Report to the AER: Alternative Asset Pricing Models

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Author’s Credentials

This report has been prepared by Graham Partington and Stephen Satchell. We have extensive experience as senior finance academics and have published several finance books and many research papers in finance. We also have extensive consulting experience, including work covering the cost of capital and valuation. Our *curricula vitae* can be found in Appendix 2.

We have read the “Federal Court of Australia: Expert Evidence Practice Note”, which is attached as Appendix 3. This report has been prepared in accordance with the guidance provided by the practice note. An expert witness compliance declaration follows the reference list at the end of our report.

Contents

1. Executive summary

The AER has approached us with a request to consider the following asset pricing models and any additional models that we considered relevant:

- SL CAPM as a domestic model (as used as the 'foundation model' in 2018)
- International CAPM (the standard CAPM populated with international parameters)
- Black CAPM (also labelled the zero-beta CAPM)
- Fama-French three factor model
- A model where equity return equals the risk-free rate plus a fixed margin
- The dividend growth model

The request also asks us to evaluate the models with respect to the following criteria and add and any criteria that we considered relevant:

- Reliability—produces estimates of the return on equity that reflect economic and finance principles, empirical evidence, and market information; estimates have minimal error, and are free from bias.
- Relevance to the Australian benchmark—as the benchmark firm operates in Australia; this may include ability to populate the model with Australian-relevant data.
- Suitability for use in regulated environment—this may include transparency, replicability, and consideration of any incentive effects.
- Simplicity–avoids unnecessary complexity or spurious precision, is able to be understood by a broad stakeholder set.

The full terms of reference relevant to this report are contained in Appendix 1.

We investigated the above models as well as several others that we considered might be relevant. We shall list each of them in turn:

- 1. SL-CAPM as a domestic model (as used as the foundation model in 2018).

Here we conclude that the SL-CAPM satisfies clear economic principles and it has a strong theoretical basis. While the model has been subject to empirical attack it also has empirical support, especially in recent research. The SL-CAPM is the foremost model for estimation of the cost of equity both in industry practice and in regulation. In our opinion it is the model most likely to give estimates that have the least error and are unbiased. Australian data is easily obtained for its estimation, although the very small sample currently available for the estimation of beta is a potential problem. Calculations are very easy to replicate. The model is straightforward and since it relates to a simple linear regression, it can be understood by a wide audience.

- 2.International CAPM (the standard CAPM populated with international parameters)

This is less a model than a procedure. Simply populating the standard CAPM with international parameters is not appropriate unless it is assumed that purchasing power parity holds universally. An alternative is to use a model that introduces currency risk factors, but the cost of a more plausible model is greater complexity. We conclude that using an international CAPM adds significant difficulties for no clear benefit. We also refer to the suggested use of betas from other countries to augment the betas from the set of energy companies that are available in Australia. There appear to be no justifiable economic principles involved. We demonstrate that there is no simple way that these estimates can be converted into Australian betas, that the data issues are complex and we argue that such a procedure would be open to gaming.

- 3. The Black CAPM

This model satisfies the same economic principles that the SL-CAPM does, indeed it is a generalisation of the SL-CAPM. However, the generality comes at a cost as it introduces some complex estimation issues which makes a clear understanding of the econometric issues something that only experts will have. The key variable to be estimated when applying the Black CAPM is the return on the zero-beta asset, which is substituted for the risk-free rate used in the SL-CAPM. There is little benefit in undertaking this estimation when there is a widely accepted and easily observable measure of the risk-free rate, which is the return on 10-year government bonds. Moreover, estimation of the zero-beta return typically throws up rather large, quite variable, and implausible values. We see no merit in its use in a regulatory environment.

- 4. Fama-French three factor model

The difficulty with this model is that has very little economic underpinnings as it is not based on a theoretical model. The risk factors in the model have been derived from the analysis of data and this approach to deriving risk factors has resulted in hundreds of such factors in recent years. The three factors involved in Fama French model can be constructed in many different ways and therefore can be easily manipulated to give specific answers. It is, however, widely used in funds management and the factors, value, size, and the market are well understood by the investment community. It is rarely used for estimation of the cost of equity by companies, or for regulatory purposes. The model has been estimated using Australian data, but the very mixed results obtained are not encouraging for its use in regulation. Recent empirical research in the US and Australia has not supported the model. We also consider several extensions of this model where the same arguments apply.

- 5. The consumption CAPM.

This was not listed by the AER but is worth addressing as it has strong theoretical arguments in its favour. Unfortunately, its empirical performance is poor and there are complex issues to do with estimation and data. We think that this model is worth considering because of its theoretical merit but it is not currently a practical tool that could be used for regulation.

- 6. A model where equity return equals the risk-free rate plus a fixed margin.

This model is simple to understand, needs very little data and would be able to be understood by a broad stakeholder set. The SL-CAPM is a special case where the fixed margin would be the equity risk premium multiplied by the appropriate beta. However, other than that case, it is not obvious how the fixed margin would be determined on an objective basis.

- 7. The dividend growth model

The dividend growth model is based on economic principles and has a solid theoretical foundation. The issues with the dividend growth model arise in relation to its implementation. There many versions of the dividend growth model that might be implemented, but all of them face difficulties in respect to forecasting dividends and the correct adjustment for capitalisation changes. In respect to estimating the cost of equity there are also substantial problems in separating the effect of cash flow news from discount rate news. Estimating of the growth rates required for these models is also a contentious issue. Dividend growth models were once used to estimate the cost of equity in practice, but their use for this purpose has now been substantially discontinued. This is unsurprising given the problems that we identify.

Overall, we consider that the only model that satisfies the criteria listed by the AER is the SL-CAPM, and recent evidence strengthens this recommendation. We do not recommend the use by the AER of any of the other models. An understanding of our reasons for making this recommendation can be obtained by reading the full report. However, for readers who are time poor, we recommend that this executive summary should be read in conjunction with the evaluation and recommendation sections that conclude the discussion of each model in the body of the report.

2. Introduction

In this report we provide a review and evaluation of asset pricing models. The recommendations that result from our review can be found in a summary and recommendation section that concludes the discussion for each asset pricing model. In evaluating the suitability of these models for use by the AER we use the criteria provided by the AER and our own criteria, which represent a particular focus within the broad criteria set by the AER. These criteria, which we discuss in Section 3, are theoretical support for the model, extensive practical use in estimating the cost of capital, limited opportunities for gaming, and empirical validation. However, as will be evident from our report the latter is not so easy to do.

Our review and evaluation is based on an extensive search of the research literature, an analysis of that literature, insights based on our combined experience which is approaching 100 years in academia, financial/economic research and consulting, and our particular experience in relation to the rate of return guidelines and to debates about determination of the regulatory rate of return for the network businesses.

Here we provide a brief summary of recent research in relation to the cost of equity. We do not attempt to summarise all the research that we have considered in the body of the report, but rather outline issues that are particularly important to the determination of the regulated rate of return. More details and relevant references can be found in the body of the report.

A striking feature of recent asset pricing research is a tsunami of factors that it is claimed determine the rate of return, over 400 at a recent count. Mirroring this trend, the Fama and French three factor model has expanded by progressively adding factors to become a six factor model. As the number of factors in the research literature has continued growing, there has been increasing concern about the quality of the evidence. In particular there has been concern about data-mining. Recent empirical research which has addressed the data mining problem finds that there is only one factor that really matters and that is the market factor. Other recent research has shown that the magnitude of alpha (low beta bias) is a function of the holding period over which the returns used to estimate beta are measured. With longer holding periods alpha shrinks to insignificance. This work concludes that betas estimated from short holding periods are poor measures of fundamental risk exposure and that regulators should prefer betas based on monthly or quarterly holding periods.

3. Asset Pricing Models

We begin with a general description of the nature of asset pricing models. We also consider criteria that represent a particular focus within the broad criteria set by the AER and the issue of averaging across models.

What are asset pricing models?

Asset pricing models give the return that investors require in order to induce them to invest. They can be used to determine the return on equity for purposes of valuation and for determining the regulated rate of return. These models are referred to as asset pricing models because in equilibrium asset prices will adjust such that the expected return is equal to the required return. Since they give the equilibrium expected return, asset pricing models are commonly described as expected return models. For example, suppose the required return on a share currently priced at $90 is 10%. Further suppose the expected cash flow in perpetuity is $10, then the expected return is 10/90 or 11.11%. Since the expected return exceeds the required return there will be buying pressure that pushes the share price to $100. Now equilibrium is restored and the expected and required returns on equity are both 10%.

Required returns generally have two components, the first is compensation for deferring consumption. This can be thought of as the price of time, as given by the risk free rate of return. In empirical applications this is usually proxied by the rate of return on government securities. The second component of the required return is compensation for the risk borne by investing in an asset, specifically the risk that the actual return obtained may not match the return expected. Uncertainty in returns means that future wealth and hence future consumption are uncertain. Traditionally, asset pricing models like the SL-CAPM (Sharpe Lintner CAPM) were based on the impact that variations in returns have on wealth and thus implicitly variation in consumption. However, the development of the C-CAPM (Consumption CAPM) signalled an increasing focus on consumption based asset pricing models. We briefly consider consumption based models in Section 9.

Desirable attributes for models

It is desirable for there to be a well-accepted theory that explains how and why an asset pricing model determines required returns. This is fundamental to understanding the nature of the model, how it works and the risk that it captures. Theory matters in asset pricing, as Fama and French (2017, p.6) put it:

> *In the ideal case, theory provides fully specified models that lead to precise statements about the relation between an asset's measurable characteristics and its expected return. The CAPM of Sharpe (1964) and Lintner (1965) is a prime example, and its fully specified predictions about risk and expected return explain its lasting attraction.*

For the purpose of regulation, it is a pre-requisite that the model be implementable, and it is desirable that the use of the model is widely accepted. Widespread use in the practice of estimating the return on equity is relevant here. Such use is evidence that the model is widely accepted, that implementation is not excessively difficult and that the model has practical usefulness.

Self-interest is a powerful force and there is a natural tendency to believe that results that serve self-interest are the truth. Thus, it is to be expected that consumer groups will favour models, and inputs to those models, which yield lower rates of return, while network businesses will favour models, and inputs to those models, which yield higher rates of return. In other words, there are incentives for sub-conscious and conscious gaming. For the purpose of regulation, therefore, it is desirable that the asset pricing model has limited opportunities for gaming.[1]

Finally, it is desirable that the model can be empirically validated. However, successfully testing asset pricing models is a challenge that has proved to be difficult to meet.[2] This is one reason why we attach significant weight to the practical use of an asset pricing model over an extended period. The test of time and extended use in estimating the cost of equity provides evidence of a model that for the practical purpose of estimating the weighted average cost of capital (WACC) has been judged good enough.

Averaging across models

We conclude this section by considering the argument that a better estimate can be obtained by averaging across asset pricing models, rather than relying on a single model. This can be true when the models are measuring the same thing and the measurements are unbiased. However, in the case of asset pricing models, it is not clear that this is always the case. The more so when gaming is a possibility. Averaging adds to the gameable dimensions of the regulatory process. Any averaging that moves the return in your favour is desirable, but the objective of the game is to get the most favourable averaging process that you can. For the regulated networks this means down weighting the models that give lower returns and up-weighting models that give higher returns, for consumers it is the reverse.

Even if there is no gaming, use of a single model can be the best option. Averaging is not always better. To illustrate this, we repeat an analogy that we have previously used. An examiner who knows about the subject material will alone provide a better assessment of the examinee's

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[1] We would like to say no opportunities for gaming, but no model that we know of has this property.

[2] We discuss several of the problems in the rest of the report, particularly in section 4.

ability than averaging his assessment with that of ten examiners who are ignorant about the subject. Let us be absolutely clear, our point is not that averaging is worse than relying on a single model, but rather that averaging is not automatically better.

4. Interpreting asset pricing test results

Before considering the individual asset pricing models, we consider the interpretation of the tests of such models. We do this because a great deal of the debate about asset pricing models revolves around empirical testing. Therefore, it instructive to consider what the results of a test of say the CAPM, or other asset pricing models, might mean. The evidence provided can be:

1. Unreliable because of data problems - the result is driven by the problems in the data.
2. Unreliable because of problems with the method (experimental design) and/or problems with the test(s) used to determine the statistical significance of the results - the result is an outcome of faults in the experimental design, or mis-specified statistical tests that give the wrong significance levels.[3]
3. Valid evidence
   i. the evidence has alternative interpretations,
   ii. the evidence is unambiguous.

We now provide examples for each case. These examples are illustrative rather than exhaustive and, in most cases, apply across tests of different models.

Problems with the data

A key issue in both the testing and implementation of asset pricing models is that the inputs required are expected values, which are not directly observable. In tests of asset pricing models actual returns are commonly used as a proxy for expected returns. If the way actual returns are used in asset pricing tests provide a poor proxy for expected returns, then clearly the tests suffer from a major data problem. It is well understood that short holding period returns are very noisy measures of expected returns. It is also clear that this is a potentially serious problem. Whether CAPM tests, for example, have successfully resolved this problem is an open question.

Since betas are generally estimated from returns, a related issue with regard to data arises in the estimation of betas (risk measures). Here we refer to the results of Gilbert, Hrdlicka, Kalodimos and Siegel (2014) who show that evidence for rejection or acceptance of the CAPM depends on the length of the holding period for the returns that are used to estimate beta.

Problems with method or statistics

There are many papers that address problems with the design of asset pricing experiments and/or problems with the test statistics. A much cited example[4] is "A skeptical appraisal of asset

[3] We include both the experimental design and statistical testing within the one point because they are often closely related.
[4] Google reports over one thousand citations.

pricing tests" Llewellen, Nagel and Shanken (2010). Their critique is particularly relevant to the "significance" of variables that in addition to market beta "explain" returns. We quote their abstract in full:

> *It has become standard practice in the cross-sectional asset pricing literature to evaluate models based on how well they explain average returns on size-B/M portfolios, something many models seem to do remarkably well. In this paper, we review and critique the empirical methods used in the literature. We argue that asset pricing tests are often highly misleading, in the sense that apparently strong explanatory power (high cross-sectional R^2s and small pricing errors) can provide quite weak support for a model. We offer a number of suggestions for improving empirical tests and evidence that several proposed models do not work as well as originally advertised.*

Another prevalent problem in testing asset pricing models is the search for significance, which Harvey (2017), in his presidential address to the American Finance Association, labels p-hacking.[5] The term p-hacking refers to both subconscious and conscious manipulation of data and methods, and particularly the running of multiple test to try and obtain a "statistically significant" result.

"I had a hypothesis, but I could not find any support for it", is not what most researchers want to report and is not so likely to get published. Thus, there is a strong temptation to say "maybe my model specification/data set is not quite right, perhaps I should change it in this way or that and run another test."[6] Multiple tests are a problem, because if you run 100 tests at the 5% significance level it is normal to get five significant results that are not really significant, but rather represent false rejections of the null hypothesis. Unfortunately, it is only the significant results that tend to get reported. This would not be such a problem if researchers gave their error rate (significance level) for the whole experiment, thus accounting for multiple tests, or if they reported that in obtaining five significant results they ran a hundred tests. However, this is not often done.

Even if all researchers only ran one test, there would still be a problem. In asset pricing research, there are hundreds, or thousands, of researchers who are working on much the same data sets. The effect is that multiple testing is taking place, the tests are just being run by different people. Because there is a publication bias towards significant results, work that finds a significant factor to explain returns is more likely to be published, which gives a one sided view of the evidence. This problem is intensified by what Harvey (2017) describes as the file drawer effect. Research with non-significant results may not even be submitted to journals. The researcher realises the chance of publication is reduced and even if the research is published non-

[5] Other labels include data mining, data dredging, and multiple comparisons.
[6] We note that sometimes such changes are entirely justified.

significant results tend to get less citations, so the researcher gives up and files the research away.

In the environment that we have described above it would be no surprise to find a flood of factors that are "significant" in explaining returns. That is exactly what has happened. The researchers are likely to claim that such factors are priced (risk factors that determine expected returns). We doubt that this is often, if ever, true and we are not alone in this view. Harvey, Liu and Zhu (2016), addressing the multiple test problem say in their abstract:

> *We argue that most claimed research findings in financial economics are likely false.*

Pause for a moment and let that statement sink in. The statement refers to empirical work, so findings from theory are excluded. Also, the statement is unlikely to apply to empirical research that fails to reject the null hypothesis, but such work is little published.[7] Whether most of the other empirical research findings in financial economics are in fact false is an open question.[8] However, we would certainly agree that most reported significance levels are misleading. Most will understate the experimental error rate, so many of the claimed results are much more likely to be false than the reported significance level would suggest. This is particularly so in the search for factors that are priced/explain returns.

Alternative interpretations

With respect to alternative interpretations of results a pervasive issue is the joint hypothesis problem. As Fama (2013) puts it in his Nobel Prize address:

> *Market efficiency is always tested jointly with a model of market equilibrium, but the converse is also true. Common asset pricing models, like the capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965), Merton's (1973a) intertemporal CAPM (the ICAPM), and the consumption CAPM of Lucas (1978) and Breeden (1979), implicitly or explicitly assume that all information is costlessly available to all market participants who use it correctly in their portfolio decisions—a strong form of market efficiency. Thus, tests of these asset pricing models jointly test market efficiency.*

A further example of alternative interpretations of results relates to the positive alpha (low beta bias) in CAPM tests. Many academics interpret this as valid evidence against the CAPM, and network businesses have argued that the regulated return should be adjusted upwards on the basis that the CAPM underestimates the expected returns for low beta stocks. We have

[7] Lack of publication opportunity is one reason why searching for insignificance by multiple testing is unlikely.
[8] With respect to anomalies (supposed sources of abnormal returns) in the asset pricing literature the evidence is that most are false or misleading. Hou, Xue and Zhang (2020) examine 452 published return anomalies and find more than 80% are no longer significant after controlling for microcaps and a modest increase, to allow for multiple testing, in the *t*-statistic used as the hurdle for significance.

suggested an alternative explanation, alpha is a measure of abnormal realised returns. That is, the actual returns to investors in low beta stocks have been a pleasant surprise. They exceeded the return that investors expected, and this has given rise to a positive alpha. Another interpretation is that the rolling beta estimates, typically used in tests of the CAPM, have measurement errors that result in a systematic bias against the CAPM. The consequence of such measurement errors is a flattening of the empirically observed relation between beta and returns.

Valid and unambiguous evidence

An example where valid and unambiguous evidence can be obtained is from the results of experimental market studies on asset pricing. These are laboratory studies, controlled experiments in which the researcher can manipulate the variables and most importantly the expected return is known since it is set by the researcher. For a well-designed experiment, the result will be valid and unambiguous. Unfortunately, there is still the question of whether the result can be generalised to real markets.

Last words on test problems

We are not dismissing out of hand all the empirical asset pricing literature. However, there are issues still to be resolved in asset pricing tests, and this needs to be borne in mind when evaluating the evidence that they provide. The issues uppermost in our minds have been measurement error in general and particularly the unobservability of expected returns, the multiple testing problem, robustness of test statistics, and the potential for bias in tests using portfolios rather than individual stocks. Progress is being made in respect to some of these issues, but we expect there are more developments to come.

We leave the last word to Fama and French (2017, p.26)

> *Finally, statistical inference is always clouded by multiple comparisons issues. In asset pricing, we typically use data scoured by many before us, and the questions addressed are conditioned by previous work, typically on much the same data. In the absence of fresh data, inferences about reliability should reflect the union of all earlier tests (reported and unreported) – an impossible goal. Our point is that, if we limit the models considered in a study, we have a shot at ordering them in a statistically meaningful way, even though the overall level of p-values is necessarily clouded.*

5. Standard SL-CAPM as a domestic model (as used as the 'foundation model' in 2018)

The SL-CAPM (hereafter CAPM)[9] is given by:

$$E[r_i] = r_f + \beta_i\left(E[r_m] - r_f\right)$$

where $E[r_i]$ is the expected rate of return on asset *i* when the price is in equilibrium, *m* is the market portfolio with expected rate of return $E[r_m]$, the risk-free rate of return is r_f and β_i is a standardised measure of covariance risk, which represents non-diversifiable risk of asset *i.*

$$\beta_i = \frac{Cov(r_i, r_m)}{\text{Var}(r_m)}$$

where $Cov(r_i, r_m)$ is the covariance of the rate of return on asset *i* with the rate of return on the market and $\text{Var}(r_m)$ is the variance of the rate of return on the market. In what follows we shall use the term return as synonymous with the rate of return.

Theory and testing

There is no doubt that the CAPM has a very clear theoretical foundation based on finance and economic principles. The Sharpe Lintner version is compatible with simple notions of market equilibrium, unlike many of the competing models. Since the development of the SL-CAPM other more complex CAPM models have been theoretically derived. However, complexity comes at a cost of greater difficulty in both understanding the models and more importantly implementing the models. None of these models has gained much traction in practice.

Early empirical tests of the CAPM were supportive of the CAPM in that returns were an increasing function of beta, for example Black, Jensen, and Scholes (1972) and Fama and MacBeth (1973). However, even in this early work there was evidence, as in Black, Jensen, and Scholes (1972), that low beta stocks did better than predicted by the CAPM and high beta stocks did worse. Subsequent to the early tests there is a considerable body of empirical work, which does not support the CAPM. Consequently, the CAPM has been the subject of substantial criticism and even outright rejection. For example, Fama and French (1992, p.428) conclude that their results *…do not support the most basic prediction of the SLB (Sharpe, Lintner, Black) model…* and Dempsey (2013) considers that the CAPM is a failed idea in finance.

While there have been plenty of critics of the CAPM, there has been no shortage of defenders. They have supported the model on both theoretical and empirical grounds. For example, Black (1993), Ang and Chen (2007), Ray, Savin and Tiwari (2009), Levy (2010), Buss and Vilkov (2012) Brown and Walter (2013), Bai, Hou, Kung, Zhang (2015), Andrei, Cujean and Wilson (2018) and Hasler and Martineau (2020). A different approach to testing asset pricing models is presented

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[9] While other variants of the CAPM have their labels, ICAPM, CCAPM and so on, the use of CAPM for the SL-CAPM is common practice.

by Berk and van Binsbergen (2016). They examine capital flows in and out of mutual funds and test asset pricing models in terms of their ability to explain these flows. In essence, they compute outperformance measures relative to alternative asset pricing models and then determine which of these metrics best explains the capital flows to mutual funds. They say in their conclusion:

> *Our study is motivated by revealed preference theory: if the asset pricing model under consideration correctly prices risk, then investors must be using it, and must be allocating their money based on that risk model. Consistent with this theory, we find that investors' capital flows in and out of mutual funds does reliably distinguish between asset pricing models. We find that the CAPM outperforms all extensions to the original model, which implies, given our current level of knowledge, that it is still the best method to use to compute the cost of capital of an investment opportunity.*

The main criticisms of the CAPM are based on two empirical results. First, that the empirically estimated slope of the CAPM is flatter than would be consistent with the CAPM[10] (the so called low beta bias), or equivalently that there is a positive alpha. In some cases, the empirical slope flattens to the point that there is no relation between beta and returns, or even goes negative. Second, variables other than beta are significant in empirically explaining returns, whereas in the CAPM it is only exposure to market risk that explains returns. There are many papers consistently supporting the two types of empirical rejection of the CAPM and this can fairly be described as a large body of evidence against the CAPM. However, as we have earlier discussed there are significant problems in testing asset pricing models, and we discuss some further major problems below. There is an important distinction to be made here, empirical work explains actual returns, whereas the CAPM explains expected returns. Because a variable does (does not) explain actual returns does not necessarily mean that it does (does not) explain expected returns.

The CAPM, has proved to be a robust model in two ways. First, as evidenced by the fact that it is still extensively taught and has continued its extensive use in practice, the CAPM has been resistant to attempts to kill it off. It has survived several obituaries. In response to the question "What do you think of the talk that beta is dead?" Burton (1998) reports Sharpe's answer as:

> *The CAPM is not dead. Anyone who believes markets are so screwy that expected returns are not related to the risk of having a bad time, which is what beta represents, must have a very harsh view of reality.*
>
> *"Is beta dead?" is really focused on whether or not individual stocks have higher expected returns if they have higher betas relative to the market. It*

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[10] It has been suggested that this is due to leverage constraints on investors leading to a clientele with a preference for high beta stocks as an alternative to leverage. Consistent with this, recent results of Jylha (2018) show that increasing margin requirements lead to a flattening of the relation between beta and returns.

> *would be irresponsible to assume that is not true. That doesn't mean we can confirm the data. We don't see expected returns; we see realized returns. We don't see ex-ante measures of beta; we see realized beta. What makes investments interesting and exciting is that you have lots of noise in the data. So it's hard to definitively answer these questions.*

Second, the CAPM has been somewhat robust to relaxing its underlying assumptions. In the words of Brealey, Myers and Partington and Robinson (2000, p.223):

> *It turns out that many of the assumptions are not crucial, and with a little pushing and pulling it is possible to modify the capital asset pricing model to handle variation in the assumptions. The really important idea is that investors are content to invest their money in a limited number of benchmark portfolios. (In the basic CAPM these benchmarks are Treasury notes and the market portfolio.)*
>
> *In these modified CAPMs expected return still depends on risk, but the definition of market risk depends on the nature of the benchmark portfolios. In practice, none of these alternative capital asset pricing models is as widely used as the standard version.*

Smith and Walsh (2013), argue that the CAPM is half right. Their paper has a striking title: *Why the CAPM is half right and everything else is wrong.* They argue that the CAPM is half right on the basis that a pricing equation closely resembling the CAPM can be derived from the classic Arrow Debreu state price approach, but it is only half right in that the derivation requires a linear model of expectations and also that the CAPM is only consistent with constant state prices. Neither condition necessarily holds. Despite this they conclude (p. 77) that:

> *We have made a strong case that in terms of asset pricing that the CAPM is still the only game in town and that the so-called factor models fall foul of the tautology of Markowitz mean variance mathematics.*

Tautology in testing

The tautology that Smith and Walsh (2013) refer to is that for *any* portfolio on the mean variance efficient frontier there will be a perfect linear relation between the return on an asset and the asset's beta computed with respect to the particular portfolio selected. Roll (1977) points out that as a consequence there is only one test for the CAPM: Is the market portfolio mean variance efficient? If it is the CAPM automatically holds. Unfortunately, since the market portfolio covers all capital assets, including asset classes such as unlisted equity, debt, art and so on, measurement of the returns on the portfolio is not feasible and hence testing the market portfolio's efficiency is not possible. Roll further points out that given any sample of ex-post returns on individual assets there will exist an infinite number of ex-post efficient portfolios. This is important, it has major implications both for interpreting the evidence against the CAPM and the evidence supporting other factor pricing models such as the Fama and French three factor model. We examine this further when we discuss the Fama and French three factor model.

A stock market index, as commonly used in empirical work, is clearly not the full market portfolio, but rather is used as a proxy. Shanken (1987) estimates that if the correlation between the proxy and the market portfolio is about 0.7 then rejection of the CAPM with the proxy implies rejection of the CAPM with the true portfolio. Tests however are sensitive to whether the proxy is an efficient portfolio. Roll and Ross (1994) show that if the proxy portfolio is not mean variance efficient then very small deviances from a true efficient market portfolio can have a substantial effect on the estimated relation between beta and returns. An even stronger position is taken by Diacogiannis and Feldman (2011, p.28) who argue that: *… it is meaningless to use inefficient benchmarks to implement regressions of CAPM, which is designed to use efficient benchmarks.*

Expected returns cannot be observed so the empirical tests have been based on assuming that some average of actual past returns equal the expected return. However, in experimental markets the expected returns can be set by the experimenter, the actual returns can be allowed to evolve in the experiment and the prices that emerge can be observed. Results for experimental markets provide support for the CAPM. Bossaerts and Plott (2002) report that in two of their other experimental market papers, Bossaerts and Plott (1999) and Bossaerts, Plott and Zame (2000), prices converged to a CAPM equilibrium. In Bossaerts and Plott (2002), where the experiment creates a thin market, there was also convergence toward the CAPM equilibrium, but it was slower and was not complete by the end of the experiment.

Beta and factors

Here we consider four recent research papers. Since the CAPM beta has been a contentious issue with respect to the regulated return, we consider two recent developments in research looking at the low beta anomaly and the term structure of beta. We also present two recent papers about which factors really explain returns. We discuss these latter two papers because they have substantial methodological strengths. They use a method that allows tests with individual stocks as well as portfolios. Portfolios are commonly used in asset pricing research, but the disadvantage of portfolios is that tests can be biased towards the factors used to sort/form the portfolios. The disadvantage of individual stocks is that they provide noisy return data, which makes it difficult to sort the signal from the noise, as a result tests lack statistical power. These papers overcome the noise problem and also control for multiple testing using robust statistical tests.

Beta

Equilibrium models that capture the salient features of the low beta anomaly are given by Zhu (2019). In equilibrium, assets with greater exposure to systematic risks either measured by CAPM beta, or duration of cash flow, carry lower risk premia, while the real risk-free bonds have an upward-sloping yield curve. The models presented (there are two) feature shocks to the future distribution of consumption growth, or long-run future. Long-maturity zero-coupon bonds provide hedges against such shocks, while short-maturity zero-coupon bonds do not.

Consequently, the demand for long-maturity bonds is higher, resulting in higher prices and lower yields.

We present this research as it shows that that low beta bias is not necessarily a contradiction of theory, but a description of what can rationally happen in a more complex economy where agents possess more complex utility functions. The theory is interesting but it does not suggest to us that any form of adjustment is necessary to beta in the regulatory framework.

Clara (2015) finds that what really matters for pricing the cross-section of returns is the slope of the beta term-structure, i.e., the difference between the long-term beta and the short-term beta. By studying the time-series properties of the slope of the term-structure of beta, he finds that it spikes on relevant macroeconomic and firm-specific events. For example, during bad times such as the Great Recession, the slope of the term-structure of systematic risk of value (growth) portfolios spikes down (up). This means that the short-term beta for value stocks spikes up vis-a-vis its long term beta.[11] Value firms have many assets in place; thus, in recessions, they are much riskier than growth firms. Market participants price this riskiness: the portfolio's term-structure becomes very negatively sloped as investors recognize the higher risk of these stocks in the short-term but expect it to diminish as the economy recovers.

The innovation here is to use information from the options market to compute betas of different maturities. The difficulty of this approach is that options are computed under the Q-measure (risk neutral probability measure appropriate for hedged instruments) rather than the P-measure (physical probability measure appropriate for normal financial entities). The conversion from one measure to the other involves calculations that are open to gaming, also low trading volumes can be an issue in the Australian options market, so the procedure is not appropriate for regulation. However, the basic idea that long run and short run beta might be helpful information is relevant. In the light of this, our subsequent discussion of estimating beta at a ten year horizon and the work of Gilbert et al. (2014),[12] it may be worthwhile to further investigate both the term and frequency of observation for estimating a regulatory beta.

What factors really explain excess returns?

Harvey and Liu (2019) provide a new methodology which they apply to asset pricing tests. In our judgement this paper is a very important contribution to the research literature and it already has hundreds of citations. Without diverting the discussion down too technical a path, they construct a resampling technique for financial data which can capture both time-series and cross-sectional correlation in the data. This is very useful as both are believed to be present. Resampling allows one to get accurate critical values for hypothesis testing in many circumstances. Their results are very striking; we quote from their abstract:

[11] There are parallels here with Bai et al. (2015) discussed earlier.
[12] This work is discussed in more detail under the heading: Implementing the CAPM.

Our method can be applied to both asset pricing tests based on portfolio sorts as well as tests using individual asset returns. In contrast to recent asset pricing research, our study of individual stocks finds that the original market factor is by far the most important factor in explaining the cross-section of expected returns.

It is worth pausing to note the relevance of this message. Using what can be thought of as state of the art methodologies, the authors find that the one model that cannot be rejected is the market model, consistent with the CAPM.

An Australian study, Hoang, Cannavan, Gaunt and Huang (2019), that is comprehensive in its scope,[13] sets out to investigate which factors really are risk factors in the Australian market.[14] Using the Harvey and Liu (2019) method, the result is very clear, the only significant factor explaining realised excess returns in Australia is the market factor. In their words:

We find that the market factor is the only true risk factor.

This is a robust result. The result is obtained in tests based on individual stocks, with both equally weighted and value weighted test statistics, using portfolios, deleting the smallest stocks (microcaps) from the sample, grouping together related factors and using block bootstrapping in the resampling to allow for possible time dependence in the data structure.

Implementing the CAPM

Relative to the other asset pricing models, we discuss implementation of the CAPM in considerable detail. This is because in several cases the same/analogous issues arise in implementing the other models, and it would be excessively tedious for the reader if we kept repeating ourselves.

For the CAPM the key problem is that we are modelling equilibrium expectations. Expectations cannot be directly observed, and neither can the inputs to the CAPM. This is a pervasive problem in asset pricing. The inputs required for the CAPM are the expected market return, the current risk-free rate, and the current beta. None of these variables can be directly observed. The latter two input variables are current variables, but there is no asset that is completely free of risk, and no way to observe the ex-ante beta.

Applications of the CAPM and other asset pricing models typically use estimates from past data and assume that the future will reflect the past. The future is unlikely to exactly reflect the past, but it is often the best we can do given the data available. As Mark Twain is reputed to have

[13] The study uses returns on 3,320 individual stocks and covers the years 1992 through 2017, which yields 359,654 monthly returns and considers 91 possible factors.

[14] What they examine is whether factors are significant in explaining excess returns on stocks and portfolios. The interpretation that any significant factors are risk factors is predicated on the assumption that the excess returns provide a satisfactory proxy for expected risk premiums. For the market factor theory also says it is a risk factor.

put it, history does not repeat itself, but it does rhyme.[15] The problem of using estimates based on past data at times of crisis, like the current Corona virus crisis, is that structural breaks become more likely.

Risk-free rate

In empirical applications, the risk free rate of return is proxied by the rate of return (current yield to maturity) on a government security. Where a longer term perspective is taken, such as for capital budgeting, valuations, and estimating expected equity returns, the return on a longer dated government security is used as the risk free rate. There is merit in matching the maturity of the government security to the expected maturity of the investment, but the common practice is to use a standard maturity as the benchmark for the long term risk free rate of return. In Australia, this benchmark is the rate of return on a ten year government bond, as at this maturity the bonds have the desirable feature of active and liquid markets.

Beta

Beta can be estimated from an ordinary least squares regression of returns on the stock against returns on the market, or a regression of the excess return on the stock against the excess return on the market. The choice of the term over which the beta is to be estimated can vary, but estimates are frequently based on two to five years of data. If it is believed that beta is time varying then a short term may be preferred, but if beta is believed to be mean reverting then a longer term may be favoured. Wright, Burns, Mason and Pickford (2018) in a report to UK regulators (CCA, Ofcom, Ofgem and the Utility Regulator) recommend that all the inputs to the CAPM be for a consistent time horizon. They recommend that the horizon be ten years, but stress that consistency is more important than the choice of horizon. Wright and Robertson in an appendix to the report further emphasise the importance of estimating beta using a term that is consistent with the CAPM investment horizon. The idea of consistency in the components of the CAPM has merit, but the use of beta estimates based on ten years of data is not common. Longer estimation periods also carry greater risks of structural breaks.

There can also be variation in the frequency with which the returns are observed, for example daily, weekly, monthly, occasionally quarterly, and even yearly. The term affects the number of observations available. Thus, daily data or weekly data is more likely to be employed for a two year term because monthly data would only supply 24 data points. Use of monthly data with a three to five year term is commonplace.

For a given term, using daily data has the advantage of providing more data points, which other things equal, would be expected to provide beta estimates with smaller standard errors. However, such data in the Australian market may suffer from thin trading. This may bias beta

[15] The exact source is uncertain, but https://quoteinvestigator.com/2014/01/12/history-rhymes/ reports the following quote in the 1874 edition of "The Gilded Age: A Tale of Today" by Mark Twain and Charles Dudley: *History never repeats itself, but the Kaleidoscopic combinations of the pictured present often seem to be constructed out of the broken fragments of antique legends*.

estimates downwards for thinly traded stocks and upwards for actively traded stocks. More importantly, irrespective of whether thin trading is a problem, there is research which concludes that low frequency (say monthly or quarterly) data is to be preferred to high frequency data (say daily or weekly). To quote Gregory, Hua and Tharyan (2016, p2):

> *Our conclusions are unequivocal and have important policy implications for regulatory use of the CAPM, as they imply that low frequency beta estimates should always be preferred to high frequency beta estimates.*

The work of Gilbert et al. (2014) for the USA, and Gregory et al. (2016), for the UK and Australia, clearly show that the magnitude of beta estimates depends on the frequency of observations. The work also shows that frequency of measurement for beta affects the results of asset pricing tests. Estimates of CAPM alphas (abnormal returns) interpreted as evidence against the CAPM, shrink as the return observation frequency used for estimating beta is reduced. The source of the beta variation is argued to be due to the information environment.

For informationally opaque firms it takes a little more time to assess the impact of systematic news and so the prices of such firms move less with the market at high frequencies. As a result, informationally opaque firms have high frequency betas that are smaller than low frequency betas and vice versa for informationally transparent firms. This argument is supported both by a theoretical model and empirical evidence. Opacity is not the whole story, empirically firm size and market microstructure also play a role. However, the conclusion is clear: to measure the fundamental risk exposures of a firm use low frequency estimates of beta.

This issue is worthy of further consideration by the AER. Low beta bias (equivalent to positive alpha) has been a contentious regulatory issue. The evidence of Gilbert is that low beta bias shrinks to insignificance with longer holding periods. How the magnitude of the regulatory beta might change with longer holding periods is not clear. On average, in Gregory et al's. Australian data low frequency estimates result in higher betas, but in Henry's (2008) study for the AER monthly betas were lower than daily betas.

A further issue with beta is changes over time, and the tendency is for mean reversion. For this reason, some analysts adjust betas towards one, reducing high betas and increasing low betas. However, the evidence is that the betas of network businesses have been rather stable over time and no mean reversion adjustment seems warranted. Henry (2008) in his report to the AER concludes that with respect to estimating beta for network businesses no adjustment is required for mean reversion, nor for thin trading. He also suggests that the frequency of observation is not an issue, although there are some differences in his beta estimates at daily, weekly, and monthly frequencies. He suggests that weekly data is a suitable compromise between the noise of daily data and the reduction in the number of observations with monthly data.

Market risk premium

The final input to be considered is the expected market risk premium. This is most commonly based on a very long run historic average. Another alternative is to use the estimate from an implied cost of capital model, such as the dividend growth model (DGM). In previous reports to the AER (Partington and Satchell, 2016b and 2017), we have pointed to the widely divergent results that can be obtained when using the DGM and have argued at length that the DGM should not be used for determining the market risk premium.

Because of the considerable volatility in realised returns, a very long run average is required in estimating the market risk premium. As a consequence of the volatility, standard errors of the market risk premium computed from short run data are large. In other words, the confidence interval admits such a wide range of values for the market risk premium that the estimate is of little practical use. One disadvantage of the use of long run data is that market data from say 100 years ago may be of no relevance to current conditions. Another disadvantage is that the long run averages by definition cannot detect changes in the risk premium that may have occurred over the averaging period.

Allowing for any changes in the risk premium is in principle desirable. Unfortunately, we know of no reliable method to detect recent changes in the risk premium and hence determine whether an adjustment to the long run average is necessary and in what direction. Survey data might provide some assistance in this regard, but views on the usefulness of survey data are polarised. There is certainly the problem that changes in survey estimates can just be due to changes in the respondents to the survey. We would attach some weight to survey data, but others would disregard that data completely. The quality of surveys can vary substantially, and we suggest more weight should be given to surveys where the respondents actually use the cost of capital in their work. Small samples of respondents can also be a problem. In such surveys an outlier response can substantially change the mean, so for small samples the median should also be considered.

An alternative to using the average market risk premium is instead to assume that the market return is constant and take a long run average of that return (the Wright approach). The consequence of this method is that changes in interest rates are offset one for one by changes in the market risk premium. Thus, if the risk-free rate drops one percent the market risk premium rises by one percent. We have previously argued that we find this implausible and it causes problems. For example, when Australian government bond rates were of the order of 15%, using the Wright approach would have resulted in a substantial negative estimate of the market risk premium. In the most elementary models of investor behaviour, negative risk premiums are not possible for risk averse investors.

Adjustments to the risk premium and risk free rate

In practice some analysts adjust the historic risk premium up or down depending on the case at hand, their prior beliefs, their incentives, and market conditions. For example, in the regime of falling interest rates consequent to the GFC, some analysts offset the effect of low interest rates in the CAPM by inflating the risk free rate. We considered that there was little basis for doing this. We commented at the time that the low interest rates in Australia were not that unusual and that a low interest rate regime could become the new normal. Our comment now is that current interest rates in Australia are at record lows in nominal terms, but not necessarily in real terms, and that low nominal interest rates are the new normal. Relatively low interest rates and a downward trend in those rates have been with us for a decade and the term structure at the time of writing suggests that very low interest rates will be with us for another decade or two.

We anticipate that there will be debate about the impact of the current Corona-virus crisis on the future path of interest rates, changes in the market risk premium, and on the appropriateness of using current low government bond rates in applying the CAPM. With respect to the future path of interest rates we suggest monitoring the term structure of interest rates. With respect to the market risk premium a natural response is to assume that it will go up. Bad times may naturally lead to increased risk aversion and also the volatility of markets has increased, either or both of these would tend to push the risk premium up.[16] However, it is possible that the risk premium could go down. The search for yield in a very low interest rate environment might drive a lower risk premium. When future consumption opportunities look poor investors may change their preferences about trading current consumption for future consumption. The desire to provide for future consumption and not drop below a given level of income may lead to an increased willingness to bear risk. As a result, the risk premium shrinks and lower required rates of return result.

We continue to recommend the use of current government bond yields for the risk free rate. It has been argued in the past, and no doubt will be in the future, that the bond yield is for some reason artificially/abnormally low and that therefore for regulatory purposes it should be increased. Wright et.al. (2018) nicely make the case that this argument is simply irrelevant. They say (p. 34):

> *It is often argued that a justification for regulators setting a value of the risk-free rate different from market rates is that various institutional features of the market for UK government debt (e.g., pension regulations, etc.) have led to yields on gilts (and especially indexed gilts) being artificially depressed…*
>
> *This argument may or may not be correct; we would argue that it is simply irrelevant: the market price of indexed debt (and hence its implied yield) is simply what it is. The following extract from Cochrane (2011) makes the point very succinctly and vividly:*
>
> *When you shop for a salad, all you care about is the price of tomatoes. Whether tomatoes are expensive because the trucks got stuck in bad weather*

[16] We note that periods of intense volatility tend to be short lived.

> *or because of an irrational bubble in the tomato futures market makes no difference to your decision.*
>
> *We see no reason to treat the market for indexed debt differently to the market for tomatoes. Pursuing the analogy, if the price of tomatoes falls (for whatever reason), this is likely also to impact on the price of substitutes for tomatoes, such as cucumbers or other salad components. In the case of the risk-free rate, a fall (for whatever reason) must also have an impact on the price of other low-risk investments.*

Use of the CAPM in practice

It is well understood that the CAPM is the dominant asset pricing model used for estimating the cost of capital in practice. Surveys show that it is the main model used for this purpose; see as examples, in the USA, Graham and Harvey (2001) and Brotherson, Eades, Harris, and Higgins (2013), in Europe Brounen, de Jong and Koedijk (2004), and in Australia Truong, Partington and Peat (2008).

It is of course possible that managers make ad-hoc modifications to the CAPM estimates, just as some analysts do. Indeed, we would be surprised if this did not happen. There may be regular adjustments for some variables, say, for example, foreign exchange risk. Graham and Harvey (2001, p.202) gave respondents the opportunity to select *using the CAPM but including some extra `risk factors'* and just over 34% of respondents made frequent use of this approach. This behaviour can be interpreted as managers using multi-factor models. For some managers, this may be the case, but if so a multi-factor model to capture all the different adjustments across managers would have to contain a lot of factors. A simple, and we believe likely explanation for many of these adjustments is that they are to correct for overestimates of the expected cash flow.[17] It is not unusual for managers to adjust the discount rate rather than adjusting the cash flow, see Brealey et al. (2000, p.255) who call this adjustment to the discount rate adding a fudge factor.

Consider, for example, a firm which has significant export sales, it is exposed to cash flow variation driven by changes in the exchange rate. Managers are likely to worry about adverse exchange rate movements and may be concerned that this has not been fully accounted for in estimating the expected cash flow. Consequently, the "expected" cash flow is an overestimate, to offset this overestimate managers add a foreign exchange "risk" adjustment to the discount rate.

Brotherson et al. (2013) survey large international investment banks and report that 100% use the CAPM. From reviews of valuation reports it is clear that where an asset pricing model is used in a valuation it is most likely to be the CAPM. Some analysts who use the CAPM do adjust

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[17] Cambell and Harvey (2001) show that some firms make adjustments for risk factors to the discount rate, some to the cash flow, and some to both.

CAPM estimates, for example adding a size premium for small firms. Similar comments apply here as made for managers above. In some cases, there may be an implicit multi-factor model, in other cases, it is a fudge factor.

Following the initial development of the CAPM, fund manager evaluations used CAPM alpha as a measure of outperformance (abnormal returns), but subsequent to the development of the Fama and French three factor model, alpha increasingly became measured relative to that model. However, CAPM alpha and beta are uniformly reported throughout the fund management industry even if portfolio construction may involve more information. This is because these two parameters provide useful inputs to construct rules of thumb and their characteristics are well-understood across a wide range of market participants.

In terms of regulatory use, the CAPM is clearly the dominant asset pricing model. McKenzie and Partington (2013, p.24) state:

> *Without doubt, the CAPM is the most widely used model for estimating the cost of equity in regulated companies. Support for the CAPM can be found in Price Waterhouse Coopers (2009, p.2) who state that it is "the most appropriate framework for calculating the cost of equity". The Water Services Regulation Authority (2010, p.N4) argue that "although the CAPM has its limitations, it is the most robust way for a regulator to measure the returns required by shareholders". Further, the Civil Aviation Authority (2001, p.4) argue that the CAPM, "is an industry standard specifically in the context of estimating appropriate return benchmarks for regulated industries.*

A survey of regulatory practices by Sudarsanam, Kaltenbronn and Park (2011) for the USA, Canada, Germany, Australia, New Zealand and the UK finds that the CAPM is used by regulators in all of these countries except in the Canadian case reviewed. For the USA the regulator only used the CAPM as a secondary model.

A survey of regulator practice for 19 counties in Europe plus Australia and New Zealand, was undertaken by Schaeffler and Weber (2012). Schaeffler and Weber investigate the merits of using the Fama and French three factor model and the APT (Arbitrage Pricing Theory), but with respect to regulatory practice they find that all the 21 regulators used the CAPM.[18]

Evaluation and Recommendation

In summary, there is substantial theoretical work to support the CAPM and a substantial volume of empirical work that rejects the CAPM. However, there are also substantial difficulties with

[18] For Australian network operators the empirical results indicate that there is no real difference between using the three models, as the only factor loading (risk factor beta) significant at the 5% level or better is the market beta.

the empirical testing. For that reason and because of empirical work supporting the CAPM[19] we do not find the empirical rejection of the CAPM convincing.

A model is an abstraction that is simpler than reality and the CAPM is a simple model, so there is likely to be scope to improve on it. Currently, however, we consider that there is no suitable candidate to replace the CAPM. This conclusion is supported by the fact that after over fifty years of use the CAPM continues its role as the dominant asset pricing model employed to estimate the cost of capital in practice. It can truly be said that the CAPM has passed the test of time and use.

Additional attractions of the CAPM are that it is simple, its application is transparent and easily replicated. The model can be populated with Australian data, although the very small sample of listed firms currently available for estimating beta has become an issue. The CAPM is clearly suited for use in a regulated environment as it has been extensively used around the world for this purpose and it has limited opportunities for gaming relative to the alternatives.

Any asset pricing model is likely to be difficult to explain to stakeholders outside the finance and accounting community. However, by the standards of asset pricing models the CAPM is a relatively simple model. Simple and intuitive explanations of the CAPM are possible. It is not so difficult to grasp the concept of market returns and that returns go up and down. Neither is it so difficult to grasp the concept that returns for different firms go up and down with the market at different rates. From these concepts it is only a short step to help a broad set of stakeholders understand the model.

Since the expected rate of return is not observed, data cannot tell us which asset pricing model gives an expected rate of return that has the minimum error and is unbiased. However, our evaluation leads us to the judgement that the CAPM is the most likely model to meet these criteria. In particular more gameable models are more likely to result in a biased rate of return.

In the light of our evaluation, we conclude that the CAPM meets the AER's criteria of reliability, relevance, suitability and simplicity and our criteria of extensive practical use over time in estimating the cost of capital. In respect of validation, the CAPM meets the informal test of practical use, but its validation as a measure of expected returns in formal tests remains an open question.

We recommend the use of the CAPM for the purposes of determining the regulated rate of return. In this respect we are in accord with a recent report to UK regulators. In that report, Wright, et al. (2018, p. 7), reject alternative models as failing either, or both, of the criteria of implementability and defensibility, and recommend:

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[19] A feature that strengthens support for the CAPM is triangulation across different methods.

Recommendation 1 (CAPM): The Capital Asset Pricing Model remains (despite numerous caveats) the best available model.

As Smith and Walsh (2013) put it, *… the CAPM is still the only game in town.*

6. International CAPM (the standard CAPM populated with international parameters)

The World CAPM and the International CAPM

The international CAPM takes a number of forms and it is worth detailing them. We turn to Brusa et al. (2014) for definitions and references. The World CAPM is a simple extension of the CAPM to global markets. The additional assumption necessary in the global context is that purchasing power parity (PPP) always holds, meaning that currency risk is assumed irrelevant. There are two senses in which the PPP hypothesis might hold. Absolute purchasing power parity holds when the purchasing power of a unit of currency is exactly equal in the domestic economy and in a foreign economy once it is converted into foreign currency at the market exchange rate. However, it is often difficult to determine whether literally the same basket of goods is available in two different countries. Thus, it is common to test relative PPP, which holds that the percentage change in the exchange rate over a given period just offsets the difference in inflation rates in the countries concerned over the same period. Notice that even these assumptions about underlying bundles of goods consumed in each country need not necessarily apply in exactly the same way to national equity portfolios without further modelling involving additional assumptions.

In the World CAPM, global market risk is the single source of systematic risk driving asset prices, and international investors should only earn a premium for exposure to this source of risk. Empirically, the measure of global market risk has generally been the excess return on the world equity market portfolio, *WMKT*, denominated in a common currency, generally U.S. dollars but for our purposes Australian dollars. Writing $r^{\$}_{i,t+1} - r_{f,t}$for the excess return of asset *i* at time *t* + 1 expressed in Australian dollars, the empirical specification of this model is:

$$r^{\$}_{i,t+1} - r_{f,t} \;=\; \alpha^{i}_{WCAPM} + \beta^{i}_{WMKT}\, WMKT_{t+1} + \epsilon_{i,t+1}$$

To explain the notation, $r^{\$}_{i,t+1}$ measures the rate of return from holding the asset one period from time t to time t+1.The term $r_{f,t}$ is the rate of return to Australian dollar from time t to time t+1. The difference in subscripts arises because the former is not known until time t+1 whilst the latter is known at time t.

The academic literature distinguishes the world CAPM from the international CAPM. In the international CAPM of Adler and Dumas (1983), PPP does not hold instantaneously, and exchange rates are an additional source of exogenous risk. This model is employed empirically by Dumas and Solnik (1995). With the same notation as before, and r^{GBP}_{t+1}, r^{JPY}_{t+1} , r^{EUR}_{t+1} representing excess currency returns denominated in Pound Sterling, Japanese Yen, and Euro, respectively, the (unconditional) model specification is where the base currency is US Dollar. Were we to calculate this from an Australian perspective, the base currency would be Australian Dollar and we would add an additional factor which would represent excess currency returns in US Dollars. Here $r_{au,t}$ is the riskless rate of return to Australian dollar.

$$r_{i,t+1}^{\$} - r_{au,t} = \alpha_{ICAPM}^{i} + \beta_{WMKT}^{i} WMKT_{t+1} + \beta_{GBP}^{i} r_{t+1}^{GBP} + \beta_{JPY}^{i} r_{t+1}^{JPY} + \beta_{EUR}^{i} r_{t+1}^{EUR} + \beta_{USD}^{i} r_{t+1}^{USD} + \epsilon_{i,t+1}$$

Theory and testing

The theory behind both CAPMs is discussed next. In the case of the world CAPM, it is just the same theory as the domestic SL-CAPM discussed above together with very strong assumptions about PPP eliminating all currency risk globally. It is as if we have a sufficiently globalised world market in which everyone views the same market portfolio. The theory behind the international CAPM is much more strongly based and is a consequence of a general theory of pricing in continuous time developed by Merton (1973). The application of this theory to international CAPM problems was first carried out by Solnik (1974).

Whilst we could use either of these models, we note that we would need to replace the Australian index by the World index with the consequence that betas of Australian energy companies would probably fall as we would expect that the variation in their returns would be much more correlated with the domestic Australian market than the World market. Adopting a world/international model would be a major change since we would also need to replace the Australian equity risk premium by the World equity risk premium and in the case of the international CAPM we would also need to add the currency factors.[20] There would also need to be a reopening of the debate about how much value, if any, should be allowed for imputation credits in the context of an international asset pricing model. We would not advise a change to an international model without some substantial benefit, which we do not see. In particular we view sensible use of an international model as more complex than just populating the standard CAPM with international parameters.

One benefit of an international model would be the relative ease of including additional companies in the comparator set. An alternative which seems to have been proposed in various reports is to simply take the betas for energy companies directly from models of other markets, particularly the US market based on a US CAPM. There is no financial or mathematical logic to this, and it does risk cherry picking by stakeholders. Consumers, for example, might prefer the low betas from Vietnam, or Edison International from the USA.

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[20] Ejara, Krapl, O'Brien and de Vargas (2017) estimate risk premiums in local currency for equity indices around the world and report that for the Australian equity market the ICAPM risk premium was estimated to be 3.12% and the World CAPM risk premium was estimated to be 1.98%. We are not endorsing these estimates, but rather are using them to illustrate that there could be a substantial change in the risk premium moving to an international model and that the choice of international model could also have a substantial effect.

Implementing the International CAPM

An approach to convert International Betas to domestic Betas

We have seen that the international CAPM or the global CAPM both make somewhat unrealistic assumptions about a world market and either assume PPP or explicitly include exchange rates. A more reasonable approach would be to assume that the CAPM holds within each country with respect to its own market portfolio and we would be interested to see how we might be able to convert betas in one market to betas in the Australian market. This is a recognised problem in international finance.

Suppose we have a set of German energy businesses whose returns satisfy a German CAPM.

$$R_{it} = \beta_i R_{gt} + e_{it} \quad (1)$$

Where R_{it} is the excess return on asset i at time t, excess relative to the German euro 10 year bond rate, and R_{gt} is the excess return on the German equity market at time t, excess relative to the German euro 10 year bond rate. We have *N* such energy companies and the philosophy that advocates the use of international comparators often says we should take the average in computing the beta for the notional Australian energy firm.

The above differs from the Australian CAPM in two critical ways; firstly the bond rate is different and secondly the market return is different. For simplicity, we shall assume that the two countries interest rates are identical when the German rate is converted into Australian dollar and focus only on differences in markets. Initially, we shall assume that e_{it} is independent of R_{aut}, the excess rate of return on the Australian market. Then measuring all excess returns relative to the Australian 10 year bond rate, and making necessary strong assumptions to eliminate any exchange rate risk, we get

$$R_{gt} = \beta_{aug} R_{aut} + v_{gt} \qquad (2) \qquad .$$

Substituting (2) into (1),

$$R_{it} = \beta_i(\beta_{aug} R_{aut} + v_{\mathrm{gt}}) + e_{it} \quad (3)$$

We see that the correct beta in this instance is $\beta_i \beta_{aug}$ and the average, if this is what we want to use, needs to be scaled by β_{aug} the beta of the German equity market on the Australian equity market. However, even in this simplified case, notice that the error structure has changed so the German energy stocks will have a common error v_{gt} as well as an idiosyncratic error, which will complicate estimation. We would expect this beta to be much less than 1 as a result leading to an overall lowering of average beta. Sadly, adroit choices by stakeholders could replace Germany by some other country whereby the appropriate beta could be raised or lowered; such gaming would not be an appropriate way to analyse the problem.

We note in the above that all returns are excess returns. If we take German market returns and subtract the Australian 10 year rate we need to switch German returns into A$. In the general case that interest rates differ and exchange rates matter to be consistent we need to add a currency rate.

We see that the previous attempts simplified this by using a global CAPM which has the advantage that betas can be compared across counties in a natural way once we have taken currency into account; for further discussion on these points, see O'Brien (2005).

The above discussion can be improved upon but we present it only to point out the serious difficulties of trying to use parameters from foreign firms to expand the comparator set; furthermore there is also sovereign risk/foreign bond default risk to factor into the equation as well, something we have ignored.

Another approach is to "export" the German returns to Australia, in effect creating Australian assets. A precise version is as follows. An Australian investor invests at time t, W_t Australian dollars in the German equity index. The investment in Euros will be $\frac{W_t}{e_t}$

where e_t is the number of A$ per Euro at time t. At time t+1, her position is worth $\frac{(1+r_{gm,t+1})W_t}{e_t}$ measured in Euros. She repatriates back to A$, hence she has

$\frac{e_{t+1}(1+r_{gm,t+1})W_t}{e_t}$ A$. This can be written as $(1+fx_{t+1})(1+r_{gm,t+1})W_t$ where fx_{t+1} is the rate of growth of the dollar to Euro exchange rate from time t to time t+1.We shall assume that this action is within the set of strategies available to the Australian investor and therefore can be priced by the Australian CAPM. Its rate of return is $(1+fx_{t+1})\left(1+r_{gm,t+1}\right)-1=r_{gm,t+1}+fx_{t+1}+r_{gm,t+1}fx_{t+1}$ and its excess rate of return in A$ is

$$r_{gm,t+1}+fx_{t+1}+r_{gm,t+1}fx_{t+1}-r_{au,t}$$

Therefore, the CAPM relationship satisfied is

$$r_{gm,t+1}+fx_{t+1}+r_{gm,t+1}fx_{t+1}-r_{au,t}$$

$$=\beta_{augm}R_{au,t+1}+v_{gm,t+1}$$

Suppose instead of investing in the German equity index, we invested W_t in German gilts with rate of return $r_{g,t}$ in Euros. By the same logic,

$$r_{g,t}+fx_{t+1}+r_{g,t}fx_{t+1}-r_{au,t}=\beta_{aug}R_{au,t+1}+\omega_{g,t+1}$$

Suppose now the German energy company satisfies the German CAPM in Euro.

$$R_{i,t+1}=\beta_i R_{gm,t+1}+e_{i,t+1}$$

$$R_{i,t+1} = \beta_i\left(r_{gm,t+1} - r_{g,t}\right) + e_{i,t+1}$$

$R_{i,t+1} = \beta_i(-fx_{t+1} - r_{gm,t+1}fx_{t+1} + r_{au,t}+\beta_{augm}R_{au,t+1} + v_{gm,t+1} + fx_{t+1} + r_{g,t}fx_{t+1} - r_{au,t}$ - $\beta_{aug}R_{au,t+1} - \omega_{g,t+1}) + e_{i,t+1}$

Or $R_{i,t+1} = \beta_i(-r_{gm,t+1}fx_{t+1} + \beta_{augm}R_{au,t+1} + v_{i,t+1} + r_{g,t}fx_t$-$\beta_{aug}R_{au,t+1} - \omega_{g,t+1}) + e_{i,t+1}$

Or $R_{i,t+1} = \beta_i(-r_{gm.t+1}fx_{t+1} +(\beta_{augm}-\beta_{aug})R_{au,t+1} + v_{i,t+1} - \omega_{g,t+1}) + e_{i,t+1}$

Or $R_{i,t+1} = -\beta_i r_{gm,t+1} + \beta_i(B_{augm}-\beta_{aug})R_{au,t+1} + \beta_i(v_{i,t+1} - \omega_{g,t+1}) + e_{i,t+1}$ (4)

Equation (4) describes the relationship between excess returns in Euro for a German energy company and the excess return of the Australian stock market measured in A$. We note the presence of excess returns to the German market multiplied by the change in FX as well as two sources of additional idiosyncratic risk; one is the idiosyncratic risk to the company in the German market, the other is the difference in idiosyncratic risk of the German index minus that of German gilts expressed in A$. The point here is that German gilts become risky from an Australian perspective because of exchange rate risk. The critical assumption here is that an Australian investor can buy and sell the German stock market. The existence of exchange traded funds in Euro make this perfectly feasible.

Suppose we wished to consider direct investment in company i, a German energy company; this is a stronger assumption. Its A$ rate of return would be equal to

$$r_{i,t+1} + fx_{t+1} + r_{i,t+1}fx_{t+1} - r_{au,t}$$

Again, we would need to assume that any investment, available to an Australian investor measured in A$ can have an Australian CAPM representation.

Then, this would satisfy, all in A$,

$$r_{i,t+1} + fx_{t+1} + r_{i,t+1}fx_{t+1} - r_{au,t} = \beta_{iau}R_{au,t+1} + h_{i,t+1}$$

So also considering German gilts, as before,

$$r_{g,t} + fx_{t+1} + r_{g,t}fx_{t+1} - r_{au,t} = \beta_{aug}R_{au,t+1} + \omega_{g,t+1}$$

And subtracting $(r_{i,t+1} - r_{g,t})(1 + fx_{t+1}) \ = (\beta_{iau}-\beta_{aug})R_{au,t+1}+h_{i,t+1}$-$\omega_{g,t+1}$; we see that

$$R_{i,t+1}(1 + fx_{t+1}) \ = (\beta_{iau}-\beta_{aug})R_{au,t+1}+h_{i,t+1}\text{-}\omega_{g,t+1} \quad (5)$$

Compared with (4), which we re-produce below.

$$R_{i,t+1} = B_i(\beta_{augm}-\beta_{aug})R_{au,t+1} - \beta_i R_{gm,t+1}fx_{t+1} + \beta_i(v_{gm,t+1} - \omega_{g,t+1}) + e_{i,t+1}$$

Whichever approach one takes, there is no logically justifiable way of taking unadjusted international betas and using them as a domestic Australian betas.

Use of the International CAPM in practice

We have found no clear evidence of use of the international CAPM in practice. There is evidence in Graham and Harvey (2001) and Brounen et al. (2004) that some firms make adjustments for foreign exchange risk. However, the most common adjustment was to the cash flow. We rather suspect that where the discount rate was adjusted that this was more along the lines of a fudge factor, rather than a systematic application of the ICAPM.

From the perspective of the US investor with returns in US dollars, the world or the international CAPM makes a certain amount of sense, or at least its implementation will not necessarily lead to huge re-evaluations of stock-level systematic risk. US domestic stocks should have similar betas whether you use the world portfolio or the US portfolio as the two market portfolios are closely related.[21] Furthermore, you can benefit from the extra companies in your comparator set.

However, if you move to a smaller country and use a world index, you can expect the betas of your domestic companies to change dramatically in some circumstances, and risk premiums are also likely to change. Our hypothesis is that US companies have not adopted use of an international CAPM because, even were it to be the appropriate model, it makes little difference to their estimated cost of capital, and that elsewhere either the benefits are not seen as sufficient to justify the effort of shifting to an international model, or the domestic CAPM is considered to be the more appropriate model.

Evaluation and Recommendation

Based on our discussion above, it should be clear that we do not recommend a move to adopting an international CAPM. We would suggest that the discussion should really be about the choice of suitable comparators to be included in the comparator set rather than the international CAPM *per se.*

We note that the relevant comparator set for the AER has been depleted in recent years due to takeovers and de-listings. Given that we have expressed our substantial reservations about expanding the comparator set by using overseas comparators, what else can be done? It is potentially possible to use accounting data from the delisted firms, and the use of accounting data was considered in the Ofgem beta study, Indepen (2018).

Work in the 1970s identified four key explanatory accounting determinants of β. They are;

[21] Dolde, Giaccotto, Mishra and O'Brien (2012) find that for US firms the domestic CAPM, the world CAPM and the ICAPM give reasonably similar estimate in many cases.

- earnings cyclicality – β depends on the relationship between swings in the firm's earnings and swings in the economy generally
- earnings variability – β is strongly related to the volatility of earnings
- financial leverage – β is related to financial risk
- growth – β is positively related to growth, given the traditional association between rapid growth and high business risk

The notion that beta is itself a function of accounting and other firm characteristic variables has been used in a variety of contexts, usually when companies are listed. For an application to the Australian banking sector, see Muijsson and Satchell, (2019).

It is possible to estimate an equation linking the accounting factors of listed firms to their estimated β values, along the lines of:

$$\beta_i = a_0 + a_1 X_{1i} + \ldots \ldots a_i X_{ji} \ldots + a_n X_{ni} + \varepsilon_i \quad (6)$$

where X_{ij} represents the *jth* accounting factor of firm i. This equation is estimated using a cross-section of companies which already have estimated betas so that a statistical relationship between the accounting factors and the betas can be established. For non-listed entities it is possible to estimate a β value using the relevant accounting measures in equation (6) since we know the right hand side of the regression. Whilst it is unlikely to provide very accurate determination unless the fit of (6) is very good and the de-listed firms behave in similar ways to listed ones, this seems a line of research that is worth exploring.

The authors of the Ofgem paper are cautious in their recommendations, they say

> *Given the academic results, limited apparent practical use and the issues, such as expected signs not being met, we believe that this is an area which requires more research before it could be an element in any β estimation process for a regulatory determination.*

Overall, we do not recommend the use of parameters from world or international CAPM's to measure Australian dollar systematic return risk for Australian energy companies or to create extra comparators for the AER comparator set. We think there is potential for examining the accounts of domestic de-listed comparator firms and computing accounting betas although we are cautious about their final applicability. In the light of our evaluation, we conclude that use of the ICAPM, in the sense discussed above, fails to meet the AER's criteria of reliability, relevance, suitability and simplicity overall and our criterion of extensive practical use over time in estimating the cost of capital.

7. Black CAPM (also labelled the zero-beta CAPM)

In a number of circumstances where the SL-CAPM may not hold, the zero-beta CAPM has been suggested. Circumstances commonly discussed for the use of a zero beta CAPM include an absence of a riskless good, or a difference between the borrowing rate and the lending rate.

Black (1972) advanced a more general version of the CAPM for which the SL-CAPM is a special case. We describe the theory next.

There is a portfolio *Z*, i.e., the zero–beta portfolio with respect to the market portfolio, such that for each risky asset or portfolio of risky assets *i*, we have:

$$\mu_i = \mu_Z + \beta_i(\mu_m - \mu_z)$$

where μ_m is the expected return of the market portfolio. Furthermore, μ_z is the expected rate of return of portfolio *Z* and β_i is the usual measure of beta. The zero-beta portfolio has the property that its co-variance with the market is zero.

Theory and testing

The theory of Black CAPM is well established and exists within the same framework as the SL-CAPM. There is, however, a subtle difference. The SL-CAPM, due to the presence of a riskless good, has two-fund money separation and this allows us to identify the market portfolio. All investors will hold equity in the same proportion and those proportions are those of aggregate demand. The only way individual risk aversions enter the investment decision is in the determination of the proportion of riskless asset vs equity held by the investor. Whilst this has been criticized for being overly strong (which it is), it is quite clear what the market portfolio is and even how to compute it. However, in the case of the Black CAPM, all we know is that the market portfolio should be on the mean variance frontier. Individual demands can be calculated but the exact position of the market portfolio will depend upon individual risk aversions and the relative wealth of the individual as well.

The difficulties with Black CAPM start with estimation. Unlike the SL-CAPM where beta can be calculated straightforwardly with sample covariances and variances, the Black CAPM involves the use of maximum likelihood. Whilst the usual assumption is that there is a linear regression with normal errors, different distributional assumptions can lead to different estimates of alpha and beta

The Black CAPM starts with a Sharpe-type linear regression:

$$R_i = \alpha_i + \beta_i R_m + e_i$$

For the Black CAPM to hold, $\alpha_i = (1 - \beta_i)\,\mu_Z$ for i=1,...,N.

It is possible to impose these constraints and calculate MLE's and the constrained likelihood; the unconstrained case is straightforward. Testing usually proceeds by using likelihood ratio tests; see Shanken (1986), for further details.

Difficulties arise with the calculation of μ_Z. To see the intuition of this suppose N=1, and that we use OLS estimates of α_i and β_i as our estimates, we denote them with hats, then our estimate of μ_Z, is $\widehat{\mu_Z} = \frac{\widehat{\alpha_i}}{1-\widehat{\beta_i}}$. But $\widehat{\alpha_i}$ and $\widehat{\beta_i}$ are known to be bivariate normally distributed and so

$\widehat{\mu_Z}$ is distributed as the ratio of normal random variables which (in the case of independence) is known to follow a Cauchy distribution. This in turn is known to have no finite mean and gives us an insight into why estimated values of μ_Z calculated from empirical data often take wild values. One can complicate this further by noting that the two variables are correlated but the non-existence of the mean in this case still stands, see Phiam-Gia et al. (2006).

The above difficulties can be glimpsed in Shanken's (1986) excellent paper where he carries out some empirical analysis. He finds that his estimate of μ_Z is in excess of 12% per annum. His interpretation of this is as an annualised real riskless rate and concedes that it is high. He also notes the flatness of the likelihood function (p. 274, ibid.).This means, intuitively that the parameter cannot be identified by the model and data, and is a further explanation as to why it seems inappropriate to use the Black CAPM to inform energy regulation.

Generally, there has been little new consequential research on the Black CAPM of relevance to regulators in the last five years. We found "Optimal Portfolio Choice with Estimation Risk: No Risk-free Asset Case", by Kan, Wang and Zhou (2020), which is implicitly related to the topic as it addresses portfolio estimation issues when there is no riskless asset. It is a high-quality paper but the challenging mathematical derivations only underline how complex the model is to use.

Implementing the Black CAPM

We have maintained over numerous reports that this model has serious implementation problems. We expressed this view in 2016. We quote from our report to the ERA, Partington and Satchell (2016a).

> *Llewelyn, Nagel and Shanken (2010, p183) express concern about the unreasonably high zero beta return estimates that come out of many asset pricing tests. They state:*
>
> *"Most clearly, theory says the zero-beta rate should equal the risk free rate. A possible retort is that Brennan's (1971) model relaxes this constraint if borrowing and lending rates differ, but this argument isn't convincing in our view: (riskless) borrowing and lending rates just aren't sufficiently different – perhaps 1–2% annually – to justify the extremely high zero-beta estimates in many papers."*
>
> *Put more simply the difference between borrowing and lending rates, which is usually touted as the reason to use the Black CAPM is typically of the order of 1% to 2%, often smaller. By some extraordinary alchemy, consultants can use this small difference to justify increasing the required return for the regulated firm by amounts closer to 10%; this is a failure of common sense.*

Although we do not want to repeat our previous arguments at length, the idea that the government 10 year bond is an inappropriate proxy for the riskless asset, whilst the equity index is a reasonable proxy for the market portfolio, which seems to underpin much of the Black-CAPM analysis presented by network businesses, seems to us, quite inappropriate.

Use of the Black CAPM in practice

We are aware of no substantive practical use of the Black CAPM in companies or in financial markets. With respect to regulation the AER has, in the past, used the theoretical construct of a zero-beta return as consistent with the evidence of a positive alpha in CAPM tests. In the 2013 determination this was used as justification for increasing beta and by so doing allowing an increased return to regulated networks to compensate for low beta bias.[22] We understand that the New York Public Service Commission have also used the Black CAPM in conjunction with the SL-CAPM, but we are not aware of widespread adoption of this approach.

Evaluation and Recommendation

We have written in previous reports to the AER, and elsewhere, that the Black CAPM should be disregarded in the calculation of the regulatory beta, as it is rarely used by market practitioners, it has complex econometrics, the estimation methods have undesirable properties and it is prone to gaming.

We have not discovered any new research that would suggest that the Black CAPM gives better answers to the calculation of the risk free rate or regulatory beta, or is widely used by market practitioners, or has robust econometrics, or is resistant to gaming.

The AER does not currently use the Black CAPM to inform beta estimates for subsequent use in the SL-CAPM. While this was done in the 2013 determination, it was not done in the 2018 determination. We recommend that the 2018 policy be continued, as use of the Black CAPM in determining the regulated rate of return would give a false legitimacy to an inappropriate methodology. We conclude that the Black CAPM fails to meet any of the AER's criteria of reliability, relevance, suitability and simplicity and our criterion of extensive practical use over time in estimating the cost of capital.

8. Fama-French three factor model

The Fama and French (1993) model (hereafter FF3) is given by:

$$r_i = r_f + \beta_{im}(r_m - r_f) + \beta_{is}(r_s - r_b) + \beta_{ib}(r_h - r_l)$$

where, r_i is the rate of return on security i, r_f is the risk free rate of return, $r_m - r_f$ is the realised market risk premium, $r_s - r_b$ is the difference in return between a portfolio of small stocks s and a portfolio of big stocks b, often referred to as SMB (small minus big) or the size factor, $r_h - r_l$ is the difference in return between a portfolio of stocks with a high book to

[22] We have, in previous reports to the AER, provided several explanations, other than low beta bias, for a positive alpha.

market ratio h and a portfolio of stocks with a low book to market ratio l, this is often referred to as HML (high minus low) or the value factor,[23] β_{im} is the beta factor (factor loading) for security i on the market factor and similarly for the size and book to market factors.

We have written the model without expectation operators to emphasise that the model is an empirical model of realised returns. The left hand side variable, r_i, could be written as an expectation, but it would be an assumption to take this as the return that investors expect.

Theory and testing

This model has no clear theoretical basis. It is an empirical model obtained from fitting data to realised returns and because of this it can be criticised as potential data mining. Fama and French (1993) suggest that the model can be interpreted as an empirical version of Merton's (1973) ICAPM (Intertemporal CAPM). In this interpretation there are up to two unspecified state variables in addition to the market factor. Fama (2013) interprets the role of SMB and HML in relation to the ICAPM, not as proxies for the state variables, but rather as portfolios, which together with the market portfolio and the risk free rate, span the efficient set. A simpler alternative is that SMB and HML are proxies for the unspecified risk factors in Ross's (1976) APT (Arbitrage Pricing Theory).[24] These links to theory are possibilities, but the same arguments could be advanced about almost any factor that was demonstrated to "explain" realised returns.

The point about theoretical justification is worth spelling out. Virtually any model has some sort of theoretical story which can give it support. The FF3 model has very little. One argument is based on the idea that an efficient portfolio and hence one on the efficient frontier would involve a linear factor model with a market term, a value growth term, and a size term. This is set up by specifying a linear equation which corresponds to a description of the returns of this efficient portfolio whereby the proportions of each of these sub-portfolios are presumably fixed and there is co-variation between this portfolio and the asset being priced. This would immediately suggest a test of proportionality for the various exposures of individual assets which would be very unlikely to be satisfied by the data. More importantly the theory in this form is just a special case of mean variance analysis and it is not clear how these particular sub-portfolios relate to the expected utility functions of the individual agents.

However, for the SL-CAPM, the theory follows directly from the expected utility functions of each of the individual agents. Consequently, we can describe their individual demand functions for risky and safe assets. These can be aggregated to create market demand and we assume that market supply is fixed at the number of shares or bonds issued and we have an equilibrium model where the price is a true equilibrium price. This is a very satisfactory theory as we can start with the primitives, which are a utility function for each investor, and end with a pricing

[23] High book to market (B/M) are often called value stocks and low B/M are often called growth stocks.

[24] The APT is silent on both on the nature of the risk factors and their number. There might only be one factor or there might be many more.

equilibrium. It is by no means clear to us that such an exercise can be done with a Fama French model in any of its variations.

Fama and French recognise the dangers of blind empirics and have made attempts to link their factor models (FF3 and later models) to theory, as for example in Fama and French (2017). However, as we explain above it cannot be said that there is a well specified theory, such as in the CAPM or consumption CAPM. Consequently, the number of the factors and what they mean has proved difficult to pin down.

The SMB and HML factors are commonly taken to be proxies for risk factors. What these risk factors are has been a source of some puzzlement. Researchers have searched for explanations, such as Fama and French's (1995) investigation of size and B/M factors in earnings, which shows high B/M firms have persistent poor earnings. Chan and Chen (1991) argue that distressed firms do worse in economic downturns and that this leads to a distress factor in returns which is captured in the relation between returns and firm size. This is plausible, but the absence of theory makes it difficult to be confident about this interpretation. In Fama's (2013) ICAPM analysis above, size and B/M are explicitly not proxying for risk (state) factors. Fama later goes on to say (p. 382):

> *The open question is: what are the underlying state variables that lead to variation in expected returns missed by the CAPM market β? There is a literature that proposes answers to this question, but the evidence so far is unconvincing.*

Fama (2013) also discusses a behavioural explanation for the role of size and book to market, although it would be fair to say that Fama has little time for behavioural explanations of anything to do with asset pricing. It would also be fair to say that we agree that there are several possible explanations for why the Fama and French factors might explain returns and that is the problem, it may be any of them or none.

The lack of a theory not only creates a lack of clarity about the model's factors, it also means there is no guidance on how many factors there should be. As it turns out, the number of factors has been a moveable feast. In Fama and French's (1992) paper the conclusion was that size and book to market explained returns and that the market beta had no role to play. Thus, a two-factor model might have been anticipated, but in Fama and French's (1993) paper market beta was rehabilitated, and the FF3 factor model emerged. Subsequent to Carhart's (1997) evidence of a momentum factor (MOM) in returns, it became common to add this factor to the FF3 model, leading to a four-factor model.[25] Fama and French (2015) introduced a five-factor model adding a profitability factor (RMW, robust minus weak) and an investment factor (CMA,

[25] Since the MOM factor is measured as difference between returns on stocks with positive momentum (price rising) and negative momentum (price falling) it is also known as UMD up minus down or WML, winners minus losers.

conservative minus aggressive) to FF3. However, the evidence from the five-factor model is that the HML factor is redundant as it does not add to the explanatory power of the model.

Once there is a five-factor model it is not a big step to go to a six-factor model, for example, add the Carhart momentum factor, as reluctantly added by Fama and French (2017). The reluctance was because Fama French were worried about the issue that they were originally criticised for. In their words (p. 7):

> *We worry, however, that opening the game to factors that seem empirically robust but lack theoretical motivation has a destructive downside – the end of discipline that produces parsimonious models and the beginning of a dark age of data dredging that produces a long list of factors with little hope of sifting through them in a statistically reliable way.*

In our view the dark age is already well advanced as the hundreds of supposedly priced factors attest.

In Fama and French (2017) the six factor model is pitted against the CAPM, the three factor model and the five factor model. Alternative measurements, for the spread portfolios used to measure factor premiums, are also considered. There is an alternative cash measure for profitability, and spread portfolios are constructed on subsets of stocks, for example spread portfolios based only on small stocks. The six factor model is found to be the best model and the winning variant of the six factor model is (pp. 23-24): *Mkt and SMB with the small stock spread factors, HML_S, RMW_{CS}, CMA_S, and UMD_S.* where the *c* subscript indicates the cash measure of profitability and the *s* subscript indicates factor premiums based on small stock spread portfolios.

Data mining

Concern over data mining/p-hacking is particularly important with respect to finding "significant" pricing factors. As Smith and Walsh (2013, p.75) observe:

> *Armed with a vector of ex post average returns and a historical variance–covariance matrix, any competent analyst could derive the entire range of ex post efficient portfolios…*

The choice is wide, since as Roll (1997) explains given any sample of ex-post returns on individual assets there will exist an infinite number of ex-post efficient portfolios. As Smith and Walsh (2013, p.75) ask:

> *What does this mean for the Fama and French factors? The implication is clear: if researchers are allowed to look ex post there will be an infinite number of portfolios that they can find that satisfy equation (1). By concentrating on the size anomaly and the market to book anomaly, Fama and French have found a workable method of constructing ex post efficient portfolios.*

As Fama and French (2017, p24) put it:

> *Through time, many patterns in average returns are discovered and become potential candidates for inclusion in factor models. There is an obvious danger that, in the absence of discipline from theory, factor models degenerate into long lists of factors that come close to spanning the ex post mean-variance-efficient (MVE) tangency portfolio of a particular period – in other words empty data dredging exercises.*

Ferson, Sarkissian and Simin (1999) and Harvey (2017) both demonstrate that it is not difficult to construct a "priced" factor that is meaningless. They illustrate the construction of an alphabet factor, based on the company name, that is "priced"/explains returns. This is clearly nonsense but based on empirics it would be possible to write down a model where the "expected return" was a function of letters of the alphabet.

A protocol to sort through lists of factors in order to determine which are priced risk factors, is suggested by Pukthuanthong, Roll and Subrahmanyam (2018). The factors that pass this protocol are the market factor, a profitability factor (RMW), and factors for credit spreads, term spreads and unexpected inflation. HML and SMB do not satisfy the protocol.

Neither does the evidence for the SMB and HML prove to be robust in Harvey and Liu's (2019) results. As explained in Section 5, their method is designed to control for multiple tests. They find only weak support for the FF3 factors. For tests based on individual stocks, where the stocks are given equal weight in computing test statistics, the HML and SMB factors are significant, but they add little to the explanation of returns, over and above the market factor. Harvey and Liu find that factors other than the market factor are of second order importance. Where value weights are used the FF3 factors are no longer significant. This implies that the significance of the FF3 factors is driven by small stocks. In the tests using portfolios it is the CMA factor from the five-factor model that is the significant second order factor rather than the HML or SMB factors.

Robustness

Out of sample tests, showing robustness of results across time and markets helps defend against the criticism of data mining. The case for the FF3 model rests on its ability to explain realised returns and there is evidence that it has some robustness in this regard, both over time Davis, Fama and French (2000) and across markets Fama and French (2012), but the research evidence is not so robust for Australia as subsequently discussed. Neither is FF3 so robust, as earlier discussion shows, against models containing additional factors

In their (2017a) paper Fama and French test the five-factor model on markets worldwide (USA and Canada, Europe, Japan and Asia Pacific) and find support for that model. However, the explanatory power of the various factors varies across regions. Two general conclusions about factors emerge from the 2017a paper. First, in contrast to the results of Fama and French

(2015), HML now has explanatory power. Second, the size factor does not matter much except in North America.

Fama and French (2017, p.7) emphasise the limitations of out of sample robustness saying:

> *Thorny issues arise for factors that have no theoretical motivation but are robust in out-of-sample tests. Without a model that identifies the forces responsible for a meaningful pattern in observed returns, it's hard to assess the likelihood that the pattern will persist.*

While FF3 has shown some robustness across time and markets, it is not so robust when the portfolios used in testing the model are not based on the usual size and B/M sorting of returns. Llewellen et al. (2010) explain that the usual portfolio sorting process can lead to misleading tests for priced factors and show that the evidence from an alternative set of portfolios provides little support for FF3.

Australian evidence

We now turn to evidence from tests of Fama and French factor models in Australia. In papers where the FF3 performance is compared with the CAPM, FF3 generally performs better in explaining realised returns. The research, however, is not a clear endorsement of FF3 for use in Australia. Discussion of the research can be found in McKenzie and Partington (2013) with more extensive discussion and more papers reviewed in Durand, Limkriangkrai and Chai (2015) and Vo (2015). What these discussions show is that the research contains substantial variation in the estimated magnitude of the SMB and HML factor premiums with signs varying between positive and negative. There is also varying evidence on whether or not the factors are significant. Without a theory there is no guidance on whether the sign on the factors should be positive or negative, but the existence of both is implausible. Relying just on empirics, consistency with Fama and French's results requires a positive sign on all factors.

The mixed Australian results and the different portfolio formation methods employed, motivate Vo's (2015) study of the robustness of FF3 to the methods of portfolio formation. On the basis of his own mixed results, he specifically recommends against using FF3 in regulation.

In other recent Australian work, Durand et al. (2015) reject the four factor model (FF3 plus momentum) and also a five factor model, where a liquidity factor is included. They also reject a model to explain Australian returns with US factor portfolios rather than Australian factor portfolios.[26] They replicate their analysis using the Brailsford et al. (2012) method of stock portfolio and factor portfolio construction and reject all the models, except the four factor

[26] This latter model is based on Durand, Limkriangkrai, and Smith's (2006) result that a Fama French model with US factors outperforms a purely domestic Fama French model and is based on the idea that the Australian market is integrated with the US market.

model using US factors. In contrast, Chai et al. (2019) conclude that restricting the sample to large stocks, using Australian factors with the FF5 model gives the best results.

The most comprehensive study of factors that explain returns in Australia is Hoang et al. (2019). This study controls for multiple comparisons, and the tests reject all the Fama and French factors.

Implementing the Fama and French three factor model

Factor portfolios

In implementing the FF3 model it is necessary to construct the factor portfolios and measure their returns. Since there is no theory to guide the construction of the portfolios, this is somewhat arbitrary. For example, the size factor is the difference in returns to a portfolio of small firms and a portfolio of big firms. But what are the cut-off points to be, in other words, what is small and what is big? Another question is what weights should be used for forming the factor portfolio? The portfolios that Fama and French use are value weighted, consistent with the normal way of measuring the return on the market.[27]

The easiest course of action is to follow Fama and French's method of factor portfolio construction and to the extent possible use data that Ken French supplies on his web site. This has the benefit of standardisation but intensifies the multiple comparison problem. The extract below from French's website describes the construction of the factor portfolios for the US FF3 model. As the extract shows different percentiles are used as the cut points for size and B/M. For Fama and French's international studies, the percentile cut points for size are also different, big stocks are the top 90% of market capitalisation for the region and small stocks are the bottom 10%. This demonstrates some of the scope for choice and judgement in the construction of factor portfolios. If we add the possibility of measuring the factor premiums as the returns to spread portfolios on a subset of stocks, say small stocks, the scope for choice gets even wider.

> *The Fama/French factors are constructed using the 6 value-weight portfolios formed on size and book-to-market.*
> *The portfolios, which are constructed at the end of each June, are the intersections of 2 portfolios formed on size (market equity, ME) and 3 portfolios formed on the ratio of book equity to market equity (BE/ME). The size breakpoint for year t is the median NYSE market equity at the end of June of year t. BE/ME for June of year t is the book equity for the last fiscal year end in t-1 divided by ME for December of t-1. The BE/ME breakpoints are the 30th and 70th NYSE percentiles.*

[27] If instead the stocks are equally weighted, portfolio returns can be interpreted as the return to a self-financing portfolio (e.g. long small, short big) exposed to the factor.

	Median ME	
	Small Value	Big Value
70th BE/ME percentile		
	Small Neutral	Big Neutral
30th BE/ME percentile		
	Small Growth	Big Growth

The Fama/French factors are constructed using the 6 value-weight portfolios formed on size and book-to-market.
SMB (Small Minus Big) is the average return on the three small portfolios minus the average return on the three big portfolios,
SMB = 1/3 (Small Value + Small Neutral + Small Growth) - 1/3 (Big Value + Big Neutral + Big Growth).
HML (High Minus Low) is the average return on the two value portfolios minus the average return on the two growth portfolios,
HML = 1/2 (Small Value + Big Value) - 1/2 (Small Growth + Big Growth).

Factor loadings and excess returns

Once the factor portfolios are constructed, it is possible to estimate the factor loadings (betas). This would normally be done by a time series regression of the realised excess return on portfolios against the realised excess return on the factors, as given by the equation below. Industry portfolios are the likely choice for estimating the cost of equity as in Fama and French (1997) and Gregory and Michou (2009).

$$r_{it} - r_f = \alpha_i + \beta_{im}(r_{mt} - r_f) + \beta_{is}(r_{st} - r_{bt}) + \beta_{ib}(r_{ht} - r_{lt}) + \varepsilon_{it}$$

Where *i* indexes the individual portfolio, the return variables denoted as *r* are as defined for the FF3 model equation above, with the *t* subscripts indicating their observed values at time *t*, $\alpha_i$is the estimated intercept term, the β_i terms are the estimated factor loadings (betas) on portfolio *i* for each of the factor portfolios, and ε_{it} is the error term.

This estimation process raises the same considerations about the term and frequency for return observation as discussed for the CAPM beta in Section 5, but now with three betas. Armed with the betas and given the risk free rate together with the factor premiums, the return according to FF3 can be estimated. The risk free rate can be determined as for the CAPM, so that is reasonably straightforward. The factor premiums could be estimated as the mean observed excess return on the factor portfolios, in the same way as used for the market factor in the CAPM, but this may be problematic.

There is likely to be a problem in following the standard prescription of using a very long time period when computing mean excess returns from historic data. The problem is that the data series available for the HML factor is likely to be relatively short, and short periods are likely to lead to high standard errors. If a short period is used for HML should a correspondingly short period be used for the other factors? Recall also that the estimate of the factor premium might be somewhat sensitive to how you form the factor portfolios. So, depending on the judgement that is made on the averaging period and how the factor portfolios are formed, we expect that there could be substantial variation in the estimates of the factor premiums.

An alternative to historic averages could be to use the factor premium estimates that are obtained from the second pass regressions of the Fama Macbeth (1973) procedure, often used to test FF3. Comparison of the factor premium estimates from the Fama Macbeth procedure and the historic averages could provide a cross check. How much comfort this would provide is an empirical question. Should the AER consider a move towards adopting the FF3 model this is an empirical question worthy of investigation.

Computing the returns on three, or more, factor portfolios, estimating their risk premiums and estimating three, or more, betas, increases the effort and data required to implement the model relative to the CAPM. In Australia, obtaining the data to build the model was a substantial barrier in the past, but less so now. However, deciding which Fama and French factor model to implement, and how, greatly increases the opportunities for gaming. For example, factor shopping, alternative ways to construct the factor portfolios including the choice of period used, different approaches to estimating the factor loadings (betas) and differing estimates of the factor premiums. Alternatively, the choice might be which model to use from the models in the Australian literature. In this case gaming would be about the choice of model. A review of past submissions to the AER will show that there has been extensive debate about the CAPM market beta and the market risk premium. Such debate would be likely to expand if Fama and French models were to be used.

Of course, the extra cost and effort involved in implementation of FF3 and dealing with submissions, should not preclude the use of FF3. The question is whether the benefit, if any, from using the FF3 model out-weighs the extra costs. One carefully conducted study concludes not. In estimating the cost of equity for use by US Federal Reserve Banks Green et al. (2003) investigate the use of an augmented FF3 model. From their analysis and their empirical estimates, they conclude that any accuracy improvements from using multifactor models are not worth the extra effort.

Use of Fama and French model in practice

Truong et al. (2008) in their Australian capital budgeting survey asked managers whether they used FF3. None reported doing so and only one respondent reported using some other multi-beta model.

As discussed in section 5 managers may adjust their CAPM estimates. Graham and Harvey (2001), and, Brounen et.al (2004), gave managers the opportunity to indicate which bases for adjustment they used. One of bases of adjustments on the list was labelled “market to book ratio”, which some managers selected. A market to book adjustment is not an obvious choice to compensate for bias in the estimate of the expected cash flow.[28] A reasonable conclusion, therefore, is that at least some managers have been influenced by Fama and French. [29] However, ranked by the number of responses, the market to book adjustment tends to rank towards the bottom of the list, reflecting the relatively small minority of managers who use it. The strongest use is reported in France and the UK, where 20% and 17.4% of respondents respectively made market to book adjustments to the discount rate.

With respect to funds management, the idea of portfolio tilts towards size and value (high book to market) became widespread after Fama and French (1992, 1993). This can be interpreted in two ways. Either fund managers take FF3 to be a model of expected returns and tilt their portfolios to adjust the expected return, or they consider that size and value factors reflect mispricing that could give them extra return for no extra risk.

We do note, however, that the practical use of FF3 often looks quite different from the way it is advocated in the academic/regulatory literature. Amongst practitioners, it is generally true that they would like their factors to be tradable and this has become possible through the expansion of exchange traded funds (ETFs). ETFs are widely available on Fama French factors but, generally, their construction is not based on a long-short portfolio as described by Fama French but on a long portfolio. In virtually any asset class, bar perhaps currency, shorting is expensive and complicated and involves margin requirements due to the unlimited liability associated with a short position. Therefore, factors based on holding portfolios of assets in ETFs tend to be long only. For a discussion of this, see Grant, Malloch and Satchell (2018).

FF3 has had extensive practical use in performance evaluation in funds management.[30] This can also be interpreted in two ways. Either as a measure of a fund manager's over/under-performance relative to the expected return, or as a method of performance attribution. As Carhart (1997, p.61) puts it after adding a momentum factor to FF3:

> *…it may be interpreted as a performance attribution model, where the coefficients and premia on the factor-mimicking portfolios indicate the proportion of mean return attributable to four elementary strategies…*

[28] However, we do not rule out a cash flow adjustment, recall the Fama and French (1995) result of persistent poor earnings of high B/M firms. Also, Graham and Harvey (2001) and Brounen et.al (2004) show that some firms did make cash flow adjustments for the market to book factor.

[29] We also think it more likely that the adjustment was based on the market to book ratio, with an increase in the discount rate for cases with a high market to book ratio, rather than Fama and French's adjustment for exposure to the HML factor. Exposure to the HML factor is measured by the HML beta, and if they have a positive HML beta, then even the stocks with a low market to book ratio get a positive return adjustment.

[30] A similar application has become commonplace in academic studies that involve measurement of abnormal returns.

In other words, the four-factor model sorts out whether there is anything to a fund manager's performance beyond a simple investment style, such as a portfolio size tilt.

It is not clear whether fund managers consider the Fama and French model as a better measure of expected returns, or whether instead they think it reflects anomalies in realised returns. We suspect that there is probably some of both.

There are examples of consideration of FF3 by regulators, but we are not aware of any substantial use for the purpose of regulation.

Summary and evaluation

The Fama and French model is not a theoretical model. There have been attempts to link it to theory, but we would describe these attempts as rationalisations grasping at possibilities. There is evidence that FF3 has done a reasonably good job in explaining realised returns and is somewhat robust across time in the USA, and across markets in various regions of the world. However, it is not so robust to variations in the way stocks are sorted when forming the portfolios used to test the model, or in tests based on individual stocks, there is also variability in the evidence on which factors matter and considerable variation in how to construct the factors.

In respect to Australia, the research about the Fama and French models has had very mixed results. The mixed results are critical, since the case for the model is that it fits the data. An empirical model where the factor premiums, both SMB and HML, change sign when different researchers fit the model to the data is hard to recommend. This sign change creates a challenge for regulators as stakeholders can argue for a higher or lower rate of return depending on their preferences and the selection of evidence. Stakeholders are likely to promote the papers that support their preferences as high-quality research and dismiss the papers that do not support their preferences as low-quality, or outdated.

FF3 was constructed as a model that explains realised returns. Whether this tells us anything about expected returns is not known, but we are not convinced that it does. What risks the HML and SMB capture and indeed whether they represent risk factors at all is ambiguous. While the FF3 factors were among the first factors suggested as explaining returns there are now over 400 such factors published in top journals Harvey and Liu (2019b). Even for careful researchers, like Fama and French, the number of factors has proved to be a moveable feast, as has the way in which they can be measured.

The danger of data mining and the comparative ease with which factors that "explain" returns can be created are well understood. Recent tests that control for this conclude that it is only the market factor that is consistently a significant factor. These tests largely reject the Fama and French factors.

FF3 uses finance and economic concepts and is based on market data, but it is not based on a theory of asset pricing. This not only leads to problems in interpreting the model, it also means there is no theoretical guidance on the choices available. Why for example use FF3, why not FF4, FF5 or FF6? The lack of theory and an expanded range of choices for models and inputs creates substantial opportunities for gaming.

The model has had a substantial impact on portfolio tilts and performance evaluation in funds management, but relatively little use in estimating the cost of capital and we are aware of no evidence of its use for this purpose in Australia. Its use in regulation is also uncommon.

The model can be implemented with Australian data and the implementation can be transparent. While there are many ways in which FF3 may be implemented, replication should be possible given detailed disclosure on exactly how all the inputs have been estimated and used. Understanding by a broad range of stakeholders will be a rather more challenging criterion to meet. Even academics are not clear on what constructs the factors, other than the market factor, represent.

In the light of our evaluation we cannot recommend the use of FF3, or its variants, for use in determining the regulated rate of return.

9. Consumption based asset pricing models

There are various ways of writing out the consumption CAPM, but a form similar to the SL-CAPM is:

$$E[r_i] = r_f + \beta_{ic}\left(E[r_m] - r_f\right)$$

Where the terms are as defined for the SL-CAPM except that β_{ic} is the consumption beta for asset *i.* This consumption beta is defined as the covariance of returns on the asset with the rate of growth of consumption divided by the covariance of returns on the market with the rate of growth of consumption. The original version of this theory replaces the equity risk premium by the expected growth rate of consumption in excess of the riskless rate and beta is then defined as the covariance of returns with the growth rate in consumption divided by the variance of the consumption growth rate.

Consumption based asset pricing models bypass the uncertainty over wealth and instead focus directly on uncertainty in returns leading to uncertainty over consumption. These models have had substantial theoretical use in examining anomalies in asset pricing. For example, consumption based analysis suggests that the equity market risk premium should be very much lower than that observed, or alternatively that investors have an implausibly high level of risk aversion. Attempts to explain this anomaly and others, such as the excess volatility puzzle, has led to significant effort devoted to the derivation of alternative consumption based models of asset pricing, a recent example is the X-CAPM (Extrapolative CAPM) of Barberis, Greenwood, Jin and Shleifer (2015). This is a consumption based CAPM which attempts to account for the impact of behavioural factors, in this case the effect of some investors forming expectations by extrapolating price trends into the future.

While there has been substantial theoretical work, the successful practical application of consumption based asset pricing models has been elusive. A key problem is how to measure the growth rate of consumption. One of the more successful papers to address this problem was *Asset Pricing with Garbage*. This paper used statistics on garbage as a proxy for consumption, Savov (2011). Savov's work prompted a paper in response, titled *Asset pricing without garbage*, by Kroencke (2017). This latter paper explains how the process for constructing consumption statistics greatly weakens the apparent correlation between consumption growth and returns. The paper also shows that adjusting the consumption data, by undoing the filters statisticians apply in compiling the data, leads to empirical results that give more plausible estimates of risk aversion/equity risk premium and also demonstrates that consumption is priced in the cross section of returns.

Kroencke's (2017) work demonstrates an important lesson. Many top academics have devoted considerable intellectual effort to developing theoretical consumption based asset pricing models that can explain asset pricing anomalies. The work of Kroencke suggests that perhaps the problem lies not so much with the basic model, but rather with the data used to test it.

Summary and Evaluation

Progress is being made in consumption based asset pricing, but we conclude that consumption based asset pricing models are still some way from use as a practical tool to estimate the return on equity. Thus, it is not suitable for use in regulation and consequently, we do not recommend adding consumption based models to the list of models that the AER might use.

10. A model where equity return equals the risk-free rate plus a fixed margin

We understand this model to mean that regulatory required return is equal to the risk-free rate plus some constant amount which would hold over the regulatory period. It is our understanding that the current use of the SL-CAPM satisfies this description as the fixed margin is the beta multiplied by the equity risk premium. More generally one could hypothesize other fixed margins depending on what models one would want to use.

In general, the fixed margin model is:

$$r_i = r_d + \theta$$

Where r_i is the return on the asset, r_d is the return on debt, and θ is the risk premium. The issues are what base value do you select for the return on debt and how do you determine the risk premium. In the current case the return on debt is specified to be the risk free rate. The choice of the risk free rate has the advantage of being consistent with asset pricing models, which generally set the expected rate of return as equal to the risk free rate plus a risk premium. It also means that the rate of return for the debt is an expected rate of return. Where risky debt is used as the base value, the complicating factor is that the observed yield on the debt is not the expected yield, but the promised yield. The expected yield is lower than the promised yield due to the risk of default. Based on these considerations it makes sense to have the risk free rate as the base rate.

The issue to resolve is setting the risk premium. The use of a widely accepted theory, such as the SL-CAPM, gives some objectivity to the process of determining what the fixed margin is to be. An alternative would be an average of the historic excess returns of stocks in the same industry.

Several problems arise with basing the risk premium on an average of industry excess returns. The excess return is likely to depend heavily on the period selected for measurement. An industry portfolio is less well diversified than the market and so excess returns on an industry are likely to be more volatile than excess returns on the market. As is well understood, measuring the average excess returns on the market requires very long run averages in order to reduce the impact of volatility on standard errors. Excess returns on industries may need even longer run averages. Use of only recent history to compute the average has the further disadvantage that recent history may reflect unusually good or bad times for the industry (returns above or below those expected), which then become locked into the allowed regulatory return. With respect to network businesses the industry is now down to two listed firms, which is a very small sample of firms on which to compute average returns.

Another approach is to estimate an industry premium based on the expected risk premium derived from an implied cost of equity, such as might be derived from the discounted dividend model for prices. We analyse the dividend growth model in Section 11 and conclude that it would not be an appropriate basis for determining the regulated rate of return, neither would it be an appropriate basis for determining the risk premium for the fixed premium model.

It may be the case that the fixed premium approach is advocated by those who would not want the fixed margin to be calculated by formulae but by negotiation and/or agreement between various parties subject to regulatory approval. Without further details as to how this would be done, it is very hard for us to comment.

Use of the risk free rate plus a fixed margin in practice

A variant of the model has been used in practice. The use of the cost of debt plus some premium for equity was, following the CAPM, the second most popular approach to determining the cost of capital in Australia, at 47% of respondents in Truong et. al (2008). However, in that survey managers could report more than one method for determining their cost of capital. There is clearly overlap between this method and the CAPM as the 72% for the CAPM plus 47% for the fixed margin model sums to 119%. The survey did not investigate how the margin was determined, but we surmise it was based on judgement distilled from many years of managerial experience. This does not seem to be an approach that would be appropriate to determination of the regulated rate of return. However, we understand that the fixed margin approach has had some use in regulation in the USA, but it is not clear whether this practice has continued.

Summary and evaluation

In our summary and evaluation, we are assuming that the risk premium is not derived from the SL-CAPM, or another asset pricing model. If so, the estimates from the fixed premium model are not derived from economic and finance principles, except in so far as there is recognition that higher risk requires a higher return. The model has had some use in practice, but we are not aware of any systematic evaluation of this model's empirical properties.

The model is simple, easy to understand and can be implemented using Australian data, whether it is transparent and replicable depends on how it is implemented. Depending on the model's implementation there may be a risk of substantial error and bias, and a lack of transparency. Determination of the reliability, relevance and suitability of the fixed premium method depends on how the premium is to be decided. A move to some new way of computing a risk premium, either added to the risk free rate, or the cost of debt, would be a substantial departure from established practice in setting the regulated rate of return. Without some very clear benefit from such a substantial change, and a clear method for deciding the premium, we cannot recommend it.

11. The dividend growth model

The dividend growth model has been a subject of extensive discussion in past submissions to the AER by us and by others. The focus of those discussions was on the use of the dividend growth model to estimate the market risk premium. In contrast, the focus here is on the use of the dividend growth model to directly estimate the cost of equity for individual firms.

We should first state that the dividend growth model is not an asset pricing model. It does not tell us about the determinants of required returns. With an asset pricing model, we can determine the required return and given the expected cash flows, we can then determine the asset's price. With the dividend growth model, it is the other way around. Given the share price and the expected cash flows we can infer the required return on equity.

The dividend growth model is one of a class of models used to compute the implied cost of capital. Given the expected cash flows for an asset and the current price, the internal rate of return that equates the present value of the expected cash flows to the current price gives the cost of capital for that asset. In other words, the cost of capital is backed out from a valuation model.

There are many implied cost of capital models. [31] Even if we restrict our attention to dividend growth models, there are many versions of the model, as we show below.

[31] Miller and Modigliani (1961) show how the discounted dividend model is equivalent to the discounted cash flow (capital budgeting) model, or the value of current earnings (assets in place) plus the value of future investment opportunities, or the value of the stream of earnings adjusted for reinvestment. Using accounting identities, cash flows may also be re-expressed in terms of accounting variables and this has led to a number of accounting based implied cost of capital models.

Theory and Testing

In our discussion of asset pricing models substantial attention was given to testing the CAPM and the Fama French models. In contrast, we give less attention to testing the dividend growth model. The dividend growth model is simply an algebraic expression of the proposition that the value of a share equals the present value of the expected cash flows to the shareholder. If this proposition is accepted, the dividend growth model properly specified is true by definition.

Any tests of the model, therefore, are likely to tell us about a failure in implementation, rather than a failure of the underlying model. For example, errors in the assumed dividends, errors in assumptions about growth, use of the wrong cost of equity, and failure to adjust for shareholders contributing or withdrawing equity capital. Using the market price as the test benchmark for estimates from the dividend growth model, we assume that markets are efficient and so we rule out speculative bubbles in prices. We do note that the excess volatility literature argues that prices are too volatile to be explained by subsequent changes in dividends and there is much debate about the rationality, or irrationality, of this volatility.[32] A discussion of these issues, however, is beyond the scope of this report.

Dividend growth models are often evaluated by comparison of their pricing errors with pricing errors from alternative accounting based valuation models, such as the residual income model. With respect to comparison of pricing errors, dividend models tend to perform worse than the accounting models, Penman and Sougiannis (1998), Francis, Olsson and Oswald (2000). However, we question what such tests really mean. Accounting valuation models are generally developed from the theory of the discounted dividend model, so if correctly implemented the dividend growth model and the accounting models should produce the same valuations. Differences in valuation thus represent differences in implementation. On this interpretation, dividend growth models have been more difficult to implement successfully.

However, the evidence of superiority of accounting based valuation models should not be overweighted, as not all the research finds that accounting models dominate dividend growth models. Courteau, Kao and Richardson (2001) find that there is not a lot difference between the pricing accuracy of the models. While, Anesten, Moller, Skogsvik and Skogsvik (2020) show that the relative rankings of the dividend growth model and the residual income model vary across different implementations of the models. However, across models and studies, mean absolute valuation errors as a percentage of the observed price tend to be large and error metrics over 50% are common. The message of this research is that it is difficult to implement these valuation models in a way that accurately reflects prices. The corollary is that it is also likely to be difficult to implement these models in a way that provides accurate estimates of the implied cost of equity.

[32] Jiang and Lee (2005) show that the excess volatility in prices relative to dividends is not such a problem, when a broad measure of dividends, adjusted for capitalisation changes such as share buybacks, is used in the volatility tests.

There is one advantage in deriving the implied cost of capital compared to estimating the share price. To estimate the share price there first needs to be an estimate of the cost of equity and a forecast of earnings and/or dividends and growth rates. Whereas, in estimating the implied cost of equity, the current share price is observable and only a forecast of earnings and/or dividends and growth rates is required. However, implied cost of equity estimates have turned out to be unsatisfactory, see for example Easton and Sommers (2007). A key reason for this is the use of analysts' forecasts of earnings and dividends in implementing the models. Analysts forecasts are upward biased, and we discuss this in more detail in the section on the implementation of the dividend growth model.

Our brief is to review the dividend growth model (DGM), but there are many versions of "the DGM." Therefore, it is to a discussion of these alternatives and the issue of specification, that we now turn.

Free cash flow and dividends

The fundamental valuation/implied cost of capital model for equity is given by:

$$E_0 = \sum_{t=1}^{\infty} \frac{\mathrm{E}[FCE_t]}{(1 + r_E)^t}$$

Where E_0 is the total value of the firm's equity at time 0, $\mathrm{E}[FCE_t]$ is the expected total free cash flow to equity at time t, where expectations are taken at time 0. The cash flow to equity is the cash available for distribution to shareholders and is computed net of any contributions of equity capital to be made at time t, r_E is the required rate of return on equity. As with asset pricing models we have the problem of working with expected values.

The relation between the free cash flow model and the dividend valuation model is given by:

$$E_0 = \sum_{t=1}^{\infty} \frac{\mathrm{E}[FCE_t]}{(1 + r_E)^t} = \sum_{t=1}^{\infty} \frac{\mathrm{E}[DIV_t + EW_t - EC_t]}{(1 + r_E)^t}$$

Where the numerator on the right hand side is the expectation of the total value of the dividend at time t, DIV_t, plus the total equity capital withdrawn from the firm at time t, EW_t, less the total equity capital contributed to the firm at time t, EC_t.

Equity is usually withdrawn via share repurchases but may also be withdrawn via a return of capital, although the latter is uncommon. Equity may be contributed through purchases of new shares issued by the firm. In Australia, this is typically via a share placement, a rights issue, a share purchase plan, or shares issued through a dividend reinvestment plan.[33]

The discounted dividend model is typically written as:

$$E_0 \approx \sum_{t=1}^{\infty} \frac{\mathrm{E}[DIV_t]}{(1 + r_E)^t}$$

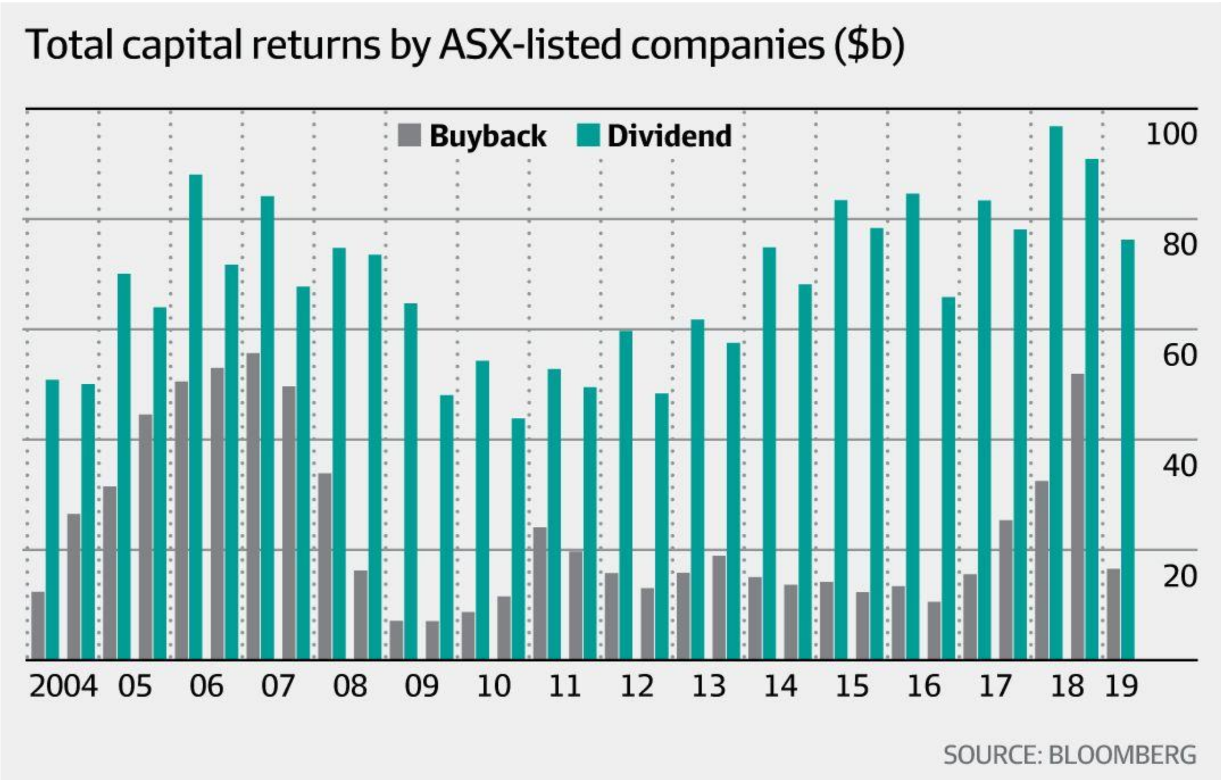
[33] New issues of shares can also arise from conversion of convertible preference shares, or convertible debt and from exercise of stock options and warrants.

We have written this equation as an approximation, rather than with the usual equality, to emphasise the potential for error in using the discounted dividend model unless there is an adjustment for expected contributions and expected withdrawals of equity capital. Another important distinction between dividends and the free cash flow that underpins the value of equity, is that dividends represent a smoothed version of the free cash flow. This smoothing can be accomplished by varying the company's cash balance. In cases where the company has insufficient cash to pay the desired dividend the dividend can be financed by the issue of shares or debt, and when there is surplus cash this can be reduced by repurchasing shares or paying down debt.

Typical applications of the discounted dividend model use explicit dividend forecasts for a few years, commonly from two to five years. Beyond the time horizon covered by explicit dividend forecasts some pattern of dividend growth is assumed. We discuss this in more detail in the section on per share models below.

Do contributions and withdrawals of equity matter?

It is natural to ask how important the adjustments for contributions and withdrawals of equity are. Total annual share repurchases (buybacks) in the US market have at times exceeded total annual dividends but repurchases have not been as popular in Australia. Nevertheless, for the years since 2004 Commins (2019) reports a median figure of $16 billion in Australian buybacks. As the chart below shows, while annual buybacks have been less than dividends, they are a material proportion of the annual distribution of cash to shareholders. Unfortunately, buybacks, particularly at the level of the firm, are inherently more difficult to predict than dividends and we know of no systematic attempt to do so. Thus, it is not so easy to incorporate expected buybacks into the valuation model. A detailed discussion of the issues in valuation arising from buybacks and the importance of adjusting for buybacks when estimating returns is given in Straehl and Ibbotson (2017).



Source: Commins, P., 2019, Don't fear the buyback blitz, *Australian Financial Review*, Aug. 30 2019.

While failure to account for buybacks leads to an underestimate of the cash flow to investors, and hence an underestimate of the implied cost of equity, failure to account for capital contributions will lead to an overestimate. Capital contributions in Australia typically exceed repurchases in aggregate. Thus, if no adjustments are made, the net effect is likely to be an overestimate of the cash flow. This in turn will lead to an overestimate of the implied cost of equity.

The table below shows total ASX capital raisings for the five years 2015 to 2019. Comparing the total capital raised with buybacks in the figure above, shows that capital raisings substantially exceeded buybacks in each of the last five years, and indeed are of comparable magnitude to the dividend payments. If we restrict the comparison to secondary capital raised, (capital raised by currently listed firms) this exceeds buybacks in each year except 2018.

A substantial proportion of the total capital raised is for initial listings, although it is less than secondary capital raising. While capital for new listings does not affect the valuation of existing companies, it goes to the argument that in order to support the expected growth in dividends for the market as a whole, there will have to be future equity investment in companies that do not currently exist.

ASX Capital Raisings ($billions)

Year	2105	2016	2017	2018	2019
Initial capital raised	$38.9	$23.6	$14.7	$25.7	$37.4
Secondary capital raised	$38.8	$45.3	$37.2	$43.0	$38.8
Other secondary capital raised	$11.2	$ 9.7	$ 4.2	$12.9	$ 9.8
Total capital raised	$88.8	$78.6	$55.9	$81.7	$86.0

Source ASX limited Annual Report 2019 (Totals may not add up due to rounding)

Dividend reinvestment plans

A particularly obvious capital contribution that offsets dividends arises from dividend reinvestment plans. In such plans, instead of receiving a cash dividend the shareholder elects not to receive the cash, but instead to reinvest that cash in newly issued shares. Many Australian companies operate dividend reinvestment plans (DRP) and it is not unusual for participation in those plans to be of the order of 30%. With 30% participation a notional $100 million dividend would involve distribution of only $70 million in cash to shareholders. Of course, dividend reinvestment plans only apply to those firms paying dividends, nonetheless they are a substantial source of capital. According to ASX (2010) DRPs contributed on average 18% of secondary equity raised over the period 2007 through 2009.

The distinguishing feature of DRPs relative to other equity raisings is that they occur regularly, every time a dividend is paid. This is important because it has an immediate impact on correctly estimating dividends from time period 1 onwards. In contrast, other capital contributions and withdrawals may, or may not, be expected over the horizon for which explicit dividend forecasts are made. Whatever the case, the impact of capital transactions will need to be factored into the growth rate assumed for periods after the last explicit forecast of dividends.

To illustrate the effect of a dividend reinvestment plan on the estimation of the cost of equity consider the case of a company that plans to pay a \$100 million dividend next year. The dividend is expected to grow at 5% per year, so in year 2 the dividend is expected to be \$105 million and so on. However, in order to support the future cash flow, the company needs to invest cash each year equal to 30% of the dividend. This will be obtained through a dividend reinvestment plan with an expected participation rate of 30%. If the participation rate varies from 30% in a given year the firm will make up shortfalls by placements and will offset excess participation by share repurchases. Consequently, the expected net cash flow to shareholders in year 1 is \$70 million, in year 2 it will be \$73.5 million and will continue to grow thereafter at 5% per year. The required return on equity is 10%. The company can be valued as a growing perpetuity. Thus, with g as the growth rate the valuation is given by:

$$E_0 = \frac{\mathrm{E}[DIV_1 \; - EC_1]}{r_E - g} = \frac{100 - 30}{.10 - .05} = \$1{,}400 \text{ Million}$$

Given the current value of \$1,400 million and the expected dividend of \$100 million, suppose that the implied cost of capital is now estimated without adjustment for the DRP. The implied cost of equity is then incorrectly calculated as:

$$r_E = \frac{\mathrm{E}[DIV_1]}{E_0} + g = \frac{100}{1400} + 0.05 = 12.14\%$$

The failure to adjust for the effect of the dividend reinvestment plan creates an upward bias in the implied cost of equity and it is not clear to us that adjustments for DRPs are commonly made when estimating the implied cost of equity.

Per share models

Thus far we have expressed the valuation equations in terms of the total value of equity, rather than value per share. We have done this because it simplifies the valuation modelling and highlights the importance of adjusting for contributions and withdrawals of equity capital. The problem in moving to an analysis at the level of individual shares is that with share issues and repurchases the number of shares changes through time. The effects across shareholders are not uniform since shareholders may choose whether or not they participate in share issues or buybacks.

The key takeaway is that the valuation at a per share level depends upon the dividends attributable to each share on issue at the time of a valuation. For example, if there are future share issues this will dilute an existing share's claim on future dividends. This means a downward adjustment in the share of total dividends attributed to existing shares and so the dividends per share are diluted by the increase in the number of shares on issue. Allowing for this dilution effect is a well-recognised problem in financial analysis.

Taking our example of the dividend reinvestment plan above, let us re-examine the analysis in per share terms. Suppose that there are 100 million shares initially on issue. The share price will therefore be \$14, next year's expected dividend per share (dps_1) will be \$1.00 and \$0.70 after adjusting for the DRP. In this case the implied cost of equity is given by:

$$r_E = \frac{\mathrm{E}[dps_1 adjusted]}{P_0} + g = \frac{0.70}{14} + 0.05 = 10.00\%$$

Whereas, without adjusting for the DRP the implied cost of equity will be incorrectly calculated as:

$$r_E = \frac{\mathrm{E}[dps_1]}{P_0} + g = \frac{1.00}{14} + 0.05 = 12.14\%$$

In this case the adjustment was relatively easy as the valuation model only required a forecast of dividends for one period ahead, which is before the extra shares are issued. However, this is not so realistic and as we show below there are several models that require dividend forecasts more than one period into the future. If we need a forecast of dividends more than one period ahead, we also need to allow for the extra shares issues in period 1. In our example there will be more than one million shares on issue in period 2, thus diluting the dividends per share in period 2, and so on. It is easy to say that an adjustment will be required, but not such an easy adjustment to make ex-ante, since the number of shares issued will depend on the ex-dividend share price in period 1.

We now move on to express the dividend models in per share terms. We do this because it is the way dividend models are usually presented. In moving to this form of presentation we are assuming that the effect of expected contributions and withdrawals of equity capital have been correctly accounted for and that we are working with dividends per share net of these effects. Thus, we write the valuation model as an equality rather than an approximation. While the assumption is that appropriate corrections have been made, whether this is the case in reality is an open question. For ease of notation we also drop the expectation operator, but it should be remembered that where a time subscript t is greater than zero, this implies an expected value. In per share terms the fundamental dividend model is given by:

$$P_0 = \sum_{t=1}^{\infty} \frac{dps_t}{(1 + r_E)^t}$$

Where dps_t is the expected dividend per share at time *t,* and P_0 is the price at time 0. Clearly it is not feasible to forecast the time series of dividends to infinity. The usual way round this problem is to assume some pattern of growth in dividends. Given the assumption of a constant growth rate in dividends *g,* the model be rewritten as the Gordon growth model:

$$P_0 = \frac{dps_1}{r_E - g}$$

An alternative is to allow several periods for expected dividends and then allow for a terminal value based on the Gordon model. This is often referred to as a two stage growth model, where after *n* periods growth settles down to a steady state rate of *g*. This can be written as:

$$P_0 = \sum_{t=1}^{n} \frac{dps_t}{(1 + r_E)^t} + \frac{dps_{n+1}}{r_E - g} \times \frac{1}{(1 + r_E)^n}$$

A further alternative is to allow for a linear decline from abnormal growth to the steady state growth rate over a time span of length 2H. This is called the H model and can be written as:

$$P_0 = \frac{dps_0\,(1 + g)}{r_E - g} + \frac{dps_0\,H\,(g_a - g)}{r_E - g}$$

Where g_a is the abnormal growth rate for the first period. This growth rate declines linearly over the 2H periods until it reaches the steady state value *g*.

Yet another alternative is a three stage model that allows for an initial stable abnormal growth rate g_a for *n* periods, followed by a varying pattern of dividends that eventually settle down to the steady state growth *g* rate at time *m*.

$$P_0 = \sum_{t=1}^{n} \frac{dps_0(1+g_a)^t}{(1+r_E)^t} + \sum_{t=n+1}^{m} \frac{dps_t}{(1+r_E)^t} + \frac{dps_{m+1}}{r_E - g} \times \frac{1}{(1+r_E)^m}$$

Gordon extended his analysis of dividend models in Gordon and Gordon (1997). The paper presents the finite horizon expected return model, FHERM. This model has the attractive feature that the firm settles down to a steady state after *n* periods such that the firm earns a return on equity investment equal to the required rate of return on its shares. This means that the investments are expected to have a zero NPV, which is the outcome to be expected under a competitive equilibrium. The attraction of this model is not only that it assumes convergence to a competitive equilibrium, but also that no forecast of growth is required beyond period *n*. The model can be written as:

$$P_0 = \sum_{t=1}^{n} \frac{dps_t}{(1+r_E)^t} + \frac{neps_{n+1}}{r_E} \times \frac{1}{(1+r_E)^n}$$

Where $neps_t$ is normalised earnings per share at time *t,* which are defined to exclude abnormal earnings. Assuming a constant growth rate *g* the model can be rewritten as:

$$P_0 = \sum_{t=1}^{n} \frac{dps_0(1+g)^t}{(1+r_E)^t} + \frac{neps_1(1+g)^n}{r_E} \times \frac{1}{(1+r_E)^n}$$

As Gordon and Gordon (1997) note, when n = 0, r_E is equal to the earnings yield, and when n tends to infinity r_E tends to the dividend yield plus *g*. They also caution that a possible source of error in the model is (p.54):

> *Investors may expect that corporations will issue or repurchase shares rather than using only retained earnings and dividends to finance equity investment and to distribute profits.*

This takes us back to our earlier discussion of this problem.

By this point the reader has probably seen enough dividend growth models, but there are other possibilities. For example, it is possible to have a closed form solution for a dividend valuation model where dividends grow by a constant dollar amount each period, and there is also a closed form solution for the case of cyclical variation in one of the components of dividends.[34]

One issue with dividend growth models is that as growth slows, firms will typically have less need to retain earnings to fund new investments, thus payout ratios are quite likely to rise.

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[34] See, Buser and Jensen (2017).

Molodovsky, May, and Chottiner (1965) propose a three stage model with high, declining, and stable growth regimes and a payout ratio that varies inversely with the growth regimes. This highlights the point that in all of the models above, the *dps* terms can be replaced by an *eps* term multiplied by the dividend payout ratio. The Molodovsky et al. model can also allow for different costs of equity in each regime. Monte Carlo simulation is another method that has been used to form dividend forecasts, and to generate prices allowing for varying dividend growth rates and varying costs of equity, Donaldson and Kamstra (1996)

There are also stochastic dividend growth models based on a Markov chain approach, see for example, Hurley and Johnson (1994, 1998). The work of Hurley and Johnson (1994) is extended by Yao (1997) and applied to the pricing of electricity utilities. Yao assumes three possible outcomes for next period's dividends. Next period's dividends grow with probability p_u, or fall with probability p_d, or stay unchanged with probability (1- p_u- p_d). Yao considers an additive growth model and a geometric growth model. In the additive model dividends rise or fall by an amount *d*, for example in the upstate $dps_{t+1}= dps_t + d$. Yao shows that the price evolves according to:

$$P_t = \frac{dps_t}{r_e} + \left(\frac{1}{r_e} + \frac{1}{{r_e}^2}\right) d(p_u - p_d)$$

For the geometric growth model dividends grow at the rate *g,* for example in the upstate $dps_{t+1}= dps_t(1+g)$. In this case, the price evolves according to:

$$P_t = dps_t \left(\frac{1 + (p_u - p_d)g}{r_e - (p_u - p_d)g}\right)$$

The models provide quite good approximations to the actual share prices for the five utilities that are valued. The relative accuracy of the price estimates is three to two in favour of the additive model.

An attractive feature of the stochastic approach is that there is the potential to form confidence intervals for the estimates. The research on stochastic dividend growth models is still continuing, see for example D'Amico (2017).

We can now see that, if the AER were to use a dividend growth model to estimate the cost of equity for network businesses, there would be several issues to consider. First, which of the possible dividend growth models best fits the nature of a regulated network. Second, the AER would need to determine the input variables. The key inputs are the magnitude of expected dividends, the growth rate(s), the pattern of growth assumed, and the assumed length of the various growth regimes. Choices about these inputs are likely to have a significant impact on the calculation of r_E. Third, the AER would need to ensure that there had been adequate adjustment for expected capital contributions and withdrawals, and in particular the impact of DRPs. We note that DRPs have been offered by listed network companies. The range of choices to be made in implementing the DGM opens significant opportunities for gaming by the stakeholders.

Implementing the dividend growth model

Implementing the DGM to estimate the implied cost of equity requires the following steps, first observe the share prices of listed network businesses. This is straightforward, but with a current sample of two listed firms, there is the potential that some abnormal event or particular characteristic of a firm may result in price behaviour and a cost of equity that is unrepresentative of the industry.

Given the price, the next step is to select the dividend growth model to be used and form expectations of future dividends and the pattern of growth as discussed immediately above. In this process adjustment for capital contributions and withdrawals, and in particular adjustment for the effect of DRPs are likely to be problematic. There are advantages in working with total cash flows and the total value of equity as this avoids the need to forecast the number of shares on issue in the future.

Inputs for expected earnings and dividends

The most common approach to implementing implied cost of capital estimates is to use the forecasts of earnings and dividends provided by analysts. In previous reports we have cautioned the AER about the problems in relying on analyst's forecasts, in particular the problem of forecast bias. Several of the relevant issues have been conveniently summarised in a recent paper by Paton, Cannavan, Gray and Hoang (2019) on the implied cost of equity in Australia. They say (p.2):

> *Despite the widespread adoption of ICC methods within both the accounting and finance literature, a number of studies have shown such models to yield expected return estimates that exhibit little to no association with future realised returns, and that this dissociation is correlated with biases embedded in analyst forecasts (Easton and Monahan, 2005). There is a wealth of literature that confirms the existence of analyst forecast bias in the US market. For instance, analysts have been shown to produce overly optimistic forecasts (De Bondt and Thaler, 1990), and under-react to certain information (Abarbanell and Bernard, 1992). This has been attributed to a variety of causes, from attempts to curry favour with firm management (Francis and Philbrick, 1993) to cognitive processing constraints (Lin and McNichols, 1998). Irrespective of the exact causes, such biases have been shown to result in measurement errors for ICC estimates when analyst forecasts are used as a proxy for market expectations (Easton and Sommers, 2007; Guay et al., 2011).*

We could add additional material on why analyst's forecasts are upward biased, but the bottom line would remain unchanged. Implied cost of capital estimates (ICC) based on analyst's forecasts are not to be relied upon as providing accurate and unbiased estimates. Paton et.al. (2019) confirm that there is upward bias in Australian analysts' forecasts. Such upward bias leads to an overestimate in the implied cost of equity.

Past submissions by regulated networks have advocated the use of the dividend growth model with analysts' forecasts as the input. Given that analysts' forecasts will give upward biased costs of equity, what is the alternative? The answer according to Paton et al. (2019) is to use earnings forecasts generated by cross sectional models, which are less biased than analysts' forecasts, and in contrast to analysts' forecasts provide estimates that correlate with future buy and hold returns. However, based on the current evidence available, we are not so sanguine as to recommend that a cross-sectional model is an approach that should be adopted by the AER for estimating the implied cost of capital for individual firms.

Since the Paton et al. paper only used accounting valuation models it is not clear what their results imply for dividend growth models, other than that there is likely to be a problem of bias if analysts' forecasts are used. Truong and Partington (2007) examine both accounting and dividend discount models in computing the implied cost of equity in Australia. They find, consistent with prior literature, that a composite forecast, combining time series and analysts' forecasts, provides the best forecast. They also find that the best model is the FHERM dividend model of Gordon and Gordon (1997).[35] However, due to limited data availability their out of sample test only covered three years. This is a very small period for a test sample, particularly given the volatility of holding period returns, and the authors describe their results as preliminary. Thus, their model ranking should be taken with a large pinch of salt.

We conclude that it is unambiguously clear that the use of analysts' forecasts will give upward biased result for the implied cost of equity. What alternative should be used to replace analysts' forecasts requires much more Australian research.

Cash flow news discount rate news and sticky dividends

A pervasive problem in implied cost of equity models is to separate the cash flow news from discount rate news in terms of the effect on price. This is an important problem because the implied cost of equity is backed out from the observed price. The price changes because of changes in the information set. Such changes cause investors to change their expectations of future cash flow and/or change their required return and this flows through to the price. Unless the component of price change due to cash flow news can be separated from the component due to discount rate news, this can lead to error in estimating the implied cost of equity. We illustrate this problem in the context of another pervasive problem, sticky dividends.

Recall our earlier example, where next year's expected *dps* adjusted for the DRP was $0.70, the expected growth rate *g* was 5%, the cost of equity was 10% and the price was $14. Now suppose bad times hit the economy. As a consequence, investors' revise their growth expectations for dividends for the firm down to 4%, but this is unobserved. The investors do not change their required return, but this is also unobserved. It is well known that dividends are sticky, particularly downwards. Managers are very reluctant to cut dividends and only increase them when they are reasonably confident that the increase can be sustained. So next year's dividend

[35] The worst performing model was the CAPM.

is expected to remain at \$0.70. The revision in growth expectations causes the price to fall. The new price is:

$$P_0 = \frac{\mathrm{E}[dps_1 adjusted]}{r_E - g} = \frac{0.70}{0.10 - 0.04} = \$11.67$$

Taking the new price and calculating the implied cost of equity, the analyst leaves the growth rate at 5%, assuming that the price decline is due to an increase in the cost of equity. This gives:

$$r_E = \frac{\mathrm{E}[dps_1 adjusted]}{P_0} + g = \frac{0.70}{11.67} + 0.05 = 11.00\%$$

Thus, the cash flow news is incorrectly interpreted as a change in the required return on equity.

Now assume that investors expect the growth rate to go down to 4% and also raise their required return to 11%. The new share price is:

$$P_0 = \frac{\mathrm{E}[dps_1 adjusted]}{r_E - g} = \frac{0.70}{0.11 - 0.04} = \$10$$

The analyst attributes the price change to a higher cost of equity and computes the implied cost of equity as:

$$r_E = \frac{\mathrm{E}[dps_1 adjusted]}{P_0} + g = \frac{0.70}{10.00} + 0.05 = 12.00\%$$

Assuming all the price change is due to discount rate news is likely to lead to an overestimate of the cost of equity when prices are falling and an underestimate when prices are rising. Without being able to reliably separate cash flow news from discount rate news, the implied cost of equity is not a reliable way of tracking changes in required returns or risk premiums. The problem is most acute when prices are most volatile.

Sticky dividends are a particular problem because this helps hide the cash flow news. The problem is exacerbated, because typically there is a very small number of dividend forecasts before the firm is assumed to settle down to the steady state growth rate. That steady state growth rate is commonly assumed to be the long run growth rate of the economy and this is often treated as a constant from one valuation to the next. Consequently, there is limited scope to accommodate cash flow news, which is already attenuated by the sticky nature of dividends.

Because of sticky dividends, when there is a crisis, such as the GFC, or the current Corona virus crisis, share prices drop sharply, but firms try and hold their dividends. Consequently, dividend yields rise. In a model like the Gordon growth model, which says the cost of equity is the dividend yield plus the expected growth rate in dividends, the immediate effect is to increase the estimated cost of equity. This result can be very misleading unless there is also an appropriate revision in the growth rates, but this is difficult to do. Furthermore, as explained in the preceding paragraph, the steady state growth is usually left unchanged. For these reasons, the DGM can be particularly unreliable when the market falls sharply.

The choice of steady state growth rates has been a contentious issue in previous submissions to the AER. In our submissions we have shown that there are substantially different values that might be chosen for the steady state growth rate. This is another difficulty in using the DGM. We also note the growth rate of the economy is often suggested as the steady state growth rate. This is on the basis that growth rates higher than this value are unlikely, as they imply that eventually the firm becomes bigger than the economy. We point out that this is an upper bound. For individual firms it is entirely feasible for the growth rate to be less than the growth rate in the economy, or indeed even to be negative if the firm is expected to eventually disappear into liquidation.

Use of the dividend growth model in practice

Before the advent of the CAPM, the discounted dividend model was a popular model for determining the implied cost of equity. Consequent to the development of the CAPM, use of the discounted dividend model to estimate the cost of equity declined over time. For the USA, Gitman and Mercurio (1982) found that just over 31% of the firms they surveyed used the discounted dividend model for the cost of equity. While in their 2001 paper Graham and Harvey report that just under 16% of respondents made substantial use of the implied cost of equity from discounted dividend/earnings models. Brotherson et al. (2013) survey leading US firms, selected from the top two firms by industry based on a Fortune/Hay Group ranking for "wise use of assets". There were 19 firms subject to an in depth interview on their approach to estimating the cost of capital and only one firm used the DGM. That firm used the DGM as a check on its CAPM estimate. For Australia, Truong et al. (2008) find that only 8% of the firms used the DGM. While for Europe, Brounen et.al (2004) find that about 10% of firms in the countries they surveyed used the DGM.

Brotherson et al. (2013) also undertook in depth interviews with large investment banks.[36] None of the respondents used the DGM as the model for estimating the cost of equity, but two did make use of the DGM in estimating the market risk premium.

With respect to regulation in the US, regulators have made considerable use of the discounted dividend model. We suggest that some of this use was probably a continuation of regulatory practices established prior to the development of the CAPM. It would be interesting to conduct a systematic survey of current US regulatory practices in order to establish the contemporary usage of the discounted dividend model relative to usage of the CAPM and possibly other models. With respect to regulation in Europe, Australia and New Zealand, Schaeffler and Weber (2012) found that only one of the regulators across the 21 countries used the DGM and that was as a cross check on their CAPM results.

[36] These investment banks were: Bank of America, Merrill Lynch, Barclays Capital, Credit Suisse, Deutsche Bank AG, Evercore Partners, Goldman Sachs & Co., Greenhill & Co, LLC, JP Morgan, Lazard, Morgan Stanley, UBS.

Summary and Evaluation

The theoretical foundation of the dividend growth model is solid, and the model is clearly based on economic and financial principles. The issues lie in implementation. From our discussion above it is clear that there is plenty that can go wrong in the implementation. The empirical evidence is consistent with this view. On the basis of our analysis we conclude that the risk of error and bias in the use of the DGM are substantial.

It is possible to implement the model using Australian data, but as for the CAPM, having only two listed firms provides a limited data set. In the case of the CAPM, given the relative stability in the betas for regulated networks, appeal can be made to historic estimates of beta. Unfortunately, appeals to history are less compelling for the DGM, the more so if, as the networks argue, the DGM tracks changes in returns over time. The choice of appropriate inputs to the model is also an issue. The use of analysts' forecast are likely to result in an upward biased estimate of the cost of equity, but it is not clear what the alternative to analysts' forecasts should be.

Depending on its implementation, the use of the DGM can be transparent and replicable but given the range of choices available it is wide open to gaming. The DGM can be relatively simple, but how simple depends on which variant of the model is implemented. For example, it is less simple if the stochastic Markov chain approach is selected. Thus, depending on which variant of the model is used it can be understandable by a broad set of stakeholders.

The DGM has in its favour that it has had empirical use in the practice of estimating the cost of equity. However, as the survey evidence shows it has fallen out of favour. Given our analysis, this is entirely understandable. On the basis of that analysis we cannot recommend the DGM for use in estimating the regulated rate of return for individual firms. We conclude that the DGM has the potential to be relevant, but it is not reliable or suitable. Whether it is simple depends on the model implemented and with respect to practical use in estimating firms' cost of equity it seems to have failed the test of time.

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Expert Witness Compliance Declaration

We have read "Expert witnesses in proceedings in the Federal Court of Australia" which are attached as Appendix 3. This report has been prepared in accordance with those guidelines. As required by the guidelines, 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.

Signed

Graham. H. Partington

Steven. E. Satchell

Appendix 1

Terms of Reference

Background

The AER applies a 'building block' model to set regulated revenues for electricity and gas network service providers. The building blocks—return on capital, return of capital, operating expenditure and tax —reflect the expected costs that would be incurred by a benchmark efficient entity operating the network. This is a form of incentive regulation, as building blocks are estimated in advance for a regulatory control period (typically five years) and the networks retain any benefit (or bears any detriment) where it is able to reduce costs below the AER's estimates. Revealed costs are then used to inform building block estimates for the following control period, so that efficiency gains are passed on to consumers. The AER also operates a number of incentive schemes in conjunction with the building block framework.

The return on capital building block is set by applying a rate of return on capital to the regulatory asset base (RAB) each year. The AER estimates the allowed rate of return for regulated businesses using the approach set out in the 2018 RoR Instrument. The Rate of Return Instrument is binding under the National Electricity Law and National Gas Law. This means that the AER and network businesses are required to set the rate of return according to the current Instrument. There is a four year cycle for the development of the next rate of return instrument (the 2022 instrument), which is to be published in December 2022.

The 2022 instrument is to be developed through a comprehensive consultation process, with consumers, investors and businesses included throughout the process. The AER has already commenced its 'Pathway to 2022' work program for the development of the 2022 instrument. The AER must be satisfied that the approach to setting the allowed rate of return achieves the National Electricity Objective (NEO) and National Gas Objective (NGO), and the related revenue and pricing principles (RPPs).

While the 2022 Instrument does not have to adopt the 2018 approaches, the 2018 RoR Instrument applies the following key characteristics when estimating a businesses' allowed rate of return:

- It use a nominal vanilla weighted average cost of capital (WACC) formulation (used in a post-tax revenue model, i.e. effect of the interest tax shield is considered in cashflows)
- It assumes a 40% equity and 60% debt capital structure.
- It uses a domestic Capital Asset Pricing Model (CAPM) to estimate the Return on Equity (RoE). This is estimated as:
    - The risk free rate is estimated from the yield on 10 year to maturity Commonwealth Government Securities (CGS) over a short averaging period prior to the commencement of the regulatory control period (between 20 and 60 business days).

    - Equity beta of 0.6 (fixed for the life of the 2018 instrument)
    - Market risk premium of 6.1 per cent (also fixed for the life of the 2018 instrument)
    - This means the RoE is the risk free rate plus a fixed premium of 3.66%.
- It uses a trailing average portfolio for the allowed return on debt, updating 10% of the portfolio estimate annually (i.e. a ten year rolling window of annual return on debt observations).
- Annual return on debt are based on debt costs for the benchmark BBB+ credit rating at a 10 year term, estimated by weighting A rated and BBB rated benchmark curves (from a number of providers) over an averaging period.
- Market data for the return on debt and risk free rate is sourced from averaging periods nominated by the network businesses in advance.

In developing the 2018 Instrument, the standard (Sharpe-Lintner) CAPM was used as the 'foundation model' and given a primary role in the determination of the return on equity. This is the focus for this request for quote.

Project scope

Summary

The AER seeks advice on the return on equity approach for use in the AER's regulatory framework to determine the regulated rate of return that meets its legislated objectives—that is, setting a return on capital building block that achieves the NEO and NGO. This means our rate of return instrument should promote—to the greatest degree—efficient investment in, and efficient operation and use of, electricity or gas network services for the long term interests of consumers. We consider efficient financing costs are reflected in the prevailing market cost of capital (or WACC) for an investment with a similar degree of risk as that which applies to a service provider in respect of the provision of regulated services.

The AER requires an expert advisor to review the use of the CAPM against alternative return on equity models. The expert advice should compare and contrast the alternative models and identify their strengths and weaknesses. The expert should make recommendations to the AER on which model (or models) should be used, and the manner in which they should be used.

There are three stages to this project:

- Stage one: Primary analysis and preparation of report
- Stage two: Involvement in stakeholder consultation phase
- Stage three: Further analysis in response to stakeholder submissions and preparation of second report.

This RFQ is for stage one only. Stage two and stage three are described only in general terms; the supplier only needs to address their capability and capacity to perform this work in the third and fourth quarters of 2020. For the purpose of clarification, suppliers are not required to provide costings for stages two and three at this time.

Detail – Stage one

The expert advisor is requested to consider the following return on equity models, for use in the AER's regulatory framework to determine the regulated rate of return for electricity and gas networks:

- Standard SL CAPM as a domestic model (as used as the 'foundation model' in 2018)
- International CAPM (the standard CAPM populated with international parameters)
- Black CAPM (also labelled the zero-beta CAPM)
- Fama-French three factor model
- A model where equity return equals the risk free rate plus a fixed margin

The expert may also include, at their discretion, additional models in their evaluation set.

The expert advisor is requested to use the following criteria to evaluate the alternative models for use in the regulatory framework (noting the overarching objective is to estimate a return on equity that will contribute to the achievement of the NEO and NGO):

- Reliability—produces estimates of the return on equity that reflect economic and finance principles, empirical evidence, and market information; estimates have minimal error, and are free from bias.
- Relevance to the Australian benchmark—as the benchmark firm operates in Australia; this may include ability to populate the model with Australian-relevant data.
- Suitability for use in regulated environment—this may include transparency, replicability, and consideration of any incentive effects.
- Simplicity–avoids unnecessary complexity or spurious precision, is able to be understood by a broad stakeholder set.

The expert may adopt alternative (or additional) criteria, though it should explain why it has adopted these criteria if so.

The expert advisor is requested to consider:

- academic literature on the return on equity, both
  - in general
  - with particular focus on any developments (new academic papers) in the last five years that the consultant considers important to the recommendations on model/s and how they should be used.
- practice in financial markets, including (but not restricted to):
  - approaches used by institutional investors
  - valuation techniques used by equity brokers/analysts.

The expert should also be familiar with the following background documents (available on the AER website):

- the 2018 RoR Instrument
- the 2018 RoR Instrument final explanatory statement, particularly:

    - section 1.3 sets out the AER's position on the content for the next review
    - section 2 sets out the AER's framework for setting the allowed rate of return
    - section 5 sets out the AER's approach in selecting the foundation model for estimating RoE
    - section 8 sets out the AER's consideration of low beta bias and the Black CAPM.
- the 2013 RoR Guideline final explanatory statement, particularly:
    - section 2.2 sets out the AER's criteria for evaluating models, methods and market data
    - section 5 sets out the AER's approach in selecting the foundation model for estimating RoE in that process
    - section 6.2 sets out the regard had to the Black CAPM in selection of an equity beta point estimate.

The key deliverable is a written report that includes:

- An introductory section:
    - outlining the assessment work undertaken by the expert
    - describing the criteria used to assess the models
    - summarising any important recent (last 5 years) developments in academic literature on the estimation of return on equity.
- For each model evaluated by the expert:
    - A brief summary of how the model is used to estimate the return on equity
    - An assessment of the basis for the model in terms of finance theory (academic literature), empirical evidence and financial market practice
    - An evaluation of the strengths and weaknesses of that approach, including in relative terms against the other models considered, using the criteria adopted by the expert.
- A recommendation on:
    - Which model or models the consultant recommends should be used in the 2022 instrument
    - Which models the consultant recommends could be used
    - Which models the consultant considers should not be used
    - The manner in which the recommended model (or models) could or should be used (for models the consultant considers they should or could be used)
    - The key reasoning supporting these recommendations
    - Any limitations or requirements for further work.

The report is to be written to the standard of the Federal Court Guidelines for Expert Witnesses, and the AER is to be provided an opportunity to comment on the draft report.

Appendix 2

CURRICULUM VITAE GRAHAM PARTINGTON

PERSONAL

Name:	Graham Harold Partington
Email:	Grahamparto@gmail.com

HIGHER EDUCATION AND EMPLOYMENT

Academic Qualifications:	B.Sc. (Hons) Economics/Forestry, University of Wales, 1971
	MEc. (Hons) by thesis, Macquarie University, 1983.

Currently, I am honorary senior visiting research fellow in the School of Business at the University of Bangor. Previously I was an Associate Professor of Finance in the Finance Discipline at the University of Sydney. I have been chair of the Finance Discipline and was also head of the postgraduate research program in finance. Concurrent with my position at the University of Sydney I was also the Education Director for the Capital Markets Co-operative Research Centre PhD program. In a career stretching back more than forty years I have held Associate Professorships in finance at The University of Technology Sydney and The University of British Columbia. I have also held academic positions at Macquarie University and the University of Bangor I have had extensive teaching and research responsibilities in finance and accounting as well as being head, or deputy head, of University Departments and Schools. I have been very influential in the design of several undergraduate and masters degrees in finance and also PhD programs.

I have written numerous research papers and of the order of fifty consulting and expert witness reports covering topics such as valuation, the cost of capital, the value of imputation tax credits, and the market risk premium

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Awards and Major Research Grants

Awards

2013 Best paper prize for accounting, banking economics and finance, Global Business Research Conference.

2010 The GARP (Global Association of Risk Professionals) Prize for Quantitative Finance/Risk Management/Derivative Instruments, Finance and Corporate Governance Conference.

2009 The CFA (Chartered Financial Analyst) Prize Asian Investments, Asian Finance Association Conference

2009 Bangor University: Honorary Visiting Senior Research Fellow for the period 2009-2012, extended for the period 2013-2016, 2016-2019, 2019-2021.

2008: PhD students name their rock group after me "The Partingtons"

2001: Manuscript award for the best paper: Education Notes, *Accounting Research Journal,* 2000.

2000: Peter Brownell Manuscript Award. Awarded by the Accounting Association of Australia and New Zealand for the best paper in *Accounting and Finance*, 1999

1985: Butterworths Travelling Fellowship

Major Research Grants

2014-2016 Centre for International Financial Regulation (CIFR), *Measuring Market Quality: Current Limitations and New Metrics*, $170,000.

2007-2014: National Co-operative Research Centre Scheme, grant for the Capital Markets Cooperative Research Centre (CMCRC) $98 million ($49 million in cash and matching in kind contributions.) About $21 million cash over the term of the grant was under my management to run the scholarship and education program.

2000-2003: Australian Research Council, industry linked grant, *Intangibles, Valuation and Dividend Imputation* ($667,000).

1985-1988: Australian Research Grants Scheme, *The Determinants and Consequences of Dividend Policy* ($30,000).

PUBLICATIONS

Books

R. Brealey, S. Myers, G. Partington and D. Robinson, 2000, *Principles of Corporate Finance*, Australian Edition, McGraw-Hill (1st printing 2000, 2nd printing 2000.)

C.A. Martin, J. McKinnon, R. Hines, G. Harrison and G. Partington, 1983, *An Introduction to Accounting*, McGraw-Hill (1st edition, 1983, 2nd edition, 1988, 3rd edition 1990.)

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R. J. Coombes, M. Craig-Lees, M. McGrath, P. O'Sullivan, G. Partington and J. M. Wood, 1991, *Business Studies Book Two*, Social Science Press.
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A. Ainsworth, K. Fong, D. Gallagher, and G. Partington, 2018, Price Pressure around the Ex-dividend Day in Australia, *International Review of Finance,* 18:3, pp.379-409.

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N. Pricha, S. Foley, G. Partington, and J. Svec, (2016) Underwritten Dividend Reinvestment Plans and Conflicts of Interest, *Journal of Business Finance and Accounting*, **43:9 & 10**, pp. 1361-84.

A. Ainsworth, G. Partington, G. Warren, 2016, The Impact of Dividend Imputation on Share prices, The Cost of Capital and Corporate Behaviour, *JASSA The Finsia Journal of Applied Finance*, 1, pp 41-49

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M. Kim and G. Partington, 2015, The Dynamic Prediction of Financial Distress of Australian Firms, *Australian Journal of Management*, **40:1**, pp.135-60.

A. Jun and G. Partington, 2014, Taxes, International Clienteles and the Value of ADR Dividends, *Journal of Business Finance & Accounting*, **41:9 & 10**, pp. 1337–1360.

H. Dang and G. Partington, 2014, Rating Migrations: The Effect of History and Time, *Abacus*, **50:2**, pp. 174-202

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Yao J., G. Partington and M. Stevenson, 2013, Predicting the Directional Change in Consumer Sentiment, *Australian Journal of Management*, **38:1**, pp. 67-80

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S. Walker and G. Partington, 2000, A Market Valuation for Optus Pre-listing: A Case Note, *Accounting Research Journal*, **13:2,** pp. 90-94. (This paper won the award for Best Paper: Education Notes.)

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G. Hobbes, G. Partington and M. Stevenson, 1996, Earnings Dividends and Returns: A Theoretical Model, *Research in Finance,* Supplement 2, pp. 221-244.

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E. Lai, G.Partington, 2018, *The Value of Dividends: Evidence from Non-parri-passu Rights Issues*, International Finance and Banking Society Latin American Meeting, Santiago.

H. Dang and G. Partington, 2018, *Sovereign Ratings and National Culture,* 25th Conference of the Multinational Finance Society, Budapest.

R. Philip, P. Buchen, G. Partington. and S. Satchell, *Doubling Times and Development*, Global Development Finance Conference, Cape Town, 2017.

K. Woodward and G. Partington, *The Price Effects of Australian Structured Share Buybacks*, 14th African Finance Association Conference, Victoria Falls, 2017.

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M. Dempsey and G. Partington, 2007, Cost of Capital and Valuation Equations that Work for Any Tax System: Their Application under the Australian Imputation Tax System, Multinational Finance Society Conference, Thessalonica.

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G. Truong and G. Partington, 2007, *Alternative Estimates of the Cost of Equity Capital for Australian Firms*, 20th Australasian Finance and Banking Conference, Sydney,

G. Partington, 2006, *Dividend Imputation Credits and Valuation*, Business Tax Reform Meet the Critics, Australian Tax Research Foundation Conference, Sydney.

G. Truong and G. Partington, 2006, *The Value of Imputation Tax Credits and Their Impact on the Cost of Capital*, Accounting and Finance Association of Australia and New Zealand Conference, Wellington.

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G. Truong, G. Partington and M. Peat, 2005, *Cost of Capital Estimation and Capital Budgeting Practice in Australia*, Accounting and Finance Association of Australia and New Zealand Conference, Melbourne,.

A. McAdam, and G. Partington, 2005, *Does the Choice of Share Price Matter when Examining Takeovers?* Accounting and Finance Association of Australia and New Zealand Conference, Melbourne.

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G. Partington, P Russell, M. Stevenson and V. Torbey, 2001, *Predicting Return Outcomes for the Shareholders of Companies Entering Chapter 11 Bankruptcy*, Accounting Association of Australia and New Zealand Conference, Auckland.

H. Chu, L. Hodgkinson and G. Partington, 2001, *Right's Trade Adjustments: Evidence from the UK,* British Accounting Association Conference, Nottingham

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L. Hodgkinson and G. Partington, 2000, *The Motivation for Takeovers in the UK*, British Accounting Association Conference, Exeter.

V. Alaganar, G. Partington and M. Stevenson, 2000, *Do Ex-dividend Drop-offs Differ Across Markets? Evidence From Internationally Traded* (*ADR*) *Stocks*, Accounting Association of Australia and New Zealand Conference, Hamilton Island.

G. Partington and S. Walker, 2000, *A Theory of Ex-Dividend Equilibrium Under Imputation and Some Empirical Results*, Accounting Association of Australia and New Zealand Conference, Hamilton Island.

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G. Hobbes, G. Partington and M. Stevenson, 1997, *A General Model of Earnings Dividends and Returns,* Australasian Finance and Banking Conference, University New South Wales, Sydney.

S. Walker and G. Partington, 1997, *The Ex-Dividend Drop-off: Evidence from Cum-dividend Trading in the Ex-dividend Period*, Accounting Association of Australia and New Zealand Conference, Hobart.

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G. Partington and E. Hutson, 1994, *Share Prices, Takeover Outcomes and the Expected Value Hypothesis*, invited paper at the University of Wales Finance & Accounting Colloquium, Gegynog.

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G. Partington, M. Peat and M. Stevenson, 1991, *Estimating the Probability and Timing of Financial Distress,* Australian Institute of Bankers Conference, Melbourne.

P. Eddey, G. Partington and M. Stevenson, 1989, *Predicting the Probability and Timing of Takeover Success,* Australasian Finance and Banking Conference, Sydney.

G. Partington and T. Valentine 1984, *Finance for Australian Industry*, Metal Trades Industry Conference, Sydney.

G. Partington, 1983, *Why Firms Use Payout Targets: A Comparative Study of Dividend Policy,* Accounting Association of Australia and New Zealand Conference, Brisbane.

Unpublished Working Papers

R. Philip, A. Kwan, G. Partington, 2015, *Is High Frequency Trading Good for Market Quality?* A Report to the Centre for International Finance and Regulation.

H. Chu and G. Partington, 2001, The Market Valuation of Cash Paid into Australian Companies: Evidence from Ex-Rights Day Share Price Behaviour.

G. Partington, 1993, Miller Modigliani and Ohlson: A Note on Old Models in New Clothes.

Submissions to Government Inquiries and the Accounting Research Foundation

G. Partington, 2017, *Submission to the National Financial Literacy Strategy*, the Australian Securities & Investments Commission (ASIC).

A. Ainsworth, G. Partington, G. Warren, (2015) *Do Franking Credits Matter: Exploring the Financial Implications of Dividend Imputation,* Australian Tax Review 2015, Submission on the Australian Tax Discussion Paper, on Behalf of the Centre for International Financial Regulation (CIFR)

A. Ainsworth, A. Lee, G. Partington and T. Walter, 2013, Analysis of ASX Cum Dividend Trading in the Ex Dividend Period 2003-2013: Submission to the Treasury on “Preventing Dividend Washing”, submission to Treasury Inquiry: Protecting the Corporate Tax base from Erosion and Loopholes - Preventing 'Dividend Washing'

G. Partington, 1991, *Pricing and Capital Adequacy: Are the Banks Getting it Wrong*? a submission to The Australian Banking Inquiry.

G. Partington, 1989, *Accounting in Higher Education*, a submission to The Review of The Accounting Discipline in Higher Education.

J. McKinnon and G. Partington, 1980, *Statement of Sources and Applications of Funds - A Comment on the Exposure Draft,* a submission to the Australian Accounting Research Foundation.

C. Le Gras and G. Partington, 1979, *Commission Rates - Sheep and Cattle Sales,* a submission to the Prices Justification Tribunal.

R. Chenhall and G. Partington, 1979, *Financial Effects of Corporate Taxation,* an invited submission, Australian Financial System Inquiry.

R. Chenhall and G. Partington, 1979, *Submission on Corporate Sector Finance,* a submission to the Australian Financial System Inquiry.

Miscellaneous

G. Partington, 1989, Careers in Finance, *Focus on Careers*; *National Graduate Careers Magazine*. (Updated 1993, at the request of the Department of Education Employment and Training, Careers Reference Centre.)

D. Leece, G. Partington and R. Skellington, 1975, *Not All Over the Audience*, Bangor Arts Festival, Bangor.

D. Leece, G. Partington, D. Power and R. Skellington, 1974, *A Spring Revue,* Bangor Arts.

CURRICULUM VITAE STEPHEN SATCHELL

NAME Stephen Ellwood SATCHELL

CURRENT POSITION College Teaching Fellow

COLLEGE Trinity College, Cambridge University

DATE OF BIRTH 22nd February 1949

CAREER	1971-73	- School Teacher
	1973-74	- Computer Executive
	1974-76	- Research Officer
	1977-78	- Economic Advisor 10 Downing Street, (part-time)
	1978-79	- Lecturer (Statistics Department) at LSE
	1979-80	- Lecturer (Economics Department) at LSE
	1980-86	- Lecturer, University of Essex
	1986-2014	- Fellow(Title C), Trinity College
	1986-89	- Assistant Lecturer, University of Cambridge
	1989-2000	- University Lecturer at the University of Cambridge
	1991-93	- Reader, Birkbeck College
	2000-2009	The Reader of Financial Econometrics, Cambridge University.
	2010-2012	Visiting Professor, Sydney University.
	2011	The Emeritus Reader of Financial Econometrics, Cambridge University.
	2012- 2014	Visiting Lecturer ,RHUL, London University
	2013	Professor, Sydney University
	2014	Fellow(Title E), Trinity College
	2016 -	Senior Departmental Fellow, Department of Land Economy, Cambridge, Reappointed 2018.
	2019	Head of Credit Research; Imagine.
	2019-2021	Honorary Professor, Sydney University
	2020	appointed (DIETI) Distinguished Fellow of International and Engineering Institute

CURRENT RESEARCH

I am working on a number of topics in the broad areas of econometrics, finance, risk measurement and utility theory. I have an interest in both theoretical and empirical problems. Many of my research problems are motivated by practical investment issues. My current research looks at alternative methods of portfolio construction and risk management, as well as work on non-linear dynamic models. I am active in researching the UK mortgage and housing markets.

I have strong links with Inquire (Institute for Quantitative Investment Research). This is a city-based organization that finances academic research on quantitative investment. I am also on the management committee of LQG (London Quant Group). I am the co-founder of Quantess, an all-woman Quant Finance research group.

JOURNAL AFFILIATIONS

I am the Founding Editor of *Journal of Asset Management* (Palgrave Macmillan publishers) first issue, July 2000, this finished in December, 2017.

I am the Series Editor of a book series, *Quantitative Finance* (Academic Press/Elsevier publishers).

I was the Editor of *Journal of Derivatives and Hedge Funds* (Palgrave Macmillan publishers). I am on the Editorial Board of *Applied Financial Economics, Journal of Financial Services Marketing, Journal of Bond Trading and Management. QASS, Journal of Financial Policy and European Journal of Finance* and senior associate editor of *Journal of Mathematical Finance*.

I am the Founding Editor of a journal for Incisive-Media Ltd, *Journal of Risk Model Validation.* and was editor for another of their journals, *Journal of Financial Forecasting.*

SUBMITTED PUBLICATIONS

"Consistent Estimation with Errors in Variables via the Cumulant Generating Function" (with R. Philip and H. Malloch) currently under revision at *Journal of Financial Econometrics*

The Four Horsemen; with D. Allen and C. Lizieri; currently under revision at *Journal of Empirical Finance*

Partial Moment Momentum", with Y. Gao and H. Leung; submitted to *Journal of Banking and Finance*, under revision

Diversification and Desynchronicity: An Organizational Portfolio Perspective on Corporate Risk Reduction with X. Shao, Xiao-Guang Yue *, Nanfeng Luo , J. Qiu, K.Gouliamos, S. Hamori, Submitted to *Risks*

Distributional Properties and the Predictability of Cross Sectional and Time Series Momentum Returns with Oh Kang Kwon, submitted to *Journal of Forecasting*.

PAPERS

Aligned with the stars: the Morningstar rating system and the cross-section of risk aversion (with S. Thorp and R. Louth)

An Equilibrium Model of Bayesian Learning (with O. Ross and M. Tehranchi)

Selfish Banks and Central Price Setting: The LIBOR price setting mechanism (with O. Ross and M. Tehranchi)

Quantifying the Non-Gaussian Gain, (with D. Allen and C. Lizieri).

The Estimation of Psychic Returns for Cultural Assets; (with R. Pownall and N. Srivastava)

The Theoretical properties of Co-Quantiles; a generalisation of Quantiles, Order Statistics, and Concomitants "(with Oh Kang Kwon)

Consistent Valuation of Equity and Options on Equity, with Oh Kang Kwon and A. Grant;

Modelling Emerging Markets using the Conditional CAPM; with Farid Ahmed,

When Does Pairs Trading Outperform Cross Sectional Momentum? with Oh Kang Kwon

An Estimation Method for Structural Models by Iterative Maximum Likelihood and Debt to Equity Ratio Matching, with Andrew Grant and Oh Kang Kwon.

FORTHCOMING

Analyst Forecast Dispersion and Market Return Predictability: Does Conditional Equity Premium Play a Role? With Shuang Liu *, Juan Yao, Stephen Satchell, forthcoming in *Journal of Risk Financial Management*

“In Defence of Portfolio Optimization: What If We Can Forecast?”,with D. Allen and C. Lizieri; Author Response forthcoming *Financial Analyst Journal(A)*

“The Distribution of Cross Sectional Momentum Returns when Underlying Asset Returns are Student's t Distributed with Oh Kang Kwon; forthcoming in *Journal of Risk Financial Management*,2019,12,123(B)

“Flash Crash in an OTC Market: Trading Behaviour of Agents in Times of Market Stress with F.Schroeder, A. Lepone and H.Leung; forthcoming in *European Journal of Finance*;

2020 publications

Styles through a Convergent/Divergent Lens: The Curious Case of ESG with Yang Gao and Nandini Srivastava.; in *Journal of Asset Management.(B)* 21(1), 4-12 DOI 10.1057/s41260-019-00146-0

2019 publications.

“The analytics of momentum,”, with Oh Kang Kwon, 2019 *Journal of Asset Management*(B), Palgrave Macmillan, vol. 20(6), pages 433-441, October.

“Investment decisions when utility depends on wealth and other attributes”, with A. Grant – Published online: 31 Oct 2019*Quantitative Finance(A)* https://www.tandfonline.com/doi/abs/10.1080/14697688.2019.1663903

“:In Defense of Portfolio Optimization ,What If We Can Forecast? “,with D. Allen and C. Lizieri; Accepted 20 March 2019 *Financial Analyst Journal(A)* https://www.cfapubs.org/doi/abs/10.1080/0015198X.2019.1600958

“The Role of Bank Funding in risk transmission”(with C. Muijsson, available online July 2nd *Finance Research Letters.(A)* https://doi.org/10.1016/j.frl.2019.06.020

“Testing for Price Bubbles in Australian Listed Equities and A-REIT Markets”, with J. Alcock, A, Aspiris, D. Wright, R. Segara and J. Yao, *AJAF(B)*

“A Random Walk through Mayfair: Is art a luxury good? Evidence from dynamic models’(with R. Pownall and N. Srivastava), in *Journal of International Money and Finance; July 2019(A)*

"Reversing disbursement rates to estimate stationary wealth processes for endowments with recursive preferences with, S Thorp, O Williams, *Applied Economics* 51 (14), 1541-1557(A)

“Trapped in Diversification” ; with (Juan Yao and Wei Cui);in *European Journal of Finance; Vol 25, issue 12(A)*

Risk discriminating portfolio Optimization (with M. Lundin et al) in *Quantitative Finance*, January 2019, 19(2):177-185,DOI: 10.1080/14697688.2017.1387281(A)

Endogenous Divorce Risk and Investment (with A.Grant) in *Journal of Population Economics*; 32,issue 3,845-876.(A)

Some Dynamic and Steady State Properties of Threshold Autogressions with Applications to Stationarity and Local Explosivity; with Farid Ahmed; July *Journal of Risk Financial Management,2019,12,123(B)*

Some Dynamic and Steady State Properties of Threshold Autogressions with Applications to Stationarity and Local Explosivity; with Farid Ahmed; *reprinted in “Financial Econometrics”,MDPI Books.*

2018 Publications

Equity momentum in corporate bonds, LOIM research paper, (with A. Maitra and M.Salt). (Nov,2018)

What Proportion of Time is a particular Market inefficient? ...A Method for analysingthe frequency of market efficiency when equity prices follow Threshold Auto regressions (with Farid Ahmed). In *Journal of Time Series Econometrics;2018,10,2.*

The Value of Momentum to Active Managers and Planned Sponsors in Australia; (with H. Malloch and A. Grant) in *JASSA.1.1, 2018*

A Critique of Momentum Strategies(with Yang Gao and Henry Leung) in *Journal of Asset Management.* June 2018, 19(3), DOI: 10.1057/s41260-018-0080-0

“The Distribution of Cross-Sectional Momentum Returns”, with Oh Kang Kwon, in *JEDC* https://doi.org/10.1016/j.jedc.2018.06.002

“Orthant probability-based correlation: sensitive to asymmetric and non-linear dependence.”(with M. Lundin) in *Asymmetric Dependence in Finance*, eds. Alcock, J.,. and S. Satchell, Wiley.(book)

“Psychic Dividends of Socially Responsible Investment Portfolios” (with A. Ainsworth and A. Corbett); in *Journal of Asset Management.*

“Misspecification in an Asymmetrically Dependent World: Implications for Volatility Forecasting “with S. Ahmed and N. Srivastava.in *Asymmetric Dependence in Finance*, eds. Alcock, J.,. and S. Satchell, Wiley.(book)

“The Size of the CTA Market and the Role of Asymmetric Dependence”; with Oliver Williams .in *Asymmetric Dependence in Finance*, eds. Alcock, J, and S. Satchell, Wiley.(book)

“The Most Entropic Copula with applications to Style Investment Forecasting “ with Ba Chu in *Asymmetric Dependence in Finance*, eds. Alcock, J. and S. Satchell, Wiley.(book)

Guide to Investment Strategy; sixth edition, (with P. Stanyer) published by Profile Books(book); financial Times, 2018

Partington G, and Satchell S (2018) Report to the AER: Allowed Rate of Return -2018 Guideline Review.

2017 Publications

Partington G, and Satchell S (2017) Report to the AER: Discussion of estimates of the returns on equity.

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Partington G, and Satchell S (2017) Report to the AER: Issues in re-levering beta and testing for structural breaks.

2016 Publications

Theoretical decompositions of the cross-sectional dispersion of stock returns(with A. Grant) in *Quantitative Finance,* February 2016;2,pp169-180.

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'Decomposing the bias in time-series estimates of CAPM betas',(Malloch H, Philip R) in *Applied Economics* A, 2016 vol.48:45, pp. 4291-98

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A General Theory of Smoothing and Anti-Smoothing (with M.Mackenzie and W.Wongwachara) in *Journal of Empirical Finance, vol 28, pp 215-219.(A)*

Risk Presentation and Portfolio Choice (with H.Bateman, S. Thorp, J. Geweke, J. Louviere, C. Eckert) in *Review of Finance.* ((A+) 12/2010; DOI: 10.2139/ssrn.1776525, Source: OAI

'Financial Competence, Risk Presentation andRetirement Portfolio Preferences', (with - Bateman, H., Eckert, C., Geweke, J., Louviere, J., Satchell, S. and Thorp, S. *) in Journal of Pension Economics and Finance*, vol. 13, no. 1, pp. 27-61

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Testing linear factor models on individual stocks using the average F-test', (with S.Hwang,) in *European Journal of Finance*, vol. 20, no. 5, pp. 463-98. DOI:10.1080/1351847X.2012.717097; Version of record first published: 10 Sep 2012

'The sensitivity of beta to the time horizon when log prices follow an Ornstein-Uhlenbeck process', (with - Hong, K.H.) in *European Journal of Finance*, vol. 20, no. 3, pp. 264-90 DOI:10.1080/1351847X.2012.698992;Version of record first published: 24 Jul 2012

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Efund research.com 07/10/2014; http://ch.e-fundresearch.com/newscenter/120-lombard-odier/artikel/23090-what-factors-drive-the-us-labour-market

Art as a Luxury Good, with N. Srivastava in"*Risk and Uncertainty in the Art World*", edited by A. Dempster, ;Chapter 9, Bloomsbury Publishing, London; 2014.

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Modelling Sustainable Spending Plans for Family Offices, Foundations and Trusts (with S. Thorp) in *Quantitative Approaches to High Net Worth Investment*, edited by Steve Satchell and Andrew Rudd, 213–251. London: Risk Books, 2014.

2013 PUBLICATIONS

How Much does an Illegal Insider Trade? (with A. Frino and H. Zheng) in *The International Review of Finance* Article first published online: 4 FEB 2013 | DOI: 10.1111/irfi.12006

Sequential Variable Selection as Bayesian Pragmatism in Linear Factor Models (with John Knight, Jessica Qi Zhang) in *Journal of Mathematical Finance* PP. 230-236, Pub. Date: March 29, 2013 DOI: 10.4236/jmf.2013.31A022

Portfolio Skewness and Kurtosis (with A.D. Hall) in *Journal of Asset Management* 14, 228–235. doi:10.1057/jam.2013.18

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Financial Competence and Expectations Formation: Evidence from Australia, (with H. Bateman, C. Eckert, J. Louviere, and S. Thorp), *Economic Record*, Vol. 88, Issue 280, pp. 39-63, March 2012.

Unsmoothing Real Estate Returns: A Regime-Switching Approach"(with C. Lizieri and W. Wongwachara) in *Real Estate Economics*. 40(4).2012.

Why All Equity Portfolios Still Remain the Exception, (with R. Lewin and M. J. Sardy), in *Academy of Economics and Finance Journal*.3,73-83.

An Assessment of the Social Desirability of High Frequency Trading; in JASSA; Finsia Journal of Applied Finance,vol 3,7-11.

Retirement investor risk tolerance in tranquil and crisis periods: experimental survey evidence (with H.Bateman, S. Thorp, J. Geweke, J. Louviere, C. Ebling.), in *Journal of Behavioural Finance. Vol 12,No 4.*

Some Exact Results for an Asset Pricing Test Based on the Average F Distribution (with S.Huang)in Theoretical Economic Letters. Vol 2,No5,435-437.

Defining Single Asset Price Momentum in terms of a Stochastic Process (with K.Hong); in Theoretical Economic Letters.Vol 2,No 3,274-277.

Nonlinearity and smoothing in venture capital performance data ,(with Michael McKenzie, ,Warapong Wongwachara), in *Journal of Empirical Finance.* DOI:10.10.10/jempfin.2012.08.004 Version of record first published: 4 Aug 2012

Discussion on “Log-optimal economic evaluation of probability forecasts” by David Johnstone. ;*Journal of the Royal Statistical SocietyA* (2*012)* 175, Part 3, pp. 1–21

2011 PUBLICATIONS

Large deviations theorems for Optimal Investment problems with large portfolios, (with B. Chu and J. Knight), *European Journal of Operations Research*, Vol. 211, No. 3 (June 2011), pp. 533-555..

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Daily Stock Returns in European Stock Markets Non-linearity, Predictability, and Transaction Costs (with A. Timmermann), *Non-Linear Dynamics in Economics*, edited by W.A. Barnett, A.P. Kirman and M. Salmon, CUP, 369-392, 1996.

Investor Preference and the Correlation Dimension, (with A. Timmermann), *Chaos and Non-Linear Dynamics in the Financial Markets*, edited by L. Trippi, 1996, Irwin.

Non-Normality of Returns in Emerging Markets: A Comparison of Mean-Variance Versus Mean-Lower Partial Moment Asset Pricing Models, (with B. Eftekhari), in refereed book *Research in International Business and Finance, Supplement 1*, edited by J. Doukas and L. Lang, 1996, 267-277, JAI Press.

Mean Variance Analysis, Trading Rates and Emerging Markets, (with P. Matheussen) in *Advanced Trading Rules*, edited by E. Acar and S.E. Satchell, 1997, 41-50, Butterworth and Heinemann.

The Portfolio Distribution of Directional Strategies (with E. Acar) in *Advanced Trading Rules* edited by E. Acar and S.E. Satchell, 1997, Butterworth and Heinemann.

Regime Switching Models and Forecasting High Frequency FX, (with R. Daccó), in *Nonlinear Modelling of High Frequency Financial Time Series*, edited by C. Dunis and B. Zhou, 1998, 177-201, John Wiley and Sons.

Modelling Intraday Equity Prices and Volatility Using Information Arrivals - A Comparative Study of Different Choices of Informational Proxies, (with S. Lin and J. Knight) edited by P. Lequeux, (forthcoming in Financial *Markets: Tick-by-Tick*, 1998, 27-64, John Wiley & Sons Ltd).

Hashing Garch (with G. Christodoulakis), in *Forecasting Financial Volatility*, edited by J. Knight and S. Satchell, 1998, 168-192, Butterworth and Heinemann.

Implied Volatility Forecasting, (with S. Hwang), in *Forecasting Financial Volatility* edited by J. Knight, S. Satchell, 1998, 193-225, Butterworth and Heinemann.

GARCH Processes, Some Difficulties and a Suggested Remedy, (with J. Knight), *Forecasting Financial Volatility*, edited by J. Knight and S. Satchell, 1998, pp.321-346, Butterworth and Heinemann.

GARCH Predictions and Predictions of Options Prices Proccesses Applied to UK Stocks, (with J. Knight), *Forecasting Financial Volatility*, edited by J. Knight and S. Satchell, 1998, pp.226-244, Butterworth and Heinemann.

Choosing the Right Measure of Risk: A Survey, *The Current State of Economic Science*, (with C. Pedersen), edited by S.B. Dahiya, 1998.

An Assessment of the Economic Value of Non-Linear Foreign Exchange Rate Forecasts, with A. Timmermann, published in *Journal of Forecasting*, 14, 1995, 447-497, reprinted in *Economic Forecasting* edited by T.C. Mills, Edward Elgar (1999).

A Data Matrix to Investigate Independence, Over-reaction and/or Shock Persistence in Financial Data, (with R. Daccó), *Decisions Technologies for Computational Finance - Proceedings of the Fifth International Conference, Computational Finance* edited by A.P.N. Refenes. Kluwer Academic Publishers, 1999 pp. 49-60.

BOOKS AND UNPUBLISHED PAPERS

A) BOOKS

Advanced Statistical Methods in Social Sciences, Francis Pinter (with Dr. N. Schofield, M. Chatterjii, and P. Whiteley), 1986.

Advanced Trading Rules, Theory and Practice (edited with E. Acar), 1997, Butterworth and Heinemann.

Forecasting Financial Volatility (edited with J. Knight), 1998, Butterworth and Heinemann.,2nd edition,2004. 3rd edition, Elsevier, 2007

Returns Distributions in Finance (edited with J. Knight), 2001, Butterworth and Heinemann.

Managing Downside Risk (edited with F. Sortino), 2001, Butterworth and Heinemann..

Performance Measurement (edited with J. Knight), 2002, Butterworth and Heinemann.

Advances in Portfolio Construction and Implementation (edited with A. Scowcroft), 2003. Butterworth and Heinemann

Linear Factor Models in Finance (edited with J. Knight) (Butterworth Heinemann, 2004).

Forecasting Expected Returns (Elsevier, 2007).

Risk Model Validation (Edited with G. Christodoulakis) (Elsevier, 2007).

Collecting and High Net Worth Investment, (Elsevier, 2009).

Optimizing the Optimizers, (Elsevier, 2009).

B) PAPERS (PAST)

Are Stock Prices Driven by the Volume of Trade? Empirical Analysis of the FT30, FT100 and Certain British Shares over 1988-1990, (with Y. Yoon), 1991.

Variance Bounds Tests Using Options Data, (M. Ncube and P. Seabright), 1992.

The Use of High-Low Volatility Estimators in Option Pricing, (with A. Timmermann), 1992.

Misspecification in Measurement of the Correlation Dimension, (with Y. Yoon), 1992.

Can We Hedge the FT30? (with C. Rogers and Y. Yoon), 1992.

Estimation of Stationary Stochastic Processes via the Empirical Characteristic Function, (with J. Knight), 1993.

Modelling U.K. Mortgage Defaults Using a Hazard Approach Based on American Options, (with M. Ncube), 1994.

Elliptical Distributions and Models of Garch Volatility, 1994.

Estimating the Mean-Generalized - Gini CAPM, 1995.

The Distribution of the Maximum Drawdown for a Continuous Time Random Walk (with E. Acar and J. Knight), 1995.

Analytical Properties of Rebalancing Strategies in TAA Models, (with M. Leigh), 1995.

The Effects of Serial Correlation on Normality Tests, (with Y. Yoon), 1996.

Index Futures Pricing with Stochastic Interest Rates: Empirical Evidence from FT-SE 100 Index Futures, (with Y. Yoon), 1996.

Forecasting the Single and Multiple Hazard. The Use of the Weibull Distribution with Application to Arrears Mortgages Facing Repossession Risk, (with Y. Shin), 1996.

Tactical Style Allocation: Applications of the Markov Switching Model to Value-Growth Investment and Tactical Asset Allocation, (with Y. Yoon), 1997.

Modelling Mortgage Population Dynamics, (with R.L. Kosowski), 1997.

Evolving Systems of Financial Asset Returns: AutoRegressive Conditional Beta , Working Paper. (With G. Christoulakis) 2000

Bayesian Analysis of the Black-Scholes Option Price. DAE Working Paper No. 0102, University of Cambridge. (With T. Darsinos) 2001.

Bayesian Forecasting of Options Prices: A Natural Framework for Pooling Historical and Implied Volatility Information, DAE Working Paper No. 0116, University of Cambridge. (With T. Darsinos) 2001.

The Implied Distribution for Stocks of Companies with Warrants and/or Executive Stock Options, DAE Working Paper No. 0217, University of Cambridge. (With T. Darsinos) 2002.

On the Valuation of Warrants and Executive Stock Options: Pricing Formulae for Firms with Multiple Warrants/Executive Options, DAE Working Paper No. 0218, University of Cambridge. (With T. Darsinos) 2002.

Reconciling Grinblatt and Titman's Positive Period Weighting Performance Measure with Loss Aversion: An application to UK active managers, Mimeo, University of Cambridge. (With N. Farah) 2002.

The Asset Allocation Decision in a Loss Aversion World, Financial Econometric Research Centre working paper WP01-7, Cass Business School. (With S. Hwang) 2001.

Returns to Moving Average Trading Rules: Interpreting Realized Returns as Conventional Rates of Return (with G. Kuo).

On the Use of Revenues to Assess Organizational Risk (with R. Lewin).

Improving the Estimates of the Risk Premia – Application in the UK Financial Market, DAE Working Paper No. 0109, University of Cambridge. (With M. Pitsillis) 2001

Ex-Ante versus Ex-Post Excess Returns, mimeo. (with D. Robertson) 2001.

The Impact of Technical Analysis of Asset Price Dynamics, DAE Working Paper No. 0219, University of Cambridge. (With J-H Yang) 2002.

A Bayesian Confidence Interval for Value-at-Risk. Submitted to theDAE Working Paper Series. (with Contreras, P.). 2003

PAPERS (CURRENT)

"Using the Large Deviation Technique to Estimate Asymmetric Financial Risk", Institute for Financial Research, Birkbeck College, IFR 1/2003 (with Ba Chu and Knight, J.). 2003

A Bayesian Confidence Interval for Value-at-Risk. Submitted to theDAE Working Paper Series. (with Contreras, P.). 2003

The Impact of Background Risks on Expected Utility Maximisation (with V. Merella).

Valuation of Options in a Setting With Happiness-Augmented Preferences (with V. Merella) (QFRC discussion paper, Number 182), (2006).

Information Ratios, Sharpe Ratios and the Trade-off Between Skill And Risk (with P. Spence and A.D. Hall)

The Impacts of Constraints on the Moments of an Active Portfolio (with P. Spence and A.D. Hall)

Exact Properties of Optimal Investment for Institutional Investors (with J. Knight), Birkbeck College WP, 0513, 2005.

Distribution of Constrained Portfolio Weights and Returns, (with J. Knight,).

Improved Testing for the Validity of Asset Pricing Theories in Linear Factor Models, Financial Econometric Research Centre working paper WP99-20, Cass Business School. (With S. Hwang) 2001.

Optimal Portfolio for Skew Symmetric Distributions, (with R. Corn).

Scenario Analysis with Recursive Utility: Dynamic Consumption Paths for Charitable Endowments, (with S. Thorp), working paper, UTS.

Incorporating Gain-Loss and Mean-Variance in a Single Framework, (with S. Cavaglia, and K. Scherer).

'Heuristic Portfolio Optimisation: Bayesian Updating with the Johnson Family of Distributions', Callanish Capital Partners Technical Paper (with R. J. Louth)

'The Impact of Ratings on the Assets Under Management of Retail Funds', S&P Internal Report, (with R. J. Louth).

'The Impact of Ratings on the Performance of Retail Funds', S&P Internal Report (with R. J. Louth)

Are There Bubbles in the Art Market? (with N. Srivastava)

EDUCATION

1965-9 - BA in Economics, Mathematics, Statistics and Politics, University of New South Wales.

1971 - Diploma in Education, Balmain Teachers' College

1972 - Teachers Certificate, Department of Education, NSW

1972-73 - MA in Mathematics, University of Sydney

1974-75 - M. Commerce in Economics, University of New South Wales

1976-80 - Ph.D. in Economics, University of London (The Ph.D. was supervised by Professor J.D. Sargan), examined by P. Phillips and D. Sargan.

1990 - MA (Cambridge).

1995 - Ph.D (Cambridge), examined by P. Robinson and P. Schmidt.

2001 - FIA (Institute of Actuaries) Honorary

SUPERVISION

1987-2007 Have supervised students from all colleges in Paper 12, now Paper 11. Have supervised papers 1, 2, 5, 6 of Prelim and papers 7, 11, and 12 of Part 2 (now 6, 10, and 11).

TEACHING

1973 - Taught for two years in high school, was inspected and received Teacher's Certificate.

1975 - Taught again at NCR, learnt and taught various computing languages.

1976-78 - Taught Introductory Econometrics in a September Mathematics Course to MA in Economics students at the LSE.

1977 - Whilst Lecturer in Statistics, taught:

(i) post-graduate course in Causal Analysis

(ii) post-graduate course in Advanced Time-Series

1978 - Shared courses in Econometric Theory

1979-86 - At Essex: Taught courses in Econometric Theory

(i) Statistics

(ii) Econometrics

(iii) Computing

(iv) Mathematical Economics

(v) Finance

1987-90 - Finance, Econometrics (Cambridge Papers 12, 25, 31)

1990-91 - Taught Advanced Econometrics at Birkbeck.

1991-92 - Taught Introduction to Mathematical Economics.

Advanced Econometrics.

BASE (Birkbeck Advanced Studies in Economics) course on Finance

1992-93 - Taught September course Mathematics, taught Theory of Finance (M.Sc.), Financial Econometrics (M.Sc.), Financial Econometrics (B.Sc.).

1993-2004 - Taught Papers 7, 12, 31 201, 231, 301 and 321 (not all simultaneously).

2005-2007 Taught Papers 7, 11, and 403, also taught Risk Management in Msc, Financial Engineering, Birkbeck , and Corporate Finance, University of Sydney.

CONSULTING EXPERIENCE

My consulting experience is very extensive, particularly in the areas of asset management and investment technology. I have supervised the building and maintenance of portfolio risk models. I have organised conferences for risk managers, investment professionals, and academics. I have carried out risk analysis on investment strategies and investment products. I can provide specific details on any of these areas if requested. I have worked with large numbers of international financial institutions and can provide testimonies as to my value – added if required.

I also work in mortgages, house prices, and real estate generally; recently, I designed with G. Christodoulakis the FT House Price Index for Acadametrics. I have also built mortgage default and loss models for Acadametrics. In conjunction with Acadametrics, I have been involved in the validation of risk models for lending institutions; this has been part of Basle II work in the recent past.

GENERAL CONTRIBUTION

I received colours from the LSE for cross-country running in 1977 and 1978 . I was also Secretary of London University Cross-Country Club 1978. I represented Trinity College at cross-country running 1987-1988, completed the London Marathon on 5 occasions, best 3.04.41 (1987). I was reserve for Cambridge University Marathon Team (1990). In recent years, I ran 10 km in 44.32, Oct 2000, 44.05 in Mar, 2001; 44.48 in Jan, 2003, 44.52 in March 2005 , 42.53 in Feb, 2006, 44.24 in April 2007. I have won a number of medals in Veteran's road running.

CAMBRIDGE FACULTY ADMINISTRATION

At various stages I have been on:

Management Board for Management Studies Tripos

Statistics Committee (Chair)

Graduate Admissions Committee, was acting Admissions Officer 1989

Organised Seminar Series in Finance

Organising Seminar Series in Econometrics

Future Needs and Lecture List Committee

Faculty Board

Appointments Committee

College Administration

Director of Studies (1987- 2011) and Director of Admissions in Economics (1987-1994)

Trinity College

Finance Committee (1991-2003) ,2008 to 2011 and Treasurer of Trinity in Camberwell (charity) (1989-1992) plus other minor committees. Inspector of Accounts 1994-5 and 1996-97.

Wine Committee from 2005 to 2012.

Birkbeck Administration 1991-92

Department Seminar Organiser

Chairman Finance Examinations

Appointments Committee

Ph.D. Admissions

M.Sc. Finance Admissions

Jointly responsible for the creation of the new M.Sc. Finance (currently 70 students) which has now run successfully for 15 years.

Cambridge Administration 1993 to present

Appointments Committee

M.Sc. Finance Admissions

Chairman Finance Exams

M.Sc. Finance Co-ordinator

<u>1993-94</u> Coordinator Papers 12, 31, 201, 231.

MSc Finance Admissions

<u>1994-95</u> Coordinator Papers 12 and 231.

<u>1995-96</u> Coordinator Papers 12, 201,231. Chairman ETE Exams.

<u>1996-1999</u> Coordinator Papers 7 and 12.

<u>1999-2000</u> Acting Graduate Chairman

2000-2001 Coordinator Paper 301.

2002-2006 Coordinator Papers 6 and 11. Head of Part 1 Examiners (2004).

PROFESSIONAL CONTRIBUTIONS

Refereeing

I have refereed articles for the Journal of Econometrics, Econometrica, IER, Mathematical Social Sciences, Journal of Public Economics, Review of Economic Studies, Econometric Theory, and Journal of Applied Econometrics plus many other journals.

Visiting and Seminars

I have given seminars at many British and Australian Universities and have been a visitor at Monash University (1985), (1987) and the University of New South Wales (1986) and Australian National University (1986), (1987). I have visited the University at Western Ontario (1988) and been a Visiting Fellow to University College, London. In 1989, I visited Complutense, Madrid. I am currently 4 times a Visiting Professor at Birkbeck College, London (1994 -). I recently visited University of Technology, Sydney (1998-2006). I have been appointed Visiting Professor at CASS/CUBS (2000-2006) and Visiting Professor at Birkbeck College (2000-2006) and Visiting Lecturer in Applied Mathematics at Oxford University (2002-2004). I am currently an Adjunct Professor at UTS (Sydney), and have had an association since 1997.

Supervision and Examination

I have supervised numerous post-graduate students and have successfully supervised the Ph.D.'s of A. Nasim at Essex and of M. Ncube and Y. Yoon, B. Eftekhari and S Hwang, G. Kuo, C. Pedersen, M. Sokalska, S. Bond, L. Middleton(Judge), M. Pitsillis, T. Darsinos, A. Sancetta, S. Yang, R. Lewin(Judge), G. Davies, W. Cheung , R. Corns, O. Williams and P. Contreras ,J.Zhang, R. Louth, Jimmy Hong, Nandini Srivastava, Omri Ross(Maths) at Cambridge, plus other Cambridge students on a joint supervision basis including A. Timmermann and L. Shi. Other successful PhD students supervised at Birkbeck include Y. Hatgioniddes, R. Daccó, M. Karanassou, G. Christodoulakis , B. Chu , Wei Jin, Wei Xia , Riko Miura and John Wylie from Sydney University.

My current students consist of four Cambridge Ph.D. students in Economics and three Birkbeck students. Plus one from Sydney University I have been an Examiner every year that I have taught at University. I have been external examiner at Queen Mary College and London School of Economics (Econometrics), and at London School of Economics (Economics), Imperial College, and Essex University. I have also examined over forrty doctoral dissertations in Econometrics, Finance and Land Economy at universities in Great Britain, Europe, Canada, and Australia.

Awards and Prizes

My research project was awarded a prize (the Inquire Prize for the best presentation at the annual Inquire Conference, Bournemouth, 1991 value £3,000).

Received Econometric Theory Multa Scripsit Award (1997).

My paper The Pricing of Market-to-Market Contingent Claims in a No-Arbitrage Economy was runner-up 1997 E. Yetton Award for the best paper published in AJM (1997).

Received Honorary Membership of the Institute of Actuaries (2001), received F.I.A.

Fund Raising

I have raised well in excess of £1,000,000 since 1991, I give details below:

I raised £105,000 for a financial econometrics project, the research was done at the Department of Applied Economics (Cambridge). This was funded by Inquire and the Newton Trust. The research project brought Professor W. Perraudin to Cambridge and employed Y. Yoon.

I have received £9,000 from the Newton Trust for 1993-94; and have had 2 research grants from ESRC joint with W. Perraudin, total value about £60,000. I have received £17,500 from Inquire for 93-94. I have received a further £20,000 from the Newton Trust (1993).

I started a new research project on the Econometrics of Emerging Markets. I received £30,000 from the Newton Trust (1994) and £10,000 from Inquire (1995) and £30,000 from Kleinwort Benson Investment Management (1995) plus a further £28,000 from Alpha Strategies (1998). This project has employed R. Daccó, and S. Huang.

I received £26,000 from the DSS to work on Pension Funds (joint with C. Pratten). I received £10,000 from Inquire (1996). I received a further £10,000 from Inquire (1997). In 1998, I received £7,500 for research on trading rules from a private donor and a further £25,000 from the Newton Trust. I received £4,500 research donation from Alpha Strategies and £2,500 from General-Re to speak at their annual conference (joint with C. Pratten), plus £6,500 from Inquire (1998) and £9,000 from Inquire (2000), £8,000 from Inquire (2003) and a grant of £6,000 from Acadametrics to employ J. Zhang.

I have received an ESRC grant of £80,000, which employed A. Sancetta for two years (2003-2004).

In 2005 I received with S. Hwang and B. Chu £45,000 from the ESRC to research on risk-management and non-linear correlation.

I have also received two grants of 3000 pounds each from Reading University(2005-2006) to work on real estate finance and a grant of (approx.) 20.000 pounds in 2006,joint with S.Bond and S.Hwang to work on asset allocation issues, the grant being from IRF.

Summary of Discovery Project Proposal for Funding to Commence in 2010

DP1093842 A/Prof HJ Bateman; Prof JJ Louviere; Dr SJ Thorp; Dr C Ebling; A/Prof T Islam; Prof S Satchell; Prof JF Geweke

Approved The paradox of choice: Unravelling complex superannuation decisions

Approximately A$960,0000

CIFR Grant Graham Partington, Steve Satchell, Richard Philip, Amy Kwan Measuring market quality: current limitations and new metrics $140,000 total

CIFR Grant: Identifying Asset Price Bubbles in Australian Listed Securities

$122,000 total

Popular Articles

Making Money Out of Chaos, Investors Chronicle, 10th July 1992. (Interview)

Articles in the *International Broker*, (with Allan Timmermann), (15 pieces), listed next.

Weekly columns on Investment Techniques:

Equity switch programme (Vol. 6, page 7)

Making money out of chaos (Vol. 7, page 6)

Where random walks trips up (Vol. 8, page 7)

Ignorance can be profitable (Vol. 9, page 7)

Making money from market volatility (Vol. 10, page 7)

High-low prices in options trading (Vol. 11, page 7)

Can heavy trading be profitable? (Vol. 12, page 7)

Economic variables show stock returns (Vol. 13, page 7)

No mean return on shares (Vol. 14, page 9)

Do option prices augur a crash? (Vol. 15, page 9)

Puzzles in closed-end fund prices (Vol. 16, page 9)

Capital asset pricing model challenged (Vol. 17, page 9)

How dividends affect share prices (Vol. 18, page 9)

The relationship between price and volume (Vol. 19, page 9)

How persistent are financial market shocks? (Vol. 22, page 9)

Research work written up by International Management (April 1993).

Article in the *Professional Investor* (May 1995), Short-termism (with D.C. Damant), (pages 21-27).

Article in the *Professional Investor* (July 1995), Accounting for Derivatives (with D.C. Damant).

Book Review on Ethnic Minorities and Higher Education in *Higher Education Review*, 1996, 28:2, 96.

Article in the *Professional Investor* (June 1996), Downside Risk (with D.C. Damant).

Contribution to discussion British *Actuarial Journal*, Volume 3, Part I, pages 10-11, 1997

Contribution to discussion British *Actuarial Journal*, 1998.

Article on Lloyd's Syndicate Valuations Methodology, (*ALM News*), 1998.

Research discussed in Observer (26th April 1998, page 11).

Research discussed in Inside Monthly (April 1998, pages 12-14).

Interviewed on Bloomberg TV (27th February 1998)

Pension Scheme Investment Policies, DSS Research Report No. 82 (with C. Pratten), 1998.

Designed the FT Acadametrics House Price Index, 2003. This Index appears monthly in the FT and is usually discussed by journalists and market pundits.

Contribution to discussion, British *Actuarial Journal,* 2006.

The Impact of Utility on Endowment Strategy, *Professional Investor, April 2007.*

Interviewed on ABC re financial crisis(October 2008)

Research Affiliations (past and present)

Head of Research, Bita-Risk.

Academic Advisor, Alpha Strategies

Advisory Panel, IFC (Subsidiary of the IMF)

Academic Advisor, Kleinwort Benson Asset Management

Academic Advisor Kiln Colesworth Stewart (Member's Agents, Lloyds)

Academic Panel, Panagora Asset Management (1992-1998)

U.K. Representative, Pension Research Institute (State University of California)

Fellow, Pensions Institute (Birkbeck College)

Academic Adviser, Quantec

Academic Panel, State Street Global Advisors

Research Advisor, Thesys Forecasting, currently Acadametrics.

Visiting Professor, Cass Business School, City University,

Visiting Professor University of Technology, Sydney.

Visiting Professor, Birkbeck College.

Honorary Visiting Professor University of Sydney

Academic Advisor, Style Research Associates

Visiting Lecturer, University of Oxford, applied mathematical finance diploma.

Academic Adviser, Northern Trust.

Academic Advisory Board, Old Mutual Asset Management.

Expert Witness between fund Manager and Pension Fund., 2003.

Expert Witness between fund Manager and Pension Fund, 2004-2006.

Expert Witness between Insurance Company and Lettuce Grower.

Adviser in Risk Management to the Governor of the Bank of Greece.

Member, Advisory Board, Quantitative Finance Research Centre, UTS.

Member, Steering Committee, CIMF, Cambridge University.

Area Coordinator, Fundamentals of Economic Analysis, Libros de Economia y Empresa, Real Academia de Ciencias Morales Y Politicas.

Consultant, JP Morgan AM,Behavioural Equity Team.

Academic Advisor, Lombard-Odier Asset Management.

Program Committees

European Meeting of the Econometric Society (1997)

Forecasting FX Conference organized by Imperial College and B.N.P. (1996 to 2007)

Inquire UK (2006, 2007)

Program Committee, UK Inquire.

Prize Committee, European Inquire.

Conferences and Seminars

NZ Econometric conference, feb,2011.

Conferences and Seminars (2009)

Presented seminars at:

Sydney University (April 3rd);

Macquarie Bank (April 7th),

CRMC Sydney (April 8th);

Sydney Q group, April 15th.

Conferences (2008)

Finance Conference, London, October, key-note speaker.

Chair, LQ conference (Cambridge, September), presented.

Prize Committee, Inquire Europe(Bordeaux, October).

Conferences (2007)

Finance Conference, Imperial College, March 2007, Discussant.

Finance Conference, Zurich, March 2007. Invited Key Note Speaker.

Alpha Strategies Finance Conference, April 2007, Duke University, chaired conference.

UKSIP Lecture on Endowments, April 2007.

Alpha Strategies Finance Conference, September 2007, Oxford University, chaired conference.

Conferences (2006)

Alpha Strategies Finance Conference, April 2006, Duke University, chaired conference.

Risk Management Conference, June 2006, Bank of Greece, Athens. Gave paper, helped organize programme.

Asset Allocation Summit, July 2006, London, presented paper.

New Zealand Econometrics Conference Dunedin August 2006, chaired session, gave paper, was on prize committee.

Alpha Strategies Finance Conference, September 2006, Cambridge University, chaired conference.

FEDERAL COURT OF AUSTRALIA

EXPERT EVIDENCE PRACTICE NOTES (GPN-EXPT)

General Practice Note

1. INTRODUCTION

1.1 This practice note, including the *Harmonised Expert Witness Code of Conduct* ("**Code**") (see **Annexure A**) and the *Concurrent Expert Evidence Guidelines* ("**Concurrent Evidence Guidelines**") (see **Annexure B**), applies to any proceeding involving the use of expert evidence and must be read together with:

(a) the Central Practice Note (CPN-1), which sets out the fundamental principles concerning the National Court Framework ("**NCF**") of the Federal Court and key principles of case management procedure;

(b) the Federal Court of Australia Act 1976 (Cth) ("**Federal Court Act**");

(c) the *Evidence Act 1995* (Cth) ("**Evidence Act**"), including Part 3.3 of the Evidence Act;

(d) Part 23 of the *Federal Court Rules 2011* (Cth) ("**Federal Court Rules**"); and

(e) where applicable, the Survey Evidence Practice Note (GPN-SURV).

1.2 This practice note takes effect from the date it is issued and, to the extent practicable, applies to proceedings whether filed before, or after, the date of issuing.

2. APPROACH TO EXPERT EVIDENCE

2.1 An expert witness may be retained to give opinion evidence in the proceeding, or, in certain circumstances, to express an opinion that may be relied upon in alternative dispute resolution procedures such as mediation or a conference of experts. In some circumstances an expert may be appointed as an independent adviser to the Court.

2.2 The purpose of the use of expert evidence in proceedings, often in relation to complex subject matter, is for the Court to receive the benefit of the objective and impartial assessment of an issue from a witness with specialised knowledge (based on training, study or experience - see generally s 79 of the Evidence Act).

2.3 However, the use or admissibility of expert evidence remains subject to the overriding requirements that:

(a) to be admissible in a proceeding, any such evidence must be relevant (s 56 of the Evidence Act); and

(b) even if relevant, any such evidence, may be refused to be admitted by the Court if its probative value is outweighed by other considerations such as the evidence being unfairly prejudicial, misleading or will result in an undue waste of time (s 135 of the Evidence Act).

2.4 An expert witness' opinion evidence may have little or no value unless the assumptions adopted by the expert (ie. the facts or grounds relied upon) and his or her reasoning are expressly stated in any written report or oral evidence given.

2.5 The Court will ensure that, in the interests of justice, parties are given a reasonable opportunity to adduce and test relevant expert opinion evidence. However, the Court expects parties and any legal representatives acting on their behalf, when dealing with expert witnesses and expert evidence, to at all times comply with their duties associated with the overarching purpose in the Federal Court Act (see ss 37M and 37N).

3. INTERACTION WITH EXPERT WITNESSES

3.1 Parties and their legal representatives should never view an expert witness retained (or partly retained) by them as that party's advocate or “hired gun”. Equally, they should never attempt to pressure or influence an expert into conforming his or her views with the party's interests.

3.2 A party or legal representative should be cautious not to have inappropriate communications when retaining or instructing an independent expert, or assisting an independent expert in the preparation of his or her evidence. However, it is important to note that there is no principle of law or practice and there is nothing in this practice note that obliges a party to embark on the costly task of engaging a “consulting expert” in order to avoid “contamination” of the expert who will give evidence. Indeed the Court would generally discourage such costly duplication.

3.3 Any witness retained by a party 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 in the specialised knowledge of the witness[37] should, at the earliest opportunity, be provided with:

- (a) a copy of this practice note, including the Code (see Annexure A); and
- (b) all relevant information (whether helpful or harmful to that party's case) so as to enable the expert to prepare a report of a truly independent nature.

3.4 Any questions or assumptions provided to an expert should be provided in an unbiased manner and in such a way that the expert is not confined to addressing selective, irrelevant or immaterial issues.

4. ROLE AND DUTIES OF THE EXPERT WITNESS

4.1 The role of the expert witness is to provide relevant and impartial evidence in his or her area of expertise. An expert should never mislead the Court or become an advocate for the cause of the party that has retained the expert.

4.2 It should be emphasised that there is nothing inherently wrong with experts disagreeing or failing to reach the same conclusion. The Court will, with the assistance of the evidence of the experts, reach its own conclusion.

4.3 However, experts should willingly be prepared to change their opinion or make concessions when it is necessary or appropriate to do so, even if doing so would be contrary to any previously held or expressed view of that expert.

Harmonised Expert Witness Code of Conduct

4.4 Every expert witness giving evidence in this Court must read the *Harmonised Expert Witness Code of Conduct* (attached in Annexure A) and agree to be bound by it.

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[37] Such a witness includes a “Court expert” as defined in r 23.01 of the Federal Court Rules. For the definition of "expert", "expert evidence" and "expert report" see the Dictionary, in Schedule 1 of the Federal Court Rules.

4.5 The Code is not intended to address all aspects of an expert witness' duties, but is intended to facilitate the admission of opinion evidence, and to assist experts to understand in general terms what the Court expects of them. Additionally, it is expected that compliance with the Code will assist individual expert witnesses to avoid criticism (rightly or wrongly) that they lack objectivity or are partisan.

5. CONTENTS OF AN EXPERT'S REPORT AND RELATED MATERIAL

5.1 The contents of an expert's report must conform with the requirements set out in the Code (including clauses 3 to 5 of the Code).

5.2 In addition, the contents of such a report must also comply with r 23.13 of the Federal Court Rules. Given that the requirements of that rule significantly overlap with the requirements in the Code, an expert, unless otherwise directed by the Court, will be taken to have complied with the requirements of r 23.13 if that expert has complied with the requirements in the Code and has complied with the additional following requirements. The expert shall:

- (a) acknowledge in the report that:
  - (i) the expert has read and complied with this practice note and agrees to be bound by it; and
  - (ii) the expert's opinions are based wholly or substantially on specialised knowledge arising from the expert's training, study or experience;
- (b) identify in the report the questions that the expert was asked to address;
- (c) sign the report and attach or exhibit to it copies of:
  - (i) documents that record any instructions given to the expert; and
  - (ii) documents and other materials that the expert has been instructed to consider.

5.3 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the other parties at the same time as the expert's report.

6. CASE MANAGEMENT CONSIDERATIONS

6.1 Parties intending to rely on expert evidence at trial are expected to consider between them and inform the Court at the earliest opportunity of their views on the following:

- (a) whether a party should adduce evidence from more than one expert in any single discipline;
- (b) whether a common expert is appropriate for all or any part of the evidence;
- (c) the nature and extent of expert reports, including any in reply;
- (d) the identity of each expert witness that a party intends to call, their area(s) of expertise and availability during the proposed hearing;
- (e) the issues that it is proposed each expert will address;
- (f) the arrangements for a conference of experts to prepare a joint-report (see Part 7 of this practice note);
- (g) whether the evidence is to be given concurrently and, if so, how (see Part 8 of this practice note); and
- (h) whether any of the evidence in chief can be given orally.

6.2 It will often be desirable, before any expert is retained, for the parties to attempt to agree on the question or questions proposed to be the subject of expert evidence as well as the relevant facts and assumptions. The Court may make orders to that effect where it considers it appropriate to do so.

7. CONFERENCE OF EXPERTS AND JOINT-REPORT

7.1 Parties, their legal representatives and experts should be familiar with aspects of the Code relating to conferences of experts and joint-reports (see clauses 6 and 7 of the Code attached in Annexure A).

7.2 In order to facilitate the proper understanding of issues arising in expert evidence and to manage expert evidence in accordance with the overarching purpose, the Court may require experts who are to give evidence or who have produced reports to meet for the purpose of identifying and addressing the issues not agreed between them with a view to reaching agreement where this is possible ("**conference of experts**"). In an appropriate case, the Court may appoint a registrar of the Court or some other suitably qualified person ("**Conference Facilitator**") to act as a facilitator at the conference of experts.

7.3 It is expected that where expert evidence may be relied on in any proceeding, at the earliest opportunity, parties will discuss and then inform the Court whether a conference of experts and/or a joint-report by the experts may be desirable to assist with or simplify the giving of expert evidence in the proceeding. The parties should discuss the necessary arrangements for any conference and/or joint-report. The arrangements discussed between the parties should address:

- (a) who should prepare any joint-report;
- (b) whether a list of issues is needed to assist the experts in the conference and, if so, whether the Court, the parties o r the experts should assist in preparing such a list;
- (c) **t**he agenda for the conference of experts; and
- (d) arrangements for the provision, to the parties and the Court, of any joint-report or any other report as to the outcomes of the conference ("**conference report**").

Conference of Experts

7.4 The purpose of the conference of experts is for the experts to have a comprehensive discussion of issues relating to their field of expertise, with a view to identifying matters and issues in a proceeding about which the experts agree, partly agree or disagree and why. For this reason the conference is attended only by the experts and any Conference Facilitator. Unless the Court orders otherwise, the parties' lawyers will not attend the conference but will be provided with a copy of any conference report.

7.5 The Court may order that a conference of experts occur in a variety of circumstances, depending on the views of the judge and the parties and the needs of the case, including:

- (a) while a case is in mediation. When this occurs the Court may also order that the outcome of the conference or any document disclosing or summarising the experts' opinions be confidential to the parties while the mediation is occurring;
- (b) before the experts have reached a final opinion on a relevant question or the facts involved in a case. When this occurs the Court may order that the parties exchange draft expert reports and that a conference report be prepared for the use of the experts in finalising their reports;
- (c) after the experts' reports have been provided to the Court but before the hearing of the experts' evidence. When this occurs the Court may also order that a conference report be prepared (jointly or otherwise) to ensure the efficient hearing of the experts' evidence.

7.6 Subject to any other order or direction of the Court, the parties and their lawyers must not involve themselves in the conference of experts process. In particular, they must not seek to encourage an expert not to agree with another expert or otherwise seek to influence the outcome of the conference of experts. The experts should raise any queries they may have in relation to the process with the Conference Facilitator (if one has been appointed) or in accordance with a protocol agreed between the lawyers prior to the conference of experts taking place (if no Conference Facilitator has been appointed).

7.7 Any list of issues prepared for the consideration of the experts as part of the conference of experts process should be prepared using non-tendentious language.

7.8 The timing and location of the conference of experts will be decided by the judge or a registrar who will take into account the location and availability of the experts and the Court's case management timetable. The conference may take place at the Court and will usually be conducted in-person. However, if not considered a hindrance to the process, the conference may also be conducted with the assistance of visual or audio technology (such as via the internet, video link and/or by telephone).

7.9 Experts should prepare for a conference of experts by ensuring that they are familiar with all of the material upon which they base their opinions. Where expert reports in draft or final form have been exchanged prior to the conference, experts should attend the conference familiar with the reports of the other experts. Prior to the conference, experts should also consider where they believe the differences of opinion lie between them and what processes and discussions may assist to identify and refine those areas of difference.

Joint-report

7.10 At the conclusion of the conference of experts, unless the Court considers it unnecessary to do so, it is expected that the experts will have narrowed the issues in respect of which they agree, partly agree or disagree in a joint-report. The joint-report should be clear, plain and concise and should summarise the views of the experts on the identified issues, including a succinct explanation for any differences of opinion, and otherwise be structured in the manner requested by the judge or registrar.

7.11 In some cases (and most particularly in some native title cases), depending on the nature, volume and complexity of the expert evidence a judge may direct a registrar to draft part, or all, of a conference report. If so, the registrar will usually provide the draft conference report to the relevant experts and seek their confirmation that the conference report accurately reflects the opinions of the experts expressed at the conference. Once that confirmation has been received the registrar will finalise the conference report and provide it to the intended recipient(s).

8. CONCURRENT EXPERT EVIDENCE

8.1 The Court may determine that it is appropriate, depending on the nature of the expert evidence and the proceeding generally, for experts to give some or all of their evidence concurrently at the final (or other) hearing.

8.2 Parties should familiarise themselves with the *Concurrent Expert Evidence Guidelines* (attached in Annexure B). The Concurrent Evidence Guidelines are not intended to be exhaustive but indicate the circumstances when the Court might consider it appropriate for concurrent expert evidence to take place, outline how that process may be undertaken, and assist experts to understand in general terms what the Court expects of them.

8.3 If an order is made for concurrent expert evidence to be given at a hearing, any expert to give such evidence should be provided with the Concurrent Evidence Guidelines well in advance of the hearing and should be familiar with those guidelines before giving evidence.

9. FURTHER PRACTICE INFORMATION AND RESOURCES

9.1 Further information regarding Expert Evidence and Expert Witnesses is available on the Court's website.

9.2 Further information to assist litigants, including a range of helpful guides, is also available on the Court's website. This information may be particularly helpful for litigants who are representing themselves.

J L B ALLSOP
Chief Justice

25 October 2016

Annexure A

HARMONISED EXPERT WITNESS CODE OF CONDUCT[38]

APPLICATION OF CODE

1. This Code of Conduct applies to any expert witness engaged or appointed:

   (a) to provide an expert's report for use as evidence in proceedings or proposed proceedings; or

   (b) to give opinion evidence in proceedings or proposed proceedings.

GENERAL DUTIES TO THE COURT

2. An expert witness is not an advocate for a party and has a paramount duty, overriding any duty to the party to the proceedings or other person retaining the expert witness, to assist the Court impartially on matters relevant to the area of expertise of the witness.

CONTENT OF REPORT

3. Every report prepared by an expert witness for use in Court shall clearly state the opinion or opinions of the expert and shall state, specify or provide:

   (a) the name and address of the expert;

   (b) an acknowledgment that the expert has read this code and agrees to be bound by it;

   (c) the qualifications of the expert to prepare the report;

   (d) the assumptions and material facts on which each opinion expressed in the report is based [a letter of instructions may be annexed];

   (e) the reasons for and any literature or other materials utilised in support of such opinion;

   (f) (if applicable) that a particular question, issue or matter falls outside the expert's field of expertise;

   (g) any examinations, tests or other investigations on which the expert has relied, identifying the person who carried them out and that person's qualifications;

   (h) the extent to which any opinion which the expert has expressed involves the acceptance of another person's opinion, the identification of that other person and the opinion expressed by that other person;

   (i) a declaration that the expert has made all the inquiries which the expert believes are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which the expert regards as relevant have, to the knowledge of the expert, been withheld from the Court;

[38] Approved by the Council of Chief Justices' Rules Harmonisation Committee

(j) any qualifications on an opinion expressed in the report without which the report is or may be incomplete or inaccurate;

(k) whether any opinion expressed in the report is not a concluded opinion because of insufficient research or insufficient data or for any other reason; and

(l) where the report is lengthy or complex, a brief summary of the report at the beginning of the report.

SUPPLEMENTARY REPORT FOLLOWING CHANGE OF OPINION

4. Where an expert witness has provided to a party (or that party's legal representative) a report for use in Court, and the expert thereafter changes his or her opinion on a material matter, the expert shall forthwith provide to the party (or that party's legal representative) a supplementary report which shall state, specify or provide the information referred to in paragraphs (a), (d), (e), (g), (h), (i), (j), (k) and (I) of clause 3 of this code and, if applicable, paragraph (f) of that clause.

5. In any subsequent report (whether prepared in accordance with clause 4 or not) the expert may refer to material contained in the earlier report without repeating it.

DUTY TO COMPLY WITH THE COURT'S DIRECTIONS

6. If directed to do so by the Court, an expert witness shall:

(a) confer with any other expert witness;

(b) provide the Court with a joint-report specifying (as the case requires) matters agreed and matters not agreed and the reasons for the experts not agreeing; and

(c) abide in a timely way by any direction of the Court.

CONFERENCE OF EXPERTS

7. Each expert witness shall:

(a) exercise his or her independent judgment in relation to every conference in which the expert participates pursuant to a direction of the Court and in relation to each report thereafter provided, and shall not act on any instruction or request to withhold or avoid agreement; and

(b) endeavour to reach agreement with the other expert witness (or witnesses) on any issue in dispute between them, or failing agreement, endeavour to identify and clarify the basis of disagreement on the issues which are in dispute.

ANNEXURE B

CONCURRENT EXPERT EVIDENCE GUIDELINES

APPLICATION OF THE COURT'S GUIDELINES

1. The Court's Concurrent Expert Evidence Guidelines ("**Concurrent Evidence Guidelines**") are intended to inform parties, practitioners and experts of the Court's general approach to concurrent expert evidence, the circumstances in which the Court might consider expert witnesses giving evidence concurrently and, if so, the procedures by which their evidence may be taken.

OBJECTIVES OF CONCURRENT EXPERT EVIDENCE TECHNIQUE

2. The use of concurrent evidence for the giving of expert evidence at hearings as a case management technique[39] will be utilised by the Court in appropriate circumstances (see r 23.15 of the *Federal Court Rules 2011* (Cth)). Not all cases will suit the process. For instance, in some patent cases, where the entire case revolves around conflicts within fields of expertise, concurrent evidence may not assist a judge. However, patent cases should not be excluded from concurrent expert evidence processes.

3. In many cases the use of concurrent expert evidence is a technique that can reduce the partisan or confrontational nature of conventional hearing processes and minimises the risk that experts become "opposing experts" rather than independent experts assisting the Court. It can elicit more precise and accurate expert evidence with greater input and assistance from the experts themselves.

4. When properly and flexibly applied, with efficiency and discipline during the hearing process, the technique may also allow the experts to more effectively focus on the critical points of disagreement between them, identify or resolve those issues more quickly, and narrow the issues in dispute. This can also allow for the key evidence to be given at the same time (rather than being spread across many days of hearing); permit the judge to assess an expert more readily, whilst allowing each party a genuine opportunity to put and test expert evidence. This can reduce the chance of the experts, lawyers and the judge misunderstanding the opinions being expressed by the experts.

5. It is essential that such a process has the full cooperation and support of all of the individuals involved, including the experts and counsel involved in the questioning process. Without that cooperation and support the process may fail in its objectives and even hinder the case management process.

CASE MANAGEMENT

6. Parties should expect that, the Court will give careful consideration to whether concurrent evidence is appropriate in circumstances where there is more than one expert witness having the same expertise who is to give evidence on the same or related topics. Whether experts should give evidence concurrently is a matter for the Court, and will depend on the circumstances of each individual case, including the

[39] Also known as the "hot tub" or as "expert panels".

character of the proceeding, the nature of the expert evidence, and the views of the parties.

7. Although this consideration may take place at any time, including the commencement of the hearing, if not raised earlier, parties should raise the issue of concurrent evidence at the first appropriate case management hearing, and no later than any pre-trial case management hearing, so that orders can be made in advance, if necessary. To that end, prior to the hearing at which expert evidence may be given concurrently, parties and their lawyers should confer and give general consideration as to:

   (a) the agenda;

   (b) the order and manner in which questions will be asked; and

   (c) whether cross-examination will take place within the context of the concurrent evidence or after its conclusion.

8. At the same time, and before any hearing date is fixed, the identity of all experts proposed to be called and their areas of expertise is to be notified to the Court by all parties.

9. The lack of any concurrent evidence orders does not mean that the Court will not consider using concurrent evidence without prior notice to the parties, if appropriate.

CONFERENCE OF EXPERTS & JOINT-REPORT OR LIST OF ISSUES

10. The process of giving concurrent evidence at hearings may be assisted by the preparation of a joint-report or list of issues prepared as part of a conference of experts.

11. Parties should expect that, where concurrent evidence is appropriate, the Court may make orders requiring a conference of experts to take place or for documents such as a joint-report to be prepared to facilitate the concurrent expert evidence process at a hearing (see Part 7 of the Expert Evidence Practice Note).

PROCEDURE AT HEARING

12. Concurrent expert evidence may be taken at any convenient time during the hearing, although it will often occur at the conclusion of both parties' lay evidence.

13. At the hearing itself, the way in which concurrent expert evidence is taken must be applied flexibly and having regard to the characteristics of the case and the nature of the evidence to be given.

14. Without intending to be prescriptive of the procedure, parties should expect that, when evidence is given by experts in concurrent session:

   (a) the judge will explain to the experts the procedure that will be followed and that the nature of the process may be different to their previous experiences of giving expert evidence;

   (b) the experts will be grouped and called to give evidence together in their respective fields of expertise;

(c) the experts will take the oath or affirmation together, as appropriate;

(d) the experts will sit together with convenient access to their materials for their ease of reference, either in the witness box or in some other location in the courtroom, including (if necessary) at the bar table;

(e) each expert may be given the opportunity to provide a summary overview of their current opinions and explain what they consider to be the principal issues of disagreement between the experts, as they see them, in their own words;

(f) the judge will guide the process by which evidence is given, including, where appropriate:

(i) using any joint-report or list of issues as a guide for all the experts to be asked questions by the judge and counsel, about each issue on an issue-by-issue basis;

(ii) ensuring that each expert is given an adequate opportunity to deal with each issue and the exposition given by other experts including, where considered appropriate, each expert asking questions of other experts or supplementing the evidence given by other experts;

(iii) inviting legal representatives to identify the topics upon which they will cross-examine;

(iv) ensuring that legal representatives have an adequate opportunity to ask all experts questions about each issue. Legal representatives may also seek responses or contributions from one or more experts in response to the evidence given by a different expert; and

(v) allowing the experts an opportunity to summarise their views at the end of the process where opinions may have been changed or clarifications are needed.

15. The fact that the experts may have been provided with a list of issues for consideration does not confine the scope of any cross-examination of any expert. The process of cross-examination remains subject to the overall control of the judge.

16. The concurrent session should allow for a sensible and orderly series of exchanges between expert and expert, and between expert and lawyer. Where appropriate, the judge may allow for more traditional cross-examination to be pursued by a legal representative on a particular issue exclusively with one expert. Where that occurs, other experts may be asked to comment on the evidence given.

17. Where any issue involves only one expert, the party wishing to ask questions about that issue should let the judge know in advance so that consideration can be given to whether arrangements should be made for that issue to be dealt with after the completion of the concurrent session. Otherwise, as far as practicable, questions (including in the form of cross-examination) will usually be dealt with in the concurrent session.

18. Throughout the concurrent evidence process the judge will ensure that the process is fair and effective (for the parties and the experts), balanced (including not permitting one expert to overwhelm or overshadow any other expert), and does not become a protracted or inefficient process.