The Fama-French model

Report for Jemena Gas Networks, ActewAGL, Transend, TransGrid, and SA PowerNetworks

13 May 2014

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1. Background and conclusions

Overview and instructions

1. SFG Consulting (**SFG**) has been retained by Jemena Gas Networks (**JGN**), ActewAGL, Transend, TransGrid and SA PowerNetworks to provide our views on the estimation of the required return on equity under the National Electricity Rules and National Gas Rules (**Rules**), using the asset pricing model developed by Fama and French (1993). In particular, we have been asked to provide an opinion report that:

    a) describes the Fama-French model, its key parameters and inputs, and the theoretical and empirical basis for its development;

    b) describes how the Fama-French model is applied in practice (and is used to estimate the return on equity) in Australia;

    c) uses the Fama-French model to estimate the return on equity for a benchmark efficient entity in Australia that is:

        i) commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to a regulated energy network in respect of the provision of reference services; and

        ii) reflective of prevailing conditions in the market for equity funds.

2. In preparing the report, we have been asked to:

    a) consider different approaches to applying the Fama-French model, including any theoretical restrictions on empirical estimates;

    b) consider the theoretical and empirical support for the Fama-French model and its factors;

    c) consider any comments raised by the Australian Energy Regulator (**AER**) and other regulators including on (but not limited to) (i) whether the Fama-French model applies in Australia and (ii) the statistical reliability of the parameter estimates;

    d) use robust methods and data; and

    e) use the sample averaging period of the 20 business days to 14 February 2014 (inclusive) to estimate any prevailing parameter estimates needed to populate the Fama-French model.

3. Our instructions are set out in an appendix to this report.

4. This report has been authored by Professor Stephen Gray and Dr Jason Hall. Stephen Gray is Professor of Finance at UQ Business School, The University of Queensland and Director of SFG Consulting, a specialist corporate finance consultancy. He has Honours degrees in Commerce and Law from The University of Queensland and a PhD in financial economics from Stanford University. He teaches graduate level courses with a focus on cost of capital issues, has published widely in high-level academic journals, and has more than 15 years' experience advising regulators, government agencies and regulated businesses on cost of capital issues. Jason Hall is Lecturer in Finance at the Ross School of Business, The University of Michigan and Director of SFG Consulting. He has an Honours degree in Commerce and a PhD in finance from The University of Queensland. He teaches

graduate level courses with a focus on valuation, has published 15 research papers in academic journals and has 17 years practical experience in valuation and corporate finance. Copies of their curriculum vitas are attached as Appendix 2 to this report.

5. The opinions set out in this report are based on the specialist knowledge acquired from our training and experience set out above.

6. We have read, understood and complied with the Federal Court of Australia Practice Note CM7 *Expert Witnesses in Proceedings in the Federal Court of Australia*.

Summary of conclusions

7. Our primary conclusions in relation to the estimation of the allowed return on equity are set out below.

Estimate of the cost of equity

8. In placing sole reliance on the Sharpe-Lintner Capital Asset Pricing Model, and no reliance on the Fama-French Model, it is highly likely the AER has understated the cost of equity for the benchmark firm. The use of the Fama-French model is supported by empirical evidence, has theoretical support and is extensively used to estimate normal returns on investment. We support the use of the Fama-French model as one of many approaches to estimating the cost of equity for the benchmark firm, alongside the Sharpe-Lintner CAPM, the Black CAPM and the dividend discount model. Our specific estimate of the cost of equity using the Fama-French model is provided in Section 5.

Theory

9. Twenty years ago, Fama and French (1993) published an empirical paper which built upon the observation from prior research that (a) the Sharpe-Lintner CAPM is not supported by empirical analysis of stock returns and (b) two firm characteristics – small firm size and high book-to-market ratio – were associated with higher stock returns. Fama and French (1993) constructed factors on the basis of this observation, and demonstrated that these factors did, indeed, perform quite well in explaining stock returns. The performance of the size factor has fluctuated somewhat over time and across markets, but the performance of the book-to-market factor has not. There is agreement amongst researchers that the book-to-market factor seems to perform well at explaining stock returns in different markets.

10. The results of Fama and French (1993) led to a substantial body of literature devoted to theoretical reasons for their empirical result. Those theoretical explanations are based upon the asset pricing theories already developed in the 1970s – the intertemporal CAPM and the arbitrage pricing theory. Some of those theories and associated empirical evidence are presented in this paper, and this is not an exhaustive list. To conclude that the Fama-French model is without theoretical foundation is incorrect. It is not appropriate to dismiss the theoretical underpinnings of the model merely because the empirical result was observed first.

Computations

11. The AER's objection to the Fama-French model on computational grounds is inappropriate. The AER is concerned that the use of the model requires estimation of more parameters, so adds an unreasonable layer of complexity to the analysis. It is correct that there is uncertainty over firms' exposure to the *SMB* and *HML* factors (*s* and *h*), and to the appropriate level of the *SMB* and *HML* factors to use in determining the cost of equity. But the dataset and estimation techniques used in this analysis are the same as those used to populate the Sharpe-Lintner CAPM. The AER's computational

concern is such that it has placed zero weight on a cost of equity estimate which is substantially above the estimate resulting from its application of the Sharpe-Lintner CAPM.

12. In the Fama-French model, there is uncertainty over the magnitude of risk exposure (s and h) and uncertainty about the return per unit of risk (*SMB* and *HML*). This uncertainty exists, whether or not, in estimating the cost of equity, we set the risk exposures to zero ($s = 0$ and $h = 0$), or the returns per unit of risk to zero ($SMB = 0$ and $HML = 0$). Making either of these assumptions simply shifts the cost of equity estimate to the Sharpe-Lintner CAPM estimate. It does not improve the precision of the cost of equity estimate.

Implications for asset pricing models

13. The AER's decision to give no weight to the Fama-French model is based upon the rationale that there is uncertainty about what risks are captured by the Fama-French factors, and uncertainty about the magnitude of the risk premiums, and until there is agreement on these issues the model should not be used. If this rationale is accepted there is unlikely to be any new asset pricing model ever adopted.

14. Our view is that if the Fama-French model is not given any consideration by the AER, the estimated cost of equity will be understated. If we were to rely solely upon the Sharpe-Lintner CAPM, populated with a regression-based estimate of beta, we would adopt a second-best solution, because we would ignore the empirical evidence that the *HML* factor proxies for risk.

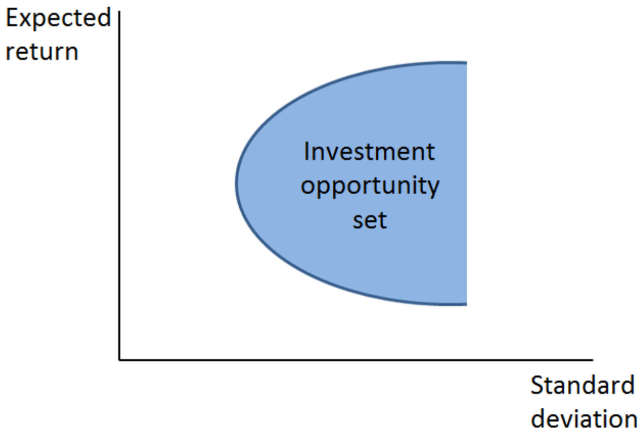
15. We consider it important for participants in the regulatory process that the AER reach a conclusion on whether it believes *HML* represents a priced risk factor. The AER's concerns over whether theory supports *HML* as a priced risk factor, and the magnitude of risk exposure, does not address this important question.

2. The development of the Fama-French model

The efficient frontier

16. Asset pricing models such as the Sharp-Lintner Capital Asset Pricing Model (**CAPM**) (Sharpe, 1964; Lintner, 1965), the Black CAPM (Black, 1972) and the Fama-French model all begin with the concept of the **investment opportunity set**. If we plot all risky assets and all possible combinations (portfolios) of risky assets in terms of their expected return and standard deviation, we obtain the investment opportunity set. This is the shaded region inside the curve in Figure 1 below. This indicates that an investor is able to obtain any risk/return combination[1] the investor chooses within the shaded area. Different points within the efficient frontier simply represent different combinations of risky assets. To move from one point within the investment opportunity set to another, the investor simply needs to re-weight the assets in the investor's portfolio.

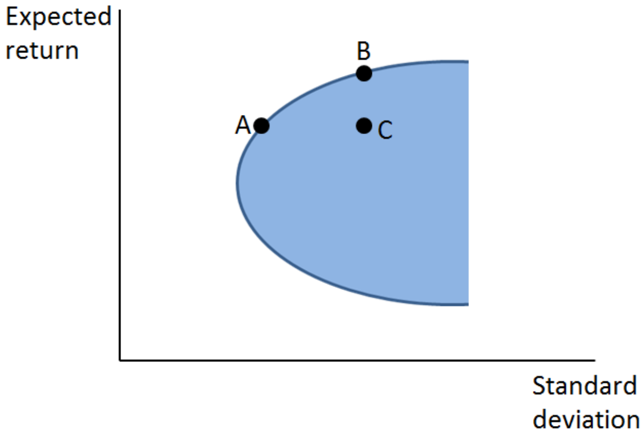
Figure 1. The investment opportunity set



17. For risk-averse investors, some points in the investment opportunity set (that is, some portfolios of risky assets) are better than others. For example, in Figure 2 below, Portfolio B dominates Portfolio C because it offers higher returns for the same level of risk. Similarly, Portfolio A dominates Portfolio C because it offers the same expected return for a lower level of risk. Because Portfolio C is dominated by other portfolios in this way, it is said to be an **inefficient portfolio**.

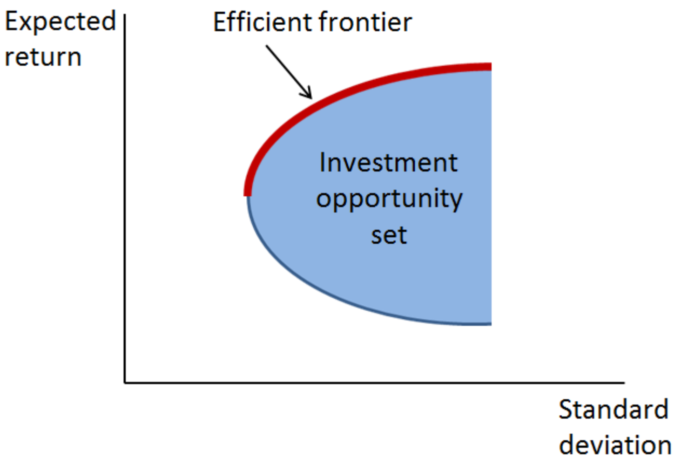
[1] That is, any combination of expected return and standard deviation.

Figure 2. An inefficient portfolio



18. Clearly, investors who like high returns and who are averse to risk[2] will not want to hold inefficient portfolios. Rather, they will all want to hold efficient portfolios that maximise return for a given level of risk and minimise risk for a given level of return. The set of efficient portfolios is called the efficient frontier of risky assets and is illustrated in Figure 3 below. For every portfolio on the efficient frontier, there is no other portfolio that offers a higher return for the same (or less) risk or lower risk for the same (or higher) returns.

Figure 3. The efficient frontier



The fundamental asset pricing relationship

19. Since the work of Markowitz (1952), Sharpe (1964), Lintner (1965) and Black (1972) it has been well known that the expected return of *every* asset can be written as a linear function of *any* efficient asset:[3]

$$r_i = r_z + \beta_i \left(r_p - r_z \right) \tag{1}$$

where:

[2] Under standard asset pricing models, all investors are assumed to exhibit these characteristics.
[3] For a useful summary, see Smith and Walsh (2013), p. 74.

a) r_i is the expected return for asset *i*;

b) r_p is the expected return for efficient portfolio *p*;

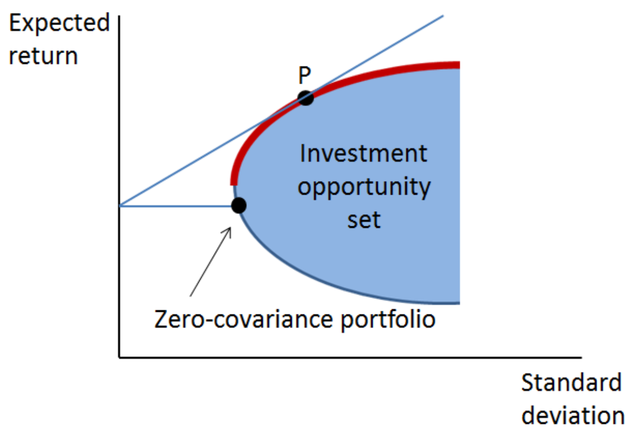
c) r_z is the expected return for a portfolio that is uncorrelated with portfolio *p*; and

d) β_i is the covariance between the returns of asset *i* and the returns of portfolio *p*, divided by the variance of the returns of portfolio *p*.

20. This is a general mathematical result that must always hold. If portfolio *p* is efficient, the simple linear relationship above *must* hold for every asset.

21. Moreover, for every efficient portfolio, there must exist a zero-covariance portfolio such that the returns of the two portfolios are uncorrelated. The zero covariance portfolio can be found by drawing a tangent to the efficient portfolio, as illustrated in Figure 4 below.[4]

Figure 4. The zero-covariance portfolio



22. By contrast, if portfolio *p* is not on the efficient frontier, the linear relationship in Equation (1) does not hold. Indeed, if portfolio *p* is inefficient, there is no reason to believe that it could be used in any way to describe or explain the returns of any asset.

23. The Sharpe-Lintner CAPM makes two important assumption beyond the basic portfolio mathematics set out above.

a) There is a risk-free asset that is available to all investors, who can borrow or lend as much as they like at the risk-free rate. An asset that is completely free of risk is obviously uncorrelated with every risky asset and with every portfolio of risky assets, in which case the risk-free rate plays the role of the more general r_z in the above equation; and

b) Investors have homogeneous expectations. This means that investors share the same views about expected returns on each asset, the volatility of returns on each asset, and the covariance of returns between each pair of assets.

[4] See, for example, Huang and Litzenberger (1988), Figure 3.15.1, p. 71.

c) The market portfolio is on the efficient frontier, in which case the expected return on the market portfolio plays the role of r_p in the above equation.

24. These assumptions mean that the market portfolio plays the role of r_p in the above equation and the risk-free rate plays the role of r_z. So, in the more specific Sharpe-Lintner CAPM, the equation becomes $r_i = r_f + \beta_i \times (r_m - r_f)$.

What if the market portfolio is not efficient?

25. If the market portfolio is not on the efficient frontier, there will not be a linear relationship between betas (estimated relative to the market portfolio) and expected returns as the Sharpe-Lintner CAPM suggests. In this case, it would be necessary to use some other means to find a portfolio that *is* efficient. In this regard, Berk and DeMarzo (2013) note that:

> When the market portfolio is not efficient, to use [Equation (1) above] we need to find an alternative method to identify an efficient portfolio.[5]

26. The question then becomes one of how to identify an efficient portfolio to use in Equation (1). In this regard, it is useful to note that we don't need to identify a single portfolio that is efficient – we only need to identify a set of portfolios (each of which might be inefficient alone) that can be combined to form an efficient portfolio. For example, suppose that we identify three portfolios that can be combined to form an efficient portfolio. In this case, Ross (1976) shows that the expected return of any asset can be written as a linear function of the sensitivity (beta) to each factor as follows:[6]

$$r_i = r_f + \beta_{1i}(r_1 - r_f) + \beta_{2i}(r_2 - r_f) + \beta_{3i}(r_3 - r_f) \quad (2)$$

where:

a) r_i is the expected return for asset *i*;

b) r_1 is the expected return for portfolio 1, and similarly for r_2 and r_3;

c) r_f is the risk-free rate of return; and

d) β_1 is the sensitivity of returns on asset *i* to returns on portfolio 1, and similarly for β_2 and β_3.

27. Berk and DeMarzo (2013) note that:

> There is nothing inconsistent between [Equation (1)] and [Equation (2)]…Both equations hold…When we use an efficient portfolio, it alone will capture all systematic risk…If we use multiple portfolios as factors, then together these factors will capture all systematic risk, but note that each factor in [Equation (2)] captures different components of the systematic risk.[7]

[5] Berk and DeMarzo (2013), p. 461.
[6] Ross (1976) develops the framework for the case in which a risk-free asset exists. If there is not a single risk-free rate at which all investors can borrow or lend, r_f is simply replaced by r_z.
[7] Berk and DeMarzo (2013), p. 461.

28. This means that if we could identify a single efficient portfolio, we could use that portfolio in Equation (1). If that portfolio really is efficient, the linear relationship in Equation (1) must hold exactly. In particular, there would be no systematic violation of Equation (1) in the observed data – the only violation of Equation (1) would come from random sampling error.

29. If we are unable to identify a single efficient portfolio, we would need to identify a set of portfolios (or "factors") that could be combined to form an efficient portfolio, in which case Equation (2) must hold exactly.

30. The analysis thus far raises two questions:

    a) Can we identify a single efficient portfolio?; and, if not,

    b) What additional portfolios or factors should be included?

Can we identify a single efficient portfolio?

31. Under the Sharpe-Lintner CAPM, the market portfolio is an efficient portfolio. This follows from three key assumptions of the model:

    a) Homogeneous expectations – all investors share the same beliefs about the joint distribution of the returns of all assets (that is, we all use the same number for the expected return of BHP and we all use the same number for the standard deviation of ANZ, and so on); and

    b) Perfect capital markets – no investor faces taxes or transactions costs of any type, liquidity presents no impediment to trade, and all assets are infinitely divisible.

    c) Unlimited borrowing and lending at the risk-free rate of interest.

32. Under these assumptions, all investors have the same view about a particular asset – they all have the same belief about the expected return and standard deviation of the asset and they all have the same belief about the correlation between assets. Moreover, there are no distortionary taxes or other market imperfections that would result in different investors receiving different payoffs from the same asset. In summary, because:

    a) all investors have the same beliefs about the joint distribution of assets;

    b) there are no taxes or other imperfections;

    c) all investors will want to hold efficient portfolios; and

    d) investors can borrow and lend at the risk-free rate of interest,

    it follows that the only portfolio that is efficient is the market portfolio of all risky assets. The risky portion of investors' portfolios will be comprised of the market portfolio. Investors with high risk aversion will lend at the risk-free rate and invest a small portion of wealth or nothing in the market portfolio; and investors with low risk aversion will borrow at the risk-free rate and invest more in the market portfolio.[8]

[8] More precisely, the efficiency of the market portfolio follows from the fact that the market portfolio is a convex combination of the portfolios of investors. See Huang and Litzenberger (1988), p. 91.

33. If the assumptions about homogeneous expectations and perfect capital markets are relaxed, it is no longer the case that the market portfolio must be efficient. More precisely, those assumptions are required for two-fund separation, whereby under the CAPM all investors hold an identical (market) portfolio of risky assets and differ only in how they apportion their wealth between that market portfolio and the risk-free asset.

34. The assumptions about homogeneous expectations and perfect capital markets *are* clearly violated in practice – investors do not agree about the joint distribution of assets and they are differentially taxed. Consequently, there is no conceptual reason why the market portfolio must be efficient.

35. However, it is possible that the market portfolio may still be efficient by chance, in which case Equation (1) would still apply. This is, of course, an empirical question. Unfortunately, it is an empirical question that is impossible to answer because:

    a) the market portfolio of all assets can never be measured – the best available proxy is a stock market index; and

    b) the CAPM requires the market portfolio to be *ex ante* efficient, but stock returns can only be observed ex post and it is possible that ex post outcomes might differ from expectations.

36. That is, the empirical tests routinely establish that the relevant stock market index is ex post inefficient – that other portfolios had superior risk/return outcomes in the historical data. Because the market portfolio is ex post inefficient, the linear relationship in Equation (1), which relies on the efficiency of the reference (market) portfolio, does not hold in the historical data. This does not disprove the CAPM as a theoretical concept, which relies on the market portfolio (not the stock index) being ex ante (not ex post) efficient. However, it is also the case that we should not continue to use the CAPM with parameter estimates from actual stock returns without exception merely because the market portfolio *might* be ex ante efficient.

37. Put another way, we know that the observed market portfolio is not efficient and we can only use empirical data to parameterise the CAPM. It is not appropriate to continue to use this empirical version of the CAPM because, in theory, someone might eventually find data that does prove the CAPM holds. If this proof is available, the data would also be available to parameterise the empirical version of the CAPM.

38. When using the CAPM to estimate required returns, it is necessary to use a particular stock market index as a proxy for the market portfolio. Thus, the assumption being made is that the particular index is ex ante efficient – otherwise the linear relationship in Equation (1) will not hold.

39. In summary:

    a) The assumptions that must hold for the market portfolio to be efficient (and for the CAPM equation to hold) do not hold in practice, so there is no conceptual reason why the market portfolio must be efficient; and

    b) Empirical tests routinely establish that the relevant stock market index (as a proxy for the market portfolio) is inefficient in the historical data; but

    c) It is theoretically possible that the relevant stock market index was ex ante efficient, and is only ex post inefficient because actual outcomes differed from what investors were expecting. That is, investors were expecting the index portfolio to have optimal risk/return properties, but over a particular period other portfolios turned out to have superior risk/return properties in a way that was unexpected.

40. What makes this latter possibility unlikely is the fact that the same portfolios consistently outperform the stock market index over time and across markets, as documented below. If the index portfolio really was ex ante efficient, it is highly unlikely that it would be consistently outperformed by the same portfolios. By way of analogy, consider the proposition that tennis fans believe (that is, expect ex ante) that Jo-Wilfried Tsonga is the best player. Even the best player will lose some matches, so that proposition is not disproved even though we observe Tsonga losing on some occasions (that is, in the ex post data). However, the fact that we observe Tsonga consistently losing to Djokovic and Nadal, over many years, in different countries, and in different match conditions, would be strong evidence against the proposition.[9] The same applies in empirical asset pricing tests. The most consistent example of this is the performance of stocks with a high book value of equity compared to market value (**high book-to-market stocks**). Over time and across markets, portfolios of high book-to-market stocks have earned higher returns than portfolios of low book-to-market stocks.

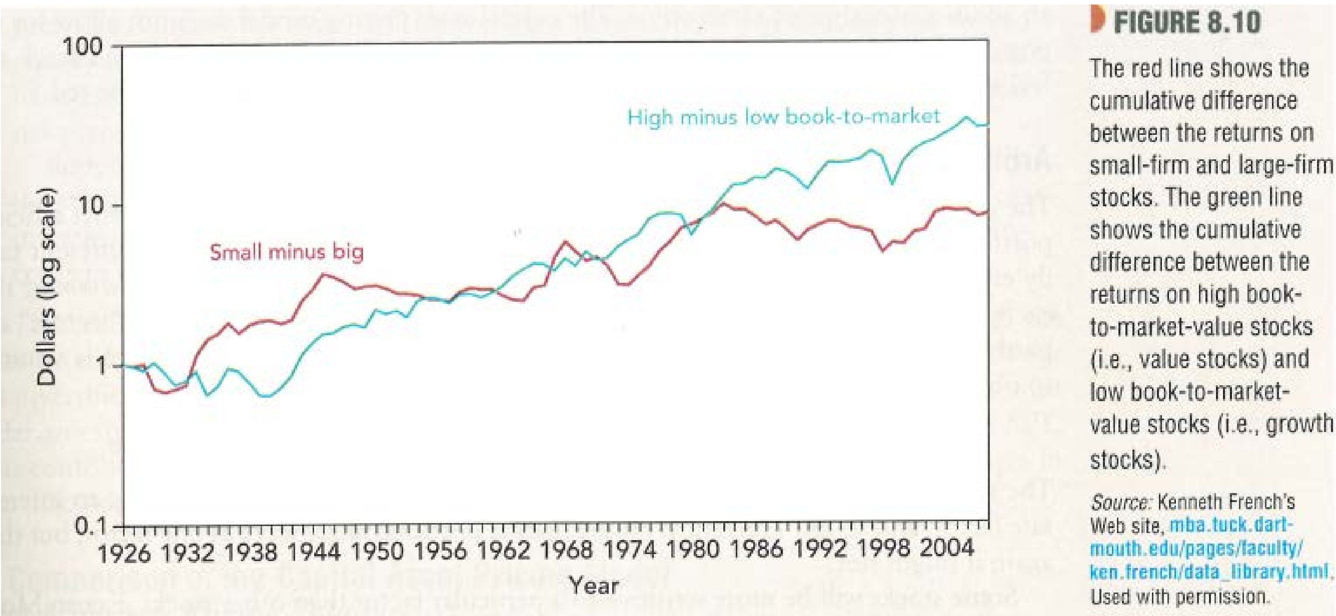
41. In Figure 5 below, we present the relative performance of U.S.-listed small market capitalisation stocks versus large market capitalisation stocks, and high book-to-market stocks versus low book-to-market stocks. The figure is extracted from a textbook by Brealey, Myers and Allen (2011), who use the data available from the website of Professor Ken French. The relative performance of small stocks compared to big stocks varies somewhat over different time periods, but on average remains positive. The performance of high book-to-market stocks is highly persistent.

42. More precisely, Berk and DeMarzo (2013) show that U.S.-listed smaller firms, and high book-to-market firms, have tended to outperform the returns that are implied by a single (market) factor model. This is illustrated in Figure 6.

43. In the figures, the term *excess return* refers to return in excess of the risk-free rate of interest. The black line represents the excess return that would be expected according to the portfolio's beta estimate, and the dots represent actual average portfolio excess returns. An abnormal return, relative to a CAPM benchmark, is the difference between the expected and actual return. In Figure 6, the smallest market capitalisation stocks, in red, have the highest abnormal returns. In Figure 7, the stocks with the highest book-to-market ratio, in blue, have the highest abnormal returns.

[9] At the time of writing, Tsonga's head to head record versus Djokovic was 5–11, and Tsonga's head to head record versus Nadal was 3–8.

Figure 5. Return performance by size and book-to-market



Source: Brealey, Myers and Allen (2011), Figure 8.10, p. 199.

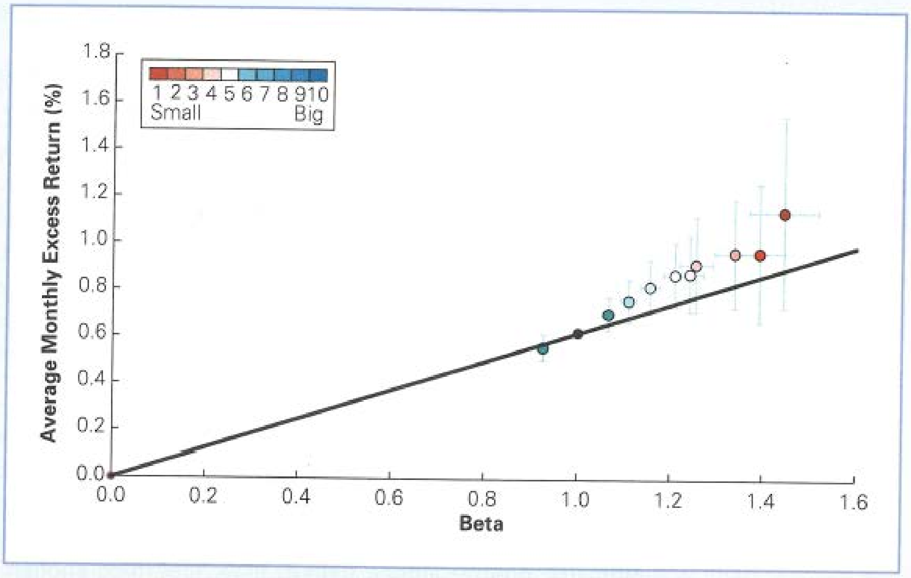
44. The most comprehensive study of the size and book-to-market effects that has been performed using Australian data was compiled by Brailsford, Gaunt and O'Brien (2012a).[10] Using returns information over a 25 year period from 1982 to 2006 the researchers demonstrate that high book-to-market stocks have persistently earned higher returns than low book-to-market stocks. However, there is no persistent difference in the returns to portfolios of small versus large market capitalisation stocks. This result is summarised in Figure 8 below, which was plotted by NERA (2013) using results reported by Brailsford, Gaunt and O'Brien (2012a). As we move from low to high book-to-market portfolios (from dark blue to red, green, purple and light blue) there is a consistent increase in abnormal returns across all five size dimensions. As we move from small to big market capitalisation portfolios (from left to right) there is not the same consistent outperformance of small market capitalisation stocks versus big market capitalisation stocks.

45. In short, in the historical data available for analysis, there is persistent evidence over time from the U.S. and Australia that high book-to-market stocks have earned higher returns than low book-to-market stocks. There is also persistent evidence from the U.S. that small stocks have earned higher returns than large stocks, but this result is not present in the historical Australian data (small stocks have performed about as well as large stocks). As discussed below, the important question for setting the cost of capital is whether investors expect the same results to occur again.

[10] There is a complementary study by Brailsford, Gaunt and O'Brien (2012b) which reiterates some of the limitations of datasets used by prior researchers. The limitations of those datasets led the researchers to reach ambiguous conclusions about the applicability of the Fama-French model in Australia. The dataset we use is not affected by the data limitations used in prior research, as we have a long time series of data and we form SMB and HML portfolios using the same techniques as Brailsford, Gaunt and O'Brien (2012a) which accounts for the large number of Australian-listed firms with low market capitalisation.

Figure 6. Out-performance by size

FIGURE 13.9 **Excess Return of Size Portfolios, 1926–2011**



The plot shows the average monthly excess return (the return minus the one-month risk-free rate) for ten portfolios formed in each year based on firms' market capitalizations, plotted as a function of the portfolio's estimated beta. The black line is the security market line. If the market portfolio is efficient and there is no measurement error, all portfolios would plot along this line. The error bars mark the 95% confidence bands of the beta and expected excess return estimates. Note the tendency of small stocks to be above the security market line.

Source: Data courtesy of Kenneth French.

Source: Berk and DeMarzo (2013), Figure 13.9, p. 455.

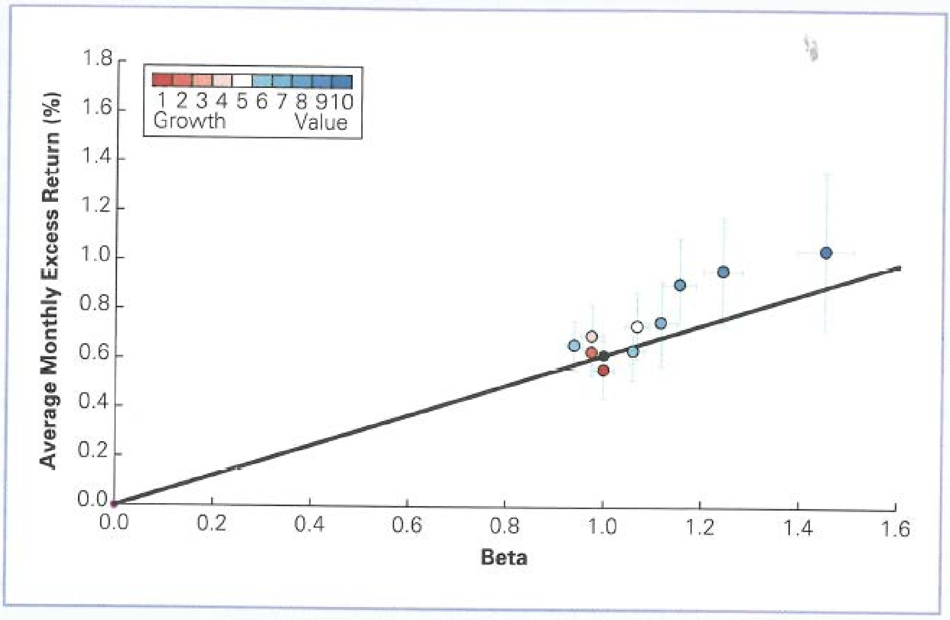
Figure 7. Out-performance by book-to-market ratio

FIGURE 13.10

Excess Return of Book-to-Market Portfolios, 1926–2011

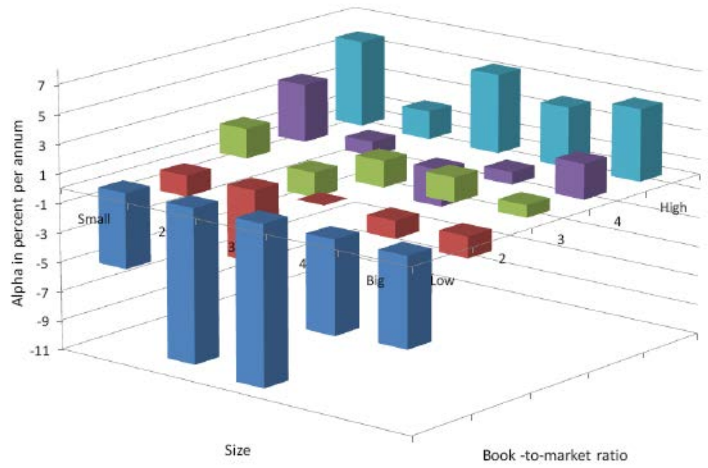
The plot shows the same data as Figure 13.9, with portfolios formed based on stocks' book-to-market ratios rather than size. Note the tendency of value stocks (high book-to-market) to be above the security market line, and growth stocks (low book-to-market) to be near or below the line.

Source: Data courtesy of Kenneth French.



Source: Berk and DeMarzo (2013), Figure 13.10, p. 456.

Figure 8. Out-performance by size and book-to-market in Australian data.



Source: NERA (2013), p. 10, citing results from Brailsford, Gaunt and O'Brien (2012), Table 4, p. 275.

46. The results from the two markets demonstrate that on an ex-post basis, the stock market was not efficient. Investors could have performed better than the market simply by purchasing small, high book-to-market stocks. In Australia, tilting the portfolio towards small stocks would not have performed better than tilting the portfolio towards large stocks, but it remains the case that high book-to-market stocks outperformed low book-to-market stocks. The important question for estimating the cost of capital, using the equation for the CAPM populated with empirical data, is whether the stock market is ex ante efficient. On this question there are four possible answers:

a) The stock market is ex ante efficient, in the sense that it is the portfolio offering the highest expected return per unit of risk (so the expected returns on listed stocks are consistent with the theoretical CAPM), and the returns performance of high book-to-market stocks occurred purely by chance – which would seem highly unlikely given the persistence in returns over time; or

b) The stock market is ex ante efficient, in the sense that it is the portfolio offering the highset expected return per unit of risk (so the expected returns on listed stocks are consistent with the theoretical CAPM), but the book-to-market ratio is a better proxy for the covariance of stock returns with market returns than regression-based beta estimates. If this is true, then the systematic risk proxies of the book-to-market ratio should be incorporated into the estimated cost of capital in some way; or

c) The stock market is *not* ex ante efficient, in the sense that other portfolios offer higher expected returns per unit of risk (so the expected returns on listed stocks are not consistent with the theoretical CAPM), and the book-to-market ratio is a proxy for risks other than the covariance of stock returns with the market. If this is true, then this proxy for different sources of risk should be incorporated into the estimated cost of capital; or

d) The stock market is *not* ex ante efficient, in the sense that other portfolios offer higher expected returns per unit of risk (so the expected returns on listed stocks are not consistent with the theoretical CAPM), and the returns to high book-to-market stocks occurs because of a persistent investor bias towards overpaying for low book-to-market stocks. If this is true, then it becomes difficult to justify the continued use of the CAPM as the sole asset pricing model. It is difficult to reconcile a market that is efficient enough for market risk to be the only priced risk factor, but the same market is so inefficient that abnormal returns can be earned on a persistent basis purely by computing the ratio of book value of equity to market value of equity.

47. In our view, the weight of empirical evidence is consistent with the third explanation – the proposition that one or more risk factors other than market risk is incorporated into asset prices – in the same way as the weight of evidence is inconsistent with the proposition that tennis fans believe Tsonga to be the best player. Distinguishing between the third and the fourth explanations is based upon the considerable theory on risk that has been developed in the last two decades following the publication by Fama and French (1993). This theory is discussed in Section 3.

What additional portfolios or factors should be included?

48. The foregoing analysis raises the question of how we should go about selecting a set of portfolios that might be able to be combined into an efficient portfolio. Berk and DeMarzo (2013) suggest that we should start with the market portfolio, as this is a large and well diversified portfolio that generates average returns materially above the yield on government bonds.[11] At this stage, we have a one-factor model as follows:

$$r_i = r_f + \beta_{mkt,i}\left(r_m - r_f\right). \quad (3)$$

49. If the market portfolio is efficient, Equation (3) will hold for assets and portfolios. This implies that in any regression of excess stock returns on excess market returns, the intercept is expected to be zero. For example, consider the following regression specification:

$$r_i - r_f = \alpha_i + \beta_{mkt,i}\left(r_m - r_f\right). \quad (4)$$

50. If the market portfolio is efficient and single-handedly captures all systematic risk, then we expect to find that $\alpha_i = 0$ for all assets and portfolios. If we do not find that $\alpha_i = 0$ for all assets and portfolios, the implication is that the market portfolio is not efficient and does not single-handedly capture all systematic risk.

51. Moreover, any portfolio for which $\alpha_i > 0$ has systematically earned a higher return than the single-factor model in Equation (3) suggests. There are two reasons why the return on a particular portfolio might be systematically higher than that suggested by the single factor model:

   a) The portfolio has some exposure to a component of systematic risk that is not well captured by the market portfolio, and the additional return is the compensation that investors require for bearing that systematic risk; or

   b) Random chance – looking backwards through an historical data set, it will always be possible to find some portfolio that, just by random chance, has outperformed the return suggested by Equation (3).

52. If one takes the view that the out-performance of a portfolio is due to its exposure to a component of systematic risk, that portfolio should be included as part of a multi-factor model as in Equation (2).

[11] Berk and DeMarzo (2013), p. 462.

What was observed in tests of the CAPM, documented above, is that portfolios based on size and book-to-market consistently outperformed a market benchmark. This consistent outperformance suggests it is more likely that the second explanation holds. It seems more likely that the higher average returns on high book-to-market stocks are compensation for a component of systematic risk that is not well captured by the stock market index. It seems quite unlikely that the same portfolios would consistently outperform just by random chance.[12] It is precisely this conclusion that led Fama and French (1993) to develop their three-factor model.

53. It is correct that, in the Australian market, small market capitalisation stocks have not outperformed large market capitalisation stocks over the 25 years from 1982 to 2006 evaluated by Brailsford, Gaunt and O'Brien (2012a). We have verified this conclusion in a dataset spanning the 29-year period from January 1985 to February 2014. This issue is discussed in more detail in Section 4. So it could be the case that, in Australia, there is no difference in the expected returns of small market capitalisation stocks compared to large market capitalisation stocks.

54. The evidence on small stock returns in Australia does imply that high book-to-market stocks in Australia do not have higher expected returns than low book-to-market stocks. Moreover, the Fama-French model was not developed as a model that jointly requires a size factor and a book-to-market factor. The model is generally implemented using both the size and book-to-market factors. But the motivation for use of size and book-to-market ratios as proxies for risk was the observations that, in violation of the CAPM prediction, small stocks earned higher returns than large stocks (as reported by Banz, 1981), and high book-to-market stocks earned higher returns than low book-to-market stocks (as reported by Rosenberg, Reid and Lanstein, 1985). In other words, the Fama-French model was not developed with a requirement that the book-to-market ratio is a proxy for risk only if size is a proxy for risk. The basis for the model was the separate observations from historical data that small stocks earned higher returns than large stocks, and high book-to-market stocks earned higher returns than low book-to-market stocks.

55. In fact, Fama and French (1998) performed an analysis on a global basis using only the book-to-market factor. One motivation for the researchers to write this paper was the contention that the relative outperformance of high book-to-market stocks in the U.S. was sample-specific.[13] The reason the size factor was evaluated in that paper was that, for markets outside the U.S., data was only available for larger market capitalisation firms. This was no impediment to evaluating what is now known as a two-factor model, which only included the market factor and the book-to-market factor in the asset pricing equation. It should also be noted that, for the Australian-listed stocks, the average annual difference in returns to high versus low book-to-market stocks, was 12.32% from 1975 to 1995.[14]

56. If the historical data suggests that size is a priced risk factor for a sample of U.S.-listed stocks, but not a priced risk factor for Australian-listed stocks, does this cast doubt on whether the book-to-market factor can be reliably used as a measure for risk? The answer is no. If this is the threshold for acceptance of any risk factor, other than market risk, there is no possibility that *any* other asset pricing model could be used for estimating the cost of capital, for the following reason.

57. Empirical researchers in asset pricing are required to establish that any proposed risk factor appears to explain the variation in returns across portfolios, after accounting for other possible risk factors. Any model tested will have several possible risk factors included. Some of those risk factors will appear to

[12] McKenzie and Partington (2013) do not endorse the use of the Fama-French model for setting the cost of equity as part of the regulated rate of return. But they agree with us that "[t]he applicability of the model in new datasets suggests that the Fama and French results are not just chance (p.30)."

[13] Fama and French (1998), p. 1976.

[14] Fama and French (1998), Table III, p. 1980.

be useful, and some will not. Through evaluation over time, in different markets and using increasingly sophisticated evaluation techniques, the weight of evidence will shift towards one or more proxies for risk as being useful for asset pricing, and away from other risk factors. The contradiction in the empirical evidence on size between Australian-listed stocks and U.S.-listed stocks could mean that the size factor is not a priced risk factor. But we will not see research papers published in which the researchers write "we excluded the size factor from the expected returns benchmark because we question whether size is a proxy for risk." If size is not included as a potential risk proxy according to this rationale, the reviewer and the editor will be left with the possibility that the researchers' findings are the result of an incomplete benchmark. So regardless of whether size really is, or is not, a proxy for risk, this will form part of the benchmark.

58. This means that:

a) If a regulated entity, customer or regulator proposes a cost of equity model which includes all three risk factors, it is subject to the criticism that it has included a risk factor that has not been positive in Australian data on an historical basis.

b) If a regulated entity, customer or regulator proposes a cost of equity model which only includes two risk factors (market risk and risk associated with the book-to-market ratio) it will not be able to justify the model with respect to empirical research into asset pricing. Research papers will include the size factor in the asset pricing equation.

c) If a regulated entity, customer or regulator proposes a model which includes only market risk as the risk factor, it will have ignored the persistent, positive return premium associated with high book-to-market stocks, which is a feature of historical returns in the Australian and U.S. markets.

59. If the single factor CAPM continues to be used as the sole asset pricing model for estimating the cost of equity, it necessarily implies that the persistent, positive book-to-market premium has no bearing on the cost of equity (the third implication directly above). In the absence of a conclusion as to why the historical book-to-market premium is irrelevant to the cost of equity, this implication is difficult to justify.

3. Assessment of the Fama-French model in the Guideline

The role of the Fama-French model

60. The Guideline concludes that the Fama-French model has no role in the estimation of the required return on equity.[15] The Explanatory Statement states that the Fama-French model is a "relevant model," but confirms that no weight is applied to it when estimating the required return on equity.[16] The reasons for excluding the Fama-French model from having any role at all are set out in Appendix A of the Guideline materials. We consider these reasons in turn below.

Lack of acceptance in practice

The Nobel Prize

61. The first issue raised in the Guideline materials is that the Fama-French model is not well-accepted and is not used for the purpose of estimating required returns in practice.[17]

62. We begin by noting that the Fama-French model is one of the key reasons for Professor Fama being awarded the 2013 Nobel Prize in Economics.[18] The Economic Sciences Prize Committee (the Committee) cites the Fama-French Model in its background paper explaining the basis for the award noting that:

> …the classical Capital Asset Pricing Model (CAPM) – for which the 1990 prize was given to William Sharpe – for a long time provided a basic framework. It asserts that assets that correlate more strongly with the market as a whole carry more risk and thus require a higher return in compensation. In a large number of studies, researchers have attempted to test this proposition. Here, Fama provided seminal methodological insights and carried out a number of tests. It has been found that an extended model with three factors – adding a stock's market value and its ratio of book value to market value – greatly improves the explanatory power relative to the single-factor CAPM model.[19]

63. In respect of the contribution of the Fama-French Model to market practice and investment analysis the Committee note:

> …following the work of Fama and French, it has become standard to evaluate performance relative to "size" and "value" benchmarks, rather than simply controlling for overall market returns.[20]

64. The Committee further notes that the Fama-French Model is used commonly by professional investors in guiding portfolio decisions and evaluating investment performance, as well as by academics.

65. The background paper also discusses the fact that a key motivating reason for the development of the Fama-French Model was the observed shortcomings and poor predictive performance of the Sharpe-Lintner CAPM which is adopted by the AER as its foundation model. For example, in tracing this empirical literature the background paper states:

[15] AER Guideline, p. 13.
[16] AER Explanatory Statement, p. 58.
[17] AER Appendix A, pp. 18–23.
[18] Formally, the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel.
[19] Economic Sciences Prize Committee, 2013, Understanding Asset Prices, p. 3.
[20] Economic Sciences Prize Committee, 2013, Understanding Asset Prices, p. 44.

> Most of these results were integrated in the widely cited paper by Fama and French (1992), which convincingly established that the CAPM beta has practically no additional explanatory power once book-to-market and size have been accounted for.[21][22]

66. In their overall conclusion on the contribution of Fama's work to the area of asset pricing the Committee note:

> New factors – in particular the book-to-market value and the price-earnings ratio – have been demonstrated to add significantly to the prior understanding of returns based on the standard CAPM.[23]

67. The award of a Nobel Prize, and the Committee's explanation for the award, needs to be considered in light of the AER's concerns over the theory underpinning the Fama-French model. The Committee did not award the Nobel Prize for identifying an interesting empirical result that subsequent examination found was sample-specific, or the result of data-mining. The publication of the Fama-French model spurned two decades of theoretical and empirical analysis that have enhanced the understanding of what determines asset prices. However, in the AER Guideline, the Sharpe-Lintner CAPM is accorded the status of the foundation model, and the Fama-French model is considered irrelevant.

68. In relation to the awarding of the Nobel Prize, the Guideline materials first note that:

> William Sharpe has previously been awarded a Nobel Prize for his work in developing the Sharpe–Lintner CAPM,[24]

and then conclude that:

> a Nobel Prize should not necessarily be interpreted as validating a given model or view. Instead, it may be more balanced to consider them as recognising contributions to a field that is still open to considerable debate.[25]

69. In our view, the Nobel Prize is the highest possible accolade. When an economist develops an economic model, the highest possible recognition they could hope to achieve is that it will one day be recognised with a Nobel Prize. Nobel Prizes are not awarded for conjectures or for throwing an idea into the mix. They are awarded for only the most substantial contributions that have stood the test of time.

70. It is correct to say that, merely because a Nobel Prize has been awarded, we should not interpret that as a basis for rejecting contrary evidence. For example, the award of the Nobel Prize for development of the CAPM needs to be evaluated in light of the empirical evidence against its usefulness; and the award of the Nobel Prize for development of the alternative Fama-French model needs to be evaluated in light of the potential explanations for its empirical support.

[21] Economic Sciences Prize Committee, 2013, Understanding Asset Prices, p. 39.
[22] It is worth pointing out that the empirical evidence was that beta estimates had no ability to explain stock returns, even prior to the publication of the paper by Fama and French (1992).
[23] Economic Sciences Prize Committee, 2013, Understanding Asset Prices, p. 45.
[24] AER Appendix A, p. 22.
[25] AER Appendix A, p. 22.

71. However, the fact that the CAPM and Fama-French Model have each been recognised by the Nobel Committee does not mean that they "cancel out" so we need to find some other basis for preferring one over the other. Rather, the fact that we have two Nobel Prize winning models should indicate that there are at least two relevant models to consider. With respect to the Fama-French model the AER has reached no conclusion on why the positive return premium to high book-to-market stocks has persisted over decades in different markets. Our conclusion is that the book-to-market factor represents a priced risk factor. The Guideline materials do not reach a conclusion on this issue.

The CFA certification

72. The Fama-French model is also an accepted tool in practice. The leading professional finance qualification in finance in the U.S. and Australia is the Chartered Financial Analyst (CFA) certification. The CFA Level II program includes extensive coverage of the Fama-French model – including rationale, development and implementation in practice. Course participants are required to be able to use the Fama-French three-factor model to estimate the required return on equity for a particular firm.[26]

73. We agree with the treatment of the Fama-French model by the CFA program materials as providing one estimate of the cost of equity, but which is not used as the exclusive cost of equity model. In an accompanying report (SFG, 2014) we reach an overall conclusion on the cost of equity from four different models.

Use as a measure of normal returns

74. The Fama-French model has only one purpose – to estimate the required return on equity, given the relevant risk. That is, the model has the purpose of estimating normal risk-adjusted returns. Estimates of normal risk-adjusted returns are required for a number of purposes including setting regulated returns and for the purposes of determining whether a portfolio or trading strategy shows out-performance on a risk-adjusted basis.

75. The use of the Fama-French model as a basis for estimating required returns has become standard in the finance literature. Evidence of the fact that the Fama-French factors are widely used for the purpose of estimating required returns can be found in the leading journals in the field, the *Journal of Finance* and the *Journal of Financial Economics*. Both of these leading journals are ranked as A-star journals (the highest possible rating) by the Australian Business Deans Council.[27] The Australian Research Council (ARC) no longer provides journal rankings but awarded both the *Journal of Finance* and the *Journal of Financial Economics* its highest rating for all the years that it did provide rankings (the latest being 2010).[28] They are commonly ranked as being in the top two or three finance journals worldwide.[29]

76. The two most recent (February 2014 and December 2013) issues of the *Journal of Finance* feature five articles that use the Fama-French factors for the purposes of estimating required returns.[30] The most recent volume (2014) of the *Journal of Financial Economics* features four articles that use the Fama-French

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[26] Pinto, Henry, Robinson, Stowe and Cohen (2010), pp. 65–69.
[27] See http://www.abdc.edu.au/pages/abdc-journal-quality-list-2013.html.
[28] See http://www.arc.gov.au.
[29] See for example, Currie and Pandher (2011).
[30] Buraschi, Trojani and Vedolin (2014), Berkman, Koch and Westerholm (2014), Ben-David, Franzoni, Landier, and Moussawi (2013), Hu, Pan and Wang (2013), Boguth and Kuehn (2013).

factors for the purposes of estimating required returns.[31] Indeed, the use of the Fama-French factors, for the purpose of estimating the required return on equity, is so widespread in the academic literature, its use as a measure of normal returns has become a matter of course.

77. Our view is that the three factors in the Fama-French model have become the minimum number of factors to be accounted by researchers in measuring normal returns on investment. In the absence of controls for risks proxied by size and the book-to-market ratio, our view is that the editor and reviewer would be left with doubt as to whether the reported abnormal returns were simply due to exposure to risky stocks. This would be a serious hurdle for acceptance of the research for publication, as demonstrated by the predominant use of the model by researchers.

Corporate finance practice

78. If you ask participants involved in capital allocation decisions at large corporations "What model do you use to estimate the cost of equity capital?" the most common answer is "the Capital Asset Pricing Model?" However, when you evaluate the responses in detail you observe a large proportion of respondents make adjustments to the CAPM estimate of the cost of equity capital to account for other risk factors. In many instances these adjustments are made without recognition of a specific asset pricing model. This is not an option for regulated business, customers, regulators or any other participant in the regulatory process. So it is not the case that, to conform to corporate finance practice, we should adopt the CAPM without additional risk premiums. What is proposed in the use of the Fama-French model is an objective measurement of risk that is consistent with the empirical evidence on stock returns.

79. In 1999, a survey was conducted amongst 392 representatives of large corporations in the U.S. (Graham and Harvey, 2001). In 2002, the same set of questions was posed to 313 representatives of large corporations in the U.K. (68), the Netherlands (52), Germany (132) and France (61) (Brounen, de Jong and Koedijk, 2004). In response to the question, "How do you determine your firm's cost of equity capital?" the percentage of respondents who said they always or almost always used the CAPM ranged from 34% to 73% across the five countries, with an aggregate percentage of 60%.[32]

80. However, this is not the only evaluation technique used in estimating the cost of equity. Another alternative answer was "using the CAPM but including some extra risk factors." The proportion of respondents who stated that they always or almost always incorporated extra risk factors into the CAPM ranged from 15% to 34%, with an aggregate percentage of 28%.

81. In a 2004 survey of Australian companies (Truong, Partington and Peat, 2008), 72% of the 74 respondents stated that they used the CAPM to estimate the cost of capital. Respondents were asked if they used the Fama-French Model, or a multi-factor asset pricing model. No respondents said they used the Fama-French Model and one respondent said that he or she used a multi-factor asset pricing model. What we do not know from the survey is whether the beta estimate in the CAPM is adjusted for risks in addition to that captured by beta estimates from historical returns, or whether there is an adjustment to the CAPM cost of capital estimate to account for other risks. But we do know from our own review of independent expert reports that the final cost of equity estimate deviates from an

[31] Roussanov (2014), Frazzini and Pedersen (2014), Fang, Kempf and Trapp (2014), Hu (2014).

[32] We have reported aggregate statistics using the number of respondents from each country in order to summarise the overall implications of the studies. Across the five countries, the percentage of 705 respondents is 56% from the U.S., 10% from the U.K., 7% from the Netherlands, 19% from Germany and 9% from France.

estimate implied by the CAPM (SFG Consulting, 2013a). On average, from 2008 to 2013, the cost of equity used by the expert was 14.4%, compared to 11.1% implied by the CAPM.[33]

82. The surveys conducted in the U.S. and Europe mentioned above progress to ask what additional risk factors are incorporated into project evaluation, either in the discount rate, the cash flows, or in both the discount rate and cash flows. For our purposes we are interested in the additional risk factors incorporated in the discount rate, either alone or in conjunction with adjustments to cash flows. The participants were provided with 10 possible risk factors to be incorporated and were asked whether they incorporated the risk factor or not. The risk factors incorporated into the discount rates are listed below, in order of the aggregate percentage of respondents who reported using this risk factor. The range across the five countries is presented in brackets.

a)	Interest rate risk	43% (40% to 49%)
b)	Foreign exchange risk	29% (22% to 32%)
c)	Size (small firms being riskier)	28% (23% to 35%)
d)	Risk of unexpected inflation	27% (24% to 44%)
e)	Term structure risk	24% (21% to 40%)
f)	GDP or business cycle risk	24% (18% to 28%)
g)	Distress risk	17% (12% to 27%)
h)	Commodity price risk	17% (13% to 27%)
i)	Market-to-book ratio	16% (11% to 33%)
j)	Momentum	13% (8% to 35%)

83. What these responses show is an acceptance amongst large corporations that the CAPM represents an incomplete model for estimating the cost of equity, which is consistent with the empirical evidence. Corporations adjust the CAPM estimate of the cost of equity to account for a multitude of risk exposures. Recall that 60% of respondents said they always or almost always used the CAPM, but 28% of respondents said they always or almost always using the CAPM with additional risk factors.

84. What do these adjustments have to do with the Fama-French model? There are two sets of figures that are relevant. First, 28% of respondents stated that they adjusted their discount rate on the basis of size, and 16% of respondents stated that they adjusted their discount rate on the basis of the market-to-book ratio. Second, the reason the Fama-French factors seem to perform so well in explaining realised returns is that they are proxies for priced risks, and corporations adjust their cost of equity estimates to account for priced risks. This issue is discussed in more detail in a subsequent section devoted to theoretical foundation. But we make the point here in the words of Fama and French (2004) that the Fama-French factors are proxies for risk exposures.

> [S]ize and book-to-market equity are not themselves state variables, the higher average returns on small stocks and high book-to-market stocks reflect unidentified state variables that produce undiversifiable risks (covariances) in returns that are not captured by the market return and are priced separately from market betas.[34]

85. Participants in the regulatory process (businesses, consumers and the regulator itself) are not in a position to make subjective assessments of exposure to risks like business cycle risk or the risk of unexpected inflation. Participants need to measure the cost of capital using quantitative inputs. Suppose we were to mirror corporate finance practice amongst large corporations, and layer on additional risk factors identified in the list above. We could incorporate a series of risk factors

[33] SFG Consulting (2013a), pp. 2 and 19. The CAPM estimate incorporates the yield on 10-year government bonds as the risk-free rate, a 6% market risk premium, and the equity beta adopted by the independent expert.
[34] Fama and French (2004), p. 38.

designed as more direct proxies for non-beta risks (but which have not been consistently shown to explain stock returns) or we could use the indirect proxies for non-beta risks (but which have been consistently shown to explain stock returns), which are the Fama-French factors.

86. If corporate finance practice is used to determine how regulation should evolve, the benchmark would be to use the CAPM with additional risk factors. Our view is that the best approach to estimating the cost of equity is to use the proxies for risk that are used across the board to estimate normal returns in academic research, and which have been shown to explain stock returns far better than estimates of beta from historical returns. It is incomplete to say that corporate finance practice is to use the CAPM, but then discard the remainder of corporate finance practice which is to incorporate additional risks into the discount rate.[35]

Adoption in U.S. courts

87. The Fama-French model has been used by courts in Delaware, U.S.,[36] to estimate the cost of equity capital. In 2003, the model was used to estimate the cost of equity for a bank. In adopting the model the judge commented that:

> The advantage of using that formula is that it attempts to better account for certain factors that explain equity return than does the original CAPM. These factors include the relationship of market returns to underlying book value, which is a proxy that, among other things, helps capture the risk associated with possible insolvency and other problems in highly leveraged firms. Although the Fama-French three factor CAPM is not wholly accepted, neither is the original CAPM itself. By better factoring in the real risks of leverage, the Fama-French model captures useful data that contributes to a more reliable and real-world cost of capital.[37]

88. Three years later the Fama-French model was again used to estimate the cost of equity for a bank. The judge placed equal weight on a Fama-French model and CAPM cost of equity estimate in reaching a conclusion no a discount rate.[38]

89. Our view is that the Fama-French model should be used as one model, amongst other models, for estimating the cost of equity (which is consistent with our approach in a companion report, SFG, 2014). The use of more than one equation for estimating the cost of equity is also used by U.S. courts.

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[35] The point is that practitioners estimate the cost of capital with reference to information other than the Sharpe-Lintner CAPM, populated with a regression-based estimate of beta. The survey response that practitioners "use the CAPM" is an incomplete summary of how practitioners arrive at their cost of capital estimate. Another way to consider this issue is the critique by McKenzie and Partington (2013) who note that "there is little evidence of the use of the Fama and French model by companies to estimate their cost of capital (p. 32)." They also note that a "common and bad practice is to add a 'fudge factor' to discount rates (p.5)" Finally, they caution against incorporating the Fama-French factors because this could lead to the possibility of even more factors being incorporated, like exposure to interest rate movements, default risk and liquidity (p.19). Here in lies the problem – corporate finance practice is to incorporate risks other than systematic risk into the discount rate, but often in an ad hoc manner that is inappropriate for regulation. But proposing an objective technique for incorporating non-beta risks is met by the AER with the concern that we could have too many factors. The argument is then that we should be consistent with corporate finance practice, but without any risk adjustments for non-beta risk that are made in practice.

[36] Delaware is significant because of its disproportionate number of incorporated companies and the Court of Chancery, which heard the cases mentioned here. The Court of Chancery rules on corporate law disputes.

[37] Union Illinois v. Union Financial Group, 847 A.2d 340 (Del. Ch. 2004)

[38] *In re* PNB Holding Co. S'holders Litig., No. 28-N (Del. Ch. Aug. 18, 2006)

Complex to implement

90. The Guideline materials state that the Fama-French model:

> is complex to implement, insomuch as two additional factor exposures and two additional risk premiums are required to estimate the expected return on equity.[39]

"Strategic behaviour"

91. The Guideline materials suggest two possible consequences of this added complexity. The first is that complexity "increases the potential for strategic behaviour."[40] In particular:

> This complexity limits the ability to understand the variables driving the models outputs, and to assess the reasonableness of these outputs.[41]

92. It is not clear what the Guideline materials mean by "strategic behaviour" or why the regulator could not identify and appropriately deal with any "strategic behaviour" during the regulatory process. If the role of the regulator is to obtain the best possible estimate of the required return on equity by having regard to all relevant financial models, it seems that the regulator would need to have regard to a relevant financial model even if it was complex.

Estimation error

93. The Guideline materials also state that:

> Each additional parameter increases the scope for estimation error.[42]

94. The risk exposure in the Sharpe-Lintner CAPM (β) is estimated by regressing historical stock returns on historical market returns. The risk exposures in the Fama-French model (β, *s* and *h*) are estimated by regressing historical stock returns on historical market returns and factor returns (*SMB* and *HML*). The historical stock and market returns were already required to estimate the Sharpe-Lintner CAPM parameters. The only additional data that is required is historical returns from the two additional factor portfolios. Regression analysis is used in both cases. That is, estimating the Fama-French model is not a more complex task, it is simply a somewhat bigger task.

95. It is true that there is a degree of estimation uncertainty with every additional parameter. There is imprecision associated with exposure to the Fama-French factors (*s* and *h*), and with the magnitude of the expected risk premiums (*SMB* and *HML*). The AER is concerned about estimation error in both the exposure to the factors and the magnitude of the expected risk factors.[43]

96. For example, we cannot definitively conclude that the factor sensitivity to the *HML* factor is 0.3, just as we cannot reach a definitive conclusion on the estimate of beta. But this does not imply that the best estimate of the required return on equity is obtained by setting that factor sensitivity to 0 (by omitting it). We also cannot definitively conclude that the expected value for *HML* is 10%, just as we cannot reach a definitive conclusion on the value for the market risk premium. But this does not imply that

[39] AER Appendix A, p. 23.
[40] AER Explanatory Statement, p. 72.
[41] AER Explanatory Statement, p. 72.
[42] AER Appendix A, p. 21.
[43] AER Appendix A, p. 22.

the best estimate of the required return on equity is obtained by setting the expected factor return to 0% (by omitting it).

97. By way of analogy, aircraft flight times are affected by engine thrust and wind speed. It is difficult to precisely estimate the effect of wind speed. But this does not mean that the best estimate of flight times is obtained by assuming that there is no wind at all.

98. Moreover, the Guideline does not reject the Fama-French model because its parameter estimates *are* imprecise (relative to the Sharpe-Lintner CAPM parameter estimates). The Guideline rejects the Fama-French model in advance (in part) because its parameter estimates *might be* imprecise.

99. In relation to estimation error the AER appears to have made a judgement call that the incremental benefit of adding additional factors to the model is offset by the cost that the overall estimate might be less precise. Under this rationale, it is challenging to see how any asset pricing model other than the CAPM could possibly be accepted by the AER. There will always be an additional parameter to estimate and this will always involve estimation error.

100. Our view is that estimation error is inherent in the cost of equity from all asset pricing models, and estimation error is mitigated by relying on more than one asset pricing model.

Parameter instability

101. The Guideline materials express concern about the fact that various academic papers have reported different estimates of the factor risk premiums:

> we have previously observed that the value and size factors used in the Fama–French three factor model vary considerably and do not follow a pattern of systematic observance in Australia.[44]

Parameter estimates vary across studies

102. In this regard, a range of estimates are set out in Table A.2 of Appendix A of the Guideline materials. The papers that are summarised in that table vary greatly in terms of the quality of analysis and the length of the data set. For example, one of the studies reports estimates of factor risk premiums based on only four years of data. Of course, estimates of the Sharpe-Lintner CAPM market risk premium that are based on four-year samples would also exhibit great variation.

103. In our view, the fact that a range of studies of variable quality produce a range of estimates should not be used as the basis for the outright rejection of the entire model. Otherwise, relevant and informative models (that would otherwise have been used to inform the estimate of the required return on equity) could be rejected due to the publication of one or more low quality studies with divergent results. A better approach is to consider the robustness and the reliability of the best available estimates of each model.

104. The most recent and comprehensive estimates of the Fama-French model using Australian data are reported by Brailsford, Gaunt and O'Brien (2012a). They use a long history of data that uses a range of electronic data bases supplemented with a large volume of data for smaller firms that has been hand-collected from historical annual reports.

105. Brailsford, Gaunt and O'Brien (2012) report that:

[44] AER Appendix A, p. 20.

> Our study provides two advances. Firstly, the study utilizes a purpose-built dataset spanning 25 years and 98% of all listed firms. Secondly, the study employs a more appropriate portfolio construction method than that employed in prior studies. With these advances, the study is more able to test the three-factor model against the capital asset-pricing model (CAPM). The findings support the superiority of the Fama–French model, and for the first time align the research in this area between Australia and the USA.[45]

106. We note that the Economic Regulation Authority (**ERA**) *has* had regard to the study by Brailsford, Gaunt and O'Brien (2012a). The ERA notes that "[t]heir 2012 study observes that prior Australian research has suffered from limited datasets, resulting in mixed and weak results compared to U.S. studies."[46] Ultimately, the ERA did not adopt the Fama-French model due, in part, to concerns over the variation in factor coefficients and risk premiums.[47] If the datasets and other technical advances that are now available 1) improve upon the ability to draw valid statistical conclusions, 2) align the Australian research with the vast U.S. literature, and 3) conclude that the Fama-French model is superior to the Sharpe-Lintner CAPM for estimating the required return on equity, then this supports utilising the Fama-French model as part of the estimation process. Whether or not some of the prior Australian research might be less reliable because it is based on a less comprehensive data set is no longer a relevant issue.

107. Brailsford, Gaunt and O'Brien (2012a) further report that:

> The factors are then tested across a range of portfolios in both time series and in cross section. The results reveal that all factors are significant in both the time series and cross-sectional tests and that the premiums carry significant positive exposures.[48]

and:

> In a series of comparative tests[49], the three-factor model is found to be consistently superior to the CAPM, although neither model can fully explain the time-series variation in portfolio returns.[50]

[45] Brailsford, Gaunt and O'Brien (2012a), p. 261.
[46] ERA Appendix 8, Paragraph 73.
[47] ERA Appendix 8, Paragraph 77. The other concern raised by the ERA is the theoretical basis for the Fama-French model, which we discuss elsewhere in this report.
[48] Brailsford, Gaunt and O'Brien (2012a), p. 279.
[49] The tests performed can be classified as *time-series* and *cross-sectional*. In the time-series tests, the researchers partitioned stocks into 25 portfolios formed on the basis of size and the book-to-market ratio, and then measured the portfolios' exposure to excess market returns (above the risk-free rate), *SMB* and *HML*. The high book-to-market portfolios earned higher returns that the low book-to-market portfolios (Table 2, p. 269). So, if the CAPM was true, we would expected high book-to-market stocks to have a high coefficient on the excess market return, and we would expect any excess stock returns not explained by excess market returns to be zero (that is, zero intercepts in the regression). But the time-series regression results show that high book-to-market stocks had lower exposure to excess market returns than low book-to-market stocks in a CAPM regression (Table 4, p. 274). On average, across the five size portfolios, as book-to-market ratio increases the coefficients on excess market returns are 1.05, 0.87, 0.84, 0.75 and 0.81. So as book-to-market ratio *increases*, the market exposure *decreases*. At the same time, there is an increase in the excess stock returns *not* explained by excess market returns. On average, as book-to-market ratio increases, the intercept in the regression increases from –0.68%, to –0.15%, +0.08%, +0.09% and +0.37% per month. So as book-to-market ratio *increases* the returns not explained by market movements *increases*. Once exposure to *SMB* and *HML* is included in the regression, the corresponding average intercepts are –0.21%, –0.09%, +0.02%, –0.12% and +0.05%. In the time-series tests, a regression is performed separately for each of 25 portfolios formed on the basis of size and book-to-market ratio. In the cross-sectional tests, there is an evaluation of whether either the CAPM or the Fama-French model can explain the portfolio returns *across* all 25 portfolios over all months. Statistically, the cross-sectional test is able to reject the CAPM but not reject the Fama-French model.
[50] Brailsford, Gaunt and O'Brien (2012a), p. 279.

108. Brailsford, Gaunt and O'Brien (2012a) conclude that:

> This evidence is important for a number of reasons. Firstly, the findings appear to settle the disputed question as to whether the value premium is indeed a positive and significant factor in the Australian market. Given the growing trend to utilize the three-factor model in asset-pricing tests and in practical strategies of portfolio formation in the funds management industry, these findings provide direction. Secondly, the evidence continues the decline of the single-factor model, which has obvious implications for future research. This future research should include the added benefits of using a multifactor model to estimate cost of capital for firms.[51]

Ex post returns vs ex ante expectations

109. The Guideline materials also state that the identification of factors in ex post returns does not necessarily mean that those factors are priced ex ante:

> even where factors are observed in ex–post returns, this does not mean that the same factors are priced ex–ante. The existence of ex–post factors (such as for value and size), therefore, may neither support nor contradict the Sharpe–Lintner CAPM.[52]

110. This is the point that is addressed in Paragraphs 30 and 31 above. By way of analogy, we may begin with an ex ante expectation that Tsonga is a better tennis player than Djokovic. Observing Djokovic defeating Tsonga in a match does not necessarily disprove the proposition. It may have been quite rational for us to expect Tsonga to win (ex ante), and for one reason or another the outcome on this occasion (ex post) differed from what we were expecting. Similarly, observing Djokovic win a second match (ex post) does not necessarily mean that people were not still expecting (ex ante) Tsonga to win. However, once the head-to-head record has reached 11–5 in favour of Djokovic – over several years, different court surfaces, and different match conditions – the logical conclusion is that people are expecting Djokovic to win. It seems quite unlikely that people were generally expecting Tsonga to win, and were surprised by the outcome time after time after time.

111. Similarly, the value premium has been consistently identified over a long period of time, in a number of markets, and over a range of market cycles. It is theoretically possible that investors are not expecting a value premium (ex ante) and are consistently surprised when it eventuates (ex post) – but this seems quite unlikely and is becoming even more unlikely with the passage of time.

112. The fact that some estimates of the value premium might be higher or lower than others should not be the basis for disregarding it. Similarly, the fact that Djokovic might beat Tsonga by different margins from match to match is not a basis for concluding that there is no reliable evidence about who is the better player.

113. Of course, one can dismiss *any* empirical evidence on the basis that there may be a difference between ex post outcomes and ex ante expectations. In our view, it is incumbent upon anyone using this argument to set out what level of empirical evidence would be required for them to consider that a particular factor might be relevant. If there is no level of empirical evidence that could ever be sufficient to convince that person that an additional factor might be required (that is, that the stock market index is not sufficient by itself), it would be clear that the adherence to the single-factor model

[51] Brailsford, Gaunt and O'Brien (2012a), p. 279.
[52] AER Appendix A, p. 21.

is a matter of faith. For example, it is difficult to imagine that there could ever be stronger evidence to support the relevance of a factor than that which is already available for the book-to-market factor.

114. This issue can only be addressed by the AER reaching a conclusion on why high book-to-market stocks have persistently earned higher returns than low book-to-market stocks, for which we posed four possible explanations in Section 2: (a) chance, (b) the book-to-market ratio is a proxy for market risk exposure, (c) the book-to-market ratio is a proxy for exposure to a priced risk other than market risk, or (d) investors overpay for growth. It is unclear whether the AER agrees with one of these explanations, or has an alternative explanation. The AER's view on why high book-to-market stocks earn high returns directly leads to whether we would expect this returns performance to continue – if the view is consistent with (b) or (c) we would expect the book-to-market effect to continue. If the AER's view is (d) then the usefulness of the CAPM is questionable because of the market inefficiency (and even then, the book-to-market effect would still persist if investors exhibited the same growth bias). If the view is that the book-to-market effect is due to chance, this is difficult to reconcile with its persistence across markets and over time.

Lack of a theoretical foundation

Theoretical development

115. The Guideline materials express a concern about a lack of theoretical foundations for the two additional risk factors in the Fama-French model:

> There is no clear theoretical foundation to identify the risk factors, if any, that the model captures. The lack of clear theoretical foundation to identify the risk factors raises a number of key questions, including why value and size factors should be relevant predictors of returns, and whether these factors apply in the Australian context.[53]

116. As set out in the previous section of this report, the general theoretical foundation for the Fama-French model is the same as for the Sharpe-Lintner CAPM. Both models posit that there is a linear relationship between the expected return of a particular stock and the expected return of a mean-variance efficient portfolio. The only difference is that the CAPM (as implemented in practice) assumes that the relevant stock market index is mean-variance efficient, whereas the Fama-French model posits that the stock market index needs to be supplemented by two additional factor portfolios to produce a mean-variance efficient benchmark. To continue the tennis analogy from above, the basis for both models is that you need to be proficient at hitting tennis balls to win tennis matches. Whereas the CAPM suggests that having a good serve alone is sufficient, the Fama-French model suggests that having a good forehand and a good backhand (that is, two other factors) are also required.

117. We note that the origins of the Fama-French model were in studies documenting the empirical failings of the CAPM. As set out above, these studies documented that when the stock market index is used as the only factor the model does not fit the data, but when the additional Fama-French factors are included the model does fit the data.

118. Since that early empirical work, the Fama-French model has been structured as a risk-factor model within the context of two asset pricing theories, which were established well before the empirical papers by Fama and French. One theory is the intertemporal capital asset pricing model of Merton (1973). This is a more general application of the Sharpe-Lintner CAPM. In the one-period Sharpe-Lintner CAPM, investors do not need to consider what happens outside of their investment horizon, which is also common to all investors. This is the basis for the *intertemporal* term in the model. In the

[53] AER Appendix A, p. 22.

more general intertemporal CAPM (compared to the more restrictive Sharpe-Lintner CAPM), investors care about what happens after the first investment ends. So assets will be priced, in a multi-factor model, according to investor expectations about future states of the economy. For instance, investors might be concerned about inflation or future investment opportunities.

119. Another theory is the arbitrage pricing theory of Ross (1976). In this theory, most of the assumptions underlying the Sharpe-Lintner CAPM are relaxed, which means that the predictions are less constrained. The model says that there are a series of systematic risk factors investors are exposed to and, in the absence of arbitrage, asset prices will reflect exposure to these risk factors. It is the assumptions that underpin the Sharpe-Lintner CAPM that lead to its prediction that the market factor is the single risk factor that matters.

120. Empirical research into the CAPM first documented that market risk was a factor that did not perform well in explaining stock returns, then documented that other factors (*SMB* and *HML*) did perform well in explaining stock returns. For the next two decades researchers have attempted to explain why this is the case, and risk-based explanations for this result have consistently referred to the two theories summarised above (the intertemporal CAPM and the arbitrage pricing theory).

121. If there is more than one risk-based explanation for the evidence, or if theory was applied to the evidence after observation, does this mean that we should ignore the empirical evidence? No. The only question is whether the relevant stock market index is already mean-variance efficient (under the CAPM) or whether it needs to be supplemented by two additional factor portfolios to produce a mean-variance efficient benchmark.

122. In terms of our tennis analogy, we might first observe Djokovic regularly beating Tsonga. We might subsequently look closely at the match statistics and conclude that Djokovic is winning because he has a good serve, forehand and backhand. From this we might develop a conceptual understanding of why those three shots (and not volleys, for example) collectively explain performance.

123. This method of theoretical development has many precedents in the physical sciences. Prior to 1600, the accepted theory was that planets traversed their sun in a circular orbit. Astronomer Tycho Brahe made a series of astronomical observations, and based on this data, Johannes Kepler proved that the orbits were not circular but elliptical. Kepler published three empirical laws that explained planetary movements in a way that was consistent with the observed data. In the 1700s, Isaac Newton showed that Kepler's laws could all be theoretically justified within his unified theory of gravity. In short, theories are retained, replaced or improved ultimately by reference to their consistency with the evidence. They do not exist in isolation from it.

124. Indeed, the Fama-French model can be viewed as a response to the empirical rejection of the Sharpe-Lintner CAPM on the basis of evidence that risks other than systematic risk are priced (that is, that the relevant stock market index as a single factor is insufficient). The extensive set of perfect market assumptions that are required for the Sharpe-Lintner CAPM to hold, and which do not hold in the real world, have two important implications. First, in a world with real market imperfections, in general, risks other than market risk will be priced (that is, additional factors will be necessary, because in imperfect capital markets there is no reason to expect that the market will be mean-variance efficient). This is an important point established by the discussion in Section 2. Second, the simple relation between mean return and market beta will no longer hold. In short, in real-world markets, multiple risks are likely to be reflected in asset prices, and the empirical evidence suggests that the *SMB* and *HML* factors are the best available proxies for those risks.

125. The existence of market imperfections should lead us to expect that risks other than market beta are likely to be priced. The next question is whether there is a body of theory to support the use of the

particular factors that Fama and French have identified. For 20 years researchers have developed and built on theories that explain *why* it is that the two Fama-French factors explain stock returns. These theoretical foundations should not be rejected simply because the factors were first used to document the empirical failings of the CAPM. Such an approach would be inconsistent with standard scientific progression, and with basic logic – that is, it would clearly be illogical to maintain exclusive reliance on the CAPM on the basis that the Fama-French model has been shown to have demonstrably superior empirical performance.

126. The theoretical work on the Fama-French model explains the size and book-to-market factors in terms of a number of risks that could be priced by the market. In the sub-sections below we canvass a number of these explanations. There is debate amongst researchers about what risks are reflected in the size and book-to-market factors. But debate about alternative theoretical explanations does not mean that risks are not priced by the market. It simply means that there is more than one possible explanation that is consistent with the empirical evidence.

127. With respect to the size factor, there is debate about the persistence of the factor itself, and we have already noted that the size factor, on average, has not been positive in Australia for the period for which data is available. So an explanation for the size factor which would apply in both the U.S. and Australia can have an asterix applied to it. In other words, if we would expect the theory to hold in both the U.S. and Australia, and the data only supports the theory in the U.S., this raises a question mark over the theoretical explanation.

128. Does the same question mark apply to explanations for the book-to-market factor? No, because the book-to-market factor has been shown to be large and persistent in the U.S. and Australia. So if an explanation for the book-to-market factor in based upon theory that would apply in both markets (as opposed to something specific about the U.S. market, such as a specific tax regime or regulation) the corroborating evidence from both markets *supports* the theoretical explanation.

129. There is no reason to place an asterix or question mark over theories merely because they were derived after making an empirical observation. This point is made by Fama and French (2004), who compare two approaches to asset pricing theory: (a) specifying a theory in advance and writing down the variables to be measured; or (b) identifying variables that appear to capture priced risks and then seeking to understand the risks captured by those variables.

> Like CAPM investors, ICAPM investors prefer high expected return and low return variance. But ICAPM investors are also concerned with the covariances of portfolio returns with state variables. As a result, optimal portfolios are "multifactor efficient," which means they have the largest possible expected returns, given their return variances and the covariances of their returns with the relevant state variables.
>
> Fama (1996) shows that the ICAPM generalizes the logic of the CAPM. That is, if there is risk-free borrowing and lending or if short sales of risky assets are allowed, market clearing prices imply that the market portfolio is multifactor efficient. Moreover, multifactor efficiency implies a relation between expected return and beta risks, but it requires additional betas, along with a market beta, to explain expected returns.
>
> An ideal implementation of the ICAPM would specify the state variables that affect expected returns. Fama and French (1993) take a more indirect approach, perhaps more in the spirit of Ross's (1976) arbitrage pricing theory. They argue that though size and book-to-market equity are not themselves state variables, the higher average returns on small stocks and high book-to-market stocks reflect unidentified state variables that produce undiversifiable risks (covariances) in returns that are not captured by the market return and are priced separately from market betas. In support of this claim, they show that the

> returns on the stocks of small firms covary more with one another than with returns on the stocks of large firms, and returns on high book-to-market (value) stocks covary more with one another than with returns on low book-to-market (growth) stocks. Fama and French (1995) show that there are similar size and book-to-market patterns in the covariation of fundamentals like earnings and sales.[54]

Distress

130. One explanation for the persistent returns performance of high book-to-market stocks is the risk of financial distress. Chan and Chen (1991) argued that distressed firms are more sensitive to changes in economic conditions and documented that distressed firms, as proxied by dividend reductions and leverage, earned relatively high returns. Thus, they were able to provide an explanation as to why small firms earn high returns – these firms were more likely to have experienced dividend reductions and be highly leveraged. When Fama and French (1992) showed that stocks with high book-to-market ratios earned relatively high returns, they proposed this could be due to the decrease in market value associated with lower earnings prospects for those firms in distress. The researchers continued to attribute the empirical evidence to distress risks in subsequent papers (Fama and French, 1995; and Fama and French, 1996).

131. How does this relate to the factors? It is important to understand what the Fama and French (1993) factors are. In 1992, Fama and French published a paper which described the relative performance of portfolios sorted on the characteristics of market capitalisation and book-to-market ratio. The following year they published the 1993 paper which introduced the now well-known *SMB* and *HML* factors. *SMB* represents the difference in returns to a portfolio of small stocks compared to big stocks; and *HML* represents the difference in returns to a portfolio of high book-to-market stocks compared to a portfolio of low book-to-market stocks.

132. The reason the factors were constructed is to determine whether returns to those factors in different time periods could explain the returns on assets or portfolios. If the return on an asset or portfolio seems to move in the same direction as the return to *SMB* or *HML*, it implies that the factor tells us something about what causes price fluctuations in that asset or portfolio. The risk of an asset or portfolio is what causes its price to fluctuate. If we can explain those price fluctuations with movements in something else we can measure, we have an idea about how to measure the risk of the asset or portfolio.

133. The explanation put forward here for the average positive return to *HML*, is that fluctuations in *HML* proxy for changes in investors' assessment of the prospects of firms more at risk of distress. If *HML* falls during the month, it means that the market has taken a more pessimistic view on economic conditions, and high book-to-market firms are relatively more likely to be exposed to that downturn. This is also why we measure each firm's exposure to *HML*, reflected in the *h* coefficient. If *HML* proxies for the market's reassessment of the prospects of firms more exposed to economic conditions, then *h* captures the exposure of the firm to the *HML* risk factor.

134. One test of whether distress can explain why *HML* is a priced risk factor was performed by Vassalou and Xing (2004). The researchers measured the default risk of individual stocks using a model developed by Merton (1974). Note that the risk of default is a relatively more extreme outcome of the risk of distress. A firm can be in economic distress even if it has no debt and therefore no risk of default. But on average we would expect firms with debt at a higher level of distress to also be at more risk of default. The Merton measure of default risk is the basis behind the credit ratings of Moody's KMV. Default risk is determined primarily by market value leverage and the volatility of asset returns.

[54] Fama and French (2004), p. 38.

It is a more timely measure of default risk than credit ratings based upon financial ratios because recent stock price movements are reflected in the leverage and volatility estimates.

135. The researchers measured how much of the variation in portfolio returns can be explained by stocks' size and book-to-market ratio, once a measure of default risk was incorporated. Their data shows that, in general, stocks with high book-to-market ratio earn higher returns than stocks with low book-to-market ratio, but this difference is largest amongst small stocks with the highest likelihood of default.[55] This means that, in part, the variation in the *HML* factor over time will proxy for the market's assessment of conditions leading to an increased risk of distress, and the level of the *HML* factor on average represents compensation for this risk exposure.

136. Does this mean we should remove the *SMB* and *HML* factors and replace them with a measure of distress risk for setting the cost of equity capital? No. What the evidence shows is that one reason for the explanatory power of *SMB* and *HML* is that, in part, this is due to the risk of distress being priced. But this does not mean that we need to separately measure the distress risk for the purpose of setting the cost of equity, and that a model without this factor cannot be used. What the evidence supports is one theoretical reason why the Fama-French factors have performed well in explaining stock returns. If we ignore these factors we likely ignore an element of priced risk.

Exposure to changes in expectations for economic growth

137. Recall that there are two theories of asset pricing that are consistent with the Fama-French model, namely the arbitrage pricing theory of Ross (1976) and the intertemporal capital asset pricing model of Merton (1973). The latter theory says that investors do not simply care about expected wealth at the end of one investment period. It says that investors care about wealth and economic conditions at the end of this period. So investors will pay more for assets which provide them with a hedge against adverse economic conditions at the end of their investment.

138. Vassalou (2003) provides empirical evidence consistent with this theory. The researcher tests whether returns to *SMB* and *HML* are proxies for news about GDP growth. To perform this test, the researcher first forms a prediction for GDP growth each year, based upon the relationship between GDP growth and variables that capture macroeconomic conditions, as well as returns on stock and bond portfolios. The second step is to test whether stock returns can be explained equally as well by the expectation for GDP growth, as by the *SMB* and *HML* factors. This turns out to be the case – the prediction for GDP growth seems to explain stock returns about as well as the *SMB* and *HML* factors.

139. Does this mean we should remove the *SMB* and *HML* factors and replace them with a measure of expected GDP growth for setting the cost of equity capital? Again, the answer is no. What the evidence shows is that one reason for the explanatory power of *SMB* and *HML* is that, in part, investors care about GDP growth and the prices of different assets respond differently to news about GDP growth. But this does not mean, for the purposes of estimating the cost of equity, we need to replace *SMB* and *HML* with another factor. The evidence suggests one theoretical reason why the Fama-French factors perform well – they are correlated with news about GDP growth.

Asymmetric exposure to market conditions

140. A third explanation for the book-to-market effect is that high book-to-market stocks experience different exposure to market risks depending upon whether market expectations for volatility are high

[55] As a reference point, amongst stocks in a portfolio formed from an intersection of the smallest one third of the sample according to size, and the highest one-third of the sample according to default risk, the difference in returns to high versus low book-to-market stocks was 1.62% per month. Across the other portfolios formed from splitting the sample into thirds, the average difference in returns to high versus low book-to-market stocks was 0.51% per month. See Table X, p. 861.

or low. This is referred to as asymmetric exposure to market conditions. The theory is that, because high book-to-market firms have most of their value associated with tangible assets, they are exposed to economic downturns because it is difficult to reduce investment in tangible assets or to assign those assets to alternative uses (Zhang, 2005).

141. This theory was tested empirically by Petkova and Zhang (2005). The researchers measured the relationship between monthly values for *HML* and market returns. They estimated a beta (that is, the market risk exposure) for the *HML* portfolio under periods of different market conditions. The results show that the *HML* portfolio has negative exposure to market returns during "good" times and positive exposure to market returns during "bad" times. This means that, when investors are most concerned about risk (the investors are pessimistic, as they would be in a recession) holding a high book-to-market portfolio increases their exposure to market returns. This means that a high book-to-market portfolio more aligns their portfolio with the market, at the very time when investors would prefer less market exposure. When investors are less concerned about risk (the investors are optimistic, as they would be in an expansion), holding a high book-to-market portfolio reduces their exposure to market returns. This means that a high book-to-market portfolio lessens investors' exposure to market returns, precisely when they have more appetite for risk. This is the basis for the term "asymmetric exposure." The systematic risk exposure of *HML* is not constant across periods when investors prefer more to less risk.

Implications

142. The theoretical discussion presented above can be disaggregated into the general theories of the intertemporal CAPM and the arbitrage pricing theory, and three specific theories discussed immediately above – distress risk, exposure to changes in economic growth, and asymmetric exposure to economic conditions. This is not an exhaustive list of specific theoretical explanations for the performance of the Fama-French model. It represents three prominent theories that have empirical support. In the two decades since the publication by Fama and French (1993) an exhaustive literature has been devoted to theoretical explanations for the explanatory power of *SMB* and *HML*

143. There is a weight of evidence that the Fama-French factors proxy for one or more priced risks. As a measurement technique, the Fama-French model has been accepted as the most widely used expected returns model amongst researchers, even though there is no consensus they are proxies for risks A, B, or C. Ultimately, a decision on whether to use the model to measure expected returns depends upon a conclusion as to whether the factors represent priced risk exposures (so would be expected to persist), or whether their historical performance is due to random chance (so would not be expected to persist).

144. The AER's assessment of the Fama-French model does not reach a conclusion on whether the theoretical and empirical evidence is consistent with either of these explanations. For Australian-listed stocks, upon which the AER places primary reliance in estimating the cost of capital, the *HML* premium and factor exposure for comparable firms is material. The weight of theoretical and empirical evidence is that this *HML* exposure represents a priced risk factor which should form part of the estimated cost of equity.

4. Empirical estimation of the Fama-French model

Introduction

145. In this section we present empirical estimates of the cost of equity capital using the Fama-French model. We perform this analysis using a sample of nine Australian-listed stocks, and 56 U.S.-listed stocks. The sample firms are the same as those used in analysis previously-submitted to the AER by the ENA (SFG Consulting, 2013b). In addition, for U.S.-listed firms, the parameter estimates (β, *s* and *h*) and Fama-French factor premiums (*SMB* and *HML*) are the same as those previously-submitted. For Australian-listed firms, the parameter estimates (β, *s* and *h*) and Fama-French factor premiums (*SMB* and *HML*) are new estimates. The new parameter estimates and factor premiums result from construction of factors according to the process adopted by Brailsford, Gaunt and O'Brien (2012a).

146. In constructing the factors we rely upon the following dataset, compiled from Datastream data. We used returns for all Australian-listed stocks with information available on returns, volume,[56] market capitalisation, book-to-market ratio, and industry classifications from the Industry Classification Benchmark (ICB). Consistent with Brailsford, Gaunt, and O'Brien (2012a) we excluded asset managers and real estate investment funds.[57] We compiled returns on a monthly basis to facilitate comparison with monthly factor returns compiled by Brailsford, Gaunt and O'Brien, and by NERA (2013).

147. Data which meets this criteria enabled factors to be constructed on a monthly basis from January 1985 to February 2014. There are 2,228 unique listed firms in the dataset and, on average, each firm appears in the dataset for 96 months. The total number of firm-months used to compile the factors is 214,823.[58] On average, the number of firms with data available for analysis in the average month is 614.

Construction of the factors

148. The idea behind the Fama-French factors is to take firm characteristics (market capitalisation and book-to-market ratio) and estimate portfolio returns. This is analogous to the manner in which the market portfolio return, compared to the risk-free rate, is a factor in the Sharpe-Lintner CAPM. The portfolios in the Fama-French model are called zero investment portfolios, because we measure the returns to a positive investment in small stocks (or high book-to-market stocks) combined with a negative investment in large stocks (or low book-to-market stocks). So *SMB* refers to *small minus big* and *HML* refers to *high minus low*.

149. The factors are constructed in a particular way, in an attempt to separately incorporate the impact of size and the book-to-market ratio on factor returns. The small and big sized stocks in the *SMB* portfolio should have approximately the same book-to-market characteristics; and the high and low book-to-market stocks should have approximately the same market capitalisation.

150. So the first step is to disaggregate the sample of Australian-listed stocks into six portfolios, consistent with the technique of Fama and French (1993). There is a split according to size (small and big), and a

[56] Volume is used simply to ensure we only retain stocks that traded.

[57] Specifically, we excluded firms with the following ICB classifications: 8633 Real estate holding and development, 8670 Real estate investment trusts, 8771 Asset managers, 8775 Specialty finance, 8777 Investment services, 8779 Mortgage finance, 8985 Equity investment instruments, and 8995 Nonequity investment instruments.

[58] The term *firm-month* refers to an observation for a firm in a particular month. For example, the data for BHP in January 2013 is one observation, the data for BHP in February 2013 is another observation, the data for NAB in January 2013 is another observation, and so on.

split according to the book-to-market ratio (high, medium and low). This means we need to decide on breakpoints to determine what constitutes a small or big stock, and what constitutes a stock with high, medium or low book-to-market ratio.

151. This is where Brailsford, Gaunt and O'Brien (2012a) make a useful contribution. They note the market for Australian-listed shares contains a relatively large number of small stocks. So if you were to take all Australian-listed shares, and classify half the shares as small stocks, and half the shares as large stocks, you would end up with many shares classified as big stocks when in reality they have a fairly small market value. Fama and French (1993) understood this also, with respect to the U.S. market. They use all listed stocks with available data for analysis in constructing the factors, but classify stocks as small or big only on the basis of the mid-point value for the larger NYSE-listed stocks.

152. For Australian-listed companies, Brailsford, Gaunt and O'Brien (2012a) rank all stocks with available data according to market capitalisation. The largest stocks which, in aggregate, comprise 90% of market capitalisation are classified as big stocks, and the remaining stocks are classified as small stocks. This means that the small stocks have about 10% of aggregate market capitalisation, which is approximately the same as the aggregate market capitalisation proportion of small stocks in the U.S. In compiling the book-to-market allocation, the researchers computed the book-to-market ratio at the 30th and 70th percentiles for stocks in the ASX 200. This is consistent with the Fama and French (1993) technique of using NYSE-listed stocks to compute breakpoints.

153. To illustrate this first step, consider the table below. Each cell contains average values for some portfolio characteristics, over 350 months from January 1985 to February 2014. For each portfolio, each month, we compute value-weighted returns. The returns presented in the table are the average portfolio returns over all 350 months. We see that high book-to-market stocks earned higher returns than low book-to-market stocks, regardless of whether they were big or small socks. But there is no consistent association between size and returns.

154. The grid represented by the shaded cells represents the portfolios used to construct the *SMB* and *HML* factors on a monthly basis.[59] To construct *SMB*, we take an average of portfolio returns to small stocks classified as low, medium and high book-to-market (this is the small component) and an average of portfolio returns to big stocks classified as low, medium and high (this is the big component). Then we take the difference in these two portfolio averages. Expressed as an equation using the labels in the cells:

SMB = Average (SL, SM, SH) – Average (BL, BM, BH)

155. As an example, suppose that in a given month the portfolio returns were exactly as the average values in the table (that is, the small/low book-to-market portfolio earned a return of 0.51%; the small/ medium book-to-market portfolio earned a return of 1.04%; and so on). If this happened in a given month, *SMB* would be computed as follows:

SMB = Average (0.51%,1.04%,1.54%) – Average (0.98%,1.18%,1.40%) = 1.03% – 1.19% = –0.16%

[59] We constructed factors on a monthly basis to allow comparison of our results in this paper with those previously-supplied to the AER, for comparison of the factor returns to those compiled by Brailsford, Gaunt and O'Brien (2012a).

Table 1. Monthly average values across six portfolios formed according to size and book-to-market

	Small	Big	Small & Big
Low book-to-market	Label = SL Ret = 0.51% Mkt cap = $147m B/M = 0.31 Firms = 148	Label = BL Ret = 0.98% Mkt cap = $6,237m B/M = 0.34 Firms = 25	Ret = 0.75% Mkt cap = $3,191m B/M = 0.32 Firms = 87
Medium book-to-market	Label = SM Ret = 1.04% Mkt cap = $151m B/M = 0.62 Firms = 168	Label = BM Ret = 1.18% Mkt cap = $5,467m B/M = 0.61 Firms = 33	Ret = 1.11% Mkt cap = $2,809m B/M = 0.61 Firms = 101
High book-to-market	Label = SH Ret = 1.54% Mkt cap = $106m B/M = 1.18 Firms = 221	Label = BH Ret = 1.40% Mkt cap = $2,612m B/M = 0.99 Firms = 18	Ret = 1.47% Mkt cap = $1,359m B/M = 1.09 Firms = 120
Low, medium and high book-to-market	Ret = 1.03% Mkt cap = $135m B/M = 0.70 Firms = 179	Ret = 1.19% Mkt cap = $4,772m B/M = 0.65 Firms = 25	Ret = 1.11% Mkt cap = $2,453m B/M = 0.67 Firms = 103

Returns and book-to-market ratio are weighted by market capitalisation; market capitalisation is the equal-weighted average for stocks in the portfolio. The figures reported in the table are the average values across 350 months from January 1985 to February 2014.

156. To compute *HML*, we take an average of returns to high book-to-market stocks classified as small and big stocks (this is the high book-to-market component) and an average of portfolio returns to low book-to-market stocks classified as small and big stocks (this is the low book-to-market component). Then we take the difference in these two portfolio averages. Expressed as an equation and using the labels in the cells:

HML = Average (SH, BH) – Average (SL, BL)

157. As with the *SMB* example, suppose that in a given month the portfolio returns were exactly as the average values in the table. If this happened in a given month, *HML* would be computed as follows:

HML = Average (1.54%, 1.40%) – Average (0.51%, 0.98%) = 1.47% – 0.75% = 0.72%

Comparison of factor returns with Brailsford, Gaunt and O'Brien (2012a)

158. In performing our analysis we needed to compile Fama-French factors using recent data. The monthly factors compiled by Brailsford, Gaunt and O'Brien (2012a) cover the 25 years from 1982 to 2006. The researchers compiled data from a more expansive set of firms than typically available, because they hand-collected information from hard copies of annual reports. So if we are to compile Fama-French factors in a similar way, but from different underlying data, it is worthwhile examining how closely the two sets of factors are aligned.

Table 2. Descriptive statistics of factor returns (%)

	SMB Average		HML average		SMB Std. Dev.		HML Std. Dev.	
	SFG	BGO	SFG	BGO	SFG	BGO	SFG	BGO
Independent and overlapping time periods								
Jan. 82 – Dec 84		0.45		1.20		2.87		3.71
Jan. 85 – Dec. 06	-0.03	-0.32	0.79	0.70	3.11	2.97	3.47	2.50
Jan. 07 – Feb. 14	-0.53		0.49		3.99		2.75	
Full time periods								
Jan. 82 – Dec. 86		-0.22		0.76		2.96		2.67
Jan. 85 – Feb. 14	-0.16		0.72		3.35		3.30	

159. In Table 2 we present a comparison of mean monthly returns and standard deviations for the factor series we compiled and those relied upon by the prior researchers. Our data runs from January 1985 to February 2014, so the overlapping period is the shaded 22-year period from January 1985 to December 2006.

160. During the overlapping time period between the two datasets we observe similar means and standard deviations for the *SMB* and *HML* factors. The most important factor for the current task is the *HML* factor, the average premium is large and we will see that listed networks have significant exposure to this factor. For the overlapping time periods the average *HML* returns are 0.79% in our dataset and 0.70% from the prior researchers. The corresponding standard deviations are 3.47% and 2.50%. Consistent with the results reported by the prior researchers, we do not find that small stocks outperform large stocks. Over the overlapping time period, the average value for *SMB* we compute is –0.03%, compared to –0.32% from the prior researchers. The corresponding standard deviations are 3.11% and 2.97%.

161. The time series of factor returns each month are positively correlated, as expected. Over the entire 22-year period of overlapping returns, the correlation in the two returns series between the *HML* factors is 0.40 and the correlation between the *SMB* series is 0.68. For the more recent 10-year period from 1997 to 2006, the correlations increase to 0.51 for the *HML* series and 0.81 for the *SMB* series.

162. If we consider the full time periods for each study, we report an average monthly value for *HML* of 0.72%, compared to an average monthly value of 0.76% from the Brailsford, Gaunt and O'Brien (2012a) series. We report an average monthly value for *SMB* of –0.16%, compared to an average monthly value of –0.22% in the data of Brailsford, Gaunt and O'Brien (2012a). In aggregate, this comparison demonstrates that our computations of *SMB* and *HML* capture the same underlying risk factors as Brailsford, Gaunt and O'Brien (2012a).

Parameter estimates and risk premiums

163. In Table 3 we present parameter estimates and associated risk premiums under both the Sharpe-Lintner CAPM and the Fama-French model. In Panel A we present analysis of the average outcomes from analysis of individual firms, in Panel B we present estimates from equal-weighted indices, and in Panel C we present results which place equal weight on outcomes from the individual firm means and index analysis. The parameter estimates for individual firms are presented in an appendix. All coefficient estimates (β, *s* and *h*) have been re-geared assuming 60% leverage using the equation that has previously been adopted by the AER.[60] The parameter estimates for U.S.-listed firms, and the

[60] The equation which relates the unlevered beta (β_a, also termed the asset beta) to the equity beta (β_e) is $\beta_e = \beta_a \times (1 + \text{Debt/Equity})$. The same equation is applied to the coefficient estimates in the Fama-French model. We first remove the impacts of leverage to estimate the asset beta using historical average debt and market capitalisation values for the firm, and

CAPM beta estimates for Australian-listed firms, are those we previously-reported (SFG Consulting, 2013b). The Fama-French parameters for Australian-listed firms are based upon the new computation of Fama-French factors.

164. We have incorporated risk premiums in the tables in order to demonstrate the aggregate impact of parameter estimates and risk premiums on the estimated cost of equity. The Sharpe-Lintner CAPM states that the cost of equity is equal to the risk-free rate (r_f) plus a premium for bearing systematic risk [($\beta \times (r_m - r_f)$]. For illustrative purposes we have adopted the market risk premium ($r_m - r_f$) estimate of 6.5% used by the AER in the Guideline.[61] The additional risk premiums incorporated into the Fama-French model are the premium for exposure to the size factor ($s \times SMB$) and the premium for exposure to the book-to-market factor ($h \times HML$).

165. For the two markets we have estimated *SMB* and *HML* as the historical annual average using all information available to us. For Australian-listed firms, we have a dataset of 29 years and two months ending in February 2014. The mean value for *SMB* is −0.43% (with a standard error of 3.17%) and the mean value for *HML* is 9.97% (with a standard error of 3.42%). For U.S.-listed firms, we have a dataset of 86 years ending in 2012. The mean value for *SMB* is 3.58% (with a standard error of 1.53%) and the mean value for *HML* is 4.81% (with a standard error of 1.49%). The risk premiums for *SMB* and *HML*, for both Australia and the U.S., do not include any compensation for imputation credits.[62]

166. With respect to the size and book-to-market premiums, the risk exposure (*s* and *h*) needs to be considered jointly with the compensation per unit of risk (*SMB* and *HML*) because the average returns to these two parameter estimates are the direct result of portfolio construction relative to the Australian and U.S. markets. We do not have a basis for saying that the market risk premium for Australian-listed stocks is different to the market risk premium for U.S.-listed stocks.

167. The most important conclusion from the parameter estimates is that there is a material, positive risk premium associated with the book-to-market factor. For the Australian-listed firms, this is estimated at 2.99%, and for the U.S.-listed firms this is estimated at 0.56%, placing equal weight on outcomes from analysis of individual firms and an equal-weighted index. The overall risk premium estimate associated with the Fama-French model is 6.10% for Australian-listed firms, and 5.98% for U.S.-listed firms.

168. To place this in perspective, the overall risk premium estimates represent 0.94 and 0.92 times the AER's market risk premium assumption of 6.50%. In other words, the analysis of the Fama-French model would imply the same cost of equity as the Sharpe-Lintner CAPM, if the CAPM incorporated beta estimates of 0.94 and 0.92.

then incorporate 60% debt and 40% leverage to arrive at the re-levered beta. The leverage figures used are the same as those previously incorporated (SFG Consulting, 2013b).

[61] The reason we use the market risk premium of 6.5% in this section is to ensure the discussion is not distorted by any disagreement over the estimated risk premium. The market risk premium estimate we use to reach a final conclusion on the cost of equity is different. It is based upon four different estimates of the market risk premium as documented in our companion report (SFG, 2014).

[62] There is no requirement that factors be estimated as total returns including imputation credits and any factor that is not a stock returns factor could not be computed with regards to imputation credits. For example, if a factor model included an estimate of the term spread for government bonds, or the corporate bond spread, the factor necessarily cannot be computed having any regard to imputation credits.

Table 3. Parameter estimates and implied risk premiums

Panel A: Mean estimates for individual listed firms

	Australia (9 comparable firms)			United States (56 comparable firms)		
Capital Asset Pricing Model						
Parameter	β			β		
Re-grd coeff.[63]	0.60			0.88		
Standard err.[64]	0.10			0.03		
95% CI	0.37-0.83			0.82-0.93		
Low to high	0.27-1.13			0.49-1.51		
R-squared	11%			31%		
Risk prem.	3.91%			5.72%		
Fama-French model						
Parameter	β	s	h	β	s	h
Re-grd coeff.	0.49	−0.05 → 0.07	0.33	0.86	−0.05	0.11
Standard err.	0.13	0.16	0.13	0.03	0.05	0.03
95% CI	0.19-0.78	−0.30-0.44	0.02-0.63	0.81-0.91	–0.16-0.06	0.05-0.17
Low to high	−0.26-1.03	−0.38-1.25	−0.02-1.26	0.52-1.39	−0.89-0.76	−0.40-0.82
R-squared	12%			33%		
Risk prem.	3.17%	−0.03%	3.25%	5.58%	–0.17%	0.53%
Total risk prem.	6.39%			5.93%		

Panel B: Estimates from equal-weighted indices

	Australia (9 comparable firms)			United States (56 comparable firms)		
Capital Asset Pricing Model						
Parameter	β			β		
Re-grd coeff.	0.55			0.91		
Standard err.	0.08			0.06		
95% CI	0.39-0.70			0.80-1.03		
R-squared	26%			58%		
Risk prem.	3.57%			5.94%		
Fama-French model						
Parameter	β	s	h	β	s	h
Re-grd coeff.	0.47	−0.01	0.27	0.88	−0.09	0.12
Standard err.	0.09	0.10	0.13	0.07	0.14	0.13
95% CI	0.30-0.64	−0.21-0.18	0.02-0.52	0.75-1.02	–0.37-0.09	–0.13-0.07
R-squared	21%[65]			58%		
Risk prem.	3.07%	0.01%	2.73%	5.75%	–0.32%	0.59%
Total risk prem.	5.81%			6.02%		

[63] The term *re-grd coeff.* is the risk exposure estimate adjusted to 60% leverage using the leverage equation adopted by the AER. For beta in the CAPM, this equation states that $\beta_e = \beta_a \times (1 + \text{Debt/Equity})$. So we compute the asset beta (β_a) from the regression-based equity beta using the Debt/Equity ratio of the firm or index, and then computed the re-geared equity beta assuming 60% Debt and 40% equity. There is a corresponding adjustment for the *s* and *h* risk exposures.
[64] For individual listed firms, the *standard error* is the standard deviation of risk parameter estimates across firms divided by the square root of the number of observations. For indexes, the standard error is the standard error from the regression equation which is adjusted for leverage using the same equation used to adjust the risk coefficients.
[65] The R-squared of 21% is lower for the Fama-French analysis because the Fama-French analysis was constructed using monthly factor returns while the CAPM analysis was conducted using four-weekly returns and repeated 20 times.

Panel C: Equal-weighted average of individual firm and index analysis

	Australia (9 comparable firms)			United States (56 comparable firms)		
Capital Asset Pricing Model						
Parameter	β			β		
Re-grd coeff.	0.58			0.89		
Risk prem.	3.74%			5.82%		
Fama-French model						
Parameter	β	s	h	β	s	h
Re-grd coeff.	0.48	0.03	0.30	0.87	−0.07	0.12
Risk prem.	3.12%	−0.01%	2.99%	5.67%	–0.25%	0.56%
Total risk prem.	6.10%			5.98%		

169. The implication of this result is that, if the Fama-French model is given no consideration, and the AER adopts the Sharpe-Linter CAPM with a beta estimate of 0.7 and market risk premium of 6.5%, the cost of equity could be understated by around 1.4% to 1.5%, depending upon how much consideration is given to Australian versus U.S.-listed firms. This does not mean that the Fama-French model should be used in isolation. In a separate report we consider the overall cost of equity estimate for an energy network which incorporates cost of equity estimates implied by the Sharpe-Lintner CAPM, the Black CAPM, the Fama-French model and the dividend discount model. The implication from the analysis summarised above is that relying exclusively on the Sharpe-Lintner CAPM is likely to ignore a material priced risk associated with listed networks.

Sub-sample of U.S.-listed firms

170. In the Guideline materials, the AER takes issue with the sample of 56 U.S.-listed firms compiled by CEG, and which we have relied upon.[66] The AER compiled a sub-sample of 17 firms that were previously-relied upon by the Allen Consulting Group (ACG) in a 2008 report.[67] The AER reports beta estimates that we compiled in a table entitled *US listed individual firm data – exclusively electricity and gas distribution and transmission businesses.* Selection of the comparable firm set is not an issue for the current report. However, we provide a comparison of the results for the sub-sample of firms commented on by the AER. The key point is that, even if this sub-sample of U.S.-listed firms is used in this analysis, omitting the Fama-French model from consideration is likely to ignore a material priced risk associated with listed networks.

171. For comparison with Panel A of Table 1, the mean CAPM-beta estimate for this sub-sample of firms is 0.76 (compared to 0.88 for the full sample). So the implied risk premium associated with the Sharpe-Lintner CAPM for this sub-sample is 4.72% (versus 5.72%).

172. Turning to the Fama-French model, the mean sub-sample risk coefficients are β of 0.72 (versus 0.86), *s* of 0.07 (versus –0.05), and *h* of 0.13 (versus 0.11). In aggregate, the risk premium in the Fama-French model is 5.57% from this sub-sample of U.S.-listed firms. This can be compared with an aggregate risk premium of 5.93% for the full sample of 56 U.S.-listed firms. The sub-sample aggregate risk premium of 5.57% remains 1.02% above the risk premium of 4.55% adopted in the Guideline.

Comparison to Fama-French results previously-reported

173. In our previous compilation of Fama-French risk exposure for the ENA, we relied upon estimates of *SMB* and *HML* for Australian-listed firms from two sources. *HML* factors for Australia were obtained

[66] Competition Economists Group (2013).

[67] AER Appendix A, pp. 62–63, referring to ACG (2008). The sample of U.S.-listed firms relied upon by ACG is 21 firms, but four of those firms are no longer separately-listed.

from the website of Professor Ken French,[68] and *SMB* factors were compiled by NERA. The *HML* factors were compiled in manner consistent with that used by Fama and French (1998) in the international study mentioned previously. The difference between the *HML* factor compiled in this method, and the *HML* factor we adopt, is that the technique used by Fama and French (1998) does not account for size. The reason Fama and French (1998) used this technique was because, for countries outside the U.S. at the time, there was not enough data on small market capitalisation firms. So sorting stocks both on book-to-market ratio and size was problematic. This compilation technique has been continued ever since.

174. In compiling the *SMB* factors, NERA compiled them in a manner to be consistent with the construction of the *HML* factors, which was appropriate. So NERA allocated the largest 500 ASX-listed stocks into large versus small stocks (allocating an equal number of stocks to both groups) and computed *SMB* as the difference in returns between small and large stocks. The portfolios were not formed to be independent of the book-to-market ratio.

175. In the current paper, we construct *SMB* and *HML* in a manner that is consistent with the method of Brailsford, Gaunt and O'Brien (2012a). This means that the *SMB* factor is constructed to be independent of the book-to-market effect (the portfolios of small stocks and large stocks have similar book-to-market ratios), and the *HML* factor is constructed to be independent of the size effect (the portfolios of high and low book-to-market stocks have similar size).

176. The approach used by NERA to construct *SMB* was appropriate (*SMB* was not independent of *HML*) because it was paired with *HML* factors that were not independent of *SMB*. In our case, we have compiled *SMB* and *HML* factors that are independent of each other. The factors NERA compiled were appropriate in the context of NERA's report, but we consider the factors we have compiled are the most reliable factors available. In this section we compare the results for Australian-listed firms that we previously-reported, using the *HML* factors from Professor Ken French, and the *SMB* factors from NERA.

177. To make this comparison we need to assess the overall risk premium associated with the two sets of results. The exposures to risk (*s* and *h*) need to be considered jointly with the construction of the risk factors (*SMB* and *HML*). In the current paper, the average annual returns for *SMB* and *HML* are –0.43% and 9.97%, respectively. In our prior paper (SFG Consulting, 2013b), the average annual estimates for *SMB* and *HML* were 3.05% and 7.68%, respectively. In the comparisons below, the market risk premium assumption remains constant at 6.50%.

178. In aggregate, placing equal weight on estimates from individual firm averages and an equal-weighted index, the risk premium estimate has fallen by 0.72% in the current paper. This can be attributed to reductions in estimates of market risk exposure (0.29%), *SMB* exposure (0.09%) and *HML* exposure (0.34%). Our estimate of the aggregate risk premium for Australian-listed stocks is 6.10%, compared to 6.82% previously-reported.

[68] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/

Table 4. Comparison of risk premium estimates (%) from different *SMB* and *HML* construction

	Factors compiled using method of Brailsford, Gaunt and O'Brien (2012) – SFG compilation				Factors compiled using method of Fama and French (1998) – NERA compilation			
	$\beta \times (r_m - r_f)$	s × SMB	h × HML	Total	$\beta \times (r_m - r_f)$	s × SMB	h × HML	Total
Firm	3.17	−0.03	3.25	6.39	3.83	0.10	3.87	7.80
Index	3.07	0.01	2.73	5.81	2.99	0.05	2.79	5.83
Average	3.12	−0.01	2.99	6.10	3.41	0.08	3.33	6.82

179. This should not be interpreted as saying that the Fama-French model is unreliable because the factors can be constructed in different ways, leading to different cost of capital estimates. The results demonstrate that, regardless of the construction of the *SMB* and *HML* factors, there is a material, positive risk premium associated with the Fama-French factors for Australian-listed energy networks. According to the *SMB* and *HML* factors adopted in the current paper, the risk premium is 1.55% higher than implied by the AER's approach in the Guideline.

5. Summary and conclusions

Estimate of the cost of equity

180. The AER has rejected the use of the Fama-French model for estimating the cost of equity on both theoretical and computational grounds. This rejection means there is a material risk that the cost of equity could be understated for the benchmark firm, as documented in the computations below. The AER's rationale for rejecting the use of the Fama-French model, on both a theoretical and computational basis, are inappropriate. The theoretical and computational issues are considered below.

181. In reaching a conclusion on the estimated cost of equity we have made the following assumptions. We first consider the total cost of equity before any adjustment for imputation credits. The risk premiums for *SMB* and *HML*, for both Australia and the U.S., do not include any compensation for imputation credits.[69] So we first estimate the cost of equity without any consideration of imputation credits (that is, the return from dividends and capital gains), and then compute what cost of equity would need to be input into the AER's post-tax revenue model (as a return from dividends, capital gains, and imputation credits).[70]

182. The risk-free rate is 4.12%, which is the average yield to maturity on 10-year government bonds for 20 days ending on 12 February 2014. The market risk premium, excluding any allowance for imputation credits, is estimated at 6.11% on the basis of four estimation techniques as outlined in detail in our accompanying report (SFG, 2014).

183. In estimating compensation for exposure to the market factor, size factor and book-to-market factor we place 24% weight on Australian-listed firms and 76% weight on U.S.-listed firms. The basis for these percentages is that double the weight is placed on an Australian observation compared to a U.S. observation.[71] With respect to the size and book-to-market premiums, the risk exposure (s and h) needs to be considered jointly with the compensation per unit of risk (*SMB* and *HML*) because the average returns to these two parameter estimates are the direct result of portfolio construction relative to the Australian and U.S. markets. We do not have a basis for saying that the market risk premium for Australian-listed stocks is different to the market risk premium for U.S.-listed stocks.

184. This means that, prior to consideration of imputation credits, we add:

a) The risk-fee rate of 4.12%;

b) Compensation for exposure to the market factor of 4.74% computed as:

$$
\begin{aligned}
&= (0.24 \times 0.48 \times 6.11\%) + (0.76 \times 0.87 \times 6.11\%) \\
&= (0.24 \times 2.93\%) + (0.76 \times 5.33\%) \\
&= 0.71\% + 4.03\% \\
&= 4.74\%
\end{aligned}
$$

[69] There is no requirement that factors be estimated as total returns including imputation credits and any factor that is not a stock returns factor could not be computed with regards to imputation credits. For example, if a factor model included an estimate of the term spread for government bonds, or the corporate bond spread, the factor necessarily cannot be computed having any regard to imputation credits.

[70] In our companion report, SFG (2014) and supporting reports we discuss the relationship between the total return to equity holders and the return from dividends and capital gains, that is embedded in the AER's post-tax revenue model.

[71] There are nine Australian-listed stocks and 56 U.S.-listed stocks, and $(9 \times 2) \div (9 \times 2 + 56) = 24\%$.

c) Compensation for exposure to the size factor of –0.19% computed as:

$$(0.24 \times 0.03 \times -0.43\%) + (0.76 \times -0.07\% \times 3.58\%$$
$$= (0.24 \times -0.01\%) + (0.76 \times -0.25\%)$$
$$= -0.00\% - 0.19\%$$
$$= -0.19\%$$

d) Compensation for exposure to the book-to-market factor of 1.15%, computed as:

$$(0.24 \times 0.30 \times 9.97\%) + (0.76 \times 0.12 \times 4.81\%)$$
$$= (0.24 \times 2.99\%) + (0.76 \times 0.56\%)$$
$$= 0.73\% + 0.42\%$$
$$= 1.15\%$$

e) Which equals:

$$r_f + \beta_e \times (r_m - r_f) + s \times \text{SMB} + h \times \text{HML}$$
$$= 4.12\% + 4.74\% - 0.19\% + 1.15\%$$
$$= 4.12\% + 5.70\%$$
$$= 9.82\%$$

185. The next step is to consider imputation. In our companion report (SFG, 2014) and associated reports we document that, if the value of imputation credits (gamma or γ) is set to 0.25 and the corporate tax rate is set to 0.30, in the AER post-tax revenue model the following relationship holds: Returns from dividends and capital gains = 0.9032 × cost of equity. We have been asked to consider the cases in which the value of imputation credits is 0.25 and the value of imputation credits is 0.50. In the latter case, the relationship is: Returns from dividends and capital gains = 0.8235 × cost of equity. This also affects the ex-imputation market risk premium of 6.11%, as discussed below.

186. **So, in order to estimate the cost of equity in the post-tax revenue model, we need to divide the return from dividends and capital gains of 9.82% by 0.9032. This means that the cost of equity is estimated to be 10.87% as an input in the AER post-tax revenue model (9.82% ÷ 0.9032 = 10.87%).**

187. **In the alternative case in which the value of imputation credits is set to 0.50, the market risk premium input is 5.79% rather than 6.11%.[72] This results in a return from dividends and capital gains of 9.57% (simply replace the input of 6.11% in point (b), above, with 5.79% and continue). This means that the cost of equity is estimated to be 11.63% as an input in the AER post-tax revenue model (9.57% ÷ 0.8235) = 11.63%.**

188. The weight applied to Australian-listed firms reflects our judgement that Australian-listed firms are more informative than U.S.-listed firms. We understand that one person may argue for more or less weight to be placed on an Australian-listed firm compared to a U.S.-listed firm – one person could argue that each observation should carry equal weight, another could argue that Australian-listed stocks are more informative than we have assumed. But ultimately, given information from different datasets we need a transparent mechanism for reaching a final conclusion according to their relative informativeness. Any final conclusion ultimately incorporates an implicit or explicit assumption about the merits of either dataset. Our computation simply means we have made the assumption explicit.

[72] This basis for this input is also described in our companion report (SFG, 2014).

189. For the benefit of those with an alternative view on the relative consideration to apply to each dataset we have the following computations:

a) If 100% weight was applied to Australian-listed firms, the return from dividends and capital gains would equal 10.03% (if gamma = 0.25), and the cost of equity for the AER post-tax revenue model would be 11.10%.

b) If 100% weight was applied to U.S.-listed firms, the return from dividends and capital gains would equal 9.75% (if gamma = 0.25), and the cost of equity for the AER post-tax revenue model would be 10.80%.

190. In the AER Guideline, the AER adopts the Sharpe-Lintner CAPM, populated with an equity beta of 0.7 and a market risk premium of 6.5%. If the risk-free rate is 4.12% the implication is that the cost of equity will be computed as 8.67%. This is not the return from dividends and capital gains. The return from dividends and capital gains will be 7.83% if the value of imputation credits is set to 0.25, and 7.14% if the value of imputation credits is set to 0.50.

Theory

191. The development of asset pricing models to estimate the cost of equity has followed three distinct phases. In the first phase (five decades ago), researchers derived the CAPM (Sharpe, 1964; Lintner, 1965) under a set of restrictive assumptions. Restrictive assumptions are useful because they allow for very specific predictions. The prediction of the Sharpe-Lintner CAPM is that there is a single risk factor relevant to the cost of capital – the excess market return – and an asset's exposure to this risk factor is captured by beta.

192. Four decades ago, researchers derived multi-factor asset pricing models under less restrictive assumptions (Merton, 1973; Ross, 1976). Under these models, there are more risk factors incorporated into asset prices. But these models make less specific predictions about what risk factors will be reflected in asset prices. Under the intertemporal CAPM of Merton (1973), investors care about what happens after the initial investment ends, so will care about risks associated with future developments in the economy. The arbitrage pricing theory of Ross (1976) relies upon even less restrictive assumptions, and makes even less specific predictions about the relevant risk factors.[73]

193. Researchers performed empirical tests of the CAPM for decades with little success in demonstrating that this model explains stock returns. This could be because other risk factors are priced, poor measurement of the market portfolio (an index of listed stocks), or poor measurement of beta (regression of stock returns on market returns). The reason for this poor performance (theory versus measurement) is moot because the measurements used in those tests are the same measurements used today to populate the CAPM. The only reason the Sharpe-Lintner CAPM was not surpassed in practice by the intertemporal CAPM or the arbitrage pricing theory is because it was difficult for researchers to show that other risk factors performed better than the market factor in explaining stock returns.

194. However, two decades ago things changed. Researchers had already observed that small stocks earned higher returns than large stocks, and high book-to-market stocks earned higher returns than low book-

[73] The intertemporal CAPM and the arbitrage pricing theory do not specify the best data to measure the risks associated with those models. They are theoretical models that can be populated with proxies for risk, just as the Sharpe-Lintner CAPM is populated with proxies for the risk-free rate, beta and the market risk premium. So it is not the case that the Fama-French model is used in preference to the intertemporal CAPM or the arbitrage pricing theory. Rather, theory has established that SMB and HML appear to be proxies for risks incorporated in the intertemporal CAPM or the arbitrage pricing theory.

to-market stocks. Fama and French (1993) constructed factors on the basis of this observation, and demonstrated that these factors did, indeed, perform quite well in explaining stock returns. The performance of the size factor has fluctuated somewhat over time and across markets, but the performance of the book-to-market factor has not. There is agreement amongst researchers that the book-to-market factor seems to perform well at explaining stock returns in different markets.

195. The results of Fama and French (1993) led to a substantial body of literature devoted to theoretical reasons for their empirical result. Those theoretical explanations are based upon the asset pricing theories already developed in the 1970s – the intertemporal CAPM and the arbitrage pricing theory. Some of those theories and associated empirical evidence are presented in this paper, and this is not an exhaustive list. To conclude that the Fama-French model is without theoretical foundation is incorrect. It is not appropriate to dismiss the theoretical underpinnings of the model merely because the empirical result was observed first.

Computations

196. The AER's objection to the Fama-French model on computational grounds is inappropriate. The AER is concerned that the use of the model requires estimation of more parameters, so adds an unreasonable layer of complexity to the analysis. It is correct that there is uncertainty over firms' exposure to the *SMB* and *HML* factors (*s* and *h*), and to the appropriate level of the *SMB* and *HML* factors to use in determining the cost of equity. But the dataset and estimation techniques used in this analysis are the same as those used to populate the Sharpe-Lintner CAPM. The AER's computational concern is such that it has placed zero weight on a cost of equity estimate which is around 1.5% above the estimate resulting from its application of the Sharpe-Lintner CAPM.

197. In this report and in our previous analysis (SFG Consulting, 2013b) the AER has been provided with risk exposures and factor returns for comparable firms listed in Australia and the U.S. Compared to the AER's recent implementation of the Sharpe-Lintner CAPM the implied risk premium is 1.4% higher based upon Australian-listed firms, and 1.5% based upon U.S.-listed firms. For U.S.-listed firms, even if we rely upon a sub-sample of 17 firms preferred by the AER as better comparables for energy networks, the increase in the equity premium is 1.0% under the Fama-French model compared to the AER's implementation of the CAPM.

198. In the Fama-French model, there is uncertainty over the magnitude of risk exposure (*s* and *h*) and uncertainty about the return per unit of risk (*SMB* and *HML*). This uncertainty exists, whether or not, in estimating the cost of equity, we set the risk exposures to zero ($s = 0$ and $h = 0$), or the returns per unit of risk to zero ($SMB = 0$ and $HML = 0$). Making either of these assumptions simply shifts the cost of equity estimate to the Sharpe-Lintner CAPM estimate. It does not improve the precision of the cost of equity estimate.

199. The AER cited a number of papers that reported varying estimates for the average *HML* premium, spanning different time periods and using different computational techniques and every single average *HML* estimate was positive. It is not appropriate to list a set of results and, without any reconciliation of which time periods, datasets or estimation techniques are most reliable, simply say that the estimates are different so the model is not sufficiently precise. There is every reason to conclude that the cost of capital for the benchmark firm incorporates a premium for exposure to the *HML* factor, but this has effectively been set to zero by the AER. This is not a situation in which a purely conceptual argument has been made for a directional adjustment, and so maybe the adjustment should be so small as to be zero. The specific estimates presented to the AER suggest that the adjustment to the cost of equity is material and quantifiable using the same techniques and sample firms the AER already relies upon.

Conclusion and implications for asset pricing models

200. The AER's decision to give no weight to the Fama-French model is based upon the rationale that there is uncertainty about what risks are captured by the Fama-French factors, and uncertainty about the magnitude of the risk premiums, and until there is agreement on these issues the model should not be used. If this rationale is accepted there is unlikely to be any new asset pricing model ever adopted. What remains is an implementation of the Sharpe-Lintner CAPM by the AER which is unlikely to generate reliable cost of equity estimates. In addition, the AER assessment does not reach a conclusion on its view as to what the *HML* factor represents. In short, is the AER's assessment of the theoretical and empirical evidence that *HML* is a priced risk factor, or is it not a priced risk factor? This conclusion is important for participants in the regulatory process.

Declaration

201. We confirm that we have made all the inquiries that we believe are desirable and appropriate and no matters of significance that we regard as relevant have, to our knowledge, been withheld from the Court.

Professor Stephen Gray. Dr Jason Hall.

References

Allen Consulting Group, 2008, "Beta for regulated electricity transmission and distribution," *Report for Energy Network Association, Grid Australia and APIA,* September.

Australian Competition Tribunal, 2012, Application by Envestra Ltd (No 2) [2012] ACompT 3.

Australian Competition Tribunal, 2012, Application by WA Gas Networks Pty Ltd (No 3) [2012] ACompT 12.

Australian Competition Tribunal, 2012, Application by DBNGP (WA) Transmission Pty Ltd (No 3) [2012] ACompT 14.

Australian Competition Tribunal, 2011, Application by Jemena Ltd, ACompT 10

Australian Competition Tribunal, 2011, Application by Actew/AGL Ltd, ACompT 4.

Australian Energy Regulator, 2013a, *Better regulation: Rate of return guideline*, December.

Australian Energy Regulator, 2013b, *Better regulation: Rate of return guideline – Explanatory Statement*, December.

Australian Energy Regulatory, 2013c, *Better regulation: Rate of return guideline – Explanatory Statement (Appendices),* December.

Banz, R.W, 1981, "The relationship between return and market value of common stocks," *Journal of Financial Economics,* 9, 3–18.

Ben-David, I., F. Franzoni, A. Landier, and R. Moussawi, 2013, "Do hedge funds manipulate stock prices?" *Journal of Finance,* 68, 2383–2434.

Berk, J., and P. DeMarzo, 2013, *Corporate Finance,* 3rd ed., Pearson, New York, NY, USA.

Berkman, H., P.D. Koch, and P.J. Westerholm, 2014, "Informed trading through the accounts of children," *Journal of Finance,* 69, 363–404.

Black, F., 1972, "Capital market equilibrium with restricted borrowing," *Journal of Business*, 45, 444–454.

Boguth, O., and L.A. Kuehn, 2013, "Consumption volatility risk," *Journal of Finance,* 68, 2589–2615.

Brailsford, T., C. Gaunt, and M. O'Brien, 2012a. "Size and book-to-market factors in Australia," *Australian Journal of Management,* 37, 261–281.

Brailsford, T., C. Gaunt, and M. O'Brien, 2012b. "The investment value of the value premium," *Pacific-Basin Finance Journal,* 20, 416–437.

Brealey, R.A., S.C. Myers, and F. Allen, 2011, *Principles of Corporate Finance,* 10th ed., McGraw-Hill Irwin, New York, NY, USA.

Brounen, D., A. de Jong, and K. Koedijk, 2004, "Corporate finance in Europe: Confronting theory with practice," *Financial Management,* 33 (4), 71–101.

Buraschi, A., F. Trojani, A. Vedolin, 2014, "When uncertainty blows in the orchard: Comovement and equity premium volatility," *Journal of Finance,* 69, 101–137.

Chan, K.C, and N.F. Chen, 1991, "Structural and return characteristics of small and large firms," *Journal of Finance,* 46, 1467–1484.

Competition Economists Group, 2013. "Information on equity beta from US companies," June.

Currie, R. and G.S. Pandher, 2011, "Finance journal rankings and tiers: An active scholar assessment methodology," *Journal of Banking and Finance,* 35, 7–20.

Economic Regulation Authority, 2013, Rate of Return Guidelines for Gas Transmission and Distribution Networks – Final Guidelines – Explanatory Statement, December.

Economic Sciences Prize Committee, 2013, *Understanding Asset Prices,* Scientific background on the Sveriges Riksbank Prize in Economic Sciences in memory of Alfred Nobel.

Fama, E.F., and K.R. French, 1993, "Common risk factors in the returns on stocks and bonds," *Journal of Financial Economics*, 33, 3–56.

Fama, E.F, and K.R. French, 1995, "Size and book-to-market factors in earnings and returns," *Journal of Finance,* 50, 131–155.

Fama, E.F., and K.R. French, 1996, "Multi-factor explanations of asset pricing anomalies," *Journal of Finance,* 51, 55–84.

Fama, E.F., and K.R. French, 1998, "Value versus growth: International evidence," *Journal of Finance,* 53, 1975–1999.

Fama, E.F., and K.R. French, 2004, "The Capital Asset Pricing Model: Theory and evidence," *Journal of Economic Perspectives*, 18, 25–46.

Fang, J., A. Kempf, and M. Trapp, 2014, "Fund manager allocation," *Journal of Financial Economics,* 111, 661–674.

Frazzini, A., and L.H. Pedersen, 2014, "Betting against beta," *Journal of Financial Economics,* 111, 1–25.

Graham, J.R., C.R. Harvey, 2001, "The theory and practice of corporate finance: Evidence from the field," *Journal of Financial Economics,* 60, 187–243.

Huang, C.F., and R. H. Litzenberger, 1988, *Foundations for Financial Economics,* North-Holland, New York.

Hu, J., 2014, "Does option trading convey stock price information?" *Journal of Financial Economics,* 111, 625–645

Hu, G.X., J. Pan, and J. Wang, 2013, "Noise as information for illiquidity," *Journal of Finance,* 68, 2341–2382.

Lintner, J., 1965, "The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets," *Review of Economics and Statistics,* 13–37.

Markowitz, H.M., 1952, "Portfolio selection," *Journal of Finance*, 7, 77–91.

McKenzie, M., and G. Partington, 2013, "Risk, asset pricing models and WACC," *Report to the AER,* June.

Merton, R.C., 1973, "An intertemporal capital asset pricing model," *Econometrica,* 41, 867–887.

Merton, R.C., 1974, "On the pricing of corporate debt: The risk structure of interest rates," *Journal of Finance,* 29, 449–470.

NERA, 2013, "The market, size and value premiums," June.

Petkova, R. and L. Zhang, 2005, "Is value riskier than growth," *Journal of Financial Economics,* 78, 187–202.

Pinto, J.E., E. Henry, T.R. Robinson, J.D. Stowe, and A. Cohen, 2010, *Equity Asset Valuation,* 2nd edition, CFA Investment Series, Wiley.

In re PNB Holding Co. Shareholders' Litigation, No. 28-N (Del. Ch. Aug. 18, 2006).

Rosenberg, B., K. Reid, and R. Lanstein, 1985, "Persuasive evidence of market inefficiency," *Journal of Portfolio Management,* 11, 9–17.

Ross, S., 1976, "The arbitrage theory of capital asset pricing," *Journal of Economic Theory*, 13, 341–360.

Roussanov, N., 2014, "Composition of wealth, conditioning information, and the cross-section of stock returns," *Journal of Financial Economics,* 111, 352–380.

SFG Consulting, 2013a, "Evidence on the required return on equity from independent expert reports," *Report for the Energy Networks Association,* June.

SFG Consulting, 2013b, "Regression-based estimates of risk parameters for the benchmark firm," *Report for the Energy Networks Association,* June.

SFG Consulting, 2014, "The required return on equity for regulated gas and electricity network businesses," May.

Sharpe, W., 1964, "Capital asset prices: A theory of market equilibrium under conditions of risk," *Journal of Finance,* 19, 425–442.

Smith, T., and K. Walsh, 2013, "Why the CAPM is half-right and everything else is wrong," *ABACUS,* 49, 73–78.

Truong, G., G. Partington, and M. Peat, 2008, "Cost-of-capital estimation and capital-budgeting practices in Australia," *Australian Journal of Management,* 33, 95–121.

The Union Illinois 1995 Investment Limited Partnership, the Denis J. O'Brien Family Irrevocable Trust, the Douglas Alan O'Brien Family Irrevocable Trust, Douglas Alan O'Brien, Douglas Alan O'Brien, as custodian for Kenneth Preston O'Brien, and Patricia Marsh O'Brien, Petitioners, v. Union Financial Group, Ltd., a Delaware Corporation, Respondent. C.A. No. 19586, Court of Chancery of Delaware, New Castle, 847 A. 2d 340; 2004 Del. Ch.

Vassalou, M., 2003, "News related to future GDP growth as a risk factor in equity returns," *Journal of Financial Economics,* 68, 47–73.

Vassalou, M. and Y. Xing, 2004, "Default risk in equity returns," *Journal of Finance,* 59, 831–868.

Zhang, L., 2005, "The value premium," *Journal of Finance,* 60, 67–103.

Appendix 1: Cost of capital parameter estimates

Table 5. Individual firm data for Australian-listed firms

	Descriptive information			Capital Asset Pricing Model				Fama-French model			
Name	MC	Lev	N	B_{OLS}	β_{Vas}	$\beta_{Re\text{-}g}$	RSQ	β	s	h	RSQ
SP Ausnet	2.5	62	87	0.26	0.29	0.27	7	0.52	-0.38	0.16	18
Gasnet	0.3	67	59	0.29	0.36	0.30	5	0.26	0.18	0.27	5
DUET	1.5	76	102	0.59	0.61	0.36	16	0.34	-0.01	0.17	13
Envestra	0.8	72	136	0.65	0.66	0.47	17	0.48	-0.01	0.62	19
Spark	1.5	48	72	0.39	0.42	0.54	10	0.35	-0.10	-0.02	5
APA	1.4	56	136	0.57	0.58	0.63	20	0.81	-0.34	0.03	22
AGL	9.0	14	58	0.32	0.36	0.77	7	0.88	-0.12	0.30	8
Alinta	1.4	37	68	0.53	0.59	0.93	8	1.03	0.15	1.26	10
HDUF	0.6	46	96	0.81	0.84	1.13	9	-0.26	1.25	0.14	6
Mean	2.1	53	91	0.49	0.52	0.60	11	0.49	0.07	0.33	12

The average daily leverage of the equal-weighted index of sample firms was 60%.

Table 6. Individual firm data for United States-listed firms

	Descriptive info.			Capital Asset Pricing Model				Fama-French model			
Name	MC	Lev	N	B_{OLS}	β_{Vas}	$\beta_{Re\text{-}g}$	RSQ	β	s	h	RSQ
Southern	41.4	39	138	0.31	0.32	0.49	15	0.52	-0.44	0.16	18
Consolidated Edison	18.6	44	138	0.38	0.39	0.55	19	0.57	-0.52	0.25	23
Laclede Group	0.9	43	138	0.40	0.41	0.58	15	0.53	0.43	-0.13	17
UNS Energy	1.7	66	138	0.68	0.69	0.58	26	0.56	-0.04	0.12	26
Wisconsin Energy	9.4	49	138	0.45	0.45	0.58	27	0.58	-0.10	0.08	28
Northwest Natural Gas	1.3	40	138	0.38	0.39	0.59	17	0.54	0.18	0.11	18
Northeast Utilities	12.5	58	138	0.58	0.58	0.61	29	0.60	-0.08	0.09	29
South Jersey Industry	1.6	38	138	0.45	0.46	0.71	21	0.65	0.31	0.05	23
WGL Holdings	2.1	34	138	0.44	0.44	0.73	23	0.76	-0.06	-0.26	24
New Jersey Resources	1.9	31	138	0.42	0.43	0.74	20	0.70	0.37	-0.27	22
Pepco Holdings	4.5	59	138	0.72	0.72	0.74	35	0.76	-0.27	0.04	37
Westar Energy	3.8	55	138	0.67	0.67	0.75	31	0.69	0.26	0.16	33
Centerpoint Energy	9.0	68	138	0.95	0.95	0.75	22	0.74	-0.05	0.12	24
DTE Energy	10.2	54	138	0.66	0.66	0.76	39	0.78	-0.51	0.26	43
MGE Energy	1.1	31	138	0.44	0.45	0.77	24	0.70	0.53	-0.08	27
Scana	6.3	48	138	0.59	0.60	0.77	39	0.77	-0.07	0.03	40
NV Energy	4.2	69	138	1.00	1.00	0.78	23	0.84	-0.42	-0.04	25
Piedmont Natural Gas	2.3	34	138	0.47	0.48	0.79	21	0.67	0.37	0.38	25
Atmos Energy	3.3	46	138	0.59	0.59	0.79	40	0.74	0.13	0.19	41
AGL Resources	4.7	47	138	0.60	0.61	0.80	40	0.76	0.15	0.08	42
CMS Energy	6.4	72	138	1.16	1.15	0.80	31	0.85	-0.25	-0.10	32
Vectren	2.5	46	138	0.58	0.59	0.80	32	0.85	-0.36	-0.14	34
Firstenergy	20.9	48	138	0.60	0.61	0.80	21	0.91	-0.89	-0.04	27
Southwest Gas	2.1	55	138	0.72	0.72	0.82	44	0.75	0.18	0.29	46
Avista	1.6	55	138	0.73	0.74	0.83	31	0.71	0.53	0.31	36
Nisource	7.2	58	138	0.80	0.81	0.84	43	0.83	-0.34	0.37	47
PPL	16.7	44	138	0.60	0.61	0.84	25	0.97	-0.69	-0.40	31
Portland General Elec.	2.0	48	83	0.65	0.66	0.85	43	0.83	0.38	-0.23	46
CH Energy Group	1.0	35	138	0.51	0.52	0.85	23	0.78	0.48	-0.04	25
Xcel Energy	14.1	53	138	0.71	0.72	0.85	24	0.88	-0.23	-0.03	25
Nextera Energy	29.2	42	138	0.59	0.60	0.86	30	0.94	-0.61	-0.11	34
El Paso Electric	1.3	45	138	0.62	0.63	0.86	28	0.75	0.12	0.58	32
Entergy	12.6	41	138	0.58	0.59	0.87	29	0.94	-0.82	0.19	35
Idacorp	2.1	49	138	0.69	0.70	0.89	33	0.90	-0.06	-0.09	34
Empire District Electric	0.9	47	138	0.67	0.67	0.89	40	0.80	0.47	0.17	43
Northwestern	1.4	47	100	0.67	0.67	0.90	33	0.85	0.44	-0.18	35
Ameren	8.1	44	138	0.65	0.65	0.91	35	0.95	-0.48	0.13	37
Edison International	14.9	54	138	0.80	0.81	0.94	35	0.95	-0.23	0.10	36
Alliant Energy Corp	5.2	42	138	0.64	0.65	0.94	29	0.88	-0.01	0.34	31
Pinnacle West Capital	5.8	48	138	0.73	0.73	0.95	36	0.95	-0.11	0.10	37
PG&E	19.0	44	138	0.67	0.68	0.95	22	0.91	0.27	0.03	23
Public Svs Enterprise Gr	16.5	44	138	0.69	0.69	0.97	26	1.00	-0.33	0.00	27
American Elec. Power	20.2	52	138	0.80	0.81	0.98	33	1.03	-0.40	-0.03	34
Teco Energy	3.9	53	138	0.85	0.86	1.00	32	0.96	-0.11	0.36	33
ITC Holdings	3.8	46	91	0.75	0.76	1.03	34	1.09	-0.54	0.08	36
UIL Holdings	1.9	47	138	0.78	0.78	1.04	31	0.87	0.38	0.82	38
Integrys Energy Group	4.7	43	138	0.72	0.73	1.05	34	1.00	-0.20	0.50	36
Duke Energy	46.1	44	138	0.75	0.76	1.07	31	1.13	-0.71	0.08	35
OGE Energy	5.3	41	138	0.74	0.74	1.09	41	1.02	0.04	0.49	44
Cleco	2.6	45	138	0.79	0.80	1.10	34	1.05	0.21	0.15	35
Great Plains Energy	3.0	46	138	0.84	0.84	1.13	49	1.13	-0.25	0.18	49
PNM Resources	1.6	57	138	1.08	1.07	1.16	38	1.12	0.03	0.28	39
Sempra Energy	16.7	39	138	0.80	0.80	1.22	41	1.31	-0.53	-0.17	44
Black Hills	1.4	48	138	0.95	0.95	1.24	41	1.14	0.43	0.34	44
Allete	1.6	30	138	0.77	0.78	1.36	38	1.24	0.55	0.30	40
Otter Tail	0.8	32	138	0.88	0.89	1.51	36	1.39	0.76	0.16	38
Mean	8.0	47	135	0.67	0.68	0.88	31	0.86	-0.05	0.11	33

The average daily leverage of the equal-weighted index of sample firms was 47%.

Appendix 2: Instructions

Expert Terms of Reference

Applying the Fama-French Three Factor Model in Australia

Jemena Gas Networks
2015-20 Access Arrangement Review

AA15-570-0053

Version C – 1 May 2014

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A	Draft	13/02/14	E Grace-Webb		
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C	Final	01/05/14	E Grace-Webb		E Grace-Webb

Contents

1 Background

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

JGN is currently preparing its revised Access Arrangement proposal (**Project**) with supporting information for the consideration of the Australian Energy Regulator (**AER**). The revised access arrangement will cover the period 1 July 2015 to 30 June 2020 (July to June financial years).

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

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

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

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

> "(2) A service provider should be provided with a reasonable opportunity to recover at least the efficient costs the service provider incurs in—
>
> a) providing reference services; and
>
> b) complying with a regulatory obligation or requirement or making a regulatory payment.
>
> (3) A service provider should be provided with effective incentives in order to promote economic efficiency with respect to reference services the service provider provides. The economic efficiency that should be promoted includes—
>
> (a) efficient investment in, or in connection with, a pipeline with which the service provider provides reference services…
>
> […]
>
> (5) A reference tariff should allow for a return commensurate with the regulatory and commercial risks involved in providing the reference service to which that tariff relates.

(6) Regard should be had to the economic costs and risks of the potential for under and over investment by a service provider in a pipeline with which the service provider provides pipeline services.”

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

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

(1) Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.

(2) A forecast or estimate:

  (a) must be arrived at on a reasonable basis; and

  (b) must represent the best forecast or estimate possible in the circumstances.

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

(1) Subject to rule 82(3), the return on the projected capital base for each regulatory year of the access arrangement period is to be calculated by applying a rate of return that is determined in accordance with this rule 87 (the allowed rate of return).

(2) The allowed rate of return is to be determined such that it achieves the allowed rate of return objective.

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

(4) Subject to subrule (2), the allowed rate of return for a regulatory year is to be:

  (a) a weighted average of the return on equity for the access arrangement period in which that regulatory year occurs (as estimated under subrule (6)) and the return on debt for that regulatory year (as estimated under subrule (8)); and

  (b) determined on a nominal vanilla basis that is consistent with the estimate of the value of imputation credits referred to in rule 87A.

(5) In determining the allowed rate of return, regard must be had to:

  (a) relevant estimation methods, financial models, market data and other evidence;

  (b) the desirability of using an approach that leads to the consistent application of any estimates of financial parameters that are relevant to the estimates of, and that are common to, the return on equity and the return on debt; and

(c) any interrelationships between estimates of financial parameters that are relevant to the estimates of the return on equity and the return on debt.

Return on equity

(6) The return on equity for an access arrangement period is to be estimated such that it contributes to the achievement of the allowed rate of return objective.

(7) In estimating the return on equity under subrule (6), regard must be had to the prevailing conditions in the market for equity funds.

[Subrules (8)–(19) omitted].

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

Accordingly, the independent opinion of SFG Consulting, as a suitably qualified independent expert (**Expert**), is sought on using the Fama-French three-factor model (**Fama-French model**) to estimate a return on equity that complies with the requirements of the National Gas Law and Rules and National Electricity Law and Rules, including as highlighted above. JGN seeks this opinion on behalf of itself, ActewAGL, SA PowerNetworks, Transend, and TransGrid.

2 Scope of Work

The Expert will provide an opinion report that:

1. describes the Fama-French model, its key parameters, and the theoretical and empirical basis for its development;

2. describes how the Fama-French model is applied in practice (and is used to estimate the return on equity) in Australia;

3. uses the Fama-French model to estimate the return on equity for a benchmark efficient entity in Australia that is:

   (a) commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to a regulated gas or electricity network in respect of the provision of reference services; and

   (b) reflective of prevailing conditions in the market for equity funds.

In preparing the report, the Expert will:

A. consider different approaches to applying the Fama-French model, including any theoretical restrictions on empirical estimates;

B. consider the theoretical and empirical support for the Fama-French model and its factors;

C. consider any comments raised by the AER and other regulators on (a) whether the Fama-French model applies in Australia and (b) the statistical reliability of the parameter estimates;

D. use robust methods and data; and

E. use the sample averaging period of the 20 business days to 12 February 2014 (inclusive) to estimate any prevailing parameter estimates needed to populate the Fama-French model.

3 Information Provided by JGN

The Expert is encouraged to draw upon the following information which JGN will make available:

- an expert report by NERA Economic Consulting titled “The Fama-French Three Factor Model, a report for the Energy Networks Association”, dated October 2013;
- an expert report by NERA Economic Consulting titled “Cost of Equity – Fama-French Three-Factor Model”, dated 12 August 2009;
- an expert report by NERA Economic Consulting titled “Jemena Access Arrangement for the NSW Gas Networks: AER Draft Decision”, dated 19 March 2010;
- an expert report by Oxera Consulting titled “Estimating the cost of equity from the Fama-French model”, dated 28 April 2010; and
- other relevant expert reports on the Fama-French model.

4 Other Information to be Considered

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

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

5 Deliverables

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

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

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

6 Timetable

The Expert will deliver the final report to Jemena Regulation by **30 April 2014**.

7 Terms of Engagement

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

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

[1] Available at: http://www.federalcourt.gov.au/law-and-practice/practice-documents/practice-notes/cm7.

ATTACHMENT 1: FEDERAL COURT PRACTICE NOTE

Practice Note CM 7

EXPERT WITNESSES IN PROCEEDINGS IN THE FEDERAL COURT OF AUSTRALIA

Commencement

1. This Practice Note commences on 4 June 2013.

Introduction

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

3. The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence[2], and to assist experts to understand in general terms what the Court expects of them. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.

<u>Guidelines</u>

1. General Duty to the Court[3]

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

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

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

2. The Form of the Expert's Report[4]

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

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

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

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

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

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

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

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

[4] Rule 23.13.

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

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

(ga) contain an acknowledgment that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c) above[5]; and

(h) comply with the Practice Note.

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

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

2.4 If, after exchange of reports or at any other stage, an expert witness changes the expert's opinion, having read another expert's report or for any other reason, the change should be communicated as soon as practicable (through the party's lawyers) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court[6].

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

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

2.7 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports[7].

3. Experts' Conference

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

J L B ALLSOP
Chief Justice
4 June 2013

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

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

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

Appendix 3: Curriculum Vitas of Professor Stephen Gray and Dr Jason Hall

Stephen F. Gray

University of Queensland
Business School
Brisbane 4072
AUSTRALIA
Office: +61-7-3346 8032
Email: s.gray@business.uq.edu.au

Academic Qualifications

1995 Ph.D. (Finance), Graduate School of Business, Stanford University.
Dissertation Title: Essays in Empirical Finance
Committee Chairman: Ken Singleton
1989 LL.B. (Hons), Bachelor of Laws with Honours, University of Queensland.
1986 B.Com. (Hons), Bachelor of Commerce with Honours, University of Queensland.

Employment History

2000-Present Professor of Finance, UQ Business School, University of Queensland.
1997-2000 Associate Professor of Finance, Department of Commerce, University of Queensland and Research Associate Professor of Finance, Fuqua School of Business, Duke University.
1994-1997 Assistant Professor of Finance, Fuqua School of Business, Duke University.
1990-1993 Research Assistant, Graduate School of Business, Stanford University.
1988-1990 Assistant Professor of Finance, Department of Commerce, University of Queensland.
1987 Specialist Tutor in Finance, Queensland University of Technology.
1986 Teaching Assistant in Finance, Department of Commerce, University of Queensland.

Academic Awards

2006 Outstanding Professor Award, Global Executive MBA, Fuqua School of Business, Duke University.
2002 Journal of Financial Economics, All-Star Paper Award, for Modeling the Conditional Distribution of Interest Rates as a Regime-Switching Process, JFE, 1996, 42, 27-62.
2002 Australian University Teaching Award – Business (a national award for all university instructors in all disciplines).
2000 University of Queensland Award for Excellence in Teaching (a University-wide award).
1999 Outstanding Professor Award, Global Executive MBA, Fuqua School of Business, Duke University.
1999 KPMG Teaching Prize, Department of Commerce, University of Queensland.
1998 Faculty Teaching Prize (Business, Economics, and Law), University of Queensland.
1991 Jaedicke Fellow in Finance, Doctoral Program, Graduate School of Business, Stanford University.
1989 Touche Ross Teaching Prize, Department of Commerce, University of Queensland.
1986 University Medal in Commerce, University of Queensland.

Large Grants (over $100, 000)

- Australian Research Council Linkage Grant, 2008—2010, Managing Asymmetry Risk ($320,000), with T. Brailsford, J.Alcock, and Tactical Global Management.
- Intelligent Grid Cluster, Distributed Energy – CSIRO Energy Transformed Flagship Collaboration Cluster Grant, 2008-2010 ($552,000)
- Australian Research Council Research Infrastructure Block Grant, 2007—2008, Australian Financial Information Database ($279,754).
- Australian Research Council Discovery Grant, 2006—2008, Capital Management in a Stochastic Earnings Environment ($270,000).
- Australian Research Council Discovery Grant, 2005—2007, Australian Cost of Equity.
- Australian Research Council Discovery Grant, 2002—2004, Quantification Issues in Corporate Valuation, the Cost of Capital, and Optimal Capital Structure.

- Australian Research Council Strategic Partnership Grant, 1997—2000, Electricity Contracts and Securities in a Deregulated Market: Valuation and Risk Management for Market Participants.

Current Research Interests

Benchmark returns and the cost of capital. Corporate Finance. Capital structure. Real and strategic options and corporate valuation. Financial and credit risk management. Empirical finance and asset pricing.

Publications

Chan, K-F., R. Brooks, S. Treepongkaruna and S. Gray, (2011), "Do Trading Hours Affect Volatility Links in the Foreign Exchange Market?" *Australian Journal of Management*, forthcoming.

Chan, K-F., R. Brooks, S. Treepongkaruna and S. Gray, (2010), "Asset market linkages: Evidence from financial, commodity and real estate assets," *Journal of Banking and Finance*, forthcoming.

Parmenter, B, A. Breckenridge, and S. Gray, (2010), 'Economic Analysis of the Government's Recent Mining Tax Proposals', *Economic Papers*: *A Journal of Economics and Policy*, 29(3), September, 279-91.

Gray, S., C. Gaunt and Y. Wu, (2010), "A comparison of alternative bankruptcy prediction models," *Journal of Contemporary Accounting and Economics*, 6, 1, 34-45.

Feuerherdt, C., S. Gray and J. Hall, (2010), "The Value of Imputation Tax Credits on Australian Hybrid Securities," *International Review of Finance*, 10, 3, 365-401.

Gray, S., J. Hall, D. Klease and A. McCrystal, (2009), "Bias, stability and predictive ability in the measurement of systematic risk," *Accounting Research Journal*, 22, 3, 220-236.

Treepongkaruna, S. and S. Gray, (2009), "Information volatility links in the foreign exchange market," *Accounting and Finance*, 49, 2, 385-405.

Costello, D., S. Gray, and A. McCrystal, (2008), "The diversification benefits of Australian equities," *JASSA*, 2008, 4, 31-35.

Gray, S. and J. Hall, (2008), "The Relationship Between Franking Credits and the Market Risk Premium: A Reply," *Accounting and Finance*, 48, 1, 133-142.

Gray, S., A. Mirkovic and V. Ragunathan, (2006), "The Determinants of Credit Ratings: Australian Evidence," *Australian Journal of Management*, 31(2), 333-354.

Choy, E., S. Gray and V. Ragunathan, (2006), "The Effect of Credit Rating Changes on Australian Stock Returns," *Accounting and Finance*, 46(5), 755-769.

Gray, S. and J. Hall, (2006), "The Relationship Between Franking Credits and the Market Risk Premium," *Accounting and Finance*, 46(3), 405-428.

Gray, S. and S. Treepongkaruna, (2006), "Are there non-linearities in short-term interest rates?" *Accounting and Finance*, 46(1), 149-167.

Gray, P., S. Gray and T. Roche, (2005), "A Note on the Efficiency in Football Betting Markets: The Economic Significance of Trading Strategies," *Accounting and Finance*, 45(2) 269-281.

Duffie, D., S. Gray and P. Hoang, (2004), "Volatility in Energy Prices. In V. Kaminski," (Ed.), *Managing Energy Price Risk: The New Challenges and Solutions* (3rd ed.). London: Risk Books.

Cannavan, D., F. Finn and S. Gray, (2004), "The Value of Dividend Imputation Tax Credits in Australia," *Journal of Financial Economics*, 73, 167-197.

Gray, S. and S. Treepongkaruna, (2003), "Valuing Interest Rate Derivatives Using a Monte-Carlo Approach," *Accounting and Finance*, 43(2), 231-259.

Gray, S., T. Smith and R. Whaley, (2003), "Stock Splits: Implications for Investor Trading Costs," *Journal of Empirical Finance*, 10, 271-303.

Gray, S. and S. Treepongkaruna, (2003), "On the Robustness of Short-term Interest Rate Models," *Accounting and Finance*, 43(1), 87-121.

Gray, S. and S. Treepongkaruna, (2002), “How to Value Interest Rate Derivatives in a No-Arbitrage Setting,” *Accounting Research Journal* (15), 1.

Gray, P. and S. Gray, (2001), “A Framework for Valuing Derivative Securities,” *Financial Markets Institutions & Instruments*, 10(5), 253-276.

Gray, P. and S. Gray, (2001), “Option Pricing: A Synthesis of Alternate Approaches,” *Accounting Research Journal*, 14(1), 75-83.

Dahlquist, M. and S. Gray, (2000), “Regime-Switching and Interest Rates in the European Monetary System,” *Journal of International Economics*, 50(2), 399-419.

Bollen, N., S. Gray and R. Whaley, (2000), “Regime-Switching in Foreign Exchange Rates: Evidence from Currency Options,” *Journal of Econometrics*, 94, 239-276.

Duffie, D., S. Gray and P. Hoang, (1999), “Volatility in Energy Prices. In R. Jameson,” (Ed.), *Managing Energy Price Risk* (2nd ed.). London: Risk Publications.

Gray, S. and R. Whaley, (1999), “Reset Put Options: Valuation, Risk Characteristics, and an Example,” *Australian Journal of Management*, 24(1), 1-21.

Bekaert, G. and S. Gray, (1998), “Target Zones and Exchange Rates: An Empirical Investigation,” *Journal of International Economics*, 45(1), 1-35.

Gray, S. and R. Whaley, (1997), “Valuing S&P 500 Bear Market Warrants with a Periodic Reset,” *Journal of Derivatives*, 5(1), 99-106.

Gray, S. and P. Gray, (1997), “Testing Market Efficiency: Evidence from the NFL Sports Betting Market,” *The Journal of Finance*, 52(4), 1725-1737.

Gray, S. (1996), “Modeling the Conditional Distribution of Interest Rates as a Regime- Switching Process,” *Journal of Financial Economics*, 42, 27-62.

Gray, S. (1996), “Regime-Switching in Australian Interest Rates,” *Accounting and Finance*, 36(1), 65-88.

Brailsford, T., S. Easton, P.Gray and S. Gray, (1995), “The Efficiency of Australian Football Betting Markets,” *Australian Journal of Management*, 20(2), 167-196.

Duffie, D. and S. Gray, (1995), “Volatility in Energy Prices,” In R. Jameson (Ed.), *Managing Energy Price Risk*, London: Risk Publications.

Gray, S. and A. Lynch, (1990), “An Alternative Explanation of the January Anomaly,” *Accounting Research Journal*, 3(1), 19-27.

Gray, S. (1989), “Put Call Parity: An Extension of Boundary Conditions,” *Australian Journal of Management*, 14(2), 151-170.

Gray, S. (1988), “The Straddle and the Efficiency of the Australian Exchange Traded Options Market,” *Accounting Research Journal*, 1(2), 15-27.

Teaching

Fuqua School of Business, Duke University, Student Evaluations (0-7 scale):

- Financial Management (MBA Core): Average 6.5 over 7 years.
- Advanced Derivatives: Average 6.6 over 4 years.
- Empirical Issues in Asset Pricing: Ph.D. Class

1999, 2006 Outstanding Professor Award, Global Executive MBA, Fuqua School of Business, Duke University.

UQ Business School, University of Queensland, Student Evaluations (0-7 scale):

- Finance (MBA Core): Average 6.6 over 10 years.
- Corporate Finance Honours: Average 6.9 over 10 years.

2002 Australian University Teaching Award – Business (a national award for all university instructors in all disciplines).

2000 University of Queensland Award for Excellence in Teaching.
1999 Department of Commerce KPMG Teaching Prize, University of Queensland.
1998 Faculty Teaching Prize, Faculty of Business Economics and Law, University of Queensland.
1998 Commendation for Excellence in Teaching, University-wide Teaching Awards, University of Queensland.
1989 Touche Ross Teaching Prize, Department of Commerce, University of Queensland.

Board Positions

2002 - Present: Director, Financial Management Association of Australia Ltd.
2003 - Present: Director, Moreton Bay Boys College Ltd. (Chairman since 2007).
2002 - 2007: External Risk Advisor to Board of Enertrade (Queensland Power Trading Corporation Ltd.)

Consulting

Managing Director, Strategic Finance Group: www.sfgconsulting.com.au.

Consulting interests and specialties, with recent examples, include:

- **Corporate finance**
  - ⇒ **Listed multi-business corporation:** Detailed financial modeling of each business unit, analysis of corporate strategy, estimation of effects of alternate strategies, development of capital allocation framework.

- **Capital management and optimal capital structure**
  - ⇒ **State-owned electricity generator:** Built detailed financial model to analyze effects of increased leverage on cost of capital, entity value, credit rating, and stability of dividends. Debt of $500 million issued.

- **Cost of capital**
  - ⇒ **Cost of Capital in the Public Sector:** Provided advice to a government enterprise on how to estimate an appropriate cost of capital and benchmark return for Government-owned enterprises. Appearance as **expert witness** in legal proceedings that followed a regulatory determination.
  - ⇒ **Expert Witness:** Produced a written report and provided court testimony on issues relating to the cost of capital of a cable TV business.
  - ⇒ **Regulatory Cost of Capital:** Extensive work for regulators and regulated entities on all matters relating to estimation of weighted-average cost of capital.

- **Valuation**
  - ⇒ **Expert Witness:** Produced a written report and provided court testimony. The issue was whether, during a takeover offer, the shares of the bidding firm were affected by a liquidity premium due to its incorporation in the major stock market index.
  - ⇒ **Expert Witness:** Produced a written report and provided court testimony in relation to valuation issues involving an integrated mine and refinery.

- **Capital Raising**
  - ⇒ Produced comprehensive valuation models in the context of capital raisings for a range of businesses in a range of industries including manufacturing, film production, and biotechnology.

- **Asset pricing and empirical finance**
  - ⇒ **Expert Witness:** Produced a written report on whether the client's arbitrage-driven trading strategy caused undue movements in the prices of certain shares.

- **Application of econometric techniques to applied problems in finance**
  - ⇒ **Debt Structure Review:** Provided advice to a large City Council on restructuring their debt portfolio. The issues involved optimisation of a range of performance measures for each business unit in the Council while simultaneously minimizing the volatility of the Council's equity in each business unit.

- ⇒ **Superannuation Fund Performance Benchmarking:** Conducted an analysis of the techniques used by a large superannuation fund to benchmark its performance against competing funds.

- **Valuation of derivative securities**
  - ⇒ **Stochastic Volatility Models in Interest Rate Futures Markets:** Estimated and implemented a number of models designed to predict volatility in interest rate futures markets.

- **Application of option-pricing techniques to real project evaluation**
  - ⇒ **Real Option Valuation:** Developed a framework for valuing an option on a large office building. Acted as arbitrator between the various parties involved and reached a consensus valuation.
  - ⇒ **Real Option Valuation:** Used real options framework in the valuation of a bio-tech company in the context of an M&A transaction.

13 November 2013

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Phone: +61 419 120 348
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Experience

2013-14	Ross School of Business, The University of Michigan (Lecturer in Finance)
2008	Ross School of Business, The University of Michigan (Visiting Assistant Professor in Finance)
2000-14	SFG Consulting (Director)
2000-12	University of Queensland Business School, The University of Queensland (Senior Lecturer)
1997-99	Credit Suisse First Boston (Equities analyst)

Education

2005	PhD in finance from The University of Queensland
2003	Chartered Financial Analyst designation by the CFA Institute
1996	Bachelor of Commerce with First Class Honours from The University of Queensland

Research

Journal articles

Impact of sector versus security choice on equity portfolios, with Ben McVicar, *Applied Financial Economics*, 2013, 23 (12), 991 – 1004.

Unconstrained estimates of the equity risk premium, with Stephen Gray, Tristan Fitzgerald and Ravi Jeyaraj, *Review of Accounting Studies*, 2013, 18 (2), 560 – 639.

Market risk exposure of merger arbitrage in Australia, with Matthew Pinnuck and Matthew Thorne, *Accounting and Finance*, 2013, 53 (1), 185 – 215.

The value of imputation credits on hybrid securities, with Clinton Feuerherdt and Stephen Gray, *International Review of Finance*, 2010, 10 (3), 365 – 401.

Forecast accuracy and stock recommendations, with Paul Tacon, *Journal of Contemporary Accounting and Economics*, 2010, 6 (1), 18 – 33.

Speculation and e-commerce: The long and the short of IT, with Colin Ferguson, Matthew Pinnuck and Frank Finn, *International Journal of Accounting Information Systems*, 2010, 11 (2), 79 – 104.

Bias, stability and predictive ability in the measurement of systematic risk, with Stephen Gray, Drew Klease and Alan McCrystal, *Accounting Research Journal*, 2009, 22 (3), 220 – 236.

Leveraged superannuation, with Peter Dunn and Scott Francis, *Accounting and Finance*, 2009, 49 (3), 505 – 529.

Persistence in growth versus market expectations, with Matthew Tochterman, *Australian Journal of Management*, 2008, 33 (1), 169 – 199.

Relationship between franking credits and the market risk premium: A reply, with Stephen Gray, *Accounting and Finance*, 2008, 48 (1), 133 – 142.

Comment on 'Regulation and the term of the risk free rate: Implications of corporate debt', *Accounting Research Journal*, 2007, 20 (2), 81 – 86.

Valuation of mining projects using option pricing techniques, with Shannon Nicholls, *JASSA*, 2007, Issue 4 (Summer), 22 – 29.

Relationship between franking credits and the market risk premium, with Stephen Gray, *Accounting and Finance*, 2006, 46 (3), 405 – 428.

Electronic commerce investments, the resource-based view of the firm, and firm market value, with Colin Ferguson and Frank Finn, *International Journal of Accounting Information Systems*, 2005, 6 (1), 5 – 29.

Auditor conservatism and voluntary disclosure: Evidence from the Year 2000 systems issue, with Peter Clarkson and Colin Ferguson, *Accounting and Finance*, 2003, 43 (1), 21 – 40.

Working papers

Portfolio rebalancing and mutual fund tournament behavior, with Paul Tacon, Finance and Corporate Governance Conference 2011, FIRN Frontiers in Finance Conference 2011, Financial Management Association Annual Meeting 2012.

The impact of security analyst recommendations on the trading of mutual funds, with David Costello, AFAANZ Conference 2010 (Winner Best Paper in Finance), Australasian Finance and Banking Conference 2010, undergoing revisions for re-submission to *Journal of Contemporary Accounting and Economics.*

Forecasting stock returns using investor flows under short-sales constraints, with Paul Tacon, Australasian Finance and Banking Conference 2011, Finance and Corporate Governance Conference 2012, AFAANZ Conference 2012, Financial Management Association Annual Meeting 2012, Southern Finance Association Annual Meeting 2012.

Presentations

Accounting and Finance Association of Australia and New Zealand Conference (5) 2005, 2007, 2009-10, 2012
Asian Finance Association Conference 2009
Australasian Finance and Banking Conference (2) 2008, 2010
Australian National University Seminar Series 2012
Coal Trade, hosted by AIC Worldwide 1999
Coaltrans Asia, hosted by Coaltrans Conference Limited 1999
Contemporary Accounting Research/Journal of Contemporary Accounting and Economics Joint Symposium 2009
CPA Mining and Energy Conference 2006
Financial Management Association 2012
First Annual Private Equity Conference, hosted by Television Education Network 2007
JBWere Family Business Conference 2010
Melbourne Centre for Consumer Finance Investment & Regulatory Symposium 2008
PhD Conference in Economics and Business, hosted by University of Western Australia 2003
Southern Finance Association 2012
University of Melbourne Seminar Series (2) 2005, 2010
University of Queensland Seminar Series 2008

Referee activity

Accounting and Finance (8 reviews) 2003, 2005, 2009-13
Accounting Research Journal (3 reviews) 2002, 2006, 2010
Applied Financial Economics (3 reviews) 2012-13
Australian Journal of Management 2012
Contemporary Economic Policy 2011
Financial Review 2013
International Journal of Emerging Markets 2013
International Review of Finance 2012
MIS Quarterly 2003
Quarterly Journal of Finance and Accounting 2010
Quarterly Review of Economics and Finance 2012

Research grants

PricewaterhouseCoopers/Accounting and Finance Association of Australia and New Zealand 2006: Returns, tax and volatility – Superannuation choice with a complete information set ($8,500)

Australian Research Council Discovery Grant 2002-4: Quantification issues in corporate valuation, the cost of capital and optimal capital structure ($126,000)

UQ New Staff Research Start-up Fund: The competitive advantage of investments in electronic commerce ($10,000)

Research students

PhD (1 student)

2012 – Paul Tacon

Honours (20 students)

2012 – Edward Parslow (Carnegie Wylie)
2011 – James Lamb (Port Jackson Partners)
2010 – Jeremy Evans (JP Morgan), Sarah Thorne (JP Morgan), Alexandra Dwyer (Reserve Bank of Australia)
2009 – Tristan Fitzgerald (UNSW), David Costello (National Australia Bank), William Toe (Ernst & Young)
2008 – Ben McVicar (Credit Suisse), Matthew Thorne (Credit Suisse)
2007 – Sam Turner (ABN Amro Morgans)
2006 – Paul Tacon (PhD, UQ), Ravi Jeyaraj (Navis Capital), Thomas Green (Crescent Capital), Alexander Pascal-Bossy (Macquarie)
2005 – Angela Gill (Wilson HTM), Andrew Wagner (Macquarie)
2004 – Matthew Tochterman (M. Fin. Eng., UC Berkeley), Justyna Lewandowska (JP Morgan), An Pham (UBS)

Masters (2 students)

2003 – Scott Francis (A Clear Direction Financial Planning), Hernando Barrero (PricewaterhouseCoopers)

PhD reader

Damien Cannavan 2012

Teaching

Ross School of Business, The University of Michigan

Corporate Financial Policy (2008; MBA students; avg. rating 4.3)

UQ Business School, The University of Queensland (Mean teacher ratings out of a possible 5.0)

Awarded undergraduate teaching prize 2009
Empirical Finance Honours (2009-12; PhD and Honours students; avg. rating 4.1)
Corporate Finance Honours (2005 & 2011; PhD and Honours students; avg. rating 4.7)
Investments & Portfolio Management (2002-7, 2009-10 & 2012; B.Com, MBA & M.Com students; avg. rating 3.8)
Corporate Finance (2002-4, 2006-10 & 2012; B.Com, MBA and M.Com students; avg. rating 3.8)
Finance (2005-6; M.Com students; avg. rating 3.7)
Corporate Finance and Investments (Mt Eliza Business School, Beijing 2003; MBA students)
Technology Valuation and Project Evaluation (Singapore 2004; Masters of Technology Management students)
Auditing (Summer 2000/1-2001/2; B.Com, MBA and M.Com students; avg. rating 3.8)

Executive education

Risk Management and Financial Analysis (Rabobank 2000-10)
Financial Analysis of Innovative Investments (UQ Business School 2007)
Credit Analysis (Queensland Treasury Corporation 2005)
Capital Management (UQ Business School 2004)
Making Critical Financial Decisions (UQ Business School 2003)
Business Valuation and Analysis (UQ Business School 2003)
Cost of Capital Estimation (UQ Business School 2003)
Analysis of Real Options (Queensland Treasury 2003)

Student competitions

Rotman International Trading Competition

Manager of the UQ Business School trading team (2007 & 2009-12) which competes annually at the University of Toronto amongst 50 teams. UQ is the 9th most successful entrant from 66 schools which have competed in any of the same years, finishing 3rd in 2010, 6th in 2007, 11th in 2009, 14th in 2011 and 18th in 2012.

UBS Investment Banking Competition

Judge for the UQ section 2006-7 & 2009-12. Faculty representative at the national section 2008.

JP Morgan Deal Competition

Judge for the UQ section 2007-8.

Wilson HTM Research Report Competition

Delivered two workshops as part of the 2006 competition and was one of three judges.

Industry engagement

From 2000-13, I have provided consulting services as part of SFG Consulting and UQBS Commercial. Services have been provided in conjunction with Frontier Economics, ARENA Consulting, Parsons Brinckerhoff and Uniquest.

Retail electricity and gas margins in NSW (Independent Pricing and Regulatory Tribunal 2012)

In 2006-7 and 2009-10 I acted as part of a team which was engaged to estimate electricity costs and margins for electricity and gas retailers in NSW. We have been reappointed for 2012-13. My role related to the estimation of a profit margin which would allow the retailer to earn a return commensurate its systematic risk. The approach developed was novel in that the margin was derived without reference to any pre-defined estimate of the asset base. Rather, the margin was a function of the potential increases or decreases in cash flows which would result from changes in economic conditions. Reports are available from IPART.

Advice on rules to determine regulated rates of return (Australian Energy Markets Commission 2012)

The AEMC is considering changes to the rules relating to regulation of electricity and gas networks. Independent rule change proposals have been put forward by the Australian Energy Regulator and the Energy Users Association of Australia. Both groups argue that application of the existing rules by the regulator generate upwardly-biased estimates of the regulated rate of return. As part of a team I am currently providing advice to the commission on whether the rule change proposals provide evidence on an upward bias, and if so, whether the proposed amendments are likely to reduce the extent of any bias.

Expert evidence relating to regulated rates of return (Electricity network businesses 2011)

In April 2011 the Australian Competition Tribunal heard an appeal by electricity networks on the regulated rate of return set by the Australian Energy Regulator. The issue was the value of dividend imputation tax credits. The Tribunal directed us to perform a dividend drop-off study to estimate the value of a distributed credit. Largely on the basis of our evidence the Tribunal determined that an appropriate value for a distributed credit was 35 per cent of face value. The Tribunal determination is available on its website and our expert report is available on request.

Estimation of risks associated with long-term generation contracts (New South Wales Treasury 2010)

In 2010 the NSW Government privatised a segment of its electricity industry, by selling three electricity retailers and entering into two generation agreements termed GenTrader contracts. The state-owned generators agreed to provide generation capacity in exchange for a charge. The generators also agreed to pay penalties in the event that their availability was less than agreed. As part of a team, I provided advice to NSW Treasury on the risks associated with the contracts. The estimated penalties resulting from this analysis are used by NSW Treasury in their budgeting role and in providing forward-looking analysis to the Government.

Litigation support relating to asset valuation (Alcan 2006-7)

In 2006-7 I acted as part of a team which provided litigation support to Alcan in a dispute with the taxation authority in the Northern Territory. The dispute related to whether Alcan was required to pay stamp duty as a result of its acquisition of an additional 30 per cent interest in Gove Alumina Limited. One issue was whether the acquisition was land-rich, meaning that the proportion of the asset considered to be land exceeded a threshold triggering stamp duty.

Methodology for evaluating public-private partnerships (Queensland Treasury Corporation 2005)

In 2005 I acted as part of a team which advised QTC on evaluating public-private partnerships, which typically require subsidies to appeal to the private sector. We rebutted the conventional wisdom, adopted in NSW and Victoria, that the standard valuation approach is flawed for negative-NPV projects. Furthermore, we developed a technique to incorporate systematic risk directly into expected cash flows, which are then discounted at the risk-free rate.

Litigation support

Insolvency proceedings relating to the collapse of Octaviar (Public Trustee of Queensland 2008-9)
Valuation of resource assets (Compass Resources 2007-8, Westpac Banking Corporation 2007)
Appeals against regulatory determinations (Envestra 2007-8, Telstra 2008)
Advice on whether loan repayments correspond to contract terms (Qld Dept. of Fair Trading 2005)
Advice on whether port and channel assets were contributed and hence not part of regulated assets (Comalco 2004-5)

Valuation

Management performance securities (Collins Foods Group 2006-11, GroundProbe 2008-9)
Ordinary shares in the context of an equity raising (Auscript 2007-8)
Intangible assets (Inbartec 2007)
Resources assets (Senex Energy 2012, Chalco 2007, Bank of Queensland 2007)

Cost of capital estimation, advice and regulatory submissions

Transport (Qantas 2008, QR National 2005 & 2012)
Water (Essential Services Commission of South Australia 2012, ActewAGL 2012, IPART 2011, Metropolitan utilities in Victoria 2004 & 2006-7, QCA 2002-3)
Energy networks (Economic Regulation Authority in Western Australia 2009, Hong Kong Electric 2007, Envestra 2006-7 & 2012, Powercor 2005, AGL 2004, Energex 2003-4, Ergon Energy 2003-4)
Local government networks (Queensland Competition Authority 2009)
Electricity generation (National Generators Forum 2008)
Environmental consulting (Ecowise 2007)
Listed vs unlisted infrastructure funds across alternative European equity markets (ABN AMRO Rothschild 2007)
Forestry assets (Queensland Department of Natural Resources 2004)

Portfolio performance measurement

Performance evaluation and benchmark derivation (Friday Investments 2010-12, Zupp Property Group 2011-12)

Corporate finance

Economic impact assessment of a proposed development of a retail shopping complex (Lend Lease 2006)
Impact of an acquisition on dividend growth, earnings per share and share price (AGL 2003-4)
Estimation of the optimal capital structure for electricity generation and distribution (NSW Treasury 2001-2)
Review of the debt valuation model used by the Snowy Hydroelectric Authority (NSW Treasury 2002)
Estimation of the optimal contract terms for coal sales to an electricity generator (NSW Treasury 2001-2)

Econometrics

Scoping study into the determinants of changes in tax debt in Australia (Australian Taxation Office 2007)

Interests

I am interested in sport as a participant and spectator. I finished 3rd on three occasions in the Brisbane Half Marathon (2005 & 2009-10), 8th in the Toronto Half Marathon (2002) and 3rd in the Australian Universities Marathon Championships (2003). I have finished 17 marathons, recording a best time of 2:47:54 in the Chicago Marathon 2011. From 1994-96 I was a member of The University of Queensland tennis team, which placed 1st at the Australian University Games in 1994.