on:

1. advise on well accepted financial models which could be used to estimate plausible ranges for return on equity which can be used as a guide for estimating the return on equity that is required to be determined for the purposes of Rule 87(1) of the NGR;
2. estimate the parameters used in each of these models having regard to the requirements of Rule 74 of the National Gas Rules, and the revenue and pricing principles of the National Gas Access (WA) Act, taking as given a market risk premium of 6.50%, a benchmark gearing of 60.00% debt, and a value to be attached to imputation credits (gamma) of 0.20; and
3. use the models identified in item 1, and for which the parameters have been estimated in item 2, to estimate the plausible range for the cost of equity as a guide to estimating the return on equity required for Rule 87(1).

The remainder of this report is structured as follows:

- Section 2 – describes the four financial models we use to estimate the required return on equity for a gas transmission business;
- Section 3 – reviews the empirical evidence on whether the financial models meet the requirements of Rule 74 of the National Gas Rules that any forecast or estimate be ‘arrived at on a reasonable basis’ and ‘represent the best forecast or estimate possible in the circumstances’;
- Section 4 – describes the underlying assumptions, data and methodology used to estimate the parameters of each model;
- Section 5 – estimates the required return on equity for an Australian gas transmission business using the four identified financial models and weekly data; and
- Section 6 – sets out the conclusions of this report.

Appendix A estimates the required return on equity for an Australian gas transmission business using the four identified financial models and monthly data. Appendix B describes an alternative data source that could be used to populate the FFM. Appendix C reproduces the terms of reference for this report.

1.1. Statement of Credentials

This report has been jointly prepared by **Simon Wheatley** and **Brendan Quach**.[6]

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

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

In preparing this report, each of the joint authors (herein after referred to as either 'we' or 'our') confirms that we have made all the inquiries we believe are desirable and appropriate and no matters of significance that we regard as relevant have, to our knowledge, been withheld from this report. We have been provided with a copy of the Federal Court guidelines *Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia* dated 5 May 2008. We have reviewed those guidelines and this report has been prepared consistently with the form of expert evidence required by those guidelines.

6 If requested a complete curriculum vitae can be provided for each of the authors.

2. Financial Models Considered

Rule 87(2) of the NGR dictate that the financial model that is used to estimate the rate of return on equity for a regulated Australian gas transmission business be 'well accepted'. We use four well accepted financial models to estimate the return on equity: two versions of the CAPM and two versions of the FFM. The two versions of the CAPM that we use are the SL CAPM and the Black CAPM. In the Black CAPM a zero-beta asset need not earn the risk-free rate. The two versions of the FFM that we use are the FFM and a zero-beta version of the model. In the zero-beta version of the model a zero-beta asset, as in the Black CAPM, need not earn the risk-free rate.

We use zero-beta versions of the CAPM and FFM because a large body of evidence indicates that a zero-beta version of the CAPM better fits the data than does the SL CAPM and because recent evidence indicates that a zero-beta version of the FFM better fits the data than does the FFM. We use the FFM because there is a substantial amount of evidence that indicates that it does a better job of pricing value stocks and low-market-capitalisation stocks than does either the Sharpe-Lintner or Black CAPM. We discuss this evidence in some detail in section 3.

2.1. Sharpe-Lintner CAPM

Modern portfolio theory can be traced to the work of Markowitz (1952).[7] It has long been known that it does not pay for an investor to put all of his or her eggs in one basket. Markowitz examined how a risk-averse investor who cares only about the mean and variance of his or her future wealth should distribute his or her capital across 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 the variance of the returns to individual elements of that portfolio. Markowitz emphasised, 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, the return would be risky.

Subsequently, Sharpe (1964) and Lintner (1965) examined how the prices of assets will be determined if all investors choose portfolios that are efficient.[8] A portfolio that is efficient is one that has the highest mean return for a given level of risk, where risk is measured by the variance of returns. Their model has become known as the Sharpe-Linter CAPM, or often simply the CAPM.

Sharpe and Lintner's insight was that the return that investors require on an individual asset will be determined not by how risky the asset would be if held alone, but rather by the way in which the asset contributes to the risk of the market portfolio. A rational risk-averse investor will never invest solely in a single risky asset. In other words, a rational investor will never place all of his or her eggs in one basket; rather the investor will diversify. So in the CAPM

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

8 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.

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 a large diversified portfolio, like the market portfolio.

The SL CAPM makes the following assumptions about the behaviour of risk-averse investors:

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

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

(iii) they face no taxes (or the same rate of taxation applies to all forms of income) and there are no transaction costs; and

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

With these assumptions, the SL CAPM implies that:

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

where

$E(R_j)$	=	is the expected return on asset j;
R_f	=	is the risk-free rate;
b_j	=	asset j's equity beta, which measures the contribution of the asset to the risk, measured by standard deviation of return, of the market portfolio; and
$E(R_m)$	=	the expected return to the market portfolio of risky assets.

While the SL CAPM is typically the first pricing model to which business students are introduced, because of its simplicity, it has been known for almost 40 years that the model tends to underestimate the returns to low-beta assets and overestimate the returns to high-beta assets. Since empirical estimates suggest that the equity of a gas transmission business has a low beta, it follows that the SL CAPM will underestimate the return required on the equity. The assumptions that the SL CAPM makes are, of course, unrealistic and so in some respects the failure of the model to correctly price assets is not surprising. 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, importantly, investors face lending rates and borrowing rates that differ. The rate at which investors can borrow generally exceeds the rate at which investors can lend. Black (1972), Vasicek (1971) and Brennan (1971) examine the impact of relaxing the assumption that investors can borrow or lend freely at a single rate.[9]

---

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

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

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

2.2. Black CAPM

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

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

then

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

where

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

Although three authors contributed to the development of the model, the model is generally known simply as the Black CAPM.

In the Black CAPM, as in the SL CAPM, the excess return an investor requires on an asset is a function of the asset's beta and the market price of risk. In the Black CAPM, though, the excess return is computed using the zero-beta rate, and not the lending or borrowing rate, and, similarly, the market price of risk is the mean return to the market in excess of the zero-beta rate, not the lending or borrowing rate.

It is useful to see how one might be misled if the Black CAPM were true, but one were to use the lending rate and the SL CAPM to compute the required return on an asset. From (1) and (2) the error in computing the return required on an asset if the Black CAPM were true, but one were to use the lending rate and the SL CAPM to compute the return would be:

$$[1 - b_j][R_l - \mathrm{E}(R_z)]. \tag{3}$$

Since $R_l < \mathrm{E}(R_z)$, that is, since the lending rate is less than the zero-beta rate, the error will be positive (negative) if $b_j > 1$ ($b_j < 1$). In other words, if the Black CAPM were true, but one were to use the lending rate and the SL CAPM to compute the required return on a low-beta asset, one would underestimate the return.

In estimating the Black CAPM, we follow Velu and Zhou (1999) and assume that the difference between the zero-beta and risk-free rates, what we will call the zero-beta premium, is a constant through time.[10] Thus we examine the following model:

$$\mathrm{E}(R_j) - R_f - z = b_j[\mathrm{E}(R_m) - R_f - \mathrm{z}], \tag{4}$$

where

z = the zero-beta premium.

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

If $z = 0$, the model collapses to the SL CAPM, illustrating the fact that the Black CAPM is a more general model than the SL CAPM. If $z > 0$, as empirically is found, then the SL CAPM will underestimate the mean returns to low-beta assets. In contrast, by construction, an empirical version of the Black CAPM will neither underestimate nor overestimate the returns to low-beta assets.

Fama and French (1992) show that, contrary to the predictions of both the Sharpe-Lintner and Black CAPMs, the market value of a firm's equity and the ratio of the book value of the equity to its market value are better predictors of the equity's return than is the equity's beta.[11] Fama and French (1993) argue that if assets are priced rationally, variables that can explain the cross-section of mean returns must be proxies for risks that cannot be diversified away about which investors care.[12] In the CAPM, an asset's risk is measured solely by how it contributes to the risk, measured by standard deviation of return, of the market portfolio. In other, more sophisticated models, an asset's risk is measured in addition by the exposure of the asset's return to other factors.

These additional sources of risk can arise because investors care about whether assets are likely to pay off unexpectedly well or badly when future investment opportunities are unexpectedly good. In the CAPM, investors behave myopically. So, in the model, investors do not consider whether an asset will pay off unexpectedly well when future investment opportunities are attractive or pay off badly. In practice, investors are likely to view assets that pay off well when future opportunities are attractive as more valuable than assets that pay off badly. If investors hold assets that pay off unexpectedly well when future opportunities are attractive, they will be better able to take advantage of the opportunities. So, all else constant, it is likely that, in practice, investors will be willing to pay to accept a lower return on these assets. As Merton (1973) shows, this means that in general risks other than just the risk of an asset relative to the market will be priced.[13]

Another way in which additional risks can be priced is if investors hold assets that are nonmarketable or that they choose not to divest. The CAPM assumes that all assets are marketable and that investors diversify. Heaton and Lucas (2000) note that in practice many large stockholders are the proprietors of small privately held businesses.[14] In other words, many large stockholders choose not to diversify – perhaps to limit agency costs. Events that are likely to adversely affect the values of small-market-capitalisation and value firms, however, are also likely to adversely affect the values of small privately held businesses.[15] So large stockholders who are also proprietors are likely to demand a premium for holding

---

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

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

[13] Merton, Robert C., *An intertemporal capital asset pricing model*, Econometrica 41, 1973, pages 867-887.

[14] Heaton, John and Deborah Lucas, 2000, *Portfolio choice and asset prices: The importance of entrepreneurial risk*, Journal of Finance 55, pages 1163-1198.

[15] A value firm is a firm with a high book-to-market ratio.

value stocks and may choose to hold portfolios of marketable assets that exhibit a growth tilt.[16]

Finally, as Fama and French (1993) make clear, if there are factors besides the return to the market portfolio that are pervasive, then the Arbitrage Pricing Theory (APT) of Ross (1976) predicts that the additional risks associated with these factors should be priced.[17] To be precise, if the factors are pervasive, the mean return to each asset should be determined by its exposure to the factors. The intuition behind the APT is that investors will be rewarded for risks that are pervasive and they cannot diversify away but will not be rewarded for risks that are idiosyncratic and that they can diversify away.

2.3. Fama-French Three-Factor Model

To explain the patterns in mean returns that one observes, Fama and French (1993) suggest that investors care about the exposure of each asset to:[18]

(i) the excess return to the market portfolio;

(ii) the difference between the return to a portfolio of high book-to-market (or ‘value’) stocks and the return to a portfolio of low book-to-market (or ‘growth’) stocks (described as ‘high minus low’, or *HML*); and

(iii) the difference between the return to a portfolio of small cap stocks and the return to a portfolio of large cap stocks (described as ‘small minus big’, or *SMB*).

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

$$\mathrm{E}(R_j) - R_f = b_j[\mathrm{E}(R_m) - R_f] + h_j HMLP + s_j SMBP, \tag{4}$$

where

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

The FFM is designed to explain the returns to (and so to price) small firms and value firms correctly.

---

16 Cochrane, John H., *Portfolio advice for a multifactor world*, Economic Perspectives: Federal Reserve Bank of Chicago 23, 1999, pages 59-78.

17 Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, page 35.

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

18 Merton, Robert C., *An intertemporal capital asset pricing model*, Econometrica 41, 1973, pages 867-887.

Characteristics versus exposures

The evidence that Fama and French (1992) provide shows that, contrary to the predictions of the SL CAPM, size and book-to-market are better predictors of return than beta.[19] Size and book-to-market are *characteristics*. Beta measures the *exposure* of an asset to market risk. To correct these problems with the SL CAPM, Fama and French (1993) introduce a pricing model that does not link the cost of equity to a set of characteristics but instead links it to the exposure of equity to three sources of risk: market risk; *HML* risk; and *SMB* risk.[20]

The predictions of a characteristics-based model and an exposure-based model can differ substantially. For example, absent synergies or tax effects, the FFM predicts that the merger of two identical unlevered companies will not affect the return required on each company. A characteristics-based model in which the cost of equity is negatively related to size, on the other hand, will predict that the return required on each company will fall. While an exposure-based model can be given a theoretical rationale consistent with the idea that investors behave rationally, a theoretical rationale for a characteristics-based model will in general require that some investors do not behave rationally.[21]

The FFM states that the return required on an asset should be explained by its *exposure* to the three factors, that is, its factor betas, irrespective of the asset's *characteristics*. As Davis, Fama and French (2000) point out, for example, the FFM[22]

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

where BE/ME denotes book-to-market. In other words, the required return on an asset depends on its exposures to the three factors *irrespective* of the asset's characteristics. Firms with large *HML* betas may be firms with high book-to-market ratios but they need not be. A firm, for example, may have a large *HML* beta but have a low book-to-market ratio. Similarly firms with high *SMB* betas may be small firms but they need not be. A small firm, for example, may have a low *SMB* beta. As Koller, Goedhart and Wessels (2005) point out, in the FFM:[23]

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

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

[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.

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

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

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

companies.'

In its recent draft decision, the AER fundamentally misunderstands how the FFM determines the required return on a stock. The AER states that:[24]

> 'The FFM seeks to adjust for business specific risks, but the regulatory framework for assessment is a benchmark exposure to risks. That is, the FFM posits that a business' return should be based on its specific *characteristics*—the business size and book-to-market ratio.'
>
> [*Emphasis added*]

The AER's concern is that if the FFM were a *characteristics-based* model – and it is not – then it would not be appropriate to use the model to estimate the return required on equity for a benchmark energy business. This is because the return required on the equity of a benchmark energy business would depend on the characteristics of the companies used to define the benchmark. A merger of some of the companies would, for example, produce a benchmark business with different characteristics and so, under a characteristics-based model, a different return required on equity. The AER's concern, though, is misplaced because the FFM links the required return on an asset to its *exposure* to the three factors *not* to the asset's characteristics.

The FFM is now accepted within the academic community as the benchmark for computing risk-adjusted returns in empirical work. Evidence supporting this assertion is provided by the statement on Morgan Stanley's web site that it awarded Eugene Fama in 2005 the first Morgan Stanley – AFA Prize in Financial Economics, an award made every two years, in part for producing:[25, 26]

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

Additional evidence supporting the assertion is provided by Da, Guo and Jagannathan (2009) who state that:[27]

> '(t)he Fama and French (1993) three-factor model ... has become the standard model for computing risk adjusted returns in the empirical finance literature'

and by Gharghori, Lee and Veeraraghavan (2009) who state that:[28]

> 'the Fama-French model has become quite popular. It is reasonable to say that it has now supplanted the CAPM as the dominant asset pricing model in the finance literature.'

---

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

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

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

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

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

Since the equity of a gas transmission business has a positive exposure to the *HML* factor, the use of the SL CAPM instead of the FFM is likely to produce a lower estimate of the return required on the equity. If one accepts the large amount of evidence that suggests that the FFM is a more accurate pricing model than the SL CAPM, one can also say that the SL CAPM is likely to produce an underestimate of the return.

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

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

A zero-beta version of the FFM can be generated by relaxing the assumption, inherent in the FFM, that investors can borrow or lend as much as they like at a single risk-free rate. Again, we follow Velu and Zhou (1999) and assume that the difference between the zero-beta and risk-free rates, the zero-beta premium, is a constant through time.[29] Thus we examine the following model:

$$\mathrm{E}(R_j) - R_f = z + b_j[\mathrm{E}(R_m) - R_f - z] + h_j HMLP + s_j SMBP, \qquad (5)$$

where

z = the zero-beta premium.

If $z = 0$, the model collapses to the FFM. Thus the zero-beta model is a more general model than the FFM. If $z > 0$, as empirically is found, then the FFM will underestimate the mean returns to low-beta assets.

Since the equity of a gas transmission business has a low beta ***and*** a positive exposure to the Fama-French value factor, it is likely that the SL CAPM, Black CAPM and FFM will all underestimate the return required on the equity. In contrast, the zero-beta version of the FFM should neither underestimate nor overestimate the return.

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

The CAPM and the Fama-French three-factor model

The AER's draft decision indicates that the AER believes that the FFM includes the SL CAPM as a special case. The AER states that:[30]

> 'The NERA report on the FFM outlines that the FFM is used because it is more accurate than the CAPM. The AER notes that any increase in accuracy arising from the use of three risk premiums (instead of one) arises only in the context of within sample explanatory power. This is a statistical artefact of the model as a consequence of including additional explanatory variables. Even variables that are not relevant to the estimation of the rate of return of capital will give this result—the greater explanatory power may even reach the threshold of statistical significance despite no true relationship between a randomly selected variable and the dependent variable.'

Thus the AER believes that adding the *HML* and *SMB* factors to the SL CAPM to produce the FFM is bound to provide the appearance of greater accuracy.

It may be tempting to conclude that because the FFM is a three-factor model and one of the factors is the return to the market portfolio in excess of the risk-free rate that the FFM must include the SL CAPM as a special case. The FFM, though, will *not* in general include the SL CAPM as a special case. The SL CAPM predicts that the required return on an asset should depend on the asset's beta while the FFM predicts that the return will depend on the asset's three factor betas. The SL CAPM does not place a restriction on what the asset's factor betas should be. Thus there is no reason why the FFM should include the SL CAPM as a special case. Thus it is *not* true that adding the *HML* and *SMB* factors to the SL CAPM to produce the FFM is bound to provide the appearance of greater accuracy.

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

3. An Empirical Assessment of the Models

The ERA, like the AER, currently uses the SL CAPM to estimate the required return on equity for a gas transmission business. The existing evidence indicates that the SL CAPM underestimates the returns required on low-beta stocks and overestimates the returns required on high-beta stocks. Since the equity of a gas transmission business has a low beta, this means that a sole reliance by a regulator on the SL CAPM will lead the regulator to *underestimate* the return required on the equity.

The Black CAPM, unlike the SL CAPM, does not underestimate the returns required on low-beta stocks. Estimates of the zero-beta premium required to ensure that this is so, though, are high. In fact, the evidence from Australia and the US indicates that the empirical version of the Black CAPM that has best fit the data of the last 40 years or so is one in which all stocks share, approximately, the same required return.

While there is less evidence against the Black CAPM than against the SL CAPM, there is also evidence that both models underestimate the returns required on value stocks and low-market-capitalisation stocks. In a recent National Bureau of Economic Research (NBER) working paper, Da, Guo and Jagannathan (2009) conjecture that, despite this evidence, the SL CAPM may still be of use in estimating the return required on a project.[31] Since the Australian Energy Regulator (AER) and the New South Wales Independent Pricing and Regulatory Tribunal (IPART) have both cited this working paper in recent statements, we discuss the paper in some detail.[32]

Da, Guo and Jagannathan argue that evidence that the SL CAPM underestimates the returns required on value stocks may be explained by variation through time in the betas of value stocks. They suggest that value firms have real options and that the betas of these options vary though time. Thus they argue that the SL CAPM may still be of use in estimating the return required on a project that has no real options. NBER associates Lewellen and Nagel (2006) disagree.[33] They argue that the variation in the betas of value stocks required to explain the extent to which the SL CAPM underestimates the returns to value stocks is implausibly large. Also, empirically, they find no evidence that the variation that one observes is capable of explaining the extent to which the SL CAPM underestimates the returns.

Da, Guo and Jagannathan also argue that while the SL CAPM may misprice some individual stocks, it need not misprice industry portfolios. They argue, essentially, that while the SL CAPM may underestimate the returns required on some stocks within an industry, it may overestimate the returns required on others. So they conjecture that, on average, the SL

---

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

32 AER, *ActewAGL Access arrangement proposal for the ACT, Queanbeyan and Palerang gas distribution network: 1 July 2010 – 30 June 2015*, November 2009.

NSW Independent Pricing and Regulatory Tribunal, *Alternative approaches to the determination of the cost of equity*, November 2009.

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

CAPM may not either underestimate of overestimate the return required on a stock drawn from the industry. The evidence that they provide does not support the conjecture. Their evidence indicates that the SL CAPM also misprices industry portfolios. In particular, the model underestimates the returns to low-beta industry portfolios and underestimates the returns to high book-to-market industry portfolios.

To test their conjecture that the SL CAPM may still be of use in estimating the return required on a project that has no real options, Da, Guo and Jagannathan examine stocks with low capex. They argue that low-capex stocks will have few real options. They find that, contrary to their conjecture, variables besides beta are useful in explaining the cross-section of mean returns to the stocks. In particular, they find, conditional on beta, a negative relation between a low-capex stock's mean return and size and a positive relation between a low-capex stock's mean return and book-to-market. In other words, contrary to the predictions of both the Sharpe-Lintner and Black CAPMs, they find that variables other than beta are required to explain the cross-section of returns to low-capex stocks. This evidence suggests that additional factors beyond an asset's beta are required to measure the return the market requires on the asset.

The FFM provides such additional factors. The FFM predicts that the return required on a stock will depend on its exposure not just to the market, but also to value and size factors. Evidence from Australia and the US indicates that the three-factor model better fits the data than the SL CAPM. Recent evidence also indicates, though, that a portfolio with no exposure to the three Fama-French factors, a zero-beta portfolio, earns, on average, more than the risk-free rate. In other words, the evidence indicates that a zero-beta version of the FFM better fits the data than a version that restricts the zero-beta and risk-free rates to be equal. Estimates of the zero-beta premium, though, are again high. The evidence from Australia and the US indicates that, empirically, the zero-beta version of the FFM that has best fit the data of the last 40 years or so is one in which an exposure to the market is not rewarded.

Since the equity of a gas transmission business has a low beta ***and*** a positive exposure to the Fama-French value factor, the evidence that we review indicates that the SL CAPM, Black CAPM and FFM will all *underestimate* the return required on the equity.

3.1 Sharpe-Lintner and Black CAPMs

There is a considerable amount of evidence against the SL CAPM – or at least against an empirical version of the model.[34] Table 3.1 provides a summary of some evidence on the

[34] The SL CAPM predicts that the market portfolio will be efficient. Theory suggests that the market portfolio should consist of all assets, not just stocks. Thus theory suggests that the market portfolio should include bonds, real estate and human capital. Measuring the returns to assets other than stocks, though, can be difficult. For these reasons, most academic work and most practitioners use the return to an index of stocks as a proxy for the return to the market portfolio.

While the use of a stock index as a proxy for the market portfolio is almost uniform, Roll (1977) emphasizes that the CAPM does not imply that a stock index should be mean-variance efficient. The CAPM implies only that the market portfolio should be efficient. So a test of the efficiency of an index of stocks cannot be viewed as a test of the CAPM. A different issue concerns us, though, than that which concerns Roll. The issue that concerns us is whether an empirical version of the CAPM produces accurate estimates of required returns. The issue that concerns Roll, but not us here, is whether the CAPM itself is true. A test of the efficiency of a stock index can be viewed as a test of whether the empirical version of the model that regulators use produces accurate estimates of returns. This is the issue that

CAPM. The table shows that the mean return to a zero-beta asset has been substantially above the risk-free rate, contrary to the prediction of the SL CAPM. Also, over the last 40 years or so there has been little relation between mean return and risk measured by beta.

Table 3.1
Summary of existing evidence on the CAPM[35]

Study	Period	Zero-beta premium	Price of risk
	US evidence		
Fama and MacBeth (1973)	1935-1968	5.76	10.20
		(2.28)	(3.96)
Campbell (2004)	1929-1963	2.76	6.12
		(3.36)	(5.52)
Lewellen, Nagel and Shanken (2008)	1963-2004	11.60	-1.76
		(3.65)	(4.51)
Campbell (2004)	1963-2001	8.28	-0.84
		(3.12)	(4.51)
	Australian evidence		
Lajbcygier and Wheatley (2009)	1979-2007	9.96	-2.64
		(2.04)	(3.72)

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

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

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

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

concerns us. A test of the efficiency of a stock index cannot be viewed as a test of the model itself. In other words, we think that Roll is right. Discovering whether the model is really true, though, is not an issue that concerns us here. For simplicity, here, when we refer to a test of the CAPM, we refer to a test of the empirical version of the model that practitioners use and not necessarily the model itself.

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

35 The zero-beta premium and price of risk are in percent per annum. Standard errors are in parentheses.

Does the SL CAPM pass Friedman's two tests of a theory?

It has been argued that the empirical version of the SL CAPM used to estimate the cost of equity for a regulated energy business has a strong theoretical basis.[36] The empirical version that regulators use employs a portfolio of stocks as a proxy for the market portfolio.

As Roll (1977) makes clear, however, the SL CAPM states that the market portfolio should include *all* assets – not just stocks.[37] As Ibbotson, Siegel and Love (1985) point out, stocks make up a relatively small fraction of total wealth, so the return to a portfolio of stocks need not track closely the return to total wealth.[38] In Australia, for example, real estate makes up a substantial portion of total wealth, but while real estate has appreciated in value over the last two years, stocks have fallen. So it is misleading to say that the empirical version of the SL CAPM that Australian regulators use has a 'strong theoretical basis.' The SL CAPM states that the risk of an asset should be measured relative to total wealth whereas the empirical version of the model that regulators use measures the risk of an asset relative to a portfolio of stocks alone.

Nobel prize-winner Milton Friedman (1953) argues that for an economic theory to be useful it must pass two tests. First, it must be true that[39]

> 'a hypothesis explains what it sets out to explain – that its implications for such phenomena are not contradicted in advance by experience that has already been observed'

and second, it must be consistent with

> 'new facts capable of being observed but not previously known.'

An empirical version of the SL CAPM that uses a portfolio of stocks as a proxy for the market portfolio fails both of these tests. Sharpe's paper introducing the SL CAPM was published in 1964, but the tests that Fama and MacBeth (1973) conduct on data from *before* 1964 reject the model.[40, 41] The tests that Campbell (2004) and Lewellen, Nagel and Shanken (2008) conduct using data drawn for the most part from *after* 1964 also reject the model.[42]

---

[36] AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, page 117.

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

[38] Ibbotson, Roger G., Laurence Siegel and Kathryn S. Love, *World Wealth: U.S. and Foreign Market Values and Returns*, Journal of Portfolio Management, Fall, 1985.

[39] Friedman, Milton, *The methodology of positive economics*, in Positive Economics, University of Chicago Press, 1953, pages 12-13.

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

[41] Fama and MacBeth (1973) use data from 1935 to 1968 to test the SL CAPM. Their Table 3, though, provides sufficient information for one to construct a test of the SL CAPM using data only from before 1964. Excluding data from 1964 through 1968 does not alter their conclusion that the zero-beta rate exceeds on average the risk-free rate.

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

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

Besides these problems, Fama and French (1992) find in US data from 1963 to 1990 that variables besides beta are useful for explaining the cross-section of mean returns. [43] They find, holding beta constant, a positive relation between a firm's book-to-market ratio and the mean return to the firm's equity. That is, they find that value stocks deliver higher returns on average than growth stocks on a risk-adjusted basis. They also find, holding beta constant, a negative relation between the market capitalisation of a firm's equity and the mean return to the equity. That is, they find that the stocks of small firms outperform the stocks of large firms on a risk-adjusted basis.

The results that Fama and French (1992) find are not unique to the US. Fama and French (1998) find a positive relation between a firm's book-to-market ratio and the mean return to its equity for a large cross-section of countries, including Australia.[44] Since both the Sharpe-Lintner and Black versions of the CAPM predict that the relation between mean return and beta should be linear, the result that size and a firm's book-to-market ratio are better predictors of return than beta provides evidence against both versions of the CAPM. As Fama and French (2004) have put it:[45]

> If betas do not suffice to explain expected returns, the market portfolio is not efficient, and the CAPM [either Sharpe-Lintner or Black] is dead in its tracks.

Despite this evidence, the SL CAPM is still used by academics as a teaching device because the model is simple and shares some of the same characteristics as more sophisticated models. The overwhelming evidence against the model, though, has meant that it has long since been discarded by academics as a research tool. In a recent NBER working paper, however, Da, Guo and Jagannathan (2009) suggest that the model may still be useful for measuring the return required on a project to which are attached no real options.[46]

3.1.1. Variation in betas and the MRP

Da, Guo and Jagannathan acknowledge that there exists a considerable body of empirical evidence against the CAPM and that it underestimates the returns to value stocks and overestimates the returns to growth stocks. They conjecture, though, that the poor empirical performance of the CAPM may stem from variation through time in the betas of both value and growth stocks. They argue that the betas of value and growth stocks may vary over time because of the real options that value and growth stocks may have.

For this conjecture to work it must be the case that there is:

- considerable variation through time in the betas of both value and growth stocks,
- considerable variation through time in the market risk premium (MRP) and

---

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

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

[45] Fama, Eugene and Kenneth French, *The Capital Asset Pricing Model: Theory and Evidence*, Journal of Economic Perspectives 18, 2004, pages 25-46.

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

- a strong positive correlation between the MRP and the beta of a 'long-short value strategy'.[47]

In a recently published paper, NBER associates Lewellen and Nagel (2006) argue that the amount of variation required to explain the extent to which the SL CAPM misprices a long-short value strategy is implausibly large.[48] For example, they show that even if:

- approximately 95 percent of the time the MRP were to lie between –6 and 18 percent per annum,
- approximately 95 percent of the time the beta of a long-short value strategy were to lie between minus one and one, and
- changes in the MRP and beta of a long-short value strategy were perfectly correlated,

the SL CAPM would still not explain the value premium that one observes.

Empirically, Lewellen and Nagel find some evidence of a variation through time in the betas of value and growth stocks. They find, though, that the variation is too small and, importantly, the links between changes in the MRP and changes in the betas of value and growth stocks are too weak to explain why the SL CAPM misprices value and growth stocks so badly.

3.1.2. Industry returns

Da, Guo and Jagannathan conjecture that the book-to-market effect is a within-industries effect and not an across-industries effect. They argue that although the SL CAPM may not hold at the individual stock level, the model may hold at the industry level. If the SL CAPM were to hold at the industry level, then the model would be the ideal tool for determining the return required on the equity of a benchmark business. The evidence that Da, Guo and Jagannathan provide, however, does not support their conjecture – although, as we shall explain, this is not the way in which they interpret their evidence.

The conjecture that Da, Guo and Jagannathan make is essentially that deviations from the SL CAPM at the stock level may be difficult to detect in industry portfolios because in any industry portfolio there may be as many stocks whose returns are underestimated by the SL CAPM as stocks whose returns are overestimated. If their conjecture is correct, then tests of the SL CAPM that use industry portfolios may lack power. In other words, tests that use industry portfolios may have difficulty rejecting the SL CAPM when it is false. So it may not be a good idea to rely on tests that use industry portfolios. This is because while it may be true for many industries that there are as many stocks whose returns are underestimated by the SL CAPM as stocks whose returns are overestimated, it may not be true of all industries.

---

[47] A long-short value strategy is a zero-investment position that is long a portfolio of value stocks and short a portfolio of growth stocks.

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

It may also be the case that for many industries there are as many stocks with positive ***HML*** exposures as there are stocks with negative ***HML*** exposures. Thus there may be less variation across industry portfolios in ***HML*** exposures than across individual stocks. If this is true, then tests of the SL CAPM against the alternative that the FFM is true that use industry portfolios may also lack power. In other words, tests that use industry portfolios may have difficulty rejecting the SL CAPM in favour of the FFM when the SL CAPM is false and the FFM is true. So, again, it may not be a good idea to rely on tests that use industry portfolios. This is because while it may be true for many industries that there are as many stocks with positive ***HML*** exposures as there are stocks with negative ***HML*** exposures, it may not be true of all industries.

Evidence that the FFM provides a better fit than the SL CAPM for at least one industry is provided by NERA (2009).[49] They examine the returns to a portfolio of US regulated utilities and find that while there is evidence that the SL CAPM significantly underestimates the return required on the portfolio, there is no evidence that the FFM does so. They find that regulated utilities, like their Australian counterparts, have a positive exposure to the Fama-French ***HML*** factor. While the SL CAPM provides no compensation for this exposure, the FFM does. For this reason, the FFM provides a better fit for the data than does the SL CAPM.

To test their conjecture that the book-to-market effect is a within-industries effect and not an across-industries effect, Da, Guo and Jagannathan form 10 industry portfolios and then split each of these 10 portfolios into three book-to-market terciles. From each industry they choose one book-to-market tercile in such a way as to maximize the variation in book-to-market across the 10 portfolios chosen. They argue that if the book-to-market effect is a within-industries effect and not an across-industries effect, then the SL CAPM should price the 10 portfolios correctly and there should be no benefit to using the Fama-French model.

Their tests indicate that one can reject the SL CAPM. We reproduce their Panel D, Table 3 as Table 3.2 below. While Da, Guo and Jagannathan report t-test statistics, we report standard errors, that we compute from the estimates and test statistics that they report, for reasons that we will make clear.

---

49 NERA, *Cost of equity - Fama-French three-factor model*, Report prepared for Jemena, 7 August 2009.

Table 3.2
Cross-sectional regressions for 10 maximum book-to-market dispersion portfolios[50]

	Exposure		
Intercept	Market	*SMB*	*HML*
0.06	0.88		
(0.26)	(0.37)		
0.73	0.08	0.10	0.62
(0.32)	(0.40)	(0.36)	(0.27)

Source: Da, Guo and Jagannathan, *CAPM for Estimating the Cost of Equity Capital: Interpreting the Empirical Evidence*, 2009, NBER Working Paper, Table 3, Panel D.

Table 3.2 shows that in a cross-sectional regression of excess return on market, *SMB* and *HML* exposures, that uses the 10 industry portfolios, there is a significant relation only between a portfolio's return and its *HML* exposure.[51] The table also indicates that the return to a zero-beta portfolio exceeds on average the risk-free rate. Both these pieces of evidence are inconsistent with the SL CAPM. [52] The second piece of evidence is also inconsistent with the Fama-French model, but is consistent with the evidence that Lewellen, Nagel and Shanken (2008) provide. [53] Again, Lewellen, Nagel and Shanken find that the Fama-French model underestimates the returns required on low-beta assets.

The interpretation that Da, Guo and Jagannathan place on their evidence on page 22 of their paper is that:

> The loading on HML does seem to drive out the CAPM beta. However, the CAPM betas and the factor loadings on HML are highly correlated across the 10 portfolios. As a result, a problem of multicollinearity emerges. As a potential sign of such a problem, the intercept in

---

50 Estimates have been multiplied by 100. Standard errors are in parentheses.

51 In many of their tests, Da, Guo and Jagannathan follow Hoberg and Welch (2007) and use betas computed from data that excludes the recent past. They do so because they believe that investors may be slow to recognise changes in betas. They call these betas 'aged' betas. Since one can use high-frequency data to improve the precision with which one estimates a stock's beta, it is difficult to see why investors should be slow to recognise changes in the parameter. Hoberg and Welch may well agree because they have withdrawn their work from circulation stating that they 'no longer believe that the theory (of slow recognition by investors) is correct.'

See http://welch.econ.brown.edu/academics/.

52 The tests of the FFM in Table 3.2 can also be viewed as tests of the SL CAPM. To see this, note that while estimates of the beta of the SL CAPM and the market beta of the FFM can, in principle, differ, because one is from a univariate regression and the other is from a multivariate regression, in practice, as Table 2B and 3C of Da, Guo and Jagannathan's paper show, they are very similar. They are very similar because the relations between the three Fama-French factors are weak. For example, in Table 2B, the correlation between the two beta estimates is 0.997 while in Table 3C, it is 0.961. The SL CAPM implies that there should be a relation only between return and the beta of a portfolio relative to the market and that a zero-beta portfolio should earn the risk-free rate. The tests in Table 3.2 provide evidence against both these hypotheses.

53 Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2008, forthcoming.

> the three-factor model is now significantly different from zero. In other words, the small improvement of the three-factor model over the standard CAPM in the cross-sectional analysis here has to be interpreted with caution.

Multicollinearity arises when there is an approximate linear relation between one regressor and another regressor or other regressors. The correlation between the market exposures and the *HML* exposures that Da, Guo and Jagannathan report for the 10 industry portfolios is 0.69. While there is no formal guide as to how approximate the relation between two regressors must be before multicollinearity becomes a problem, a correlation this low would not normally be expected to give rise to a problem.

Peter Kennedy's *A guide to econometrics* provides a clear discussion of the impact of multicollinearity.[54] Multicollinearity does not give rise to bias but can lead to large standard errors. As Table 3.2 indicates, the standard error on the intercept rises from 0.26 to just 0.32 and the standard error on the market exposure rises from 0.37 to just 0.40 with the inclusion in the regression of the two Fama-French exposures. This strongly suggests that multicollinearity is not a problem. The large and significant intercept is not a sign of multicollinearity – because multicollinearity does not give rise to bias – but a sign that the Fama-French model, like the SL CAPM, underestimates the returns required on low-beta assets.

3.1.3. Tests on low-capex stocks

The central hypothesis of Da, Guo and Jagannathan's work is that value and growth stocks have real options whose betas change over time in such a way as to ensure that the SL CAPM misprices the stocks. To test this hypothesis, they do not test directly whether changes in the betas of value and growth stocks over time can explain the inability of the SL CAPM to correctly price the stocks. Instead, they test whether the model can correctly price the stocks of firms that they believe do not hold real options – firms with low capital expenditure. We reproduce these results here.

The results in Table 3.3 indicate that both the Sharpe-Lintner and Black CAPMs can be rejected for both low-capex stocks and for high-capex stocks. Both versions of the CAPM say that, conditional on beta, no other variables should be useful in explaining the cross-section of returns. The results in Table 3.3, though, indicate that, conditional on an asset's beta, size and book-to-market are useful in explaining the cross-section of returns.

Again, as Fama and French (2004) point out:[55]

> If betas do not suffice to explain expected returns, the market portfolio is not efficient, and the CAPM [either Sharpe-Lintner or Black] is dead in its tracks.

---

54 Kennedy, P., *A guide to econometrics*, Wiley-Blackwell, 2008.

55 Fama, Eugene and Kenneth French, *The Capital Asset Pricing Model: Theory and Evidence*, Journal of Economic Perspectives 18, 2004, pages 25-46.

Table 3.3
Cross-sectional regressions for low-capex and high-capex stocks[56]

Capex	Aged beta	Size	Book-to-market
Lowest	4.23		
	(1.82)		
	4.69	-1.23	4.33
	(2.27)	(-1.99)	(3.08)
Highest	0.75		
	(0.23)		
	1.26	-0.53	0.39
	(0.44)	(-0.87)	(2.27)

3.2. Fama-French Three-Factor Model

The results that Fama and French, Da, Guo and Jagannathan and many others provide indicate that additional factors beyond an asset's beta are required to measure the return the market requires on the asset. The FFM provides such additional factors.

Fama and French (1993) show, like Da, Guo and Jagannathan, that low-market-capitalisation firms and firms with high book-to-market ratios deliver returns that are too high for the SL CAPM to explain.[57] Figure 1 uses data from 1927 to 2009, drawn from Ken French's web site, to illustrate these empirical regularities. The figure uses 25 portfolios formed on the basis of each firm's book-to-market ratio and size. Small high book-to-market firms have had alphas relative to the SL CAPM of six per cent per annum over the last 83 years. These firms plot in the middle at the back of the figure. An asset's alpha is a measure of the error with which a model prices the asset. It is the difference between the mean return to the asset and the return the model predicts the asset should on average earn. If an asset has a positive alpha, the model underestimates the return the market requires the asset earn. If an asset has a negative alpha, the model overestimates the return the market requires on the asset.

The FFM is designed to price small firms and value firms correctly. Figure 2 shows that the abnormal returns that these portfolios deliver relative to the Fama-French model are much smaller. Small high book-to-market firms, for example, have had alphas relative to the Fama-French model of only one per cent per annum over the last 83 years. Again, these firms plot in the middle at the back of the figure.

56 Estimates have been multiplied by 100. t test statistics are in parentheses.

57 Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, page 35.

Figure 1. Plot of Sharpe-Lintner CAPM alpha against book-to-market ratio and size. US data from 1927 to 2009. Source: Kenneth French.

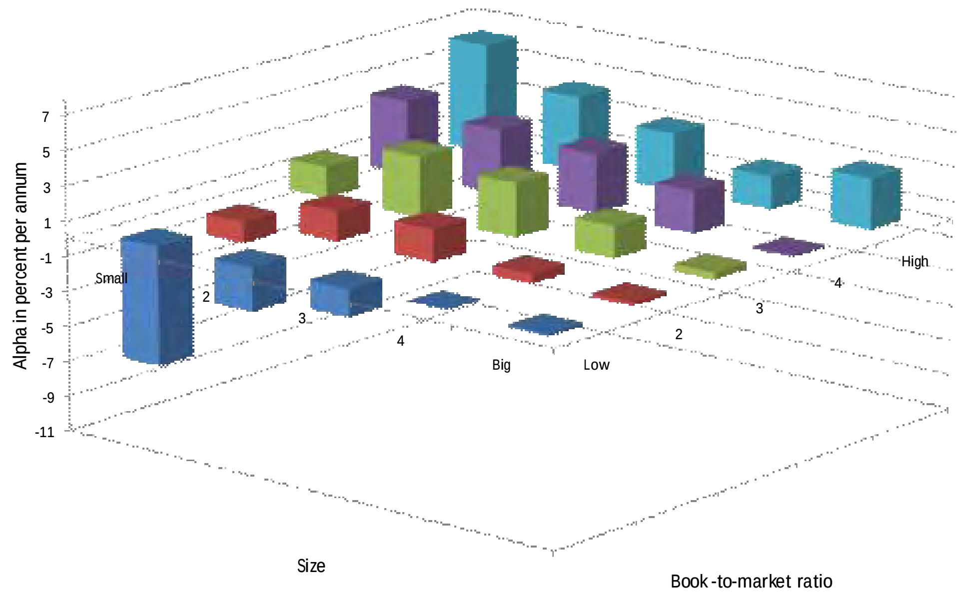
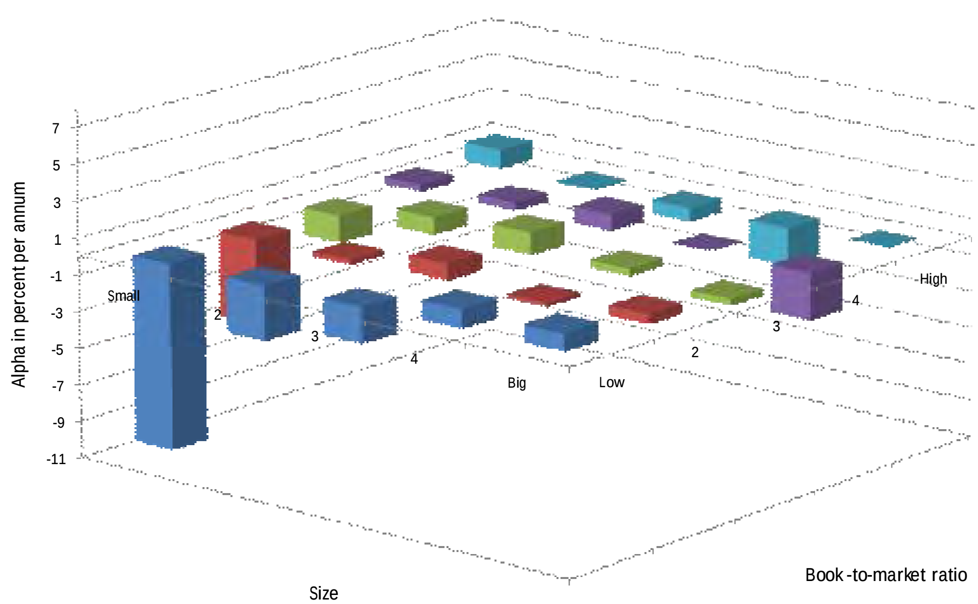


Figure 2. Plot of Fama-French 3-factor alpha against book-to-market ratio and size. US data from 1927 to 2009. Source: Kenneth French.



Does the FFM pass Friedman's two tests of a theory?

It is sometimes argued that the FFM has no theoretical basis. For example, the AER states:[58]

> 'the FFM has no theoretical grounding, and is driven by an econometric search for variables exhibiting correlations in historical data.'

As Fama and French (1993) make clear, however, the FFM does have a theoretical grounding. They argue that:[59]

> 'if assets are priced rationally, variables that are related to average returns, such as size and book-to-market equity, must proxy for sensitivity to common (shared and thus undiversifiable) risk factors in returns.'
>
> 'Suppose the explanatory returns have minimal variance due to firm specific factors, so they are good mimicking returns for the underlying state variables or common risk factors of concern to investors. Then the multifactor asset-pricing models of Merton (1973) and Ross (1976) imply a simple test of whether the premiums associated with any set of explanatory returns suffice to describe the cross-section of average returns: the intercepts in the time-series regressions of excess returns on the mimicking portfolio returns should be indistinguishable from zero.'

The AER refers instead to the FFM as the result of a 'data mining exercise'.[60] If the FFM were purely the result of a data mining exercise, one would not expect the model to fare well out of sample. However, this is not the case. Davis, Fama and French (2000) find that the model works well in US data prior to 1963 while Fama and French (1996) find that the model can explain the tendency of five-year returns to reverse.[61] Thus the FFM passes the second of Friedman's tests of a theory because it is consistent with 'new facts ... not previously known'.

The FFM also does a reasonable job of explaining the mean returns to the 25 portfolios sorted on size and book-to-market that Fama and French (1993) construct, and a better job than the SL CAPM.[62] The mean absolute FFM alpha across the 25 portfolios is 1.06 percent per annum while the mean absolute SL CAPM alpha is 3.12 percent per annum.[63] So the FFM also passes the first of Friedman's tests, albeit not with flying colours because they are just able to reject the hypothesis that all of the FFM alphas are simultaneously zero.

---

58 AER, *Jemena access arrangement proposal for the NSW gas networks: Draft Decision*, February 2010, page 117.

59 Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 4-5 and pages 31-35.

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

61 Fama, Eugene and Kenneth French, *Multifactor explanations of asset-pricing anomalies*, Journal of Finance 47, 1996, pages 426-465.

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

62 Fama, Eugene and Kenneth French, *Common risk factors in the returns to stocks and bonds*, Journal of Financial Economics 33, 1993, pages 4-5 and pages 31-35.

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

These results are not unique to US data. O'Brien, Brailsford and Gaunt (2008) find similar results with a shorter time series of Australian data.[64] Both Fama and French (1993) and O'Brien, Brailsford and Gaunt (2008) find that the Fama-French three factor model is better at predicting the returns on stocks than the SL CAPM. In other words, both sets of authors find that the Fama-French model tends to produce smaller pricing errors than does the SL CAPM. The pricing errors associated with the Fama-French model, however, can be estimated more precisely than their Sharpe-Lintner counterparts. So even though the pricing errors associated with the Fama-French model are smaller than their Sharpe-Lintner counterparts, both sets of authors reject the hypothesis that all of the errors are zero.[65]

While the evidence that Fama and French and O'Brien, Brailsford and Gaunt provide indicates that the FFM represents an improvement over the SL CAPM, both models share a problem. That problem is that both models underestimate the returns required on low-beta assets. As Table 3.4 shows, recent US and Australian evidence indicates that the zero-beta premium is large and positive and that the premium for bearing market risk is not significantly different from zero.

Table 3.4
Some recent evidence on the Fama-French three-factor model[66]

			Risk Premium		
Study	Period	Zero-beta premium	Market	*HML*	*SMB*
		US evidence			
Lewellen, Nagel and Shanken (2008)	1963-2004	11.96	-5.68	5.76	3.20
		(5.13)	(5.80)	(1.85)	(1.88)
		Australian evidence			
Lajbcygier and Wheatley (2009)	1979-2007	9.00	-1.68	5.88	2.28
		(2.04)	(3.72)	(2.76)	(3.96)

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

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

64 O'Brien, Michael, Tim Brailsford and Clive Gaunt, *Size and book-to-market factors in Australia*, Electronic copy available at: http://ssrn.com/abstract=1206542.

65 Fama and French (1993) find that an F test rejects the hypothesis that the model correctly prices all 25 portfolios they use simultaneously at significance levels above 4.9 percent. A similarly constructed F test rejects the SL CAPM at all significance levels above 0.4 percent, that is, at all conventional levels.

66 The zero-beta premium and price of risk are in percent per month. Standard errors are in parentheses.

4. Underlying Assumptions, Data and Methodology

In this section we describe the assumption that we make about the impact of the imputation system on the returns required on stocks and the data that we employ. We also outline the methodology we have adopted to estimate the parameters of the four financial models.

When determining allowable revenues and prices Australian regulators have assumed that equity investors place a value, gamma, on the creation of a one dollar imputation credit that can be attached to a dividend. To ensure consistency between the assumption used to set regulated revenues and our assessment of the required return on equity we have increased observed market and firm returns to take account of the value that the market places on imputation credits created. For the purposes of this report we have been instructed by DBP to assume that gamma, the product of the distribution rate and the market value of a one dollar credit distributed, is 0.2.

To estimate the parameters of the four asset pricing models, we use data on the nine regulated energy businesses that the AER employs in its review of the *WACC* parameters for electricity lines businesses.[67] We also use data provided by Dimensional Fund Advisors Australia Ltd (DFA). DFA is a fund manager with whom Fama and French are affiliated. Other parameters we take from the ERA's ***Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power***.

We follow Henry (2009) and estimate the betas of the nine regulated energy businesses using both ordinary least squares (OLS) and least absolute deviations (LAD).[68] We also compute estimates using an equally weighted and a value-weighted portfolio of the businesses and by averaging estimates across firms. NERA (2009) point out that it is unclear whether OLS or LAD estimates will be most precise and unclear whether estimates computed using an equally or value-weighted portfolio or computed by averaging across firms will be most precise.[69] So we use all beta estimates. In particular, for each asset pricing model we use the means of each set of six beta estimates that we produce.[70]

4.1. Australian Imputation Tax Regime

In Australia, investors face taxes on capital gains and dividends but also receive imputation credits. Officer (1994) derives a version of the CAPM in which imputation tax credits can reduce the return the market requires from firms.[71] The Officer form of the CAPM maintains assumptions (i), (ii), and (iv) set out above. However, instead of assumption (iii) it assumes that:

---

[67] AER, *Electricity transmission and distribution network service providers, Review of the weighted average cost of capital (WACC) parameters: Final Decision*, May 2009, page 255.

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

[69] NERA, *Cost Of Equity - Fama-French Three-Factor Model*, Report for Jemena, August 2009.

[70] We compute estimates in two ways (by OLS and LAD) and we aggregate individual security estimates in three ways (we compute estimates using an equally weighted and a value-weighted portfolio and by averaging estimates across securities). So for each asset pricing model we compute a set of $2 \times 3 = 6$ estimates.

[71] Officer, Robert R., *The cost of capital of a company under an imputation tax system,* Accounting and Finance, 1994, pages 1-17.

(vi) investors may be taxed differently but each investor faces the same rate of tax on capital gains and dividends; imputation credits are attached to the dividends that some assets deliver, that some investors can redeem for cash; and investors face no other taxes and no transaction costs.

Under this assumption, investors receive returns in three forms: as capital gains, as dividends and as imputation credits. The assumption that each investor faces the same rate of tax on capital gains and dividends implies that these taxes will not affect the investor's decision about what portfolio to hold. An investor's ability to use imputation credits, though, will affect his or her portfolio choice. All else constant, one would expect investors who can use the imputation credits to hold portfolios more heavily weighted with assets with high imputation credit yields and investors who cannot use the credits to hold portfolios more heavily weighted with assets with low imputation credit yields. It follows that, in principle, this model can explain why Australian investors hold portfolios heavily weighted with Australian stocks. This is because Australian investors can use imputation credits while foreign investors cannot easily use the credits.

Australian utility regulators have consistently used Officer's model to determine the cost of equity for regulated businesses. One of the first such applications of the Officer CAPM was in 1998 by the then Office of Regulator-General Victoria (ORG)[72] to establish the cost of equity for the Victorian gas distribution businesses.[73]

The only difference between the SL CAPM and the Officer CAPM is that the latter adds a fraction of the imputation credits that a firm delivers to the firm's return. The market risk premium (MRP) that the ERA uses in its *Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power* incorporates the value of credits delivered. Thus, generating an estimate of the return required on equity for a gas transmission business that uses the Officer CAPM and incorporates the value of credits delivered is straightforward.

The other three pricing models can be modified in a similar manner to take into account the impact of imputation credits. To do so, one must add a fraction of the imputation credits that a firm delivers to the firm's return. So, for example, when we estimate the Fama-French risk premiums, we must adjust the premiums to take into account the impact of imputation credits. We describe in detail how we do this later in the section.

---

72 Note that the Office of Regulator-General Victoria was renamed the Essential Services Commission of Victoria (ESCV) on the 1 January 2002.

73 ORG, *Access Arrangements – Multinet Energy Pty Ltd & Multinet (Assets) Pty Ltd, Westar (Gas) Pty Ltd & Westar (Assets) Pty Ltd, Stratus (Gas) Pty Ltd & Stratus Networks (Assets) Pty Ltd: Final Decision*, October 1998.

4.2. Australian Financial Data

To estimate the return required on equity for a gas transmission business using the four models, we require the following data:

- the risk-free rate;
- the zero-beta premium;
- the betas of a comparable group of Australian regulated energy businesses; and
- the means of the three Fama-French factors.

We use the risk-free rate of 5.51 percent per annum that the ERA employs in its *Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power*.

For the SL CAPM and FFM, we use the MRP of 6.50 percent that the ERA also employs in its *Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power*. For the two zero-beta models, we use a zero-beta premium of 6.50 percent per annum and a MRP of zero percent per annum. This choice is motivated by the evidence that Lewellen, Nagel and Shanken (2008) and Lajbcygier and Wheatley (2009) provide.[74] In US data from 1963 through 2004, Lewellen, Nagel and Shanken estimate the zero-beta premium to lie between 8.12 and 11.60 percent per annum for the Black CAPM and between 8.84 percent and 11.96 percent per annum for the zero-beta FFM. They estimate the MRP to lie between -1.76 and 0.40 percent per annum for the Black CAPM and between -5.68 and -1.96 percent per annum for the zero-beta FFM. In Australian data from 1979 through 2007, Lajbcygier and Wheatley estimate the zero-beta premium to be 9.96 percent for the Black CAPM and 9.00 percent per annum for the zero-beta version of the FFM. They estimate the MRP to be -2.64 percent per annum for the Black CAPM and -1.68 percent per annum for the zero-beta FFM. Relative to these estimates a choice for the zero-beta premium of 6.50 percent per annum and a choice for the MRP of zero percent per annum are conservative. They are conservative in that these choices will lead to lower estimates of the return required on a gas transmission business than one would produce using the estimates that Lewellen, Nagel and Shanken and Lajbcygier and Wheatley report. On the other hand, theory suggests that the zero-beta premium should not exceed the difference between the rates at which investors can borrow and lend and some might view 6.50 percent as being higher than one would expect this difference to be.

To estimate the betas of a comparable group of Australian regulated energy businesses, we use weekly and monthly with-dividend returns for the nine Australian regulated businesses that the AER employs in its review of the *WACC* parameters for electricity lines businesses.[75]

---

[74] Lewellen, J., S. Nagel and J. Shanken, *A skeptical appraisal of asset pricing tests*, Journal of Financial Economics, 2008, forthcoming.

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

[75] AER, *Electricity transmission and distribution network service providers, Review of the weighted average cost of capital (WACC) parameters: Final Decision*, May 2009, page 255.

The nine businesses, their tickers and the period over which returns are available for each company appear in Table 4.1.

Table 4.1
Sample of regulated energy businesses

Company	Ticker	Period	Debt-to-Value
Alinta Limited	AAN	01/01/2002 – 17/08/2007	0.341
The Australian Gas Light Company	AGL	01/01/2002 – 11/10/2006	0.288
APA Group	APA	01/01/2002 – 31/12/2009	0.563
Duet Group	DUE	12/08/2004 – 31/12/2009	0.760
Envestra Limited	ENV	01/01/2002 – 31/12/2009	0.727
GasNet	GAS	01/01/2002 – 14/11/2006	0.641
Hastings Diversified Utilities Fund	HDF	10/12/2004 – 31/12/2009	0.407
Spark Infrastructure Group	SKI	01/03/2007 – 31/12/2009	0.516
SP AusNet	SPN	15/12/2005 – 31/12/2009	0.608

We note that electricity businesses are similar to but not perfectly comparable to gas transmission businesses. In fact, the inclusion of electricity businesses in the sample may lead one to underestimate the beta of gas transmission business as:[76]

> regulated gas businesses may have a higher level of business risk arising from such factors as higher volume risk.

The use of a larger sample of listed businesses, though, allows one to produce more precise estimates of beta and so we, like the AER, use all nine companies.

Table 4.1 also reports each company's debt-to-value ratio. Since book values of debt are typically updated semi-annually, this ratio has been computed as the average net debt-to-value ratio sampled semi-annually over the period for which data for each company are available. Specifically, the ratio is calculated at the end of each June and the end of each December. Firm value is calculated as the sum of net book debt and the market value of equity. The data for the nine Australian regulated energy businesses are from Bloomberg information service.

To estimate the betas of the nine Australian regulated energy businesses, we also use data on the following three factors:

- the excess return to the market over the risk-free rate;
- the Fama-French *HML* factor; and
- the Fama-French *SMB* factor.

[76] AER, *Electricity transmission and distribution network service providers, Review of the weighted average cost of capital (WACC) parameters: Final Decision*, May 2009, page 258.

Characteristics and relevering

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

The AER believes that relevering returns creates a distortion. It states that:[77]

> 'manipulating data prior to parameter estimation represents a distortion of the original FFM by the adjustment of returns for gearing.'

and that:[78]

> 'the gearing change would alter other business fundamentals (for instance, changes in interest costs, business distress risks and the book-to-market ratio).'

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

The process of relevering betas one uses with the FFM is *identical* to the process one uses with the SL CAPM. So the concern expressed by the AER about estimating the parameters of the FFM using relevered returns is *misplaced*.

We use as the with-dividend market return the percentage change in the *S and P All Ordinaries Accumulation Index*. Monthly data for the other two Fama-French factors have been provided by DFA.

From January 1980 through June 1989, DFA compute the *HML* factor as the difference between the with-dividend returns to the *Fama-French Australian Value Index* and the *Fama-French Australian Growth Index*. From July 1989 through December 2009, DFA compute the *HML* factor as the difference between the with-dividend returns to the *S and P Australian BMI Value Index* and the *S and P Australian BMI Growth Index*. BMI stands for Broad Market Index. The index is described as being broad because it includes both large firms and small firms.

From January 1980 through December 1990, DFA compute the *SMB* factor as the difference between the with-dividend returns to an *ASX Ex-50 Leaders Simulated Index* and the *ASX 50 Leaders Index*. The term 'ASX Ex-50' means outside of the ASX 50. The Simulated Index

---

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

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

was sourced from John Nolan and Associates (now JANA). From January 1991 through December 2009, DFA compute the *SMB* factor as the difference between the with-dividend returns to the *S and P ASX Small Ordinaries* and the *S and P ASX 100 Index*.

Weekly values of the *HML* and *SMB* factors are computed for the period from January 2002 to December 2009 to correspond with the monthly values provided by DFA. Weekly values for the *HML* factor are computed as the difference between the weekly with-dividend returns to the *S and P Australian BMI Value Index* and the *S and P Australian BMI Growth Index*. Weekly values of the *SMB* factor are computed as the difference between the weekly with-dividend returns to the *S and P ASX Small Ordinaries* and the *S and P ASX 100 Index*. The weekly data are taken from either Bloomberg or FactSet information services.

4.3. Methodology

The use of each model requires that we produce estimates of risk premiums and betas.

4.3.1. Risk premiums

Again, we use as an estimate of the MRP the estimate that the ERA employs in its *Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power*. So the only premiums we must estimate are the means of the Fama-French *HML* and *SMB* factors. The *HML* factor is 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. The *SMB* factor is the difference between the return to a portfolio of small cap stocks and the return to a portfolio of large cap stocks.

Unlike the MRP, the *HML* and *SMB* risk premiums are not required by the CAPM and so estimates of the premiums have not previously been used by Australian regulators. We find that the DFA *HML* premium is economically and statistically significantly different from zero. The DFA *SMB* premium, on the other hand, is neither economically nor statistically different from zero.

Using the raw data provided by DFA we carry out the following steps to estimate the *HML* and *SMB* risk premiums.

§ First, we calculate the arithmetic average of the differences between the annual returns to a portfolio of high book-to-market stocks and a portfolio of low book-to-market stocks. Similarly, we calculate the arithmetic average of the differences between the annual returns to a portfolio of small cap stocks and a portfolio of large cap stocks.

§ Second, we adjust these averages to reflect an assumption that investors place a positive value on distributed franking credits.

Thus the *HML* and *SMB* risk premiums that we use are the historical averages of the imputation credit-adjusted annual returns to the *HML* and *SMB* zero-investment portfolios created by DFA. The use of arithmetic averages of historical annual returns is consistent with the approach adopted by Handley (2009) in his report to the AER on the *WACC* parameters of electricity lines businesses.[79]

Variation in estimates of the *HML* and *SMB* risk premiums

It has been noted that estimates of the Australian *HML* and *SMB* risk premiums produced by different authors vary considerably.[80] There are two reasons why estimates of the premiums vary.

First, estimates of the premiums that appear in the literature are typically based on a variety of short but different periods. For example, the average period over which the estimates that the AER examines in its recent draft decision are computed is less than 13 years.[81] There will also be a significant variation in estimates of the market risk premium computed over a variety of different but short periods. For example, estimates of the market risk premium computed over 13 years of data range from -1.87 to 14.43 percent per annum over the period February 1985 through December 2009.[82]

Second, different authors have computed the premiums using different sets of data. For example, Faff (2001) uses data from the Frank Russell company to compute the factors, Fama and French (1998) use data from Morgan Stanley, while O'Brien, Brailsford and Gaunt (2008) use data from the ASX and company accounts.[83] Similarly, different authors measure the return to the market portfolio in different ways. As Roll (1977) points out, there may be no ambiguity about how, *in theory*, to measure the return to the market portfolio but there is ambiguity about how, *in practice*, to measure the return.[84] As Stambaugh (1982) shows, estimates of the market risk premium vary widely across different measures of the market portfolio. Stambaugh also shows, though, that a lack of consensus about how to measure the return to the market portfolio need not imply that different authors will measure the required return on an asset to be different.[85] Similarly, a lack of consensus about how to measure the Fama-French factors need not imply that different authors will measure the required return to

---

79 John C Handley, Further Comments on the Historical Equity Premium: Report for the Australian Energy Regulator, 14 April 2009, pages 4-6.

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

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

82 Calculated using the MSCI Australia Standard Core Index and the 90-day bill rate from the Reserve Bank.

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

Fama, E. and K. French, *Value versus growth: The international evidence*, Journal of Finance 54, 1998, pages 1975–1999.

O'Brien, Michael, Tim Brailsford and Clive Gaunt, *Size and book-to-market factors in Australia*, Electronic copy available at: http://ssrn.com/abstract=1206542.

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

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

be different.

In our analysis we adopt a market risk premium consistent with that used by the ERA in its Western Power decision while we compute the *HML* and *SMB* premiums using data from DFA (a company with which Fama and French are affiliated) which represent the longest available series. For completeness, we have also employed an alternative data source (ie, MSCI) which while it produces different estimates of the *HML* and *SMB* premiums results in a similar estimate of the cost of equity for a benchmark gas transmission business.

To determine the maximum quantity of franking credits that can be attached to the dividends that each portfolio pays out each year, we use the statutory corporate tax rates in effect at the time. To compute the quantity of franking credits distributed, we follow Handley and Maheswaran (2008) and assume that 75 percent of dividends are franked.[86] Finally, to compute the value the market places on these franking credits, we have been instructed to assume that the market places a value of 20 cents on a dollar of franking credits created. To be conservative, we assume that all credits created are distributed so that the value the market places on a dollar of credits distributed is also 50 cents – not higher. The assumption is in our opinion conservative because we find that the dividend yield of the high book-to-market portfolio exceeds the yield of the low book-to-market portfolio and the dividend yield of the portfolio of small firms exceeds the yield of the portfolio of big firms.

Thus, for example, in 2008 the statutory corporate tax rate was 30 percent and so 43 cents of franking credits would have been attached to a fully franked dividend of one dollar in that year. If 75 percent of 2008 dividends were franked, on average 32 cents of franking credits would have been attached to a dividend of one dollar. Finally, if the market placed a value of 20 cents on a dollar of franking credits distributed, the market would have placed a value of six cents on the franking credits attached on average to a 2008 dividend of one dollar.

In 2008, the dividend yields on the value and growth portfolios were 7.38 and 4.44 percent, measured as the sum of the dividends paid out over the year divided by end-of-year price. So we assume that the credits attached to the dividends paid out by the value and growth portfolios were $0.43 \times 0.75 \times 7.38 = 2.37$ percent and $0.43 \times 0.75 \times 4.44 = 1.43$ percent of the end-of-year price. The *HML* factor, exclusive of franking credits, in 2008 was – 3.33 percent. It follows that, with the assumptions we make, the factor inclusive of the value of franking credits was $-3.33 + 0.2 \times (2.37 - 1.43) = -3.14$.

[86] Handley J. and Maheswaran K., A Measure of the Efficacy of the Australian Imputation Tax System, *The Economic Record*, Vol 84 No 264, March 2008, page 91.

4.3.2. Betas

We compute beta estimates for the nine individual securities and for two portfolios of the securities, one equally weighted and the other value-weighted, using weekly and monthly data. To compute estimates, we regress the with-dividend returns on the nine utilities and two portfolios on the market return either alone or together with the *HML* and *SMB* factors. Like Henry (2009), we ignore the franking credits that a firm may deliver.[87]

Table 4.1 shows that none of the nine utilities has a debt-to-value ratio of precisely 0.6, ie, the ratio that the ERA assumes a benchmark utility should have. We have therefore adjusted (relevered) all of our beta estimates to reflect this benchmark assumption. More specifically, we have followed Henry (2009) and multiplied the return to the equity of each benchmark utility by $(1 - L_j)/(1 - 0.6)$, where L_j is the average net debt-to-value ratio over the period for which net debt and market capitalisation data are available for the utility.[88] If the utility follows a strategy of issuing or retiring debt to ensure its leverage is constant through time, then relevering in this way is appropriate.

Relevering and taxes

Delevering and relevering betas requires one make an assumption about the debt policy each firm pursues. One policy a firm might pursue is to maintain a constant leverage through time. A policy of maintaining a constant leverage through time requires a firm continually issue or retire debt (a Miles-Ezzell framework).[89] A second, policy a firm might pursue is to maintain a constant dollar amount of debt outstanding through time. A third policy might be to issue some new debt when the value of the firm rises and retire some debt when the value of the firm falls but to allow the leverage of the firm to fall as the value of the firm rises and rise as the value of the firm falls. In delevering and relevering betas, one must also make an

[87] Olan T. Henry, Estimating *b*: Report for the Australian Energy Regulator, 23 April 2009.

[88] Olan T. Henry, Estimating *b*: Report for the Australian Energy Regulator, 23 April 2009.

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

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

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

[91] Olan T. Henry, *Econometric advice and beta estimation: Report for the Australian Energy Regulator*, 28 November 2008, pages 17-18.

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

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

assumption about whether a firm will ever default on its debt.

Taggart (1991) shows that delevering and relevering is particularly simple if one assumes that a firm follows a strategy of continually maintaining a constant leverage through time and that it never defaults on its debt.[90] It is particularly simple because one can ***ignore*** corporate and personal taxes – and so imputation credits, which are nothing more than negative personal taxes. In contrast, if one assumes that a firm follows a strategy of maintaining a constant dollar amount of debt outstanding through time, then one cannot ignore corporate and personal taxes. It is, perhaps, for this reason that Henry (2008) assumes that a firm follows a strategy of continually maintaining a constant leverage through time and never defaults on its debt in his recent report for the AER.[91] It may also be that Henry recognises that the AER view that an efficient regulated energy business should have a gearing of 0.6 ***requires*** that the business maintain a constant leverage through time.[92]

Here we follow the methodology endorsed by the AER in its Explanatory Statement for its Review of the WACC parameters, ***precisely***.[93]

We compute estimates of betas in two ways. First, we compute OLS estimates and, second, we compute LAD estimates. LAD estimates can be more efficient if a sufficient number of outliers are present. We compute LAD estimates using the LAV routine in SAS/IML. This routine uses the algorithm that Madsen and Nielsen (1993) introduce and computes standard errors using the approximation suggested by McKean and Schrader (1987).[94]

Estimates of individual security betas can be imprecise. Thus Myers (2008) recommends that[95]

> 'when a sample of similar companies can be identified, industry betas should be estimated, as this will significantly improve the statistical reliability (lower the standard errors) of the estimates.'

We combine the individual security data in three ways. First, we compute simple averages of the security beta estimates. Second, we form an equally weighted portfolio of the nine securities and estimate its beta. Since six of the nine utilities either listed or delisted over the sample period, there are often fewer than nine utilities in the portfolio. When a new firm is listed we sell some of what we have invested in the other listed securities and invest the proceeds in the newly listed entity. When a firm delists, we sell the security and invest the proceeds in the remaining listed securities. Third, we form a value-weighted portfolio and estimate its beta.

---

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

94 Madsen, K., H.B. Nielsen, A Finite Smoothing Algorithm for Linear l_1 Estimation, *SIAM J. on Optimization* 3, 1993, pages 223-235.

McKean, J.W., and R.M. Schrader, Least Absolute Errors Analysis of Variance, in *Statistical Data Analysis Based on the L_1-Norm and Related Methods* (edited by Yadolah Dodge), North-Holland, Amsterdam, 1987, pages 297-305.

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

Myers (2008) recommends that:[96]

> 'industry betas should be estimated using returns on a portfolio of the sample companies, *not* solely as an average of individual company betas as the (New Zealand Commerce) Commission presently does. This approach is desirable because the standard error of the industry estimate is readily obtained.'

If no firms list or delist during the sample period, then the average of the OLS security beta estimates will be identical to the OLS estimate of the beta of an equally weighted portfolio. If some firms list or delist during the sample period, however, the two estimates will generally differ. Myers emphasises that 'the standard error of the industry estimate is readily obtained' because computing the standard error of the portfolio estimator is straightforward whereas computing the standard error of the average estimator is a more complicated task when some data are missing. Put another way, Myers is advocating that portfolio estimates be used because they are more efficient than individual security estimates and because their standard errors are readily obtained when some of the securities list or delist in the sample period.

Besides the ease with which their standard errors are computed, though, portfolio estimates may be more efficient. A simple average of security beta estimates places an equal weight on each estimate. In other words, a simple average places as much weight on estimates computed from a few observations as on estimates computed from many observations. A portfolio estimate effectively places a greater weight on securities for which more observations are available and so for which more information is available.

We compute portfolio beta estimates in two ways. First, we compute estimates for an equally weighted portfolio. Second, we compute estimates for a value-weighted portfolio. A rationale for using a value-weighted portfolio is that it is likely that value-weighted estimates are less sensitive to merger and breakup activity than equally weighted estimates – at least if the market correctly prices assets. Suppose, for example, there are two companies in the industry one examines of equal size and one company breaks up into nine new companies. A value-weighted portfolio would continue to invest half of its assets in the nine new companies whereas an equally weighted portfolio would sell 80 percent of its investment in the company that had not been broken up and would raise its stake in the nine new companies from 50 to 90 percent. The value-weighted portfolio would continue to hold the same portfolio of underlying projects as before whereas the equally weighted portfolio would not continue to hold the same portfolio.

We do not report the standard errors attached to the average of the LAD estimates for the individual securities as computing these standard errors is a complicated task when data are missing. We are not aware of an analytical formula for the standard error of the average of the LAD estimates when data are missing. Computing the standard error of the average by simulation would require we make an assumption about the distribution of returns and the incidence of outliers.

---

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

Again, in the absence of missing data, the average OLS estimate will be identical to the OLS estimate of the beta of an equally weighted portfolio. It is not in general true, on the other hand, that the average LAD estimate will match the LAD estimate of the beta of an equally weighted portfolio, even in the absence of missing data. The question then arises as to whether it is better to use the average LAD estimate or the LAD estimate of the beta of an equally weighted portfolio or whether it is not possible to conclude without further information. NERA (2009) investigate the behaviour of the average LAD estimator, the LAD estimator for an equally weighted portfolio and the OLS estimator for the portfolio by conducting simulations.[97]

Their results suggest that if there are large industry-wide outliers it is best to use LAD to deal with the outliers at the portfolio level while, if there are large firm-specific outliers, it is best to use LAD to deal with the outliers at the firm level. On the other hand, if there are few outliers, it is best to use OLS.

Thus their simulations show that there are circumstances where the average LAD estimator is most efficient, there are other circumstances where the portfolio LAD estimator is most efficient, and there are yet another set of circumstances where the portfolio OLS estimator is most efficient. Since trying to identify which set of circumstances is best described by our data is difficult, we use all of the average and portfolio estimates that we produce.

Finally, we prefer to use weekly data because these give rise to more precise estimates than can be produced with monthly data. Roughly speaking, weekly beta estimates are twice as precise as monthly estimates. In other words, the standard errors of weekly estimates are around half the size of their monthly counterparts.

97 NERA, *Cost Of Equity - Fama-French Three-Factor Model*, Report for Jemena, August 2009.

5. Estimated Rate of Return on Equity

We have estimated the required return on equity for an Australian gas transmission business using the following four financial models:

1. the SL CAPM;
2. the Black CAPM;
3. the FFM; and
4. a zero-beta version of the FFM.

Table 5.1 sets out our estimates of the parameters and required return on equity for each of the financial models.

Table 5.1
Estimates of the return required on an Australian utility stock computed using weekly DFA data

			Beta			Risk Premium			
Model	Risk-Free Rate*	Zero-Beta Premium	Market	*HML*	*SMB*	Market	*HML*	*SMB*	Return On Equity
Sharpe-Lintner CAPM	5.51		0.51			6.50			8.85
Black CAPM	5.51	6.50	0.51			0.00			12.01
Fama-French	5.51		0.57	0.41	0.28	6.50	6.12	-0.45	11.59
Zero-Beta Fama-French	5.51	6.50	0.57	0.41	0.28	0.00	6.12	-0.45	14.40

* *The risk-free rate and market risk premium are from the Economic Regulation Authority's 'Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power'.*

The four financial models provide a plausible range for the return on equity required by an Australian regulated gas transmission business of between 8.85 per cent and 14.40 per cent.

5.1. Sharpe-Lintner CAPM

An estimate of the return required on equity for a gas transmission business that uses the SL CAPM requires three inputs: the risk-free rate, the MRP and the equity's beta. Table 5.2 provides OLS and LAD estimates of the betas of the equities of the nine regulated energy utilities. The table shows that the some of the estimates are imprecise and that there is partly for this reason, a significant variation across the estimates. Also, the LAD estimates tend to be lower than their OLS counterparts.

Table 5.2
Individual security beta estimates computed using weekly data from 1 January 2002 to 31 December 2009

	AAN	AGL	APA	DUE	ENV	GAS	HDF	SKI	SPN
OLS	1.10	0.71	0.63	0.30	0.32	0.35	1.21	0.51	0.17
	(0.21)	(0.17)	(0.08)	(0.06)	(0.05)	(0.09)	(0.22)	(0.13)	(0.08)
LAD	0.69	0.56	0.61	0.21	0.26	0.27	0.79	0.46	0.20
	(0.18)	(0.21)	(0.09)	(0.06)	(0.03)	(0.10)	(0.10)	(0.12)	(0.07)

Standard errors are in parentheses.

Table 5.3
Average and portfolio beta estimates computed using weekly data from 1 January 2002 to 31 December 2009

	AV	EW	VW
OLS	0.59	0.54	0.50
	(0.06)	(0.05)	(0.06)
LAD	0.45	0.47	0.54
		(0.05)	(0.05)

Standard errors are in parentheses.

Table 5.3 displays our average and portfolio estimates. Two observations may be drawn from the results in the table. First, the standard errors of the average and portfolio estimates are typically lower than their individual security counterparts, that is, the average and portfolio estimates are more precise than the individual security estimates. Second, consistent with our earlier discussion, the standard errors attached to the average of the OLS estimates for individual firms are higher than their equally weighted portfolio counterparts, albeit marginally so.

Table 5.4 provides estimates of the risk premium on the equity of a gas transmission business computed using the estimates in Table 5.3 and the SL CAPM. The mean risk premium is only 3.34 percent per annum. This low estimate is the result of an estimate of the beta of the equity of a gas transmission business of only 0.51, an estimate that is consistent with the estimates that Henry (2009) provides and that appear in the ERA's *Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power* but that is substantially below the value of 0.8 that both the ERA and AER have used in recent decisions.

Table 5.4
Risk premiums computed using weekly data and the Sharpe-Lintner and Black CAPMs

			Risk Premium	
		Beta	SL	Black
OLS	Firm Average	0.59	3.83	6.50
	Equally Weighted Portfolio	0.54	3.53	6.50
	Value-Weighted Portfolio	0.50	3.23	6.50
LAD	Firm Average	0.45	2.91	6.50
	Equally Weighted Portfolio	0.47	3.03	6.50
	Value-Weighted Portfolio	0.54	3.48	6.50
	Mean Value	**0.51**	**3.34**	**6.50**

5.2. Black CAPM

The assumption that we make that the zero-beta risk premium is 6.50 percent per annum and that the MRP is zero makes the predictions of the Black CAPM particularly simple to interpret. With these assumptions, the Black CAPM says that the returns required on all stocks should be identical. Thus, as Table 5.4 shows, the Black CAPM provides an estimate of the risk premium on the equity of a gas transmission business of 6.50 percent per annum. This estimate is identical to the estimate that one would produce were one to use the SL CAPM and set the beta of the equity to one.

5.3. Fama-French Three-Factor Model

An estimate of the return required on equity for a gas transmission business that uses the FFM requires seven inputs: the risk-free rate, the three Fama-French premiums and the equity's three Fama-French betas.

Table 5.5 provides estimates of the *HML* and *SMB* premiums computed using the data supplied to us by DFA. The time period of 1975 to 2009 is the longest period over which data on the Fama-French factors are available in Australia. The *HML* estimate is significantly greater than zero at conventional levels and of the same order of magnitude as the market risk premium. The *SMB* estimate is negative, although not significantly different from zero.

Table 5.5
Fama-French risk premiums computed using DFA data

	HML	***SMB***
Australia	6.12	–0.45
	(2.98)	(2.29)
Period	1975 – 2009	1980 – 2009
US	5.68	1.50
	(2.52)	(2.03)
Period	1975 – 2009	1980 – 2009
US	5.02	3.61
	(1.54)	(1.57)
Period	1927 – 2009	1927 – 2009

Premium estimates in percent per annum are outside of parentheses. Standard errors are in parentheses

For comparison, we also report US estimates computed with data taken from Ken French's web site over the same periods that we use to estimate the Australian premiums, as well as over the period from 1926 through 2009, the longest period over which data on the Fama-French factors are available in the US. The US *HML* and *SMB* estimates are similar to their Australian counterparts over matching periods. On the other hand, the US *HML* estimate computed over the longer period is lower than its Australian counterpart while the US *SMB* estimate computed over the longer period is substantially higher than its Australian counterpart. The US *SMB* estimate computed over the longer period is both economically and statistically significantly different from zero.

Table 5.6 provides OLS and LAD estimates of the betas of the equities of the nine regulated energy utilities. The table shows that many of the individual security beta estimates are imprecise. The table also shows that estimates of the *HML* and *SMB* betas tend to be less precise than their market counterparts. The reason for this difference is that the precision with which a slope coefficient in a regression is estimated is typically inversely related to the volatility of the corresponding regressor and the *HML* and *SMB* factors are less volatile than the market return.

Table 5.6
Individual security Fama-French beta estimates computed using weekly DFA data from 1 January 2002 to 31 December 2009

	AAN	AGL	APA	DUE	ENV	GAS	HDF	SKI	SPN
					Market				
OLS	1.18	0.69	0.65	0.30	0.36	0.39	1.48	0.55	0.22
	(0.23)	(0.19)	(0.08)	(0.06)	(0.05)	(0.10)	(0.21)	(0.13)	(0.08)
LAD	0.72	0.73	0.67	0.22	0.28	0.34	0.90	0.43	0.20
	(0.22)	(0.19)	(0.08)	(0.05)	(0.03)	(0.11)	(0.09)	(0.12)	(0.06)
					HML				
OLS	0.34	-0.30	0.25	0.15	0.39	0.06	2.13	0.51	0.36
	(0.45)	(0.35)	(0.13)	(0.09)	(0.08)	(0.19)	(0.33)	(0.20)	(0.13)
LAD	0.02	-0.03	0.36	0.18	0.23	0.27	1.07	0.42	0.26
	(0.43)	(0.35)	(0.13)	(0.09)	(0.05)	(0.20)	(0.14)	(0.19)	(0.09)
					SMB				
OLS	0.27	0.13	0.31	0.27	0.45	0.19	0.93	0.40	0.03
	(0.30)	(0.24)	(0.13)	(0.10)	(0.08)	(0.13)	(0.38)	(0.25)	(0.15)
LAD	0.24	0.49	0.39	0.33	0.24	0.32	0.34	0.23	0.32
	(0.29)	(0.24)	(0.13)	(0.10)	(0.05)	(0.14)	(0.16)	(0.23)	(0.11)

Standard errors are in parentheses.

Table 5.7 displays our average and portfolio estimates of the three Fama-French betas. Three observations can be made about the results. First, the evidence indicates that the returns to utility stocks are related to all three Fama-French factors. Second, the standard errors of the average and portfolio estimates are typically lower than their individual security counterparts, that is, the average and portfolio estimates are more precise than the individual security estimates. Third, consistent with our earlier discussion, the standard errors attached to the average of the OLS estimates for individual firms are marginally higher than their equally weighted portfolio counterparts.

Table 5.8 provides estimates of the risk premium on the equity of a gas transmission business computed using the estimates in Table 5.7 and the Fama-French three factor model. The mean risk premium is 6.08 percent per annum, almost twice as large as its Sharpe-Lintner counterpart. This larger risk premium is primarily a result of the positive exposure a gas transmission business has towards the *HML* factor. The DFA estimate of the HML premium is almost as large as the MRP and our estimate of the *HML* beta is almost as large as our estimate of the market beta.

Table 5.7
Average and portfolio Fama-French beta estimates computed using weekly DFA data from 1 January 2002 to 31 December 2009

	Market			***HML***			***SMB***		
	AV	**EW**	**VW**	**AV**	**EW**	**VW**	**AV**	**EW**	**VW**
OLS	0.65	0.61	0.54	0.43	0.59	0.36	0.33	0.38	0.20
	(0.06)	(0.05)	(0.06)	(0.10)	(0.08)	(0.09)	(0.09)	(0.08)	(0.10)
LAD	0.50	0.51	0.60	0.31	0.43	0.33	0.32	0.31	0.11
		(0.04)	(0.05)		(0.07)	(0.09)		(0.07)	(0.09)

Standard errors are in parentheses.

5.4. Zero-Beta Fama-French Three-Factor Model

Again, we assume that the zero-beta risk premium is 6.50 percent per annum and that the MRP is zero. With these assumptions the zero-beta model will deliver a larger risk premium for low-beta stocks than the FFM. Consistent with this observation, we compute an estimate of the risk premium on the equity of a gas transmission business of 8.89. This estimate is almost three times as large as the estimate delivered by the SL CAPM.

Table 5.8
Risk premiums computed using the Fama-French three-factor model and weekly DFA Data

		Beta			Risk Premium	
		Market	*HML*	*SMB*	FF	Zero-Beta
OLS	Firm Average	0.65	0.43	0.33	6.71	9.01
	Equally Weighted Portfolio	0.61	0.59	0.38	7.44	9.94
	Value-Weighted Portfolio	0.54	0.36	0.20	5.64	8.63
LAD	Firm Average	0.50	0.31	0.32	4.99	8.25
	Equally Weighted Portfolio	0.51	0.43	0.31	5.82	9.00
	Value-Weighted Portfolio	0.60	0.33	0.11	5.87	8.48
	Mean Value	**0.57**	**0.41**	**0.28**	**6.08**	**8.89**

6. Conclusions

There are a range of financial models available to estimate the cost of equity that measure the risk of owning equity in a variety of different ways. We use four pricing models to estimate the cost of equity. The model that has traditionally been employed by Australian regulators to estimate the cost of equity is the SL CAPM and is the first model considered.

The SL CAPM states that an asset's risk should be measured by its beta and that an asset with a zero beta should earn the risk-free rate. Although the SL CAPM is an attractively simple model, there is a large body of evidence against it to the effect that it does not properly estimate the cost of equity for a gas transmission business. Empirically, the SL CAPM underestimates the returns to low-beta stocks, value stocks and low-market-capitalisation stocks. Since the equity of a gas transmission business has both a low beta and value characteristics, it follows that one can expect the SL CAPM to underestimate the return required on the equity.

A more general version of the CAPM, the Black version, states that while an asset's risk should be measured by its beta, an asset with a zero beta need not earn the risk-free rate. This is the second model used to estimate the required return on equity for a gas transmission business. There is less evidence against the Black version of the CAPM than against the Sharpe-Lintner version. Empirically, the Black CAPM does not underestimate the returns to low-beta assets. The Black CAPM, though, like the SL CAPM underestimates the returns to value stocks and low-market-capitalisation stocks. Thus one can expect the Black CAPM, like the SL CAPM, to underestimate the return required on the equity of a gas transmission business.

The third model is the FFM. This model is designed to correctly price value stocks and the equities of small firms. The ability of the Fama- French three-factor model to correctly price the equities of small firms and value stocks has meant that it has become the standard model for estimating required returns in the academic finance literature. However, recent evidence indicates that the FFM, like the SL CAPM, underestimates the returns to low-beta stocks. Thus one can expect the FFM, like the Black CAPM and SL CAPM, to underestimate the return required on the equity of a gas transmission business.

So the fourth model considered is a zero-beta version of the FFM.

The NGR does not require that the ERA continue to use the CAPM to determine the return on capital. Rather, the NGR allow a transmission business to propose a financial model so long as it complies with the requirements of the NGR and the NGL(WA). In our opinion, the NGR and NGL(WA) impose two different types of requirements with respect to the derivation of the rate of return:

- the outcome of the estimation process be as accurate as possible (but not less than) an estimate of the cost of capital associated with the relevant activity (Rule 87(1), Rule 74(2)(b) and Sections 24(2) and (5) of the NGL(WA)); and
- the financial model that is used to estimate the rate of return be 'well accepted' (Rule 87(2)) and any forecast or estimate be 'arrived at on a reasonable basis' (Rule 74(2)(b)).

In our opinion, the four models that we use are all well accepted. In the academic world the SL CAPM is widely used as a teaching device. It has long since been discarded, though, a research tool because of its poor empirical performance. The FFM is designed to explain the returns to (and so to price) small firms and value firms correctly and is widely used in the academic world in research. For example, in a recent NBER working paper, Da, Guo and Jagannathan (2009) note that:[98]

> '(t)he Fama and French (1993) three-factor model ... has become the standard model for computing risk adjusted returns in the empirical finance literature'.

The recent evidence that we review on the performance of the four models we use indicates that among the four the zero-beta version of the FFM best fits the data. An enthusiasm for this model, though, should be tempered by the fact that empirical estimates of the difference between the zero-beta and risk-free rates are higher than perhaps theory might lead one to expect. Empirical estimates from the last 40 years or so of Australian and US data are no less than 6.50 percent per annum while theory suggests that the difference should not exceed the difference between the rates at which investors can borrow and lend.

Estimates of the cost of equity for a gas transmission business have been computed using domestic versions of the four models. Where appropriate, the models have been populated with the same data and parameters as those employed by the ERA in its *Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power*.[99]

To estimate parameters not shared with the SL CAPM, we primarily use data provided by Dimensional Fund Advisors Australia Ltd (DFA), an investment group affiliated with Fama and French.

Table 1, sets out our estimates of the parameters and required return on equity for each of the financial models considered by NERA.

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

99 ERA, *Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power*, 2009.

Table 6.1
Estimates of the return required on an Australian utility stock computed using weekly DFA data

Model	Risk-Free Rate*	Zero-Beta Premium	Beta: Market	Beta: *HML*	Beta: *SMB*	Risk Premium: Market	Risk Premium: *HML*	Risk Premium: *SMB*	Return On Equity
Sharpe-Lintner CAPM	5.51		0.51			6.50			8.85
Black CAPM	5.51	6.50	0.51			0.00			12.01
Fama-French	5.51		0.57	0.41	0.28	6.50	6.12	-0.45	11.59
Zero-Beta Fama-French	5.51	6.50	0.57	0.41	0.28	0.00	6.12	-0.45	14.40

* *The risk-free rate and market risk premium are from the Economic Regulation Authority's 'Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power'.*

The four well accepted financial models provide a plausible range for the return on equity for an Australian regulated gas transmission business of between 8.85 per cent and 14.40 per cent.

Appendix A. Monthly Data

A.1. Summary

In this appendix we investigate the impact of using monthly rather than weekly data to estimate the betas of the sample of nine Australian utility stocks. As one would expect, we find that estimates of the betas computed using monthly data are less precise than their weekly counterparts. Nevertheless, we find that estimates of the return required on the equity of a regulated energy business computed using monthly data are similar to estimates computed using weekly data.

Table A.1 provides estimates of the return required on a regulated energy business computed using monthly data. Estimates of the return using the four pricing models and monthly data are 8.95, 12.01, 11.21 and 14.15 percent per annum. From Table 5.1, the corresponding estimates computed using weekly data are 8.85, 12.01, 11.59 and 14.40 percent. Thus our results show little sensitivity to whether one uses weekly or monthly data.

Table A.1
Estimates of the return required on an Australian utility stock computed using monthly DFA data

			Beta			Risk Premium			
Model	Risk-Free Rate*	Zero-Beta Premium	Market	*HML*	*SMB*	Market	*HML*	*SMB*	Return On Equity
Sharpe-Lintner	5.51		0.53			6.50			8.95
Black	5.51	6.50	0.53			0.00			12.01
Fama-French	5.51		0.55	0.35	0.03	6.50	6.12	-0.45	11.21
Zero-Beta FF	5.51	6.50	0.55	0.35	0.03	0.00	6.12	-0.45	14.15

* *The risk-free rate and market risk premium are from the Economic Regulation Authority's 'Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power'.*

A.2. CAPM

Table A.2 provides estimates of the betas of the nine individual utility stocks. As one would expect, the standard errors of the estimates are higher than the standard errors of the weekly estimates in Table 5.2. For example, the standard error of AAN's monthly OLS estimate, from Table A.2, is 0.47, while the standard error of its weekly OLS estimate is, from Table 5.2, 0.21. The standard error of the monthly estimate is about twice as large as the standard error of the weekly estimate because there are only about one quarter as many monthly observations as there are weekly observations and the standard error depends on the inverse of the square root of the number of observations.

Table A.3 provide average and portfolio estimates that use monthly data. The average and portfolio estimates are more precise than the security estimates. So, partly as a result, there is less variation across the estimates than across the security estimates. Again, the standard errors of the monthly estimates are about twice as large as the standard errors of their weekly counterparts. For example, the standard error of the monthly OLS estimate for an equally weighted portfolio, from Table A.3, is 0.12, while the standard error of the corresponding weekly OLS estimate is, from Table 5.3, 0.05. Also, consistent with our discussion in the text, the standard errors attached to the average OLS estimates are marginally higher than their equally weighted portfolio counterparts.

Table A.2
Individual security beta estimates computed using monthly DFA data from 1 January 2002 to 31 December 2009

	AAN	AGL	APA	DUE	ENV	GAS	HDF	SKI	SPN
OLS	0.82	0.63	0.72	0.42	0.45	0.34	0.44	0.51	0.17
	(0.47)	(0.33)	(0.16)	(0.12)	(0.13)	(0.20)	(0.59)	(0.19)	(0.15)
LAD	0.94	0.78	0.85	0.39	0.41	0.32	0.81	0.85	0.17
	(0.44)	(0.51)	(0.13)	(0.13)	(0.12)	(0.12)	(0.32)	(0.22)	(0.23)

Standard errors are in parentheses.

Table A.4 shows estimates of the risk premium on the equity of a regulated energy business computed using the Sharpe-Lintner and Black CAPMs. As we point out in Section 4.3, it is unclear whether OLS or LAD estimates will be most precise and unclear whether estimates computed using an equally or value-weighted portfolio or computed by averaging across firms will provide the most precise estimates. So we use all monthly beta estimates. In particular, we use the mean of the six monthly beta estimates and, here, the Sharpe-Lintner and Black CAPMs to estimate the risk premium.

Table A.3
Average and portfolio beta estimates computed using monthly DFA data from 1 January 2002 to 31 December 2009

	AV	EW	VW
OLS	0.50	0.48	0.56
	(0.13)	(0.12)	(0.12)
LAD	0.61	0.41	0.62
		(0.14)	(0.17)

Standard errors are in parentheses.

Table A.4
Risk premiums computed using monthly DFA data and the Sharpe-Lintner and Black CAPMs

			Risk Premium	
		Beta	SL	Black
OLS	Firm Average	0.50	3.25	6.50
	Equally Weighted Portfolio	0.48	3.13	6.50
	Value-Weighted Portfolio	0.56	3.61	6.50
LAD	Firm Average	0.61	3.99	6.50
	Equally Weighted Portfolio	0.41	2.67	6.50
	Value-Weighted Portfolio	0.62	4.01	6.50
	Mean Value	**0.53**	**3.44**	**6.50**

A.3. Fama-French Three-Factor Model

Table A.5 provides estimates of the Fama-French betas of the nine individual utility stocks computed using monthly data. Again, the standard errors of the estimates are about twice as large as the standard errors of the corresponding weekly estimates. Table A.6 provides average and portfolio estimates that use monthly data. The average and portfolio estimates are more precise than the security estimates. So, as one would expect, there is less variation across the estimates than across the security estimates. Again, though, the standard errors of the monthly estimates are about twice as large as the standard errors of their weekly counterparts. Also, the standard errors attached to the average OLS estimates are marginally higher than their equally weighted portfolio counterparts.

Table A.5
Individual security Fama-French beta estimates computed using monthly DFA data from 1 January 2002 to 31 December 2009

	AAN	AGL	APA	DUE	ENV	GAS	HDF	SKI	SPN
					Market				
OLS	1.04	0.83	0.77	0.33	0.44	0.59	-0.31	0.65	0.24
	(0.51)	(0.35)	(0.18)	(0.14)	(0.14)	(0.21)	(0.70)	(0.25)	(0.19)
LAD	1.17	0.59	0.87	0.37	0.44	0.39	0.52	0.98	0.11
	(0.54)	(0.47)	(0.16)	(0.15)	(0.10)	(0.20)	(0.37)	(0.23)	(0.24)
					HML				
OLS	1.12	1.26	0.10	-0.08	0.74	1.11	0.60	-0.10	-0.04
	(0.98)	(0.69)	(0.32)	(0.23)	(0.24)	(0.41)	(1.09)	(0.38)	(0.29)
LAD	0.66	0.83	-0.08	0.11	0.85	0.77	1.03	0.00	-0.14
	(1.04)	(0.93)	(0.29)	(0.24)	(0.18)	(0.40)	(0.57)	(0.36)	(0.36)
					SMB				
OLS	0.68	-0.58	-0.14	0.26	0.18	0.28	2.09	-0.32	-0.17
	(0.62)	(0.41)	(0.26)	(0.22)	(0.19)	(0.25)	(1.02)	(0.36)	(0.29)
LAD	0.44	-0.99	-0.40	0.21	0.13	0.10	0.81	-0.46	0.29
	(0.65)	(0.56)	(0.23)	(0.23)	(0.14)	(0.24)	(0.54)	(0.34)	(0.36)

Standard errors are in parentheses.

Table A.6
Average and portfolio Fama-French beta estimates computed using monthly DFA data from 1 January 2002 to 31 December 2009

	Market			*HML*			*SMB*		
	AV	EW	VW	AV	EW	VW	AV	EW	VW
OLS	0.51	0.42	0.60	0.52	0.30	0.29	0.25	0.26	-0.10
	(0.14)	(0.13)	(0.14)	(0.24)	(0.23)	(0.24)	(0.20)	(0.18)	(0.19)
LAD	0.60	0.49	0.65	0.45	0.38	0.17	0.02	-0.03	-0.19
		(0.15)	(0.19)		(0.26)	(0.35)		(0.21)	(0.27)

Standard errors are in parentheses.

Table A.7 shows estimates of the risk premium on the equity of a regulated energy business computed using the FFM and monthly DFA data. Again, it is unclear whether OLS or LAD estimates will be most precise and unclear whether estimates computed using an equally or value-weighted portfolio or computed by averaging across firms will be most precise. So we use the means of each set of six monthly beta estimates and the two versions of the FFM to estimate the risk premium.

From Table A.7, using monthly data, an estimate of the risk premium computed using the FFM is 5.70 percent per annum while using the zero-beta version of the model, it is 8.64 percent per annum. These estimates are not substantially different from their weekly counterparts in Table 5.8 of 6.08 percent for the FFM and 8.89 percent per annum for the zero-beta model. Thus we conclude that our estimates are robust to the use of monthly rather than weekly data.

Table A.7
Risk premiums computed using the Fama-French three-factor model and monthly DFA Data

		Beta			Risk Premium	
		Market	*HML*	*SMB*	FF	Zero-Beta
OLS	Firm Average	0.51	0.52	0.25	6.41	9.59
	Equally Weighted Portfolio	0.42	0.30	0.26	4.44	8.21
	Value-Weighted Portfolio	0.60	0.29	-0.10	5.76	8.33
LAD	Firm Average	0.60	0.45	0.02	6.67	9.24
	Equally Weighted Portfolio	0.49	0.38	-0.03	5.53	8.82
	Value-Weighted Portfolio	0.65	0.17	-0.19	5.40	7.65
	Mean Value	**0.55**	**0.35**	**0.03**	**5.70**	**8.64**

Appendix B. Alternative Data Sources

B.1. Summary

In this appendix we investigate the impact of using alternative measures for the Fama-French factors. In particular, we examine the impact of using factors constructed from data supplied by Morgan Stanley Capital International (MSCI).

We use as a proxy for the market return the gross return to the MSCI Australian Standard Core portfolio. We compute the *HML* factor as the difference between the returns to the MSCI Australia Standard Value and MSCI Australia Standard Growth portfolios. We compute the *SMB* factor as the difference between the returns to the MSCI Australian Small Core and MSCI Australian Large Core portfolios. Data on the MSCI Australian Standard Core portfolio are available from January 1970 through December 2009, data on the MSCI Australian Standard Value and Growth portfolios are available from January 1975 through December 2009 while data on the MSCI Australian Small and Large Core portfolios are available from June 1994 and from January 2001 through December 2009. The short time series of small company returns makes it difficult to estimate the *SMB* premium precisely.

Table B.1
Estimates of the return required on a portfolio of Australian utility stocks computed using MSCI data

Model	Risk-Free Rate*	Zero-Beta Premium	Beta Market	Beta *HML*	Beta *SMB*	Risk Premium Market	Risk Premium *HML*	Risk Premium *SMB*	Return On Equity
				Weekly data					
Fama-French	5.51		0.55	0.23	0.39	6.50	3.57	5.67	12.12
Zero-Beta FF	5.51	6.50	0.55	0.23	0.39	0.00	3.57	5.67	15.03
				Monthly data					
Fama-French	5.51		0.58	0.29	0.15	6.50	3.57	5.67	11.15
Zero-Beta FF	5.51	6.50	0.58	0.29	0.15	0.00	3.57	5.67	13.89

* *The risk-free rate and market risk premium are from the Economic Regulation Authority's 'Final Decision on Proposed Revisions to the Access Arrangement for the South West Interconnected Network Submitted by Western Power'.*

Table B.1 provides estimates of the return required on the equity of a regulated energy business computed using these data. The MSCI *HML* premium and *HML* beta estimates are lower than their DFA counterparts. On the other hand, the estimate of the *SMB* premium is higher than its DFA counterpart. As a result, the estimates of the return required on the equity of a regulated energy business that Table B.1 provides do not differ substantially from the DFA estimates that appear in Table 5.1 and Table A.1.

B.2. Results

B.2.1. Risk premiums

As with the DFA data, we use the same estimate of the MRP as that employed by the ERA, that is, 6.50 per cent per annum. Again, this estimate includes an amount that recognizes the value of franking credits to the investor.

To estimate the risk premiums on the *HML* and *SMB* factors we first form annual returns from the monthly MSCI data that we assemble. We then compute the arithmetic mean of the difference between the annual returns to the high book-to-market and low book-to-market portfolios and the arithmetic mean of the difference between the annual returns to the portfolios of small companies and big companies. We then, as with the DFA data, adjust these mean differences to take into account the value an investor places on franking credits distributed.

Table B.2 shows estimates of the *HML* and *SMB* premiums computed using the MSCI data. Both the *HML* and *SMB* estimate are positive but neither estimate is significantly different from zero at conventional (5 per cent) levels.

Table B.2
Fama-French risk premiums computed using MSCI data

	Market	*HML*	*SMB*
Australia	6.50	3.57	5.67
		(2.76)	(3.81)
Period		1975 – 2009	2001 – 2009

Premium estimates in percent per annum are outside of parentheses. Standard errors are in parentheses

B.2.2. Beta estimates

We compute beta estimates for the nine individual securities and for two portfolios of the securities, one equally weighted and the other value-weighted, using weekly and monthly data as before.

Table B.3 and Table B.4 show estimates, computed using weekly and monthly data, of the betas of the nine utilities relative to the three Fama-French factors. Again, the individual security estimates are typically not very precise and the monthly estimates are less precise than the weekly estimates.

Table B.3
Individual security Fama-French beta estimates computed using weekly MSCI data from 1 January 2002 to 31 December 2009

	AAN	AGL	APA	DUE	ENV	GAS	HDF	SKI	SPN
					Market				
OLS	1.29	0.86	0.62	0.29	0.34	0.29	1.34	0.52	0.19
	(0.22)	(0.18)	(0.07)	(0.05)	(0.05)	(0.10)	(0.20)	(0.12)	(0.08)
LAD	0.87	0.83	0.62	0.20	0.27	0.25	0.84	0.41	0.16
	(0.23)	(0.28)	(0.06)	(0.04)	(0.03)	(0.13)	(0.09)	(0.13)	(0.07)
					HML				
OLS	0.25	0.17	0.09	0.06	0.20	-0.15	1.28	0.35	0.29
	(0.24)	(0.18)	(0.09)	(0.06)	(0.06)	(0.10)	(0.24)	(0.15)	(0.09)
LAD	0.10	0.21	0.18	0.09	0.13	-0.15	0.73	0.16	0.21
	(0.25)	(0.29)	(0.07)	(0.05)	(0.03)	(0.13)	(0.11)	(0.16)	(0.08)
					SML				
OLS	0.82	0.47	0.35	0.33	0.43	0.09	1.34	0.36	0.16
	(0.25)	(0.20)	(0.11)	(0.09)	(0.07)	(0.11)	(0.36)	(0.23)	(0.14)
LAD	0.79	0.37	0.45	0.37	0.26	0.08	0.56	0.23	0.38
	(0.26)	(0.31)	(0.09)	(0.07)	(0.04)	(0.14)	(0.17)	(0.24)	(0.12)

Standard errors are in parentheses.

Table B.4
Individual security Fama-French beta estimates computed using monthly MSCI data from 1 January 2002 to 31 December 2009

	AAN	AGL	APA	DUE	ENV	GAS	HDF	SKI	SPN
					Market				
OLS	0.85	1.01	0.80	0.32	0.46	0.47	-0.17	0.58	0.25
	(0.50)	(0.32)	(0.18)	(0.14)	(0.13)	(0.20)	(0.68)	(0.24)	(0.19)
LAD	1.11	0.84	0.89	0.44	0.47	0.33	0.75	0.51	-0.07
	(0.44)	(0.34)	(0.14)	(0.11)	(0.08)	(0.20)	(0.40)	(0.37)	(0.21)
					HML				
OLS	0.18	0.96	0.17	0.02	0.43	0.46	0.53	0.04	0.08
	(0.55)	(0.36)	(0.20)	(0.15)	(0.15)	(0.23)	(0.72)	(0.25)	(0.19)
LAD	0.50	1.01	0.18	0.19	0.48	0.14	0.58	-0.30	0.27
	(0.49)	(0.37)	(0.16)	(0.11)	(0.09)	(0.22)	(0.42)	(0.37)	(0.21)
					SMB				
OLS	0.54	-0.25	-0.03	0.39	0.26	-0.05	1.68	-0.08	-0.14
	(0.55)	(0.35)	(0.22)	(0.18)	(0.16)	(0.22)	(0.87)	(0.30)	(0.24)
LAD	0.18	-0.48	-0.29	0.39	0.13	-0.16	0.63	-0.15	0.26
	(0.49)	(0.36)	(0.17)	(0.14)	(0.10)	(0.21)	(0.51)	(0.46)	(0.26)

Standard errors are in parentheses.

Table B.5 displays the average and portfolio estimates that use the MSCI data. The evidence indicates that a utility stock has exposure to all three Fama-French factors. The standard errors of the average and portfolio estimates are typically a great deal lower than their individual security counterparts. In other words, the average and portfolio estimates are more precise than the security estimates. So, partly for this reason, there is for each parameter less variation across the estimates. As is true of Table B.3 and Table B.4, the weekly estimates are more precise than their monthly counterparts. Also, once more, consistent with our discussion in the text, the standard errors attached to the average OLS estimates are higher than their equally weighted portfolio counterparts, although, again, only marginally so.

Table B.5
Average and portfolio Fama-French beta estimates computed using MSCI data from 1 January 2002 to 31 December 2009

	Market			***HML***			***SMB***		
	AV	**EW**	**VW**	**AV**	**EW**	**VW**	**AV**	**EW**	**VW**
					Weekly data				
OLS	0.64	0.59	0.53	0.28	0.32	0.22	0.48	0.48	0.38
	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.06)	(0.08)	(0.07)	(0.08)
LAD	0.49	0.52	0.54	0.18	0.20	0.19	0.39	0.32	0.27
		(0.05)	(0.05)		(0.06)	(0.06)		(0.08)	(0.08)
					Monthly data				
OLS	0.51	0.45	0.62	0.32	0.23	0.27	0.26	0.29	0.07
	(0.14)	(0.13)	(0.13)	(0.15)	(0.14)	(0.15)	(0.16)	(0.15)	(0.16)
LAD	0.59	0.67	0.64	0.34	0.40	0.21	0.06	0.15	0.05
		(0.14)	(0.18)		(0.15)	(0.20)		(0.16)	(0.21)

Standard errors are in parentheses.

Table B.6 shows estimates of the risk premium on the equity of the equity of a regulated energy business computed using the FFM and the data supplied by Morgan Stanley Capital International. Again estimates derived from weekly data have significantly lower standard errors than those estimated from monthly data. So we focus on estimates derived from weekly data rather than those derived from monthly data.

Also, as discussed in Section 4.3, it is unclear whether OLS or LAD estimates will be most precise and unclear whether estimates computed using an equally or value-weighted portfolio or computed by averaging across firms will be most precise. So we use all weekly beta estimates. In particular, we use the means of each set of six monthly beta estimates and the two versions of the FFM to estimate the risk premium.

Using weekly MSCI data, an estimate of the risk premium computed using the FFM is 6.61 percent per annum while using the zero-beta version of the model, it is 9.52 percent per annum. These estimates are not substantially different from their DFA counterparts in Table 5.8 of 6.08 percent for the FFM and 8.89 percent per annum for the zero-beta model. Thus we conclude that our estimates are robust to the use of alternative sets of data.

**Table B.6
Risk premiums computed using the Fama-French
three-factor model and MSCI data**

		Beta			Risk Premium	
		Market	*HML*	*SMB*	FF	Zero-Beta
		Weekly data				
OLS	Firm Average	0.64	0.28	0.48	7.88	10.23
	Equally Weighted Portfolio	0.59	0.32	0.48	7.68	10.36
	Value-Weighted Portfolio	0.53	0.22	0.38	6.37	9.43
LAD	Firm Average	0.49	0.18	0.39	6.05	9.35
	Equally Weighted Portfolio	0.52	0.20	0.32	5.97	9.06
	Value-Weighted Portfolio	0.54	0.19	0.27	5.73	8.71
	Mean Value	**0.55**	**0.23**	**0.39**	**6.61**	**9.52**
		Monthly data				
OLS	Firm Average	0.51	0.32	0.26	5.91	9.09
	Equally Weighted Portfolio	0.45	0.23	0.29	5.39	8.99
	Value-Weighted Portfolio	0.62	0.27	0.07	5.38	7.88
LAD	Firm Average	0.59	0.34	0.06	5.34	8.02
	Equally Weighted Portfolio	0.67	0.40	0.15	6.64	8.78
	Value-Weighted Portfolio	0.64	0.21	0.05	5.17	7.53
	Mean Value	**0.58**	**0.29**	**0.15**	**5.64**	**8.38**

Appendix C. Terms of Reference

C.1. Background

The Dampier to Bunbury Natural Gas Pipeline (DBNGP) extends from the Pilbara region to the South-West of Western Australia. It is a major natural gas transmission pipeline that supplies industrial, commercial and residential customers in Perth and major regional centres along the pipeline route. The DBNGP is operated subject to terms and conditions set out in an Access Arrangement prepared under the National Third Party Access Code for Natural Gas Pipeline Systems and approved by the Economic Regulation Authority (ERA).

DBP Transmission is due to submit to the ERA its 2010-2014 Access Arrangement in early 2010. Under the scheme of the National Gas Rules (Rules), they are to be set to recover the total revenue forecast for the next access arrangement period. The forecast total revenue is to be determined from, among other things, a return on the capital base of the transmission network. That return is to be calculated by applying a rate of return determined in accordance with Rule 87 of the National Gas Rules.

Rule 87(1) requires that the rate of return be commensurate with prevailing conditions in the market for funds, and with the risks involved in providing reference services.

In determining the rate of return in accordance with Rule 87(2), a well accepted approach that incorporates the costs of equity and debt, such as a weighted average cost of capital, is to be used, together with a well accepted financial model, such as the Capital Asset Pricing Model, to estimate the current cost of equity. Furthermore, the service provider is to be assumed to:

- meet benchmark levels of efficiency; and
- use a financing structure which meets benchmark standards as to gearing and other financial parameters for a going concern, and which reflects in other respects best practice.

C.2. Scope of Work

The Consultant will be required to perform the following services: -

1. advise on well accepted financial models which could be used to estimate plausible ranges for return on equity which can be used as a guide for estimating the return on equity that is required to be determined for the purposes of Rule 87(1) of the NGR;
2. estimate the parameters used in each of these models having regard to the requirements of Rule 74 of the National Gas Rules, and the revenue and pricing principles of the National Gas Access (WA) Act, taking as given a market risk premium of 6.50%, a benchmark gearing of 60.00% debt, and a value to be attached to imputation credits (gamma) of 0.20; and
3. use the models identified in item 1, and for which the parameters have been estimated in item 2, to estimate the plausible range for the cost of equity as a guide to estimating the return on equity required for Rule 87(1).

§

C.3. Information to be considered

The report is to have regard to:

- the Australian Energy Regulator's (AER's) May 2009 '*Decision for Review of the weighted cost of capital (WACC) parameters for electrical transmission and distribution*' (the "*WACC* parameter decision");
- the AER's November 2009 '*ActewAGL Access arrangement proposal for the ACT, Queanbeyan and Palerang gas distribution network: 1 July 2010 – 30 June 2015'* (the "ActewAGL draft decision"); and
- the AER's February 2010 *'Jemena Access arrangement proposal for the NSW gas networks 1July 2010 – 30 June 2015: Draft decision (Public)* (the "Jemena draft decision")
- the NSW Independent Pricing and Regulatory Tribunal (IPART), November 2009, '*Alternative approaches to the determination of the cost of equity*' (the "IPART discussion paper").

The analysis of the Sharpe-Linter CAPM will include a critique of the April 2009 National Bureau of Economic Research working paper authored by Da, Guo and Jagannathan entitled CAPM for Estimating the Cost of Equity Capital: Interpreting the Empirical Evidence which was cited by both the AER and IPART as supporting their continued use of the CAPM.

C.4. Timetable

The independent expert will deliver the draft report to DBP by **31 January 2010**.

NERA
Economic Consulting

NERA Economic Consulting
Darling Park Tower 3
201 Sussex Street
Sydney NSW 2000
Tel: +61 2 8864 6500
Fax: +61 2 8864 6549
www.nera.com

NERA Australia Pty Ltd, ABN 34 092 959 665