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Prevailing Conditions and the Market Risk Premium

A report for APA Group, Envestra, Multinet & SP AusNet

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Executive Summary

This report has been prepared for APA Group, Envestra, Multinet and SP AusNet by NERA Economic Consulting (NERA). APA Group, Envestra, Multinet and SP AusNet have asked NERA to examine a number of issues concerning the market risk premium (*MRP*) that arise from the Australian Energy Regulator's recently published *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17* and from the Australian Competition Tribunal's decision *Application by Envestra Limited (No 2) [2012] ACompT 4* (*11 January 2012*).

In particular, APA Group, Envestra, Multinet and SP AusNet have asked NERA to assess:

- whether an estimate of the *MRP* computed using historical data should be based on the arithmetic mean of a sample of returns to the market portfolio, on the geometric mean or on some weighted average of the two means;

- whether the historical evidence indicates, given current market conditions, that an *MRP* of 6 per cent per annum inclusive of the value of imputation credits is appropriate;

- what forecasts of the *MRP* are generated by the Dividend Growth Model (DGM), current consensus forecasts of future dividend growth and the current yield on the market portfolio; and

- whether the survey evidence that the AER summarises provides support for an *MRP* of 6 per cent per annum inclusive of the value of imputation credits.

Regulators use an estimate of the *MRP* to compute an estimate of the cost of equity and an estimate of the cost of equity to compute an estimate of the weighted average cost of capital (*WACC*). Regulators use an estimate of the *WACC* to compute an estimate of the return that the market requires on the regulated asset base (*RAB*) in each year. We emphasise that:

- an estimate of the *WACC* that is based on the arithmetic mean of a sample of annual excess returns to the market portfolio will – so long as the other components of the *WACC* have been correctly computed and ignoring minor adjustments to the *RAB* and to the evolution of prices – produce an *unbiased* estimate of the revenue that the market requires in any one year on the *RAB*. In contrast, an estimate of the *WACC* that is in part based on an estimate of the *MRP* that places a positive weight on the geometric mean of a sample of annual excess returns to the market portfolio will – so long as the other components of the *WACC* have been correctly computed – produce a *downwardly biased* estimate of the revenue that the market requires in any one year;

- the downwards bias associated with an estimate of the *MRP* that uses the geometric mean can be *substantial*. We show using simulations, for example, that the downward bias associated with an estimate of the *MRP* over any single year that uses the geometric mean computed using data, generated to have the same characteristics as the data that Brailsford, Handley and Maheswaran provide and that we update, from 1883 through 2011 (1958 through 2011) is 130 (250) basis points; [1] and

- while an estimate of the *WACC* compounded over more than one year, based on the arithmetic mean of a sample of annual excess returns to the market portfolio, will be biased, the AER, aside from some minor adjustments to the *RAB* and to the evolution of prices over the regulatory period, *never* compounds the *WACC* over more than one year.

The volatility of the return to the Australian market portfolio – or at least a typical choice of a proxy for the portfolio, the All Ordinaries – has been far from constant over time. We find that:

- the historical evidence indicates that the Australian market portfolio has been typically riskier over the last half century than it was over the 75 years or so before. Estimates of the parameters of a regime-switching model that allows for episodes of high volatility and episodes of low volatility suggest that over the last half century the standard deviation of the return to the market portfolio has typically been around twice what it was over the 75 years or so before. The Capital Asset Pricing Model (CAPM) – the model on which the AER relies to compute the cost of equity – implies that there should be a positive relation between the *MRP* and the volatility of the return to the market portfolio. Merton (1973) develops a model that makes this relation explicit; [2] and

- estimates that use the regime-switching model and the restriction that Merton's model places on the relation between the *MRP* and the volatility of the return to the market portfolio suggest that the *MRP* is currently *above* its long-term average. Estimates that use the regime-switching model and Merton's model indicate that the *MRP* for the next five years, relative to the 10-year government bond yield, is 8.44 per cent per annum.

The DGM provides, in principle, an attractive way of estimating the *MRP*. In practice, the model requires reliable forecasts of future dividend growth. We find that

- estimates of the *MRP* provided by the DGM that use current data lie *above* 6 per cent per annum. These relatively high estimates reflect the high current forward dividend yield on the market portfolio and the low yield on 10-year bonds. They do *not* rely on high forecasts of long-run growth in dividends per share (DPS); and

- Bloomberg consensus forecasts indicate that a conservative estimate of the *MRP*, adjusted for the value that the market places on imputation credits, for the next five years, relative to the 10-year government bond yield, is 7.69 per cent per annum. [3]

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1 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

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

3 We adjust for the provision of imputation credits under the assumption that the value of a one-dollar credit distributed has a market value of 35 cents. This market value is the value laid down by the Australian Competition Tribunal in its recent decision on the market value of a one-dollar credit distributed. We also assume, like Brailsford, Handley and Maheswaran (2008), that 75 per cent of dividends distributed are franked.

This estimate is *conservative* in that it uses as a forecast of long-run DPS growth a number, based on past real DPS growth and Reserve Bank of Australia (RBA) targets for inflation, that lies marginally below the forecast for long-run DPS growth that the AER uses and well below current consensus forecasts of short-term DPS growth.

An estimate of the *MRP* computed using the regime-switching model lies above an estimate computed using the DGM. Note, however, that:

- the regime-switching model provides an estimate of the *MRP* in *each* future year. Because the data suggest that there is a high probability that we are currently in the high-volatility regime, the *MRP* forecast for 2012 is high. After 2012, however, the *MRP* is expected to decline as the probability increases that we will move from the high-volatility regime to the low-volatility regime;

- the DGM, on the other hand, provides a single estimate of the *MRP* that is based on the internal rate of return that will discount back the market's expectations of the dividends that the market portfolio will pay in *all* future periods – not just over the next five years – back to the current market value of the market portfolio. The value for the *MRP* that the DGM attempts to estimate will be a complicated average of the *MRP* over the next year and over all future years. Thus an estimate that the DGM provides will tend to lie below the current *MRP* when the current *MRP* lies above its long-run mean and above the current *MRP* when the current *MRP* lies below its long-run mean; and

- so, for these reasons, we judge the estimate of the *MRP* provided by the regime-switching model of 8.44 per cent per annum to provide the most suitable guide as to the *MRP* prevailing in the market over the five years of the regulatory period.

The AER places some emphasis on survey evidence.[4] We see a number of problems with the surveys that the AER cites:

- the surveys that the AER cites typically do not explain how those surveyed were chosen and a majority of those surveyed do not respond. Thus it is unclear whether the sample of respondents that the surveys use is representative of the population;
- it is unclear what incentives have been provided to individuals contacted by the surveys that the AER cites to ensure that respondents provide accurate responses; and
- it is unclear how relevant some of the surveys that the AER cites are because of changes in market conditions since the time at which the surveys were conducted.

As an example of the problems that can arise, we note that with regard to the survey conducted by Asher (2011), that the AER cites, that:[5]

Australian Competition Tribunal, Application by Energex Limited (Gamma) (No 5) [2011] ACompT 9, May 2011.

Brailsford, T., J. Handley and K. Maheswaran, *Re-examination of the historical equity risk premium in Australia*, Accounting and Finance 48, 2008, pages 73-97.

4 AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, pages 229-230.

- only 49 of 2,000 surveyed responded; and that
- the survey was conducted in February 2011 when bond yields and stock prices were relatively high and when a DGM forecast of the *MRP* would have been 295 basis points lower than an otherwise identical forecast constructed in December 2011.

We also note that:

- Asher stated in a seminar in May 2010 in front of individuals whom he later surveyed that 'the implied equity premium is more or less equal to the dividend yield which is probably at this stage somewhere between 3 and 4 per cent – I think that may be a reasonable thing to work on.' [6, 7]

This public statement about the surveyor's view of what would be a correct response to the primary question he plans to ask in a survey he plans to conduct raises the possibility that the results of the survey will merely mirror his own views.

5 Asher, *Equity Risk Premium Survey – results and comments*, Actuary Australia 2011 Issue 161, July 2011, pages. 13-15.

6 http://www.actuaries.asn.au/Library/6b_Asher_Ashe.mp3

7 Asher, like many academics, refers to the *MRP* as the equity premium.

1 Introduction

This report has been prepared for APA Group, Envestra, Multinet and SP AusNet by NERA Economic Consulting (NERA). APA Group, Envestra, Multinet and SP AusNet have asked NERA to examine a number of issues concerning the market risk premium (*MRP*) that arise from the Australian Energy Regulator's recently published *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17* ("the AER's *Aurora Draft Decision*") and from the Australian Competition Tribunal's *Application by Envestra Limited (No 2) [2012] ACompT 4* (*11 January 2012*) ("the ACT's *MRP Decision*").

In particular, APA Group, Envestra, Multinet and SP AusNet have asked NERA to assess:

- whether an estimate of the *MRP* computed using historical data should be based on the arithmetic mean of a sample of returns to the market portfolio, on the geometric mean or on some weighted average of the two means;
- whether the historical evidence indicates, given current market conditions, that an *MRP* of 6 per cent per annum inclusive of the value of imputation credits is appropriate;
- what forecasts of the *MRP* are generated by the Dividend Growth Model (DGM), current consensus forecasts of future dividend growth and the current yield on the market portfolio; and
- whether the survey evidence that the AER summarises provides support for an *MRP* of 6 per cent per annum inclusive of the value of imputation credits.

The remainder of this report is structured as follows:

- Section 2 – examines the arguments for using arithmetic means and geometric means;
- Section 3 – examines whether the historical evidence points to an estimate of the *MRP* of 6 per cent per annum;
- Section 4 – constructs DGM forecasts of the *MRP*;
- Section 5 – examines whether the survey evidence that the AER summarises provides support for a particular value for the *MRP*; and
- Section 6 – provides conclusions.

1.1 Statement of Credentials

This report has been jointly prepared by **Simon Wheatley** and **Brendan Quach**.[8]

Simon Wheatley is a Special Consultant with NERA, and was until recently a Professor of Finance at the University of Melbourne. Since 2008, Simon has applied his finance expertise in investment management and consulting outside the university sector. Simon's interests

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

and expertise are in testing asset-pricing models, determining the extent to which returns are predictable and individual portfolio choice theory. Prior to joining the University of Melbourne, Simon taught finance at the Universities of British Columbia, Chicago, New South Wales, Rochester and Washington.

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

2 Arithmetic Versus Geometric Means

In its *Aurora Draft Decision*, the AER reports both arithmetic and geometric means of the return to the market portfolio in excess of the 10-year government bond yield computed over a number of periods. The AER argues that both arithmetic means and geometric means provide important information about the value that it should adopt for the *MRP*. For example, the AER states that: [9]

> 'The AER considers that the arithmetic average results in an overestimate and the best estimate of historical excess returns over a 10 year period is likely to be somewhere between the geometric mean and the arithmetic mean of annual excess returns.'

The AER does not state explicitly, however, what weight it feels should be attached to each estimate. In this section we examine the issue of what weight the AER should attach to arithmetic mean estimates of the *MRP* and what weight the AER should attach to geometric mean estimates of the *MRP*. The AER has not responded to the arguments that we made about this issue in our August 2011 report *The Market Risk Premium: A report for CitiPower, Jemena Electricity Networks, Powercor, SP AusNet and United Energy Distribution* and the ACT has not had an opportunity to consider our arguments and so much of what we say here is of necessity a repetition of material contained in that report.

While the arithmetic mean of a sample of returns will provide an *unbiased* estimate of the unconditional expected return to an asset over a single period (so long as it exists), the use of arithmetic means and the use of geometric means can provide biased estimates of unconditional expected multi-period returns. [10, 11] To see why the use of arithmetic means can provide biased estimates of expected multi-period returns, it will be useful to consider a simple example. Define A to be the arithmetic mean of a sample of gross annual returns, that is, define:

$$A = \sum_{t=1}^{T} \frac{R(t)}{T}, \qquad (1)$$

where

$R(t)$ = one plus the rate of return to some asset from t-1 to t; and

T = the number of observations.

9 AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, page 214.

10 There are random variables which have no means. The mathematical expectation of a Cauchy random variable, for example, does not exist. We assume from henceforth that the expected values to which we refer exist.

11 The unconditional expectation of a random variable is the mean of its marginal probability distribution. The conditional expectation of a random variable, on the other hand, is the mean of the probability distribution of a random variable conditional on some other variable or variables. Our focus in this section of the report is on unconditional expectations.

If the return to the asset is serially uncorrelated, that is, if past returns are not useful for forecasting future returns, then the expected value of an estimate of the expected return to the asset over two years that uses the arithmetic mean will be:

$$\mathrm{E}(A^2) = [\mathrm{E}(A)]^2 + \mathrm{Var}(A) = \mathrm{E}(R(t)^2) + \mathrm{Var}(A) > \mathrm{E}(R(t)^2). \quad (2)$$

The bias associated with estimates of expected multi-period returns that use the arithmetic mean arises from the fact that the expectation of a function of a random variable will not in general equal the same function of the expectation of the variable. So in this simple example, the expectation of the square of the random variable does not equal, but exceeds the square of the expectation.[12]

The key point that we wish to make in this section, however, is that the AER, aside from some minor adjustments to the regulated asset base (*RAB*) and to the evolution of prices over the regulatory period, *never* uses the arithmetic mean of a sample of annual returns to estimate the expected value of a return over more than one year. The AER uses an estimate of the weighted average cost of capital (*WACC*) in three ways. First, and most importantly, the *WACC* is used to determine the return on capital that a regulated utility must make each year. Second, the *WACC* is used to make minor adjustments to the *RAB*. Third, the *WACC* is used to ensure that in smoothing prices, the NPV of the post-tax revenue that the utility is expected to earn is unaffected.

Although revenue must be forecast for each of the several years of the typical regulatory period, at no stage, aside from in making minor adjustments to the *RAB* and to the evolution of prices, is the *WACC* compounded over more than one year. Thus a *WACC* that is based solely on the arithmetic mean of a sample of annual excess returns to the market portfolio will – so long as the other components of the *WACC* have been correctly computed and ignoring minor adjustments – produce an *unbiased* estimate of the revenue that the market requires the utility earn in any single year of an Access Arrangement Period.

If excess returns to the market portfolio are serially uncorrelated – and the evidence against the hypothesis is weak – then an unbiased estimator of the discount factor that the AER should use in determining how prices are to be smoothed will require one use an estimate of the *MRP* that *exceeds* the arithmetic mean of a sample of annual excess returns to the market portfolio.

We use simulations to examine the properties of estimators of the expected excess return to the market portfolio that use the arithmetic mean of a sample of annual excess returns and of estimators that use the geometric mean. These simulations show that:

- the arithmetic mean of a sample of annual excess returns to the market portfolio is an unbiased estimator of the expected excess return to the market portfolio over any

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12 To see that the arithmetic mean of a sample of returns will provide an *unbiased* estimate of the unconditional expected return to an asset over a single period, note that:

$$\mathrm{E}(A) = \mathrm{E}\left(\sum_{t=1}^{T} \frac{R(t)}{T}\right) = \sum_{t=1}^{T} \frac{\mathrm{E}(R(t))}{T} = \frac{T\,\mathrm{E}(R(t))}{T} = \mathrm{E}(R(t)).$$

single year but estimates of the expected excess return to the market over more than one year that use this mean are upwardly biased; and

- the geometric mean of a sample of annual excess returns to the market portfolio computed using $T > 1$ years of data is a downwardly biased estimator of the expected excess return to the market portfolio over any single year and estimates of the expected excess return to the market over $N < T$ years that use this mean are also downwardly biased. Thus, for example, the geometric mean of a sample of 129 annual excess returns to the market portfolio will be a downwardly biased estimator of the expected excess return to the market portfolio over any single year and estimates of the expected excess return to the market over $N < 129$ years that use this mean will also be downwardly biased.

While these facts are well known, our simulations, which we calibrate to the data that Brailsford, Handley and Maheswaran (2011) provide and that we update, illustrate how important these biases are in computing estimates of the *MRP* for use in regulating Australian utilities.[13] We find, for example, that the downward bias associated with an estimate of the *MRP* over any single year that uses the geometric mean computed using data generated to have the same characteristics as the data that Brailsford, Handley and Maheswaran provide and that we update from 1883 through 2011 (1958 through 2011) is 130 (250) basis points. In other words, our simulations indicate that one would expect the geometric mean computed using data from 1883 through 2011 (1958 through 2011) to lie 130 (250) basis points below the true mean.

Thus a *WACC* that is in part based on an estimate of the *MRP* that places a positive weight on the geometric mean of a sample of annual excess returns to the market portfolio will – so long as the other components of the *WACC* have been correctly computed and ignoring minor adjustments – produce a *downwardly biased* estimate of the revenue that the market requires in any one year on the *RAB*. In contrast a *WACC* that is based solely on the arithmetic mean of a sample of annual excess returns to the market portfolio will – so long as the other components of the *WACC* have been correctly computed and ignoring minor adjustments – produce an *unbiased* estimate of the revenue that the market requires in any one year.

We also use simulations to examine the properties of discount factor estimates that use the arithmetic mean of a sample of annual excess returns to the market portfolio and discount factor estimates that use the geometric mean. The results of these simulations show that if returns are serially uncorrelated:

- discount factor estimates that use the arithmetic mean and discount factor estimates that use the geometric mean are both upwardly biased; but

- discount factor estimates that use the geometric mean exhibit a larger bias than discount factor estimates that use the arithmetic mean.

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13 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

Again, while these results are well known, our simulations show how important the biases are for regulated Australian utilities. The results imply that if the excess return to the market portfolio is serially uncorrelated, then an unbiased estimator of a discount factor will require one use an estimate of the *MRP* that *exceeds* the arithmetic mean of a sample of annual excess returns to the market portfolio and places a negative weight on the geometric mean.

There is some weak evidence in the annual data that Brailsford, Handley and Maheswaran (2011) provide and that we update of negative first-order serial dependence. [14] In a world in which returns are serially dependent, past returns can provide information that is useful for setting an *MRP* conditional on all currently available information. Serial dependence can also have an impact on the bias associated with estimates of the unconditional expected excess return to the market portfolio and the bias associated with estimates of unconditional discount factors. An unconditional expectation is not constructed conditional on past returns. We use simulations to examine this impact in Appendix A.

The simulations in Appendix A show that, as is well known, the arithmetic mean of a sample of annual excess returns to the market portfolio is an unbiased estimator of the unconditional expected excess return to the market portfolio over any one year regardless of whether returns are serially dependent. Thus the use of the arithmetic mean will deliver an unbiased estimate of the unconditional return on capital necessary for a regulated firm to recover its costs in any one year – so long as the other components of the *WACC* have been correctly computed and ignoring minor adjustments. Determining the return on capital required to cover costs is the *primary* use to which the *WACC* is put.

The simulations show, however, that if returns exhibit negative first-order serial dependence, then unconditional discount factor estimates that use the arithmetic mean can be downwardly biased while estimates that use the geometric mean are upwardly biased. These results imply that if the excess return to the market portfolio is negatively serially dependent, then an unbiased estimator of an unconditional discount factor may require one use an estimate of the *MRP* that falls below the arithmetic mean of a sample of annual excess returns to the market portfolio. Thus there is an argument – albeit very weak, because the evidence of serial dependence is so weak – for using an estimate of the *MRP* that falls below the arithmetic mean – not to determine the return on capital necessary for a regulated firm to recover its costs – but to determine how that return should be distributed across time so as to smooth prices. Relative to determining the revenue required to cover expected costs, determining how that revenue should be distributed across time is a *secondary* issue.

2.1 Regulatory Use of the *WACC*

The *WACC* that the AER chooses is used to determine the revenue that the regulator allows a regulated utility each year. The revenue equation is:

$$REV(t) = RAB(t-1) \times WACC + DEP(t) + OPEX(t) + TAX(t), \quad (3)$$

where

[14] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

$REV(t)$	=	the utility's revenue in year t;
$RAB(t\text{-}1)$	=	the regulated asset base of the utility at the end of year t-1;
$WACC$	=	the utility's $WACC$, a constant over the regulatory period;
$DEP(t)$	=	depreciation in year t;
$OPEX(t)$	=	operating expenditure in year t;
$TAX(t)$	=	compensation for the cost of company tax paid in year t;

and where the evolution of the regulatory asset base is described by the asset-base roll-forward equation:

$$RAB(t) = RAB(t-1) + CAPEX(t) - DEP(t), \qquad (4)$$

where

$CAPEX(t)$	=	the utility's capital expenditure in year t net of asset disposals and customer contributions.

From the revenue equation and the asset-base roll-forward equation, it is appears that while revenue must be forecast for each of the several years of the typical regulatory period, at no stage is the *WACC* compounded over more than one year.[15] In practice, minor adjustments are made to the *RAB* that create a minor dependence of the *RAB* on the *WACC*. The first of these adjustments has to do with the timing of capital expenditure. The second has to do with the difference between actual and forecast capital expenditure.

2.1.1 Timing of capital expenditure

The AER recognises that capital expenditure does not occur at the end of each year but occurs throughout each year. To make matters simple the AER assumes that all capital expenditure occurs halfway through each year.[16] To adjust for the revenue that would be lost by assuming all capital expenditure occurs at the end of each year, the AER raises the *RAB* at the end year *t* by the amount:

$$CAPEX(t) \times ((1 + \widehat{WACC})^{1/2} - 1), \qquad (5)$$

where

$\widehat{WACC}$	=	the AER's estimate of the *WACC*.

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15 Rule 73 of the National Gas Rules states that:

Financial information must be provided on:

(a) a nominal basis; or

(b) a real basis; or

(c) some other recognised basis for dealing with the effects of inflation.

Thus the quantities in (3) and (4) may be adjusted for the effects of inflation.

16 AER, Electricity distribution network service providers post-tax revenue model handbook, June 2008, page 11.

The value, determined at the end of year *t*, of making this adjustment is:

$$CAPEX(t) \times ((1+\hat{WACC})^{1/2} - 1) \sum_{s=1}^{\infty} \frac{\hat{WACC}}{(1+RDSC)^s}$$

$$= CAPEX(t) \times ((1+\hat{WACC})^{1/2} - 1) \frac{\hat{WACC}}{RDSC}, \qquad (6)$$

where

RDSC = the rate that the market uses to discount the additional revenue.[17]

If the *WACC* is based solely on the arithmetic mean of a sample of annual excess returns to the market portfolio, then:

$$\mathrm{E}\left(((1+\hat{WACC})^{1/2} - 1)\ \hat{WACC} \right) > ((1+WACC)^{1/2} - 1)\ WACC \qquad (7)$$

We will use simulations to show, however, that the difference between the left- and right-hand sides of (7), the bias about which one might be concerned, is trivial.

2.1.2 Difference between actual and forecast capital expenditure

In each year of the regulatory period, revenue is determined in part by the *RAB* at the start of the year. In determining parameters for the next regulatory period, however, the AER will not know the *RAB* at the start of the regulatory period, but will only have a forecast of the *RAB*. It will not know the *RAB* because it will not know what actual capital expenditure will be in the last year of the regulatory period. The regulator will know only what a forecast of capital expenditure is for the year. To adjust for differences between actual capital expenditure and forecast capital expenditure in the last year of the previous regulatory period, the AER adjusts the *RAB* at the end of the regulatory period. This adjustment includes a return on the difference between actual and forecast capital expenditure in the last year of the previous regulatory period that is compounded. So if the adjustment is positive, because actual capital expenditure exceeded forecast capital expenditure in the last year of the previous regulatory period, the use of a *WACC* that is based solely on the arithmetic mean of a sample of annual excess returns to the market portfolio will produce an upwardly biased estimate of this adjustment.

This bias is likely to be empirically unimportant, though, for two reasons:

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[17] If the *WACC* were known and was identical to the rate that the market uses to discount the additional revenue, then (6) would collapse to:

$$CAPEX(t) \times ((1+WACC)^{1/2} - 1),$$

which would match the revenue that one would expect to earn over half a year on capital of *CAPEX*(*t*).

- the adjustment is based on the *difference* between actual and forecast capital expenditure not on the level (either actual or forecast) of capital expenditure; and
- the adjustment is based on the difference between actual and forecast capital expenditure in only the *last* year of a regulatory period not on the difference in each of the five years of the regulatory period.

In addition, it is typically the case that actual capital expenditure is below forecast capital expenditure in the last year of a regulatory period.[18] Under these conditions the use of a *WACC* that is based solely on the arithmetic mean of a sample of annual excess returns to the market portfolio will produce a downwardly rather than an upwardly biased estimate of the adjustment.

2.1.3 Smoothing prices

Application of the building block approach can lead to volatility across time in the prices necessary to recover expected costs each year. To avoid this volatility, prices can be smoothed. The AER requires that they be smoothed, however, in such a way that the net present value (NPV) of the post-tax revenues that the regulated utility expects to receive is unaffected. Computing the NPV of post-tax revenues requires a series of discount factors. Estimates of these factors that use the arithmetic mean of a sample of annual excess returns to the market portfolio and estimates that use the geometric mean both tend to be biased.

Like Brailsford, Handley and Maheswaran (2008), we compute the arithmetic and geometric means of the return to a portfolio that:[19]

- places a weight of 100 per cent in non-interest bearing cash;
- places a weight of 100 per cent in the market portfolio; and
- borrows 100 per cent of the value of the portfolio at a rate equal to the 10-year bond yield.

2.2 Arithmetic Mean

Following Blume (1974) and Cooper (1996), we define A to be the arithmetic mean of a sample of returns.[20] In particular, we define:[21]

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[18] For United Energy actual capital expenditure fell below forecast capital expenditure by $59.26 million in 2005. See: United Energy RFM Final Decision.xls

[19] Brailsford, T., J. Handley and K. Maheswaran, *Re-examination of the historical equity risk premium in Australia*, Accounting and Finance 48, 2008, pages 73-97.

[20] Blume, M., *Unbiased estimators of long-run expected rates of return*, Journal of the American Statistical Association, 1974, pages 634-638.

Cooper, I., *Arithmetic versus geometric mean estimators: Setting discount rates for capital budgeting*, European Financial Management, 1996, pages 157-167.

[21] The symbol $\sum_{t=1}^{T} R(t)$ means $R(1) + R(2) + ... + R(T)$.

$$A = \sum_{t=1}^{T} \frac{R(t)}{T}, \tag{8}$$

where

$R(t)$	=	one plus the return in year t to the portfolio that is long the market portfolio and short the 10-year bond; and
T	=	the number of annual observations.

An estimate of the rate of return to the portfolio over N years that uses the arithmetic mean is:

$$A^N - 1 \tag{9}$$

while an estimate of the discount factor for a cash flow occurring N years hence that uses the mean is:

$$A^{-N} \tag{10}$$

Note that we use the notation $R(t)$ to denote one *plus* a rate of return in this section to be consistent with the notation that Blume and Cooper employ.

2.3 Geometric Mean

Also, like Blume (1974) and Cooper (1996), we define G to be the geometric mean of a sample of returns. [22] In particular, we define: [23]

$$G = \left[\prod_{t=1}^{T} R(t) \right]^{1/T} \tag{11}$$

An estimate of the rate of return over N years to the portfolio that is long the market portfolio and short the 10-year bond that uses the geometric mean is:

$$G^N - 1 \tag{12}$$

while an estimate of the discount factor for a cash flow occurring N years hence that uses the mean is:

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[22] Blume, M., *Unbiased estimators of long-run expected rates of return*, Journal of the American Statistical Association, 1974, pages 634-638.

Cooper, I., *Arithmetic versus geometric mean estimators: Setting discount rates for capital budgeting*, European Financial Management, 1996, pages 157-167.

[23] The symbol $\prod_{t=1}^{T} R(t)$ means $R(1) \times R(2) \times ... \times R(T)$.

$$G^{-N} \tag{13}$$

2.4 Bias

Blume (1974) documents the bias that can arise when arithmetic and geometric mean returns are used to estimate expected multi-period returns.[24] Similarly, Cooper (1996) documents the bias that can arise when arithmetic and geometric mean returns are used to estimate discount factors.[25] We conduct simulations, calibrated to the annual data that Brailsford, Handley and Maheswaran (2011) provide and that we update, to determine how important these biases are in computing estimates of the *MRP* for use in regulating Australian utilities.[26] In particular, we calibrate the simulations to the distribution of the return, adjusted for the value that the market places on imputation credits, to a portfolio that is, again:[27, 28]

- 100 per cent long non-interest bearing cash;
- 100 per cent long the market portfolio; and
- 100 per cent short a risk-free portfolio that pays a rate equal to the 10-year bond yield.

We generate data under the assumption that:

$$R(t) - 1 \sim \text{NID}(\mu, \sigma), \tag{14}$$

where

μ	=	the mean of the distribution;
σ	=	the standard deviation of the distribution; and

NID stands for normally and independently distributed. In Appendix A we relax the assumption to allow for serial dependence. We choose the mean and standard deviation of

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24 Blume, M., *Unbiased estimators of long-run expected rates of return*, Journal of the American Statistical Association, 1974, pages 634-638.

25 Cooper, I., *Arithmetic versus geometric mean estimators: Setting discount rates for capital budgeting*, European Financial Management, 1996, pages 157-167.

26 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

27 We adjust the returns for the provision of imputation credits under the assumption that the value of a one-dollar credit distributed has a market value of 35 cents using data on credits assembled in the way that Brailsford, Handley and Maheswaran (2011) describe. This value is the value laid down by the Australian Competition Tribunal in its recent decision on the market value of a one-dollar credit distributed. See

Australian Competition Tribunal, Application by Energex Limited (Gamma) (No 5) [2011] ACompT 9, May 2011.

Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

28 Conveniently, the sample mean of these returns from 1883 to 2011 matches the sample mean from 1958 to 2011. 1883 to 2011 and 1958 to 2011 are the two periods that we examine in the current report. In our August 2011 report *The Market Risk Premium: A report for CitiPower, Jemena Electricity Networks, Powercor, SP AusNet and United Energy Distribution*, we calibrate the simulations to the distribution of returns that are not grossed up for imputation credits because the sample mean of those returns from 1883 to 2010 matches the sample mean from 1958 to 2010. 1883 to 2010 and 1958 to 2010 are the two periods that we examine in our August 2011 report.

the distribution of returns to match the sample mean and sample standard deviation of the return to the portfolio that is long the market portfolio and short the 10-year bond computed using the data that Brailsford, Handley and Maheswaran (2011) provide and that we update for two periods: 1883 to 2011 and 1958 to 2011. [29]

Table 2.1 provides the results of simulations that examine the bias that can arise when arithmetic and geometric mean returns are used to estimate expected multi-period returns. Panel A uses 129 years of data to estimate the returns and is calibrated to data, that Brailsford, Handley and Maheswaran (2011) provide and that we update, from 1883 through 2011.[30] Panel B uses 54 years of data and is calibrated to data, that they provide and that we update, from 1958 through 2011. The table shows, as is well known, that the arithmetic mean of a sample of annual returns is an unbiased estimator of the expected return over one year but that the geometric mean is a downwardly biased estimator. The downward bias associated with the geometric mean using 129 years of simulated data is 130 basis points (6.1 – 4.8) while using 54 years of simulated data it is 250 basis points (6.1 – 3.6).

Table 2.1
Bias in estimating expected multi-period returns

Year	1	2	3	4	5	10
	Panel A: μ = 6.1%, σ = 16.6%, T = 129 years					
Parameter	6.1	12.6	19.4	26.7	34.5	80.8
Arithmetic	6.1	12.6	19.5	26.8	34.7	82.3
Geometric	4.8	9.8	15.1	20.6	26.5	60.7
	Panel B: μ = 6.1%, σ = 22.6%, T = 54 years					
Parameter	6.1	12.6	19.4	26.7	34.5	80.8
Arithmetic	6.1	12.7	19.8	27.4	35.7	87.9
Geometric	3.6	7.4	11.5	15.8	20.4	48.5

Notes: Simulation results are in per cent per annum. The N-period return is $(1+\mu)^N - 1$. *An estimate of the N-period return computed using the arithmetic mean is* $A^N - 1$ *while an estimate of the N-period return computed using the geometric mean is* $G^N - 1$, *where A and G are defined by* (8) *and* (11).

Table 2.1 also shows that estimates of the expected return over more than one year that use the arithmetic mean are upwardly biased. The bias can be substantial if the time series used

[29] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

[30] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

to compute the mean is short and the expected return is over many years. Panel B, for example, shows that the bias associated with an estimate of the expected 10-year return that uses the arithmetic mean computed using 54 years of data is 710 basis points (87.9 – 80.8).[31] At no stage in the regulatory process, however, is the *WACC* compounded over 10 years. Thus the observation is purely academic.

Table 2.1 also indicates that the bias associated with the adjustment that the AER makes to the *RAB* to reflect the timing of capital expenditure is trivial. We find, for example, that the bias associated with an estimate of the expected two-year return that uses the arithmetic mean and 129 years of data is one basis point, that is, half a basis point per annum.[32] By interpolation, the bias associated with an estimate of the expected 18-month return that uses the arithmetic mean and 129 years of data is half a basis point, that is, one quarter of a basis point per annum.

Table 2.2
Bias in estimating discount factors

Year	1	2	3	4	5	10
			Panel A: μ = 6.1%, σ = 16.6%, T = 129 years			
Parameter	0.943	0.888	0.837	0.789	0.744	0.553
Arithmetic	0.943	0.889	0.838	0.790	0.746	0.559
Geometric	0.955	0.912	0.871	0.832	0.794	0.634
			Panel B: μ = 6.1%, σ = 22.6%, T = 54 years			
Parameter	0.943	0.888	0.837	0.789	0.744	0.553
Arithmetic	0.943	0.890	0.841	0.796	0.753	0.579
Geometric	0.966	0.935	0.905	0.877	0.851	0.743

Notes: The N-period discount factor is $(1+\mu)^{-N}$. *An estimate of the N-period discount factor computed using the arithmetic mean is* A^{-N} *while an estimate of the N-period discount factor computed using the geometric mean is* G^{-N}*, where A and G are defined by* (8) *and* (11).

Table 2.2 provides the results of simulations that examine the bias that can arise when arithmetic and geometric mean returns are used to estimate discount factors. The table shows that discount factor estimates that use the arithmetic mean and discount factor estimates that use the geometric mean are both upwardly biased. Discount factor estimates that use the geometric mean exhibit a larger bias than discount factor estimates that use the arithmetic

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31 The downward bias associated with an estimate of the expected 10-year return that uses the geometric mean computed using 54 years of data is even worse. It is 3,230 basis points (80.8 – 48.5).

32 These results are from our simulation output. Table 2.1 provides only one decimal place.

mean. Thus a weighted average of the two estimates that is unbiased is one that places a negative rather than a positive weight on the estimate that uses the geometric mean.

2.5 Discussion

The AER uses an estimate of the *WACC* in three ways. First, and most importantly, the *WACC* is used to determine the return on capital that a regulated utility must make each year. Second, the *WACC* is used to make minor adjustments to the *RAB*. Third, the *WACC* is used to ensure that in smoothing prices, the NPV of the post-tax revenue that the utility is expected to earn is unaffected.

Although revenue must be forecast for each of the several years of the typical regulatory period, at no stage – aside from in making minor adjustments – is the *WACC* compounded over more than one year. Thus a *WACC* that is based solely on the arithmetic mean of a sample of annual excess returns to the market portfolio will – so long as the other components of the *WACC* have been correctly computed and ignoring the impact of minor adjustments – produce an *unbiased* estimate of the revenue that the market requires the utility earn in any one year.

The AER, on the other hand, states in its recent *Aurora Draft Decision* that: [33]

> 'The AER has previously noted the widely held view that the use of arithmetic means is appropriate when arriving at a forward looking estimate. However, it is also imperative to understand the nature of the value being estimated. As noted previously, the CAPM is a single period model, with its components aligning to that period. Consistent with the Tribunal's decision, the risk-free rate component of the CAPM is set at 10 years. Consequently, the MRP must be a 10-year estimate, even though it is expressed in annual terms.'
>
> 'Therefore, in estimating the MRP, one must look at the return on the market for 10 years over the return on the risk-free asset for the same 10 years. This is similar to the AER's determination of the DRP, where the debt premium is determined for the entire 10 year period, rather than the arithmetic average of premia from 10 one-year periods.'
>
> 'Historical data, on the other hand, is usually presented in terms of annual returns and annual MRPs. However, a 10 year MRP can be approximated from annual MRPs by determining a geometric average of ten annual MRPs within that 10 year period. This geometric average approximates the 10 yearly MRP in annual terms.'
>
> 'In historical studies noted above, the geometric averages estimate a cumulative return over the relevant sample period. This period is significantly longer than the 10 year time horizon assumed for the forward looking MRP, and is likely to understate the historical excess return over a 10 year horizon. On the other hand, arithmetic means of historical excess returns are likely to overstate the historical 10 year excess return to some degree. This is because they do not take account of the cumulative effect of returns over a 10 year horizon.'

[33] AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, pages 228-229.

> 'The AER considers that the best estimate of historical excess returns over a 10 year period is likely to be somewhere between the geometric mean and the arithmetic mean of annual excess returns (between 3.6–6.4 per cent). Consequently, the AER considers that the latest historical excess return estimates, derived from more up to date data since the SRI, supports a forward looking long-term MRP of 6 per cent. Given that this estimate is at the top of the quoted range, the AER considers that, if anything, it has erred on the side of caution when making its assessment for regulated businesses.'

While we agree that an estimate of the expected 10-year excess return that uses the arithmetic mean will be upwardly biased, at no stage in the regulatory process is the *WACC* compounded over 10 years – or indeed – aside from minor adjustments – over more than one year. In other words, a regulated utility is not in general given the opportunity of reinvesting all of the return that it receives on its capital at the *WACC*. The utility can only earn the *WACC* on the *RAB* and the evolution of the *RAB* does not – aside from the impact of minor adjustments – depend on the *WACC*.

If excess returns to the market portfolio are serially uncorrelated – and the evidence against the hypothesis is weak – then an unbiased estimator of the discount factor that the AER should use in determining how prices are to be smoothed will require one use an estimate of the *MRP* that exceeds the arithmetic mean of a sample of annual excess returns to the market portfolio. If excess returns to the market portfolio are negatively serially dependent, then an unbiased estimator of the discount factor that the AER should use in determining how prices are to be smoothed may require one use an estimate of the *MRP* that falls below the arithmetic mean. Relative to determining the revenue required to cover expected costs, however, determining how that revenue should be distributed across time is a *secondary* issue.

2.6 ACT Analysis

The ACT in its *MRP* Decision states about the *MRP* that: [34]

> 'the relevant benchmark [is] ... a ten year rate, expressed in annual terms.'

It is not clear why the ACT believes that the relevant benchmark is a 10-year rate but we leave this issue aside here. What matters is how the rate, expressed in annual terms, is derived. The raw material with which the AER has to work is the set of arithmetic mean and geometric mean estimates that Handley (2011) provides, A and G. [35] Estimates of a 10-year rate derived from these estimates are:

$$A^{10} - 1 \qquad \text{and} \qquad G^{10} - 1 \tag{15}$$

As we show, both these estimates will in general be biased – as indeed the ACT and AER agree is true. The corresponding estimates of the 'relevant benchmark' expressed in annual terms are:

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[34] ACT, *Application by Envestra Limited (No 2) [2012] ACompT 4* (*11 January 2012*), paragraph 154.

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

$$(1+A^{10}-1)^{1/10}=A \qquad \text{and} \qquad (1+G^{10}-1)^{1/10}=G \tag{16}$$

The first estimator, the arithmetic mean, again as we show, will be unbiased while the second estimator, the geometric mean will be biased downwards.

We are therefore forced to conclude that ACT, who had not had the benefit of reading our August 2011 report *The Market Risk Premium: A report for CitiPower, Jemena Electricity Networks, Powercor, SP AusNet and United Energy Distribution*, is in error when it states that: [36]

> 'Envestra's submission that ... only the arithmetic mean may be used cannot be accepted once it is understood that the arithmetic mean of annual historic returns is not an unbiased estimate of ten year returns.'

At no stage is the annual *WACC* compounded – aside from in making minor adjustments – and at no stage are 10-year returns to equity used by the AER. So the observation that the ACT makes that an estimate of the 10-year return to equity constructed from an arithmetic mean estimate of the one-year return to equity is upwardly biased is purely academic

36 ACT, *Application by Envestra Limited (No 2) [2012] ACompT 4* (*11 January 2012*), paragraph 157.

3 Historical Volatility and the *MRP*

An important guide as to what is a sensible value for the *MRP* comes from historical data. A very long time series of returns, however, is necessary to produce a precise estimate of the *MRP*. The longer the series of returns one uses, though, the greater the danger that:

- one will be forced to rely in part on low quality data; and that
- the characteristics of the market portfolio will have changed over the sample.

The data, assembled by Brailsford, Handley and Maheswaran (2011), on which the AER relies in large part for estimates of the *MRP*, indicate that the Australian market portfolio was substantially less risky in the later part of the 19th century and the earlier part of the 20th century than in the later part of the 20th century and the early part of the 21st century.[37, 38] The pricing model that the regulator uses to determine the cost of equity for a regulated energy utility, a domestic version of the Capital Asset Pricing Model (CAPM), assumes that investors are risk averse and care only about the mean return to the Australian market portfolio in excess of the risk-free rate, the *MRP*, and the variance of the return to the portfolio. If the assumption that the model makes is correct and preferences have not shifted dramatically, then the *MRP* should have been higher in the later part of the 20th century and the early part of the 21st century than in the later part of the 19th century and the earlier part of the 20th century. This suggests that an estimate of the *MRP* commensurate with prevailing conditions in the market for funds that uses a long time series of returns and that ignores the change in the characteristics of the market portfolio that has taken place will *underestimate* the *MRP*.

Merton (1973) examines the conditions under which the CAPM will hold through time.[39] He shows that the model will hold through time if over each instant the distribution of returns is multivariate normal and that either it is not possible to hedge against changes in the investment opportunity set or a representative investor does not wish to do so. Under these conditions, Merton shows that the *MRP* will be proportional to the variance of the return to the market portfolio. Merton (1980) uses this relation to construct estimates of the *MRP*.[40, 41]

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[37] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance*,* 2011.

[38] In Appendix B we respond to a number of criticisms of our April 2011 report *The market risk premium: A report for Multinet Gas and SP AusNet* that the AER makes in its June 2011 report *Envestra Ltd Access arrangement proposal for the SA gas network, 1 July 2011 – 30 June 2016: Final Decision.* The AER has not responded to the analysis contained in our August 2011 report *The Market Risk Premium: A report for CitiPower, Jemena Electricity Networks, Powercor, SP AusNet and United Energy Distribution* and so much of what we say in the appendix is of necessity a repetition of material contained in that report..

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

[40] Merton, Robert C., *On estimating the expected return on the market: An exploratory investigation*, Journal of Financial Economics, 1980, pages 323-361.

[41] Lally (2004) also uses the relation to construct an estimate of the *MRP*.

Lally, Martin, The cost of capital for regulated entities: Report prepared for the Queensland Competition Authority, February 2004.

The data that Brailsford, Handley and Maheswaran (2011) provide suggest that there have been long periods over which the variance of the return to the market has been low and long periods over which the variance of the return to the market has been high.[42] In other words, the data appear to behave as if there are two regimes: a low-volatility regime and a high-volatility regime. So in this section we use a regime-switching model that contains a high-volatility state and a low-volatility state together with Merton's (1973) model to estimate:[43]

- how the variance of the return to the market portfolio and the *MRP* have changed over time; and
- to produce an estimate of the expected return to the market portfolio over each of the next five years.

Since Merton's model imposes restrictions on the behaviour of the continuously compounded return to the market portfolio in excess of the continuously compounded risk-free rate, we estimate the parameters of his model using continuously compounded returns. We then infer from these estimates what the expected *not* continuously compounded return to the market portfolio must be. The continuously compounded return and *not* continuously compounded return to an asset can differ substantially from one another and so we endeavour throughout this section to make as clear as is possible at each point to which return we are referring.[44]

Since we use the annual data that Brailsford, Handley and Maheswaran (2011) provide and Merton's model places restrictions on the *MRP* relative to a short-term risk-free rate, we use the annual returns to a strategy of rolling over three-month bills as a measure of the risk-free rate rather than the yield to a 10-year bond.[45] Brailsford, Handley and Maheswaran label the return to this strategy the 'bill return' and for convenience we use this label in what follows.

We estimate that:

- the standard deviation of the continuously compounded return to the market portfolio in excess of the continuously compounded risk-free rate is 20.73 per cent per annum in the high-volatility state and 10.21 per cent per annum in the low volatility state;
- the mean length of a stay in the high volatility state is 15.37 years and of a stay in the low volatility state is 20.39 years;
- the *MRP* in the high-volatility state, measured as the expectation of the continuously compounded return to the market portfolio less the continuously compounded bill

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[42] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

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

[44] Let $r_j(t)$ be the continuously compounded return to asset *j* from year *t*-1 to year *t* and $R_j(t)$ be the *not* continuously compounded return to asset *j* from year *t*-1 to year *t*. Then

$$r_j(t) = \ln(1 + R_j(t)) \qquad \text{and} \qquad R_j(t) = \exp(r_j(t)) - 1.$$

[45] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

return, is 8.85 per cent per annum while the *MRP* in the low-volatility state is 2.15 per cent; and

- an estimate of the probability that the market was in the high-volatility state at the end of 2011 is 74.83 per cent.

It is important to note that one cannot observe the regime that governs the process. One must instead use the data to form an assessment of the probabilities that the process is in each regime. Thus an estimate of the *MRP* will in general be neither 8.85 per cent per annum nor 2.15 per cent but will be a weighted average of the two numbers.

We use forward one-year bill rates to extract from our forecasts of the *MRP* estimates of the expected return to the market portfolio over each of the next five years. We find that:

- an estimate of the expected *not* continuously compounded return to the market portfolio is on average over the five years from the end of 2011 to the end of 2016 12.43 per cent per annum.

It follows that with a 10-year bond yield of 3.99 per cent per annum, an estimate of the *MRP* for the next five years derived from the regime-switching model, relative to the yield, will be 8.44 per cent per annum.[46]

3.1 Behaviour of Volatility

Kearns and Pagan (1993) show that the Australian market portfolio was substantially less risky in the later part of the 19th century and the earlier part of the 20th century than in the later part of the 20th century and note that the US market portfolio does not exhibit this behaviour.[47] Kearns and Pagan do not provide an explanation for the behaviour but speculate that it may stem from the Australian market's relative dependence on commodity prices, a dependence which the US market does not share.

Figure 3.1 below plots the continuously compounded annual with-dividend return to the All Ordinaries from 1883 to 2011 while Figure 3.2 plots the continuously compounded annual with-dividend return to the S&P Composite. The annual return to the All Ordinaries from 1883 to 2010 is from Brailsford, Handley and Maheswaran (2011) and the return for 2011 is from Bloomberg.[48, 49] Brailsford, Handley and Maheswaran construct the series using the

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46 A risk-free rate of 3.99 per cent per annum is obtained by applying the AER's method of interpolation to the observed yields on 10-year Commonwealth Government Securities (CGS), as measured over the 20-day averaging period to 16 December 2011. The AER's method of interpolation is consistent with clause 6.5.2(d) of the National Electricity Rules.

47 Kearns, P. and A. Pagan, Australian stock market volatility: 1875-1987. Economic Record, 69, 1993, pages 163-178.

48 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

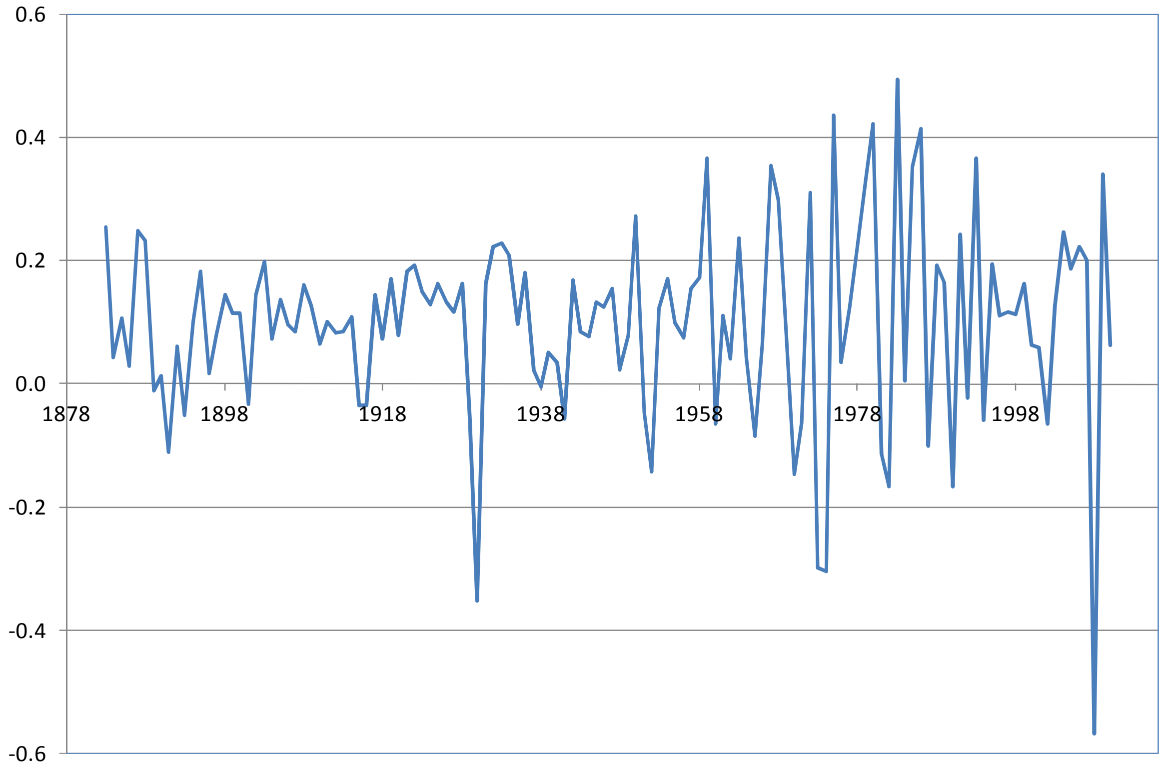
49 We adjust the returns for the provision of imputation credits under the assumption that the value of a one-dollar credit distributed has a market value of 35 cents using data on credits assembled in the way that Brailsford, Handley and Maheswaran describe. This value is the value laid down by the Australian Competition Tribunal in its recent decision on the market value of a one-dollar credit distributed. See

Australian Competition Tribunal, Application by Energex Limited (Gamma) (No 5) [2011] ACompT 9, May 2011.

Commercial and Industrial index from 1882 to 1936, the Sydney All Ordinary Shares index from 1936 to 1979 and the Australian Stock Exchange (ASX) All Ordinaries index from 1980 to 2010. The annual return to the S&P Composite is from Robert Shiller's web site.[50]

Figure 3.1 shows that there were fewer years in which the volatility of the return to the All Ordinaries was high in the later part of the 19th century and the earlier part of the 20th century than there were in the later part of the 20th century and the early part of the 21st century. In contrast, Figure 3.2 shows that the return to the S&P Composite was around as volatile in the later part of the 19th century and the earlier part of the 20th century as it was in the later part of the 20th century and the early part of the 21st century.

Figure 3.1
Annual return to the All Ordinaries



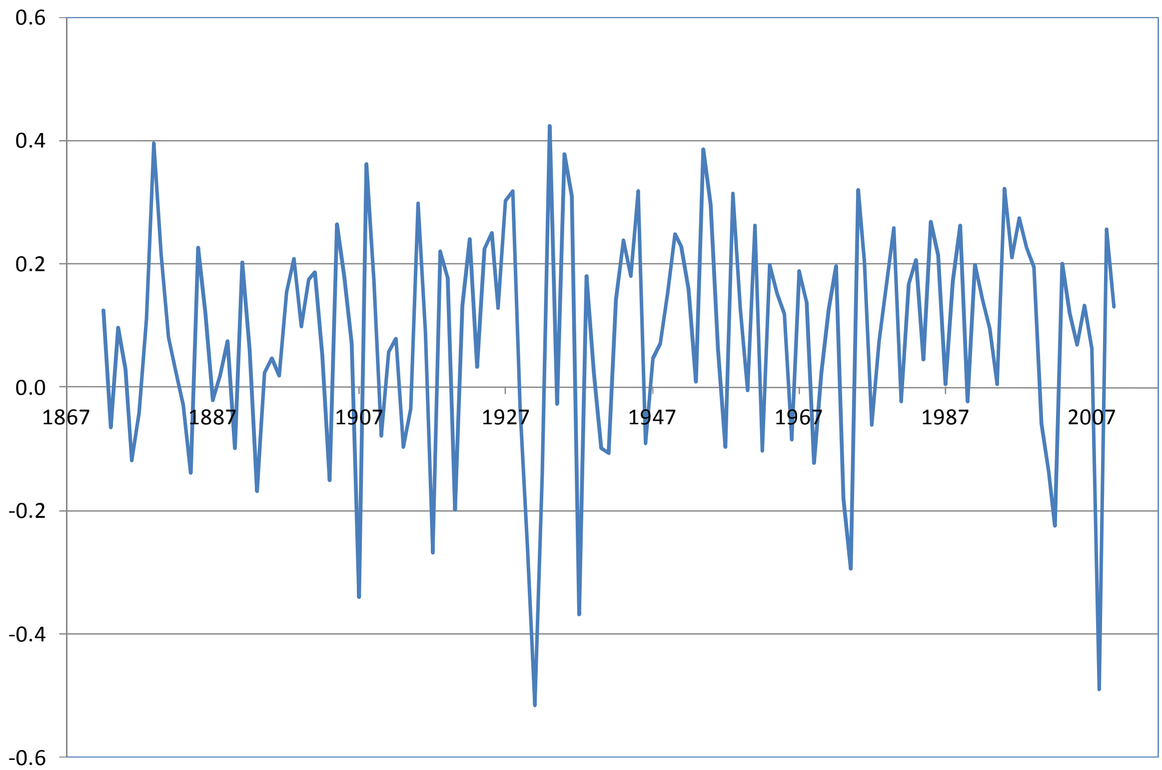
Note: Data are from Bloomberg and Brailsford, T., J. Handley and K. Maheswaran, The historical equity risk premium in Australia: Post-GFC and 128 years of data, Accounting and Finance, 2011.

The pricing model that the AER uses to determine the cost of equity for a regulated energy utility, a domestic version of the CAPM, assumes that investors are risk averse and care only about the mean return to the Australian market portfolio in excess of the risk-free rate and the variance of the return to the portfolio. If the assumption that the model makes is correct, then

50 http://www.econ.yale.edu/~shiller/data/ie_data.xls

there should be a link between the mean return to the Australian market portfolio in excess of the risk-free rate, that is, the *MRP*, and the variance of the return to the portfolio.[51]

Figure 3.2
Annual return to the S&P Composite



Note: Data are from Robert Shiller's web site.

3.2 Theoretical Link Between Volatility and the *MRP*

Merton (1973) shows that the conditions which allow the CAPM to hold instant by instant are also the conditions which guarantee that a simple relation exists between the *MRP* and the volatility of the return to the market portfolio.[52] The conditions are that over each instant the distribution of returns is multivariate normal and that either it is not possible to hedge against

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[51] Lally (2004) also recognises that a link must exist. He states that:

'It is implicit in the CAPM that the market risk premium is proportional to market variance, with the coefficient equal to aggregate relative risk aversion (Merton (1973). Furthermore, Friend and Blume (1975) conclude that aggregate relative risk aversion is constant. This suggests estimating the ratio of the market risk premium to market volatility from time series data, and then coupling it with a current estimate of market variance.'

Friend, I. And M. Blume, The demand for risky assets, American Economic Review, 1975, pages 900-922.

Lally, Martin, The cost of capital for regulated entities: Report prepared for the Queensland Competition Authority, February 2004.

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

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

changes in the investment opportunity set or a representative investor does not wish to do so. From equation (19) of his paper:

$$MRP = \theta \sigma_m^2 , \qquad (17)$$

where

θ	=	the relative risk aversion of a representative investor, a measure of the investor's aversion to risk; and
σ_m^2	=	the variance of the return to the market portfolio.

This simple relation states that the *MRP* will be higher the more averse to risk is a representative investor and the more volatile is the return to the market portfolio.

Under the conditions necessary for (17) to hold a representative investor will care only about the mean return to the market portfolio in excess of the risk-free rate, the *MRP*, and the variance of the return to the portfolio. So under these conditions the investor will measure the risk of an individual security by the contribution that it makes to the risk of the market portfolio. This contribution is measured by the security's beta.

If the conditions necessary for (17) to hold are not satisfied, then a representative investor will not care solely about the *MRP* and the variance of the return to the portfolio. The investor may care, for example, about whether one can use the market portfolio to hedge against changes in the risk-free rate. If the conditions necessary for (17) to hold are not satisfied, though, it will also be the case that the investor will not measure the risk of an individual security solely by its beta. In other words, if the conditions for (17) to hold are not satisfied, the CAPM will not hold. Instead, other factors will be required to explain the cross-section of mean returns. Because the AER relies solely on the CAPM, we do not examine here alternative models in which other factors play a role.

3.3 Regime-Switching Models

Figure 3.1 indicates that there have been long periods over the last two centuries in which the volatility of the return to the Australian market portfolio has been low and long periods in which the volatility has been high. In other words, the data appear to behave as if there are two regimes: a low-volatility regime and a high-volatility regime. So we use a regime-switching model that contains a high-volatility state and a low-volatility state together with Merton's (1973) model to estimate how the variance of the return to the market portfolio and the *MRP* have changed over time.[53] In particular, we use the regime-switching model of Hamilton (1989) in which the joint distribution of variables can differ across regimes or states and in which the probability of being in each state is governed by a Markov chain.[54]

A Markov chain is a random process with a finite number of states whose future depends only on the state currently occupied by the process and not, in addition, on the states occupied

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

[54] Hamilton, James D., *A new approach to the economic analysis of nonstationary time series and the business cycle*, Econometrica, 1989, pages 357-384.

by the process in the past. Thus, in a model that contains a high-volatility state and a low-volatility state, the probability of being in the high-volatility state next year will depend only on whether the process is currently in the high-volatility state and not, in addition, on whether the process was in the high-volatility state in the recent past.

We assume that there are two regimes or states and that in state *j*:

$$r_m(t) - r_f(t) = \mu_j + \varepsilon(t), \qquad \varepsilon(t) \sim \mathrm{N}(0, \sigma_j^2), \qquad j = 1,2, \quad t = 1,2,\ldots,T, \tag{18}$$

where

$r_m(t)$	=	the continuously compounded return to the market portfolio from year t-1to year t;
$r_f(t)$	=	the continuously compounded return to the risk-free asset from year t-1to year t;
μ_j	=	the *MRP* from year t-1to year t;
$\varepsilon_j(t)$	=	the unexpected continuously compounded return to the market portfolio from year t-1 to year t; and
σ_j	=	the standard deviation of the return to the market portfolio in state j.

We use continuously compounded returns because Merton's (1973) model implies that continuously compounded returns over discrete intervals are normally distributed and because his model imposes restrictions on these returns.[55] As Merton (1980) shows, his model predicts that the mean continuously compounded return to the market portfolio in excess of the continuously compounded risk-free rate is related to the variance of the continuously compounded return to the portfolio in the following way:[56]

$$\mu_j = (\theta - 0.5)\sigma_j^2, \qquad j = 1,2. \tag{19}$$

We impose this restriction on the data.

The probability of moving from one state to another is governed by the transition matrix:

$$P = \begin{bmatrix} p_{11} & 1 - p_{22} \\ 1 - p_{11} & p_{22} \end{bmatrix}, \tag{20}$$

where

p_{kk}	=	the probability of remaining in state k.

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

56 Merton, Robert C., *On estimating the expected return on the market: An exploratory investigation*, Journal of Financial Economics, 1980, pages 323-361.

The upper left cell denotes the probability of remaining in state 1, the lower left cell, the probability of moving from state 1 to state 2, the upper right cell, the probability of moving from state 2 to state 1 and the bottom right, the probability of remaining in state 2. So, for example, the probability of moving from state 1 to state 2 after two years will be:

$$p_{11}(1-p_{11})+(1-p_{11})p_{22} \tag{21}$$

Hamilton (1994) describes in detail how one can construct maximum likelihood estimates of the parameters of the model.[57] The likelihood function depends on the time series of filtered state probabilities and the time series of densities conditional on being in each state. The filtered probability of being in each state will depend on the transition probabilities and the history of past continuously compounded returns.[58] A string of large positive or negative continuously compounded returns will be reflected in an assessment that the process is probably in the high-volatility state. A string of small positive or negative continuously compounded returns will be reflected in an assessment that the process is probably in the low-volatility state. The conditional densities will depend on the relative risk aversion of a representative investor and the standard deviation of the continuously compounded return to the market portfolio in each state. We employ the procedure that Hamilton lays out and the Newton-Raphson method, that allows one to locate the maximum of a nonlinear function, to produce estimates.[59]

3.4 Empirical Evidence

We use the annual data from 1883 to 2010 that Brailsford, Handley and Maheswaran (2011) provide and retrieve data for 2011 from Bloomberg and the Reserve Bank of Australia (RBA).[60] We adjust returns for the provision of imputation credits under the assumption that the value of a one-dollar credit distributed has a market value of 35 cents using data on credits assembled in the way that Brailsford, Handley and Maheswaran describe.[61] Since we use annual data and Merton's model places restrictions on the *MRP* relative to a short-term risk-free rate, we use the annual returns to a strategy of rolling over three-month bills as a measure of the risk-free rate rather than the yield to a 10-year bond.

Table 3.1 provides estimates of the parameters of the model. An estimate of the variance of the return to the market portfolio in state 1 is more than four times as large as an estimate of the variance in state 2. It follows that Merton's (1973) model implies that an estimate of the

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57 Hamilton, James D., Time series analysis, 1994, Princeton University Press, Princeton, NJ, Chapter 22.

58 Filtered estimates use only information available at the time the estimate is constructed whereas smoothed estimates also use future information. See

Hamilton, James D., Time series analysis, 1994, Princeton University Press, Princeton, NJ, Chapter 22.

59 For a description of the Newton-Raphson method, see

Hamilton, James D., Time series analysis, 1994, Princeton University Press, Princeton, NJ, pages 138-139.

60 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance*,* 2011.

61 This value is the value laid down by the Australian Competition Tribunal in its recent decision on the market value of a one-dollar credit distributed. See

Australian Competition Tribunal, Application by Energex Limited (Gamma) (No 5) [2011] ACompT 9, May 2011.

MRP in state 1, measured as the expectation of the continuously compounded return to the market portfolio less the continuously compounded bill return, is around four times as large as an estimate of the *MRP* in state 2.[62] An estimate of the ratio of the *MRP* to the variance of the return to the market portfolio ($\theta - 0.5$ in equation (19)) is 2.059. Thus an estimate of the *MRP*, measured as the expectation of the continuously compounded return to the market portfolio less the continuously compounded bill return, is 2.059 × 0.043 = 8.852 in state 1 and 2.146 in state 2.

It is important to note that one cannot observe the regime that governs the process. One must instead use the data to form an assessment of the probabilities that the process is in each regime. Thus an estimate of the *MRP* will in general be neither 8.852 per cent per annum nor 2.146 per cent but will be a weighted average of the two numbers.

An estimate of the probability of remaining in state 1 is 0.935 while an estimate of the probability of remaining in state 2 is 0.951. Regime *k* will persist on average for $1/(1 - p_{kk})$ years.[63] Thus the data suggest that the market tends to move slowly between regimes. In particular, the estimates of the transition probabilities suggest that the high-volatility state, state 1, will persist on average for 15.374 years while the low-volatility state, state 2, will persist on average for 20.393 years.

Table 3.1
Estimates of the parameters of a regime-switching model computed using annual data from 1883 to 2011

Ratio of *MRP* to variance of return	Variance of return in state		Probability of remaining in state	
	1	2	1	2
2.059	0.043	0.010	0.935	0.951
(0.651)	(0.010)	(0.002)	(0.054)	(0.033)

Note: Data are from Bloomberg, the RBA and Brailsford, T., J. Handley and K. Maheswaran, The historical equity risk premium in Australia: Post-GFC and 128 years of data, Accounting and Finance, 2011. Standard errors are in parentheses. All returns in the table are continuously compounded. The ratio of the MRP to the variance of the excess return to the market portfolio is, in Merton's (1973) model, $\theta - 0.5$*; the variance of the return to the market portfolio in state k is* σ_k^2*, the probability of remaining in state k is* p_{kk}*.*

Figure 3.3 provides filtered estimates across time of the probability that the market is in the high-volatility state. The figure shows that the data indicate that the probability of being in the high-volatility state in the later part of the 19th century and the earlier part of the 20th century was typically, but not always, lower than in the later part of the 20th century and the early part of the 21st century.

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

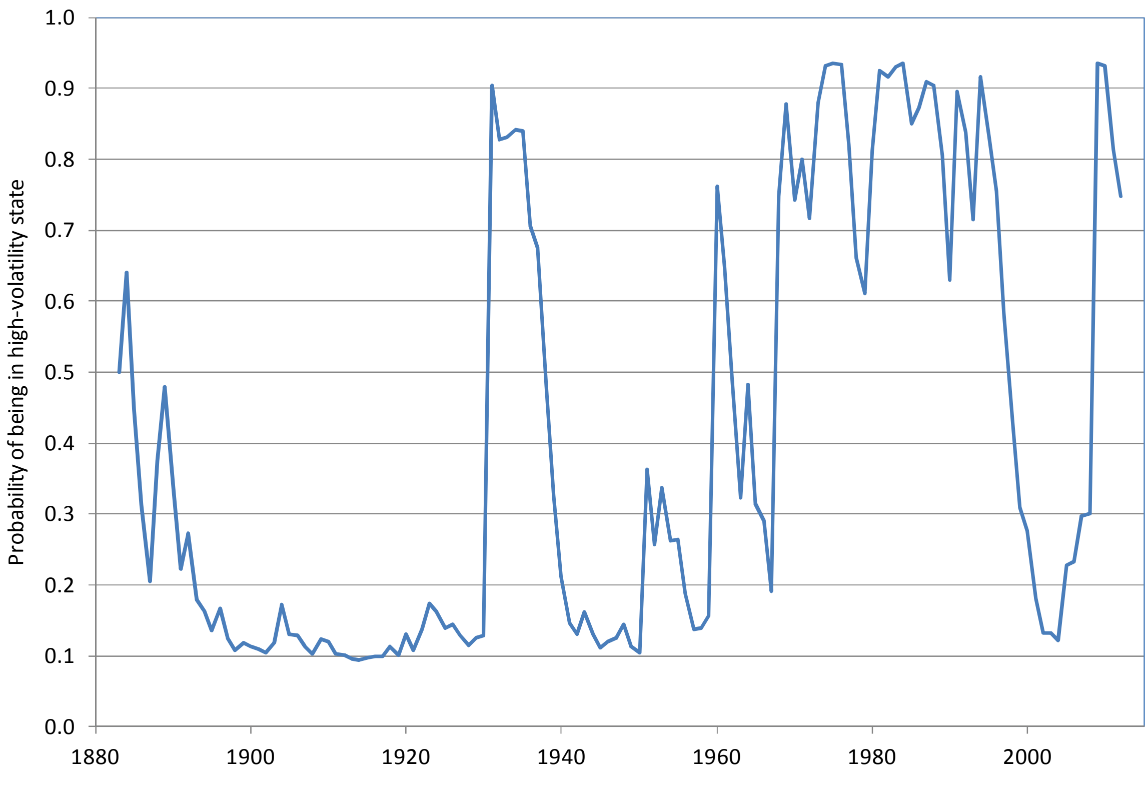
63 Hamilton, James D., Time series analysis, 1994, Princeton University Press, Princeton, NJ, Chapter 22.

An estimate of the probability that the market was in the high-volatility state at the end of 2011 is 78.93 per cent and estimates of the probability that the market will be in the high-volatility state at the end of 2012, 2013, 2014, 2015 and 2016 appear in the first row of Table 3.2 below. These probabilities are drifting down and if one were to look out far enough would eventually approach the unconditional probability of being in the high-volatility state of: [64]

$$\frac{1 - p_{22}}{2 - p_{11} - p_{22}} = 0.430. \qquad (22)$$

The relatively low unconditional probability of being in the high-volatility state arises primarily from the length of the period in the later part of the 19th century and the earlier part of the 20th century in which the market appears to have been in a low-volatility state. The model that we use does not rule out a return to a long period of low volatility. Ruling out a return to the low volatility state would require we set $p_{11} = 1$.

Figure 3.3
Probability of being in high-volatility state



Note: Data are from Brailsford, Handley and Maheswaran (2011) and Bloomberg.

With estimates of the probability that the market will be in the high-volatility state in each of the next five years, one can construct forecasts of the *MRP* in each of the years, measured as

64 Hamilton, James D., Time series analysis, 1994, Princeton University Press, Princeton, NJ, Chapter 22.

the expectation of the continuously compounded return to the market portfolio less the continuously compounded bill return. This is not quite the quantity that we seek, however. We seek to compute the expectation of the *not* continuously compounded return to the market portfolio less the 10-year bond yield, that is, the *MRP* as the AER defines it. To compute this quantity, first we compute a forecast of the quantity

$$(1+R_m(T+m))/(1+R_f(T+m))-1, \tag{23}$$

where

$R_m(T+m)$ = the *not* continuously compounded rate of return to the market portfolio from year $T+m$-1to year $T+m$; and

$R_f(T+m)$ = the *not* continuously compounded rate of return to the risk-free asset from year $T+m$-1to year $T+m$.

Note that in this section $R_m(T+m)$ and $R_f(T+m)$ denote *rates* of return. (23) is the geometric difference between the *not* continuously compounded return to the market portfolio and the *not* continuously compounded bill return. In other words, (23) is the geometric excess return to the market portfolio. [65]

A forecast of the quantity (23) produced by the regime-switching model will be

$$M\hat{R}P(T+m\,|\,T)=\hat{\xi}_1(T+m\,|\,T)\exp(\hat{\theta}\hat{\sigma}_1^2)+\hat{\xi}_2(T+m\,|\,T)\exp(\hat{\theta}\hat{\sigma}_2^2)-1, \tag{24}$$

where

$\xi_k(T+m\,|\,T)$ = an estimate of the probability that the market will be in state k m years from now, given what is known today;

and a hat denotes a maximum likelihood estimate. [66] The forecasts that we compute using (24) appear in the second row of Table 3.2. To see how these estimates compare to the time series of estimates that the regime-switching model generates, we plot in Figure 3.4 for each year the average forecast geometric difference between the *not* continuously compounded return to the market portfolio and the *not* continuously compounded bill return over each of the next five years. We label this average the 5-year *MRP* relative to the bill rate. The mean of the series is 6.37 per cent per annum.

Figure 3.4 shows that the 5-year *MRP* relative to the bill rate has never fallen below 4 per cent per annum and has only rarely reached 10 per cent per annum. The reason for why the *MRP* has never fallen below 4 per cent nor risen far above 10 per cent is because:

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[65] See

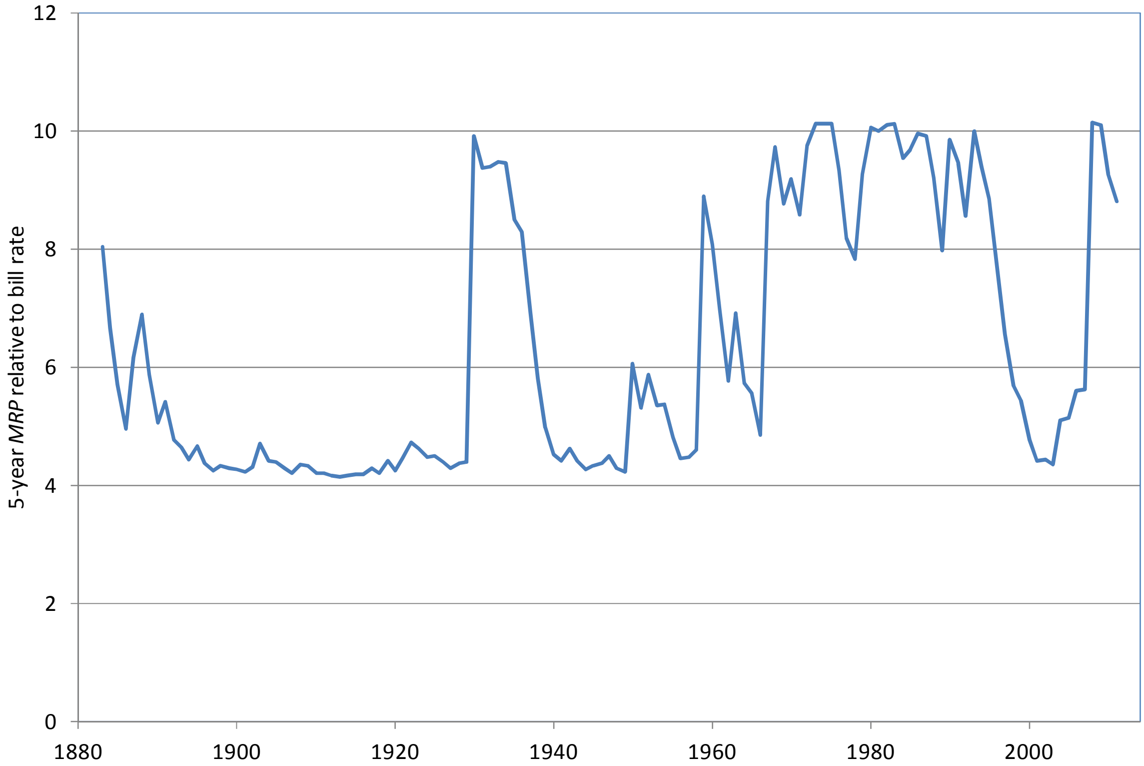
http://corporate.morningstar.com/us/documents/MethodologyDocuments/MethodologyPapers/EquityPerformanceAttributionMeth.pdf

for a discussion of the difference between arithmetic excess returns and geometric excess returns.

[66] This follows from the fact that if $x \sim \mathrm{N}(\mu,\sigma^2)$, then $\mathrm{E}(\exp(x))=\exp(\mu+0.5\sigma^2)$.

- the probability based on current information that the process is in each state will drift, over any five-year period, towards the unconditional probability that the process is in the state; and
- as an empirical matter, the probability based on current information that the process is in each state never reaches zero or one.

Figure 3.4
5-year *MRP* relative to bill rate



Note: Data are from Brailsford, Handley and Maheswaran (2011) and Bloomberg. The 5-year MRP relative to the bill rate is the average forecast geometric difference between the not continuously compounded return to the market portfolio and the not continuously compounded bill return over each of the next five years.

We construct a forecast of the *not* continuously compounded return to the market as

$$(1+M\hat{R}P(T+m\,|\,T))(1+F(T+m\,|\,T))-1 \tag{25}$$

where

$F(T+m,T)$ = the one-year forward rate quoted now for an investment starting $m-1$ years from now and maturing m years from now.

The use of this formula involves two approximations. First, it assumes that approximately

$$\mathrm{E}\left(\frac{1+R_m(T+m)}{1+R_f(T+m)}\right)\mathrm{E}(1+R_f(T+m))-1=\mathrm{E}(R_m(T+m)) \qquad (26)$$

Using the annual data that we employ from 1883 to 2011, an estimate of the left-hand side of (24) is 11.79 per cent per annum while an estimate of the right-hand side is 11.74 per cent, where the risk-free rate is, again, the bill return. This evidence suggests that the use of formula (25) will, for this reason, tend to overestimate the expected return to the market portfolio by 5 basis points.

Second, the use of (25) assumes that the forward rate will be an approximately unbiased estimator of the future bill rate. To examine what bias the use of the forward rate as a predictor of the future bill rate might involve, we construct a series of forward rates from data on government bond prices, as of the end of December 2011, provided by the RBA, and compare these to consensus forecasts of interest rates provided by Bloomberg made in January 2011. We do not use the Bloomberg forecasts themselves because there are too few of them.

Table 3.2
Forecasts for the years 2012 to 2016

	2012	2013	2014	2015	2016
Probability of high-volatility state	0.75	0.71	0.68	0.65	0.63
MRP relative to bill return	9.38	9.06	8.77	8.52	8.29
Forward one-year bill rate	3.46	2.89	3.11	3.64	3.55
Return to market portfolio	13.17	12.21	12.15	12.47	12.13
MRP relative to 10-year yield of 3.99%	9.18	8.22	8.16	8.48	8.14

Note: Data are from Bloomberg, the RBA and Brailsford, T., J. Handley and K. Maheswaran, The historical equity risk premium in Australia: Post-GFC and 128 years of data, Accounting and Finance, 2011. The returns in the table are in per cent per annum and are not continuously compounded. The MRP relative to the bill return is the mean geometric difference between the return to the market portfolio and the bill return. The MRP relative to the 10-year bond yield is the arithmetic mean return to the market portfolio in excess of the yield. The forward rate for each year is the rate quoted, at the end of 2011, for an investment over the year. Thus the forward rate for 2012 is the one-year spot rate quoted at the end of 2011. The forward rate for 2013 is the rate, quoted at the end of 2011, for an investment beginning at the start of 2013 and finishing at the end of 2013.

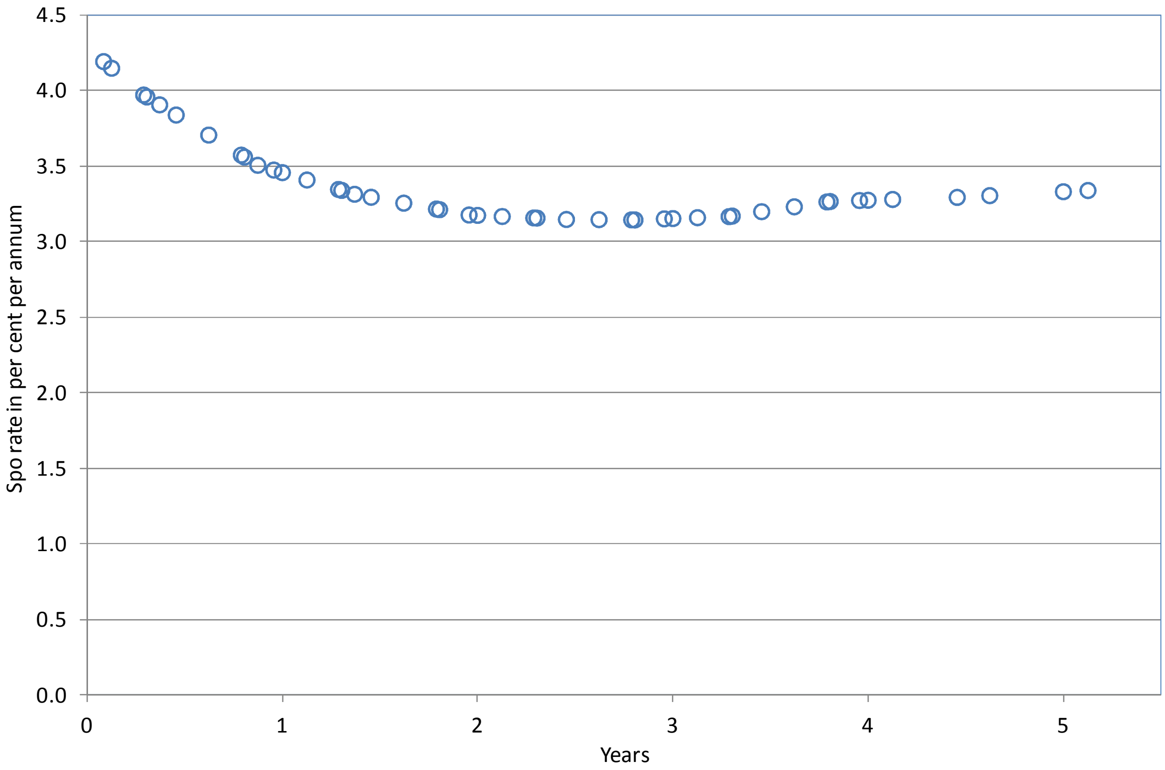
To construct a series of forward rates, we first construct a series of spot interest rates from the bond prices and interest rates that the RBA lists in the spreadsheets f01dhist.xls and f16.xls, available from its web site, using, where necessary, interpolation.[67] A spot interest rate is the yield on a zero-coupon bond.[68] Figure 3.5 below shows the spot rates that we extract from

[67] http://www.rba.gov.au/statistics/tables/index.html

[68] See, for example the discussion in

the bond prices and interest rates that the RBA provides. The one-year forward rates that we uncover from these spot rates appear in the third row of Table 3.2. Bloomberg provides consensus forecasts of the 10-year government bond yield, the 2-year government bond yield, 3-month LIBOR and the RBA cash rate and the forecasts of these quantities on 27 January 2012 appear in Table 3.3.

Figure 3.5
Spot rates implied by government bond prices as of 31 December 2011



Note: Data are from the RBA.

The consensus forecast of the two-year yield at the end of 2012 of 3.72 per cent lies well above the forward two-year yield which, from Table 3.2, will lie somewhere between 2.89 and 3.11. A small part of the difference between the forward rate and the consensus forecast can be explained by an increase of around 15 basis points in the two-year yield between the end of 2011 and 27 January 2012. It appears nevertheless, though, that the forward rate lies below the market's expectation of the corresponding spot rate.

Together these two pieces of evidence suggest that our use of (25) will produce an under-estimate of the market's expectation of the *not* continuously compounded return to the market portfolio.

Forecasts of the *not* continuously compounded return to the market portfolio computed using (25) appear in the fourth row of Table 3.2 while forecasts of the *MRP* relative to a 10-yield of

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Schaefer, Stephen M., The problem with redemption yields, Financial Analysts Journal, 1977, pages 59-67.

3.99 per cent per annum appear in the last row of the table. These forecasts indicate that with a 10-year bond yield of 3.99 per cent per annum, an estimate of the *MRP* for the next five years derived from the regime-switching model, relative to the yield, will be 8.44 per cent per annum.

Table 3.3
Consensus forecasts of interest rates

	27 January 2012	December 2012	June 2013
10-year yield	3.81	4.44	5.25
2-year yield	3.28	3.72	
3-month LIBOR	4.65	4.14	4.70
RBA cash rate	4.25	3.88	4.50

Note: Data are from Bloomberg.

4 DGM Estimates of the *MRP*

A natural place to look for information on what the market thinks the *MRP* should be is in market prices. The Dividend Growth Model (DGM) allows one, in principle, to use market prices together with forecasts of future dividends to compute the return that the market requires on an asset or portfolio. While one can, of course, observe market prices and forecasts of dividends over horizons of one or two years, few analysts forecast dividends at longer horizons. Thus as a practical matter, the use of the DGM requires that one make an assumption about the long-term growth of dividends.

There are three ways in which one can construct a forecast of the long-run growth in dividends per share (DPS). First, one can assume that real DPS growth in the future will match real DPS growth over the past. Past real DPS growth is volatile and so a forecast of real DPS growth based on past data is imprecise, although a forecast of DPS growth that uses past data is no less precise than an estimate of the *MRP* that uses a time series of the same length. Second, one can use short-term consensus forecasts of DPS and extrapolation to construct long-run forecasts. A drawback with doing this is that we do not have a sufficiently long time series of extrapolated forecasts to judge whether extrapolation provides reliable forecasts. Third, one can form an estimate of the speed with which real DPS growth has in the past reverted to its mean and use this estimate and short-term forecasts to generate long-term forecasts.

We find that an estimate of the speed with which real DPS growth reverts to its mean is sufficiently high that there is, as a practical matter, no difference between the first and third strategies. So to be conservative, we use current consensus forecasts to predict DPS one and two years from the end of December 2011 and an estimate of real DPS growth over the past to predict DPS three or more years from that date. These predictions are conservative in that they use as a forecast of long-run nominal DPS growth a number, based on past real DPS growth and RBA targets for inflation, lying marginally below the forecast for long-run DPS growth that the AER uses and well below current consensus forecasts of short-term DPS growth.

The DGM estimates of the return that the market requires on the market portfolio that use Bloomberg consensus forecasts indicate that with a 10-year bond yield of 3.99 per cent per annum, an estimate of the *MRP* for the next five years, relative to the yield, will be 7.69 per cent per annum.[69] Estimates of the *MRP* that use Institutional Brokers' Estimate System (I/B/E/S) consensus forecasts are almost identical.

We note that these estimates do not differ markedly from estimates constructed using the assumptions that the AER makes in its *Aurora Draft Decision* about the dividend yield, the long-run growth in dividends, the value that the market place on a one-dollar credit distributed and the risk-free rate. Using the AER's assumptions, the *MRP* should lie between

69 A risk-free rate of 3.99 per cent per annum is obtained by applying the AER's method of interpolation to the observed yields on 10-year Commonwealth Government Securities (CGS), as measured over the 20-day averaging period to 16 December 2011. The AER's method of interpolation is consistent with clause 6.5.2(d) of the National Electricity Rules.

6.44 and 7.62 per cent per annum – far above the range that they claim to produce using the DGM.

4.1 Theory

It will be helpful for the discussion that follows to show how the DGM is derived. The expected rate of return to a stock from time *t* to time *t*+1 is

$$\mathrm{E}(R(t+1)) = \frac{\mathrm{E}(P(t+1)+D(t+1))}{P(t)} - 1, \tag{27}$$

where

$R(t+1)$	=	the rate of return to the stock from *t* to *t*+1;
$P(t+1)$	=	the price of the stock at *t*+1; and
$D(t+1)$	=	the dividend the stock pays at *t*+1.

Solving (27) for *P*(*t*) yields

$$P(t) = \frac{\mathrm{E}(P(t+1)+D(t+1))}{1+\mathrm{E}(R(t+1))}. \tag{28}$$

But

$$P(t+1) = \frac{\mathrm{E}(P(t+2)+D(t+2))}{1+\mathrm{E}(R(t+2))} \tag{29}$$

and so

$$P(t) = \frac{\mathrm{E}(D(t+1))}{1+\mathrm{E}(R(t+1)} + \frac{\mathrm{E}(P(t+2)+D(t+2))}{(1+\mathrm{E}(R(t+1)))(1+\mathrm{E}(R(t+2)))}. \tag{30}$$

Proceeding in a similar manner and assuming that

$$\lim_{s\to\infty} \frac{\mathrm{E}(P(t+s))}{\prod_{k=1}^{s}(1+\mathrm{E}(R(t+k)))} = 0 \tag{31}$$

yields

$$P(t) = \sum_{s=1}^{\infty} \frac{\mathrm{E}(D(t+s))}{\prod_{k=1}^{s}(1+\mathrm{E}(R(t+k)))}. \tag{32}$$

Equation (32) is an accounting identity rather than an economic model that, given (31), must hold. This identity implies, as Cochrane (2008) emphasises, that the predictability of dividends, returns and yields must be intimately related.[70]

Commercial use of (32) typically does not attempt to produce a term structure of return forecasts but instead tries to find the single internal rate of return that discounts the dividends that a stock or portfolio is expected to pay back to the current price. In other words, commercial use of (32) typically tries to find the value of E(R) that satisfies

$$P(t) = \sum_{s=1}^{\infty} \frac{\mathrm{E}(D(t+s))}{(1+\mathrm{E}(R))^{s}} \qquad (33)$$

To find the internal rate of return that discounts the dividends that a stock or portfolio is expected to pay back to the current price requires a series of dividend forecasts. Consensus forecasts typically only predict the dividends that a stock or portfolio will pay over at most three years. The present value of the dividends that a stock or portfolio will pay over the next three years, though, typically constitutes only a small part of the value of the asset. Suppose, for example, that the internal rate of return for a particular asset is nine per cent – approximately the average annual real return to the All Ordinaries since 1980 – and that dividends are expected to grow by three per cent per year – approximately the annual real growth in the dividends that the All Ordinaries has paid since 1980. Then the present value of the dividends that the asset will pay over the next three years will constitute less than 16 per cent of the value of the asset. Thus whatever assumption is made about the long-run growth of the dividends that an asset will pay will play an important role in determining the return that the DGM will predict the asset should earn.

We have consensus forecasts over only two years and so in what follows, we assume that

$$\mathrm{E}(D(t+s)) = \mathrm{E}(D(t+2))(1+g)^{s-2}, \qquad s > 2. \qquad (34)$$

where

g = long-run dividend growth.

With this assumption

$$P(t) = \frac{\mathrm{E}(D(t+1))}{1+\mathrm{E}(R)} + \frac{\mathrm{E}(D(t+2))}{1+\mathrm{E}(R)}\left(\frac{1}{\mathrm{E}(R)-g}\right). \qquad (35)$$

This expression can be solved for $\mathrm{E}(R)$.

4.2 Empirical Evidence

As we have emphasised, an estimate of the return that the market requires on an asset or portfolio that uses the DGM depends crucially on estimates of the long-run growth in

70 Cochrane J., *The dog that did not bark: A defense of return predictability*, Review of Financial Studies, 2008, pages 1533-1575.

dividends. One place to look for estimates of what the growth in dividends might be in the long-run is in the past behaviour of dividends.

Table 4.1 provides summary statistics for the real growth in DPS for the All Ordinaries and for the real growth in GDP using data from 1981 to 2011. We examine the behaviour of real GDP growth as well as real DPS growth because the AER suggests that there should be a link between the two quantities.[71] We use data over this period because daily price and accumulation indices are available from 1980 onwards that allow one to accurately compute a DPS series for the index. We use the inflation data that Brailsford, Handley and Maheswaran (2011) provide and update their series using, like they do, the December year-end value of the "CPI: All Groups Weighted Average of Eight Capital Cities" series from the Australian Bureau of Statistics (ABS).[72] We also collect real GDP growth (series ID A2304370T) from the ABS.

Table 4.1 shows that the mean growth in real DPS and the mean growth in real GDP have both been around three per cent per annum over the period 1981 to 2011. The growth in real DPS, however, has been far more volatile than the growth in real GDP. As a result, a 95 per cent confidence interval for mean real DPS growth is far wider than a 95 per cent confidence interval for mean real GDP growth. A 95 per cent confidence interval for mean real DPS growth is from -1.30 to 7.44 per cent per annum.[73] A 95 per cent confidence interval for mean real GDP growth is from 2.59 to 3.89 per cent per annum.

Table 4.1
Summary statistics for real DPS and GDP growth from 1981 to 2011

Variable	Mean	Standard deviation
Real DPS growth	3.07	12.41
	(2.23)	
Real GDP growth	3.24	1.82
	(0.33)	

Note: Data are from the ABS and Bloomberg. Standard errors are in parentheses

To test for a link between real DPS growth and real GDP growth, we regress real DPS growth on real GDP growth and real GDP growth lagged one year. The results of this regression appear in Table 4.2. The table shows that there is a significant positive contemporaneous relation between real DPS growth and real GDP growth and also a significant positive relation between real DPS growth and real GDP growth lagged one year. Although we do

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71 AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011.

72 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance*,* 2011.

73 A tighter, but not dramatically tighter, 95 per cent confidence interval for mean real DPS growth can be constructed using the annual data that Brailsford, Handley and Maheswaran (2011) provide. Using their data, updated to 2011, we find that a 95 per cent confidence interval for mean real DPS growth lies from 0.26 to 4.84 per cent.

not report the results of further tests, we find no significant relation between real DPS growth and real GDP growth at longer lags.

Around one half of the variation in real DPS growth, however, cannot be explained by real GDP growth. Figure 4.1 plots real DPS growth, real GDP growth and that portion of real DPS growth unexplained by Table 4.2's regression against time. In 2005 there was an increase in DPS from the year before of 23.38 per cent that is largely unexplained by Table 4.2's regression while in 2009 there was a fall in DPS from the year before of 24.31 per cent that is largely unexplained by the regression.

Table 4.2
Relation between real DPS and GDP growth from 1981 to 2011

Ordinary least squares estimates			
	Coefficient on		
Intercept	GDP growth	Lagged GDP growth	R^2
-17.29	3.25	3.11	45.70
(5.09)	(0.95)	(0.96)	

Note: Data are from the ABS and Bloomberg. The table shows the results of regressing real DPS growth on real GDP growth and real GDP growth lagged one year. Estimates are outside parentheses while heteroscedasticity and autocorrelation consistent standard errors are in parentheses.

The fall in real DPS in 2009 can also be seen in Figure 4.2 which plots real DPS against time. One explanation for the abnormal decline in dividends paid is that companies have been conserving cash because of conditions in credit markets.

Figure 4.2 also plots consensus forecasts of DPS that Bloomberg provides. These consensus forecasts appear in Table 4.3 along with I/B/E/S consensus forecasts. The DPS forecasts are for the All Ordinaries and correspond to values of the All Ordinaries Price Index. Table 4.3 shows that the consensus is that dividends are expected to grow over the next two years by around eight per cent per annum.

Using interpolation and the Bloomberg consensus forecasts that appear in Table 4.3 below, an estimate of the DPS for the All Ordinaries for December 2012 is

$$(212.347 + 226.889) \div 2 = 219.618 \qquad (36)$$

and for December 2013

$$(226.889 + 244.585) \div 2 = 235.737. \qquad (37)$$

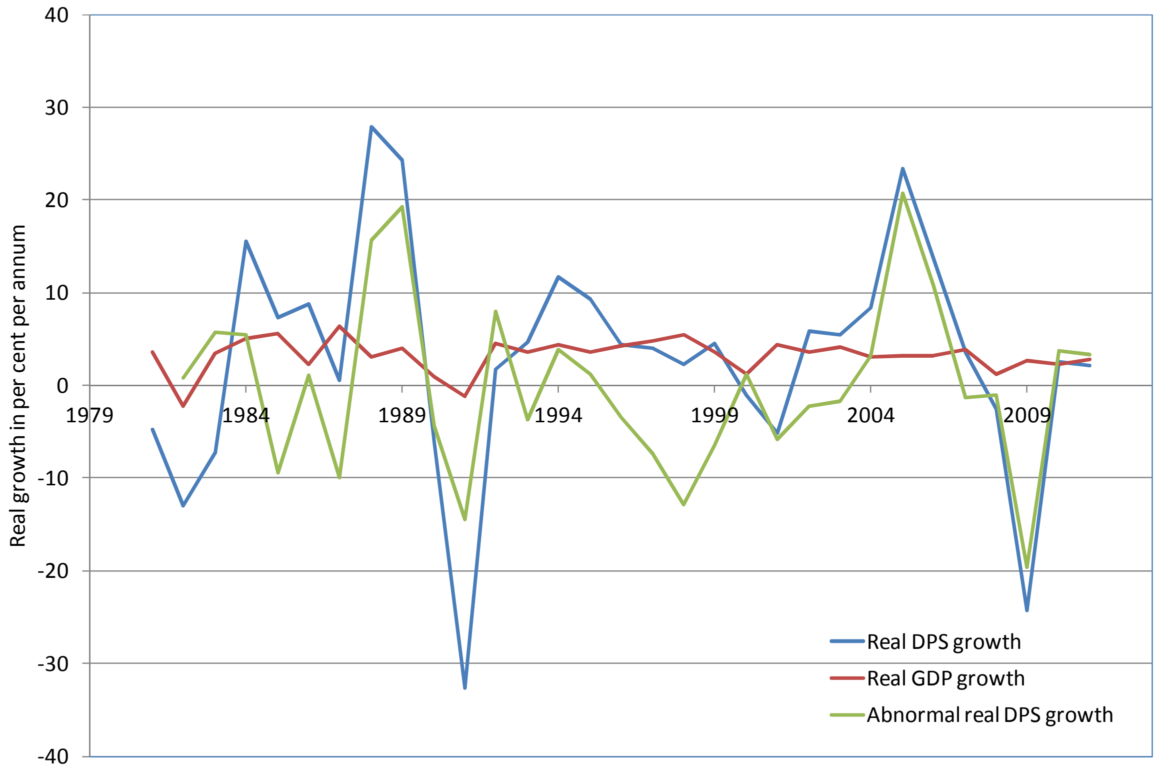
Using interpolation and the I/B/E/S consensus forecasts, an estimate of the DPS for the All Ordinaries for December 2012 is

$$(209.690 + 227.532) \div 2 = 218.611 \tag{38}$$

and for December 2013

$$(227.532 + 246.752) \div 2 = 237.142. \tag{39}$$

Figure 4.1
Real DPS growth for the All Ordinaries from 1981 to 2011



Note: Data are from the ABS and Bloomberg.

The Australian Competition Tribunal in its recent decision found that the AER should place a value of 35 cents on each one dollar of imputation credits distributed. [74] Brailsford, Handley and Maheswaran (2008) indicate that on average 75 per cent of dividends distributed are franked and the corporate tax rate is currently 30 per cent. [75] So to take into account the value of credits distributed, we multiply each DPS forecast by: [76]

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[74] This value is the value laid down by the Australian Competition Tribunal in its recent decision on the market value of a one-dollar credit distributed. See

Australian Competition Tribunal, Application by Energex Limited (Gamma) (No 5) [2011] ACompT 9, May 2011.

[75] Brailsford, T., J. Handley and K. Maheswaran, *Re-examination of the historical equity risk premium in Australia*, Accounting and Finance 48, 2008, page 85.

[76] With a corporate tax rate of 28 per cent, which the government hopes to introduce in 2014, the adjustment factor would be 1.1021. Using this lower corporate tax rate lowers the expected return to the market portfolio by around 5 basis points.

$$1+0.35\times0.75\times\left(\frac{0.30}{1-0.30}\right)=1.1125 \tag{40}$$

Table 4.3
Consensus forecasts of DPS

	June 2012	June 2013	June 2014
Bloomberg	212.347	226.889	244.585
I/B/E/S	209.690	227.532	246.752

Note: Data are from Bloomberg and I/B/E/S. The DPS forecasts are for the All Ordinaries and correspond to values of the All Ordinaries Price Index.

It is difficult to forecast the long-run growth in dividends. We fit a regime-switching model to real DPS growth in which there is a high-growth state and a low-growth state and find that the rate at which the model tends to move from one state to another is sufficiently fast that there is little point in using short-term consensus forecasts and estimates of past real DPS growth together to forecast long-run DPS growth.[77] So instead we assume that the expected long-run growth in real DPS equals the past growth in real DPS over the period 1981 to 2011 of 3.07 per cent per annum, although, as we have pointed out, the past growth is sufficiently volatile that it is difficult to determine with any degree of precision what is the mean growth in real DPS. We also assume that expected inflation lies at the middle of the RBA target range of 2 to 3 per cent, that is, it equals 2.5 per cent.[78] With these assumptions the expected long-run growth in dividends will be

$$100\times((1+0.0307)\times(1+0.0250)-1)=5.65 \text{ per cent.} \tag{41}$$

Thus the assumption that we make about the long-run growth in dividends is conservative in the sense that we assume that it lies below the consensus forecast of the growth in dividends of around 8 per cent per annum on average over the next two years. The level of the All Ordinaries Price Index at the end of 2011 was 4,111. So from (35), it follows that if we use the Bloomberg DPS forecasts, the expected return to the market portfolio, E(R), must satisfy

$$4{,}111=\frac{219.6178\times1.1125}{1+\mathrm{E}(R)}+\frac{235.7368\times1.1125}{1+\mathrm{E}(R)}\left(\frac{1}{\mathrm{E}(R)-0.0565}\right). \tag{42}$$

The value of E(R) that satisfies (42) is 11.68 per cent per annum. From (35), if we use the I/B/E/S DPS forecasts, the expected return to the market portfolio, E(R), must satisfy

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77 We fit a regime-switching model to real DPS growth because Hamilton (1989) finds that:

‘The business cycle is better characterized by a recurrent pattern of [discrete] shifts between a recessionary state and a growth state than by positive coefficients at low lags in an autoregressive model.’

Hamilton, James D., *A new approach to the economic analysis of nonstationary time series and the business cycle*, Econometrica, 1989, pages 357-384.

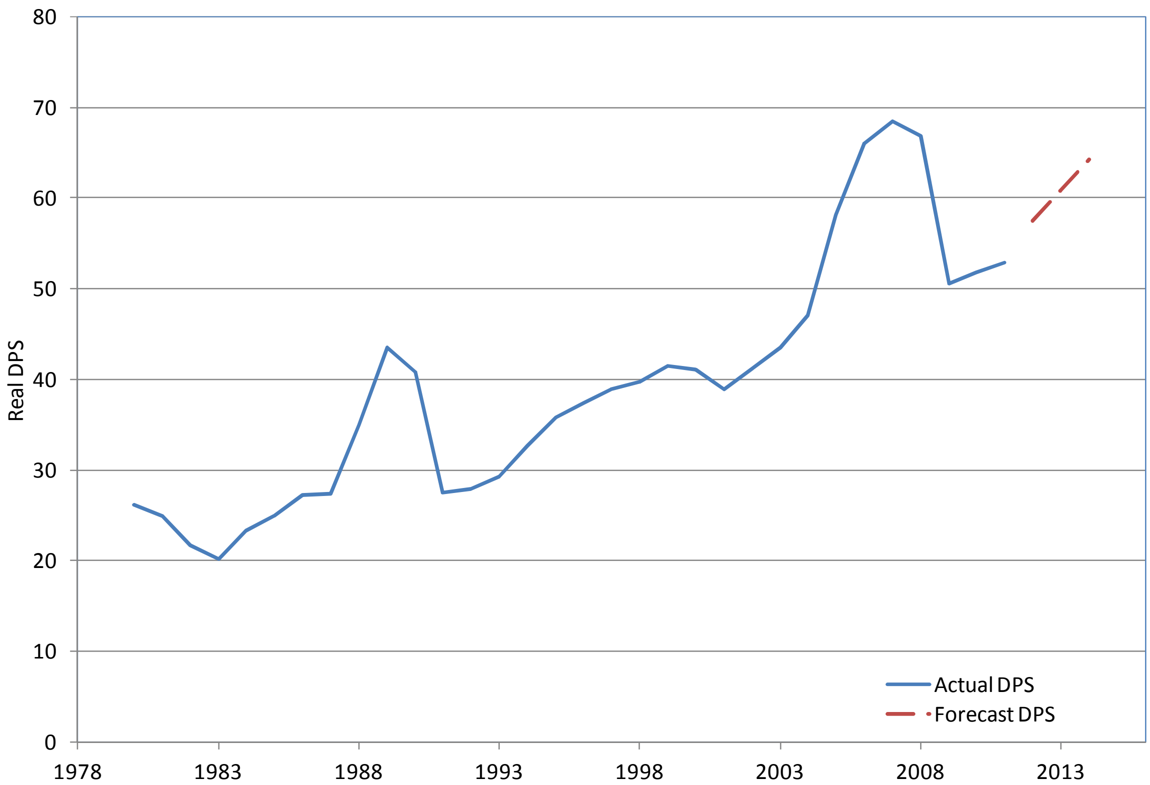
78 http://www.rba.gov.au/monetary-policy/about.html

$$4{,}111 = \frac{218.6110 \times 1.1125}{1+\mathrm{E}(R)} + \frac{237.1420 \times 1.1125}{1+\mathrm{E}(R)} \left(\frac{1}{\mathrm{E}(R) - 0.0565} \right). \qquad (43)$$

The value of E(R) that satisfies (43) is 11.71 per cent per annum.

The DGM estimates of the return that the market requires on the market portfolio that use the Bloomberg consensus forecasts indicate that with a 10-year bond yield of 3.99 per cent per annum, an estimate of the *MRP* for the next five years, relative to the yield, will be 7.69 per cent per annum.

Figure 4.2
Real dividends on the All Ordinaries



Note: Data are from the ABS and Bloomberg.

The I/B/E/S forecasts produce almost identical results. The DGM estimates of the return that the market requires on the market portfolio that use the I/B/E/S consensus forecasts indicate that with a 10-year bond yield of 3.99 per cent per annum, an estimate of the *MRP* for the next five years, relative to the yield, will be 7.72 per cent per annum.

4.3 AER's DGM Estimates

The AER in its *Aurora Draft Decision* claims that it uses the DGM to produce estimates of the *MRP* of between 4.5 and 5.6 per cent per annum.[79] The AER states that it bases these estimates on:

- a market value for a one-dollar imputation credit distributed of 35 cents;
- an assumed dividend growth rate of 6 per cent; and
- a dividend yield of between 4 and 5 per cent drawn from the RBA table f07.pdf.[80]

Imposing the assumption that

$$\mathrm{E}(D(t+s)) = \mathrm{E}(D(t))(1+g)^s, \qquad s > 0 \tag{44}$$

yields the familiar form of the DGM

$$\mathrm{E}(R) = \frac{D(t+1)}{P(t)} + g = \frac{(1+g)D(t)}{P(t)} + g. \tag{45}$$

Plugging in the numbers that the AER states that it uses and a yield at the top of their range of 5 per cent per annum and grossing up the yield for the assumed value of imputation credits distributed using (40) produces an estimate of the return to the market of

$$\mathrm{E}(R) = 100 \times ((1+0.06) \times 1.1125 \times 0.05 + 0.06) = 11.90 \text{ per cent} \tag{46}$$

This estimate is 22 basis points higher than the estimate that we construct using Bloomberg consensus forecasts and 19 basis points higher than the estimate that we construct using I/B/E/S forecasts. Plugging in the numbers that the AER states that it uses and a yield at the bottom of their range of 4 per cent per annum and grossing up the yield for the assumed value of imputation credits distributed produces an estimate of the return to the market of

$$\mathrm{E}(R) = 100 \times ((1+0.06) \times 1.1125 \times 0.04 + 0.06) = 10.72 \text{ per cent} \tag{47}$$

In its *Aurora Draft Decision* the AER uses a risk-free rate of 4.28 per cent. So using the AER's assumptions and the risk-free rate that they choose, the *MRP* should lie between 6.44 and 7.62 per cent per annum – far above the range that the AER claims to produce using the DGM.

4.4 Hathaway's DGM Estimates

Hathaway (2012) uses the DGM and consensus forecasts of dividend yields to produce forward looking estimates of the *MRP* that are on average 7.60 per cent per annum over the

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[79] AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, page 234.

[80] http://www.rba.gov.au/statistics/tables/pdf/f07.pdf

period 2009 to 2012.[81] The forecast of long-run DPS growth that he uses is 7 per cent per annum that is an average of past nominal DPS growth. This corresponds to expected growth in real terms of approximately

$$100 \times ((1 + 0.070) \div 1.02500 - 1) = 4.14 \text{ per cent.} \qquad (48)$$

Although higher than mean real DPS growth between 1981 and 2011, this figure does not fall outside a 95 per cent confidence interval for the mean constructed using data from 1981 to 2011.

4.5 Bloomberg's MRP Estimates

Bloomberg produces (under CRP which stands for country risk premium) estimates of the *MRP* for a number of countries, including Australia, using the DGM. Officer and Bishop describe the way in which Bloomberg constructs these estimates as follows:[82]

> 'Bloomberg works with individual stocks in each country's equity index. They use a three stage growth approach generally transitioning over 14 years from a 3 year near term growth rate to a long term or maturity growth rate. The internal rate of return is derived from solving for the discount rate that equates the present value of the dividend forecasts with the current share price. These internal rates of return are market capitalisation weighted to generate an overall market rate of return. The current yield on 10 year Treasury Bonds is deducted from this to determine a market risk premium.'

Bloomberg's estimate of the *MRP* for Australia computed in this way was 10.52 per cent per annum as of 10 January 2012. The lower estimates that we produce will reflect the more conservative assumption that we make about long-run DPS growth.

81 Hathaway, N., *Forward estimates of the market risk premium: Update*, Capital Research, February 2012.

82 Officer, R. and S. Bishop, *Market risk premium: A Review paper, Prepared for Energy Networks Association, Australian Pipeline Industry Association and Grid Australia*, Value Adviser Associates, August 2008, page 14.

5 Comparison of Regime-Switching and DGM Estimates

An estimate of the *MRP* computed using the regime-switching model lies above an estimate computed using the DGM. In this short section we consider why, besides by chance, the two estimates might differ and which estimate will provide the most suitable guide as to the *MRP* prevailing in the market over the five years of the regulatory period.

The regime-switching model provides an estimate of the *MRP* in *each* future year. The estimates of the *MRP* in each year will differ because the regime-switching model attaches a different probability to being in each state in each period. The data suggest that there is a high probability that we are currently in the high-volatility regime and so the *MRP* forecast for 2012 is high. After 2012, however, the probability of a transition from the high-volatility regime to the low-volatility regime, assessed on the basis of currently available information, will rise and so the *MRP* will be expected to decline. The estimate that we provide of an *MRP* of 8.44 per cent per annum, derived from the regime-switching model, is an average of the forecasts that the model makes over each of the five years of the regulatory period.

The DGM, on the other hand, provides a single estimate of the *MRP* that is based on the internal rate of return that will discount back the market's expectations of the dividends that the market portfolio will pay in *all* future periods – not just over the next five years – back to the current market value of the market portfolio. The value for the *MRP* that the DGM attempts to estimate will be a complicated average of the *MRP* over the next year and over all future years. Thus an estimate that the DGM provides will tend to lie below the current *MRP* when the current *MRP* lies above its long-run mean and above the current *MRP* when the current *MRP* lies below its long-run mean.

For these reasons, we judge the estimate of the *MRP* provided by the regime-switching model of 8.44 per cent per annum to provide the most suitable guide as to the *MRP* prevailing in the market over each of the five years of the regulatory period.

6 Survey Evidence

In choosing a value for the *MRP* the AER places some weight on survey evidence. For example, the AER states in its recent *Aurora Draft Decision* that: [83]

> 'Surveys of market practitioners and academics provide information on the expected forward looking MRP and their application in practice.'

The AER summarises the survey evidence in the following way: [84]

> 'The latest survey based estimates of the MRP indicate that the forward looking MRP expected to prevail in the future has not changed as a result of the GFC. In fact, the survey evidence did not indicate a [steep] change in the MRP employed by market practitioners even at the height of the GFC.'

We will emphasise in this section that there are a number of problems with the surveys that the AER cites:

- the surveys that the AER cites typically do not explain how those surveyed were chosen;
- a majority of those surveyed in the surveys that the AER cites did not respond;
- it is unclear what incentives were provided to individuals contacted by the surveys that the AER cites to ensure that respondents would provide accurate responses;
- it is unclear whether respondents are supplying estimates of the *MRP* that use continuously compounded returns or not continuously compounded returns;
- it is often unclear what value respondents place on imputation credits;
- it unclear what risk-free rate respondents use; and importantly
- it is unclear how relevant some of the surveys that the AER cites are because of changes in market conditions since the time at which the surveys were conducted.

The AER states in its *Aurora Draft Decision* that: [85]

> 'Survey based estimates may be subjective, though this concern is mitigated as the sample size increases.'

This statement assumes that the error with which surveys estimate the *MRP* can be diversified away across surveys. This need not be true. For example, if all of the surveys were conducted at a time when the *MRP* was low, then they will all tend to underestimate the *MRP* and the error that they make in estimating the current *MRP* will not be diversified away.

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[83] AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, page 214.

[84] AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, page 229.

[85] AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, page 215.

As an example of the problems that can arise, we note that with regard to one of the most recent surveys to which the AER refers, the survey conducted by Asher (2011), that: [86]

- only 49 of 2,000 surveyed responded; and that
- the survey was conducted in February 2011 when bond yields and stock prices were relatively high and when a DGM forecast of the *MRP* would have been 295 basis points lower than an otherwise identical forecast constructed in December 2011.

The low number of responses raises the possibility that the sample of respondents is not representative of the population. We also note that:

- Asher stated in a seminar in May 2010 in front of individuals whom he later surveyed that 'the implied equity premium is more or less equal to the dividend yield which is probably at this stage somewhere between 3 and 4 per cent – I think that may be a reasonable thing to work on.' [87]

This public statement about the surveyor's view of what would be a correct response to the primary question he plans to ask in a survey he plans to conduct raises the possibility that the results of the survey will merely mirror his own views.

We note in addition that:

- Asher stated in the seminar in May 2010 in front of individuals whom he later surveyed that he intended to conduct surveys on a regular basis and publish the results to produce 'a more informed consensus.' [88]

This raises the possibility that some of the participants felt encouraged to respond to the survey with the view about the *MRP* expressed by Asher in the seminar.

Because of the problems with Asher's survey, we set his results aside.

The AER states in its recent *Aurora Draft Decision* that: [89]

> 'survey evidence of the MRP prior to the onset of the GFC supported a forward looking estimate of 6 per cent. The latest survey based estimates of the MRP indicate that the forward looking MRP expected to prevail in the future has not changed as a result of the GFC.'

The values for the *MRP* to which the AER refers are typically values that *exclude* the value of imputation credits. The with-imputation credit value for the *MRP* that corresponds to a without-credit estimate of 6 per cent is around 50 basis points higher. Thus the survey evidence, if correctly interpreted, indicates the average imputation-adjusted *MRP* adopted by

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86 Asher, *Equity Risk Premium Survey – results and comments*, Actuary Australia 2011 Issue 161, July 2011, pages. 13-15.

87 http://www.actuaries.asn.au/Library/1110%20Ashe-Asher.pdf

http://www.actuaries.asn.au/Library/6b_Asher_Ashe.mp3

88 http://www.actuaries.asn.au/Library/6b_Asher_Ashe.mp3

89 AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, page 229.

market practitioners is 6.5 per cent. It is the imputation-adjusted *MRP* that the AER uses to determine an appropriate return on capital for a regulated utility.

6.1 Survey Estimates of the MRP

The seven surveys to which the AER refers in its recent *Aurora Draft Decision* are: [90]

- a KPMG (2005) study of 118 independent expert valuation reports of which 33 used estimates of the *MRP*; [91]
- a Capital Research (2006) study of 12 broker 'dailies' containing estimates of the *MRP*; [92]
- a comprehensive survey of 356 Australian firms by Truong, Partington and Peat (2008) that elicited 87 responses; [93]
- a survey of an unknown number of Australian academics by Fernández (2009) that elicited 23 responses; [94]
- a survey of an unknown number of Australian analysts by Fernández and Del Campo (2010) that elicited seven responses; [95]
- a survey of an unknown number of Australian academics and practitioners by Fernández, Aguirreamalloa and Corres (2011) that elicited 40 responses; [96] and
- a survey of 2,000 Australian actuaries by Asher (2011) that elicited 49 responses. [97]

Because of the problems with Asher's survey to which we have alluded, we will set aside his results for the time being. Table 6.1 suggests – *setting aside also for the time being the issue of whether the estimates of the MRP that the surveys report exclude or include the value of imputation credits* – that the AER's summary of the results of the remaining six surveys is not unreasonable. The mean of the *MRP* estimates contained in the five surveys is marginally higher than 6 per cent per annum but the mode appears to be exactly 6 per cent. Of course,

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90 AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, pages 229-230.

91 KPMG, *Cost of capital – market practice in relation to imputation credits*, August 2005.

92 Capital Research, *Telstra's WACC for network ULLS and the ULLS and SSS businesses – Review of reports by Prof. Bowman – Associated Professor Neville Hathaway*, March 2006.

93 Truong, G., G. Partington and M. Peat, *Cost of capital estimation and capital budgeting practice in Australia*, Australian Journal of Management, 2008, pages 95-122.

94 Fernández P., *Market risk premium used by professors in 2008: A survey with 1400 answers*, IESE Business School Working Paper, WP-796, May 2009.

95 Fernández, P. and J. Del Campo, *Market risk premium used in 2010 by analysts and companies: A survey with 2400 answers*, IESE Business School, May 21 2010.

96 Fernández, P., J. Aguirreamalloa and L. Corres, *Equity market risk premium used in 56 countries in 2011: A survey with 6,014 answers*, IESE Business School, July, 2011.

97 Asher, *Equity Risk Premium Survey – results and comments*, Actuary Australia 2011 Issue 161, July 2011, pages. 13-15.

Fernández has conducted three surveys of Australian academics and practitioners and so some individuals may have responded more than once.

From Table 6.1, the mean estimate of the *MRP* computed using the 153 responses from the five surveys is 6.14 per cent – marginally higher than the 6 per cent that the AER states is the average, but little different. Fernández (2009), Fernández & del Campo (2010) and Fernández, Aguirreamalloa and Corres (2011) do not provide sufficient information to determine the modes of the responses to their surveys. KPMG (2005), however, reports that 25 of the 33 estimates of the *MRP* that it found contained in independent expert valuation reports were 6 per cent per annum, Capital Research (2006) reports that one of the 12 estimates that it extracted from broker 'dailies' was 6 per cent and Truong, Partington and Peat (2008) report that 18 of the 38 estimates of the *MRP* that they were sent were 6 per cent. Thus the AER's previously expressed view that surveys indicate that 6 per cent is the most commonly adopted value for the *MRP* also appears to be correct.

Table 6.1
Survey estimates of the *MRP*

	Responses	Mean	Median	Mode
KPMG (2005)	33	7.51	6.00	6.00
Capital Research (2006)	12	5.09	5.00	5.00
Troung et al. (2008)	38	5.94	6.00	6.00
Fernández (2009)	23	5.90	6.00	
Fernández & del Campo (2010)	7	5.40	5.50	
Fernández et alia (2011)	40	5.80	5.20	
Total	153	6.14		

It is also important to know whether the estimates of the *MRP* reported are adjusted for the value, if any, that the market places on imputation credits.

6.2 Do the Survey Estimates Include Imputation Credits?

Of the six surveys, only the KPMG (2005) survey provides comprehensive information on whether respondents include or exclude a value for imputation credits from the value they place on the *MRP*. KPMG states that: [98]

> 'Of the 118 reports reviewed, we found that 33 reports adopted the Capital Asset Pricing Model ("CAPM") for estimating the cost of equity. Of these reports none made any adjustment for the value of imputation credits.'
>
> 'none attributed their choice of value for the MRP to the decision not to adjust for dividend imputation'

98 KPMG, *Cost of capital – market practice in relation to imputation credits*, August 2005, pages 1-2.

Two of the surveys provide information on whether companies – not necessarily those providing estimates of the *MRP* – account for imputation credits in conducting valuations.

Capital Research (2006) cites an unpublished in-house County Investment Management survey of nine brokers that finds that five of these brokers place a value on imputation credits in valuing companies, while one sometimes does and sometimes does not and three do not place a value on imputation credits.

Truong, Partington and Peat (2008) report that 13 companies stated that they accounted for imputation credits in project evaluation while 60 companies stated that they did not account for imputation credits in project evaluation.[99] Thus Truong, Partington and Peat found that 82 per cent of respondents (60 out of 73) did not account for imputation credits.

The survey questions that Fernández (2009), Fernández and del Campo (2010) and Fernández, Aguirreamalloa and Corres (2011) sent out do not mention imputation credits or taxes. A keyword search of the three papers for the words 'franking' and 'imputation' produced only one hit – the following response in Fernández and del Campo's study from an analyst: [100]

> 'Possibly an area where a practitioner like me would benefit is whether it makes sense to use different *MRP* estimates as economic conditions change and/or the use of ranges for cost of capital estimates for valuations/ capital budgeting/ performance measurement etc. The long run historical average seems almost meaningless when one looks at both the standard error of the estimate (7.5% imputation adjusted average with a[n] SE of 23%) and at the ranges/volatility of annual estimates.'

This analyst provides in his or her response an imputation-adjusted estimate of the *MRP* of 7.5 per cent while Table 4 of Fernández and del Campo (2010) reports that the maximum *MRP* reported by Australian respondents is 6 per cent. [101,102] This implies that, for at least this responder, his or her response of, presumably 6 per cent, was imputation credit unadjusted. This illustrates the fact that responders that take into account imputation credits in conducting valuations will not necessarily provide estimates of the *MRP* that are imputation-adjusted. In contrast, responders who do not take into account imputation credits will always provide estimates of the *MRP* that are imputation-unadjusted.

Table 6.2 summarises what we know about whether the responders to the six surveys reviewed by the AER in its *Aurora Draft Decision* adjust or do not adjust for imputation

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99 Truong, G., G. Partington and M. Peat, *Cost of capital estimation and capital budgeting practice in Australia*, Australian Journal of Management, 2008, page 115.

100 Fernandez, P. and J. Del Campo, *Market risk premium used in 2010 by analysts and companies: A survey with 2400 answers*, IESE Business School, May 21 2010, page 13.

101 The analyst surely provides an estimate of the imputation adjusted *MRP* of 7.5 per cent per annum and an estimate, not of the standard error of the estimate, but of the standard deviation of the annual excess return to the market portfolio of 23 per cent per annum.

102 Fernandez, P. and J. Del Campo, *Market risk premium used in 2010 by analysts and companies: A survey with 2400 answers*, IESE Business School, May 21 2010, page 4.

credits. The table provides only the numbers of individuals or institutions that we know adjust and those that we know do not adjust. The table indicates that 83 per cent (96 ÷ (96 + 19)) of individuals or institutions that provided information on whether they adjust do not adjust. This suggests that a lower bound on the proportion of individuals or institutions providing estimates of the *MRP* that are imputation-unadjusted is 83 per cent. A figure of 83 per cent is likely to be a lower bound because, as we have seen, some individuals or institutions may take into account imputation credits in conducting valuations but will not provide estimates of the *MRP* that are imputation-adjusted.

Table 6.2
Do survey responders adjust for imputation credits?

	Adjust	Do not adjust
KPMG (2005)	0	33
Capital Research (2006)	5	3
Troung et al. (2008)	13	60
Fernández (2009)	0	0
Fernández & del Campo (2010)	1	0
Fernández et alia (2011)	0	0
Total	19	96

The evidence that Table 6.2 provides is consistent with the view of McKenzie and Partington (2010) who state that:[103]

> ‘it probably is the case that ignoring imputation credits in valuations is widespread.’

Since the AER does place a value on imputation credits distributed, it is necessary for these survey estimates – the vast majority of which are unadjusted – to be adjusted.

6.3 The Impact of Imputation Credits on the *MRP*

Determining the impact of imputation credits on the *MRP* requires one make assumptions about what value the market places on a dollar of credits distributed and the face value of the credits distributed. The AER assumes that the market value of a one dollar credit distributed is 35 cents.[104] The yield on the All Ordinaries at the close of trade on 30 December 2011 was 4.74 per cent while the corporate tax rate is currently 30 per cent. So if we follow Brailsford, Handley and Maheswaran (2008) and assume that 75 per cent of dividends

[103] McKenzie, M., and G. Partington, *Report to AER: Evidence and submissions on gamma*, 25 March 2010, page 27.

[104] AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, page 227.

distributed are franked, the value to the market of credits distributed, with these figures, must be:[105, 106]

$$0.35 \times 0.75 \times \frac{0.30}{1-0.30} \times 4.74 = 0.53 \text{ per cent.} \qquad (49)$$

So, with these figures, an adjustment for credits distributed is 53 basis points, which, relative to an *MRP* of 6 per cent, is a significant number. [107] For example, it marginally exceeds the upward revision of the *MRP* from 6 to 6.5 per cent per annum that the AER provided in 2008 and the downward revision from 6.5 to 6 per cent per annum that the AER has recommended in 2011.

6.4 Asher's Survey

Asher's survey was conducted in February 2011. [108] Even though we see serious problems with his survey, it will be useful to investigate what an estimate of the *MRP*, constructed using the DGM, would have been at the end of February 2011 and so by how much a DGM-based estimate will have changed between that time and the end of 2011.

Consensus forecasts taken from Bloomberg at the end of February 2011 appear in Table 6.3. The DPS forecasts are for the All Ordinaries and correspond to the All Ordinaries Price Index. Using interpolation and these forecasts, an estimate of the DPS for the All Ordinaries made at the end of February 2011 would have been for February 2012

$$(4 \times 197.698 + 8 \times 216.738) \div 12 = 210.391 \qquad (50)$$

and for February 2013

$$(4 \times 216.738 + 8 \times 234.301) \div 12 = 228.446. \qquad (51)$$

The level of the All Ordinaries Price Index at the end of February 2011 was 4,923.6. So using the forecast for long-run growth in DPS of 5.65 per cent per annum that we employed

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105 Brailsford, T., J. Handley and K. Maheswaran, *Re-examination of the historical equity risk premium in Australia*, Accounting and Finance 48, 2008, page 85.

106 Note that the rate at which dividends distributed are franked need not match the fraction of credits created that are distributed.

107 At the time that the surveys were conducted the yield on the All Ordinaries may have been lower, on average, than 4.74 per cent. Also, the evidence in Table 6.2 suggests that up to 17 per cent of the estimates of the *MRP* provided by the five surveys may have been adjusted for the value that the market attaches to imputation credits. The evidence provided in Table 6.1, however, shows that the average estimate of the *MRP* provided by the 153 respondents to the five surveys was 6.14 per cent. Thus so long as the yield when the surveys were taken was no lower on average than

$$\frac{(6.50-6.14)}{(1-0.17)\times 0.35 \times 0.75} \times \left(\frac{1-0.3}{0.3}\right) = 3.86 \text{ per cent,}$$

then an average imputation-adjusted estimate of the *MRP* will be no lower than 6.5 per cent.

108 Asher, *Equity Risk Premium Survey – results and comments*, Actuary Australia 2011 Issue 161, July 2011, pages. 13-15.

in Section 4, it follows from (35) that the expected return to the market portfolio, E(R), must satisfy

$$4{,}923.6000 = \frac{210.3912 \times 1.1125}{1+\mathrm{E}(R)} + \frac{228.4464 \times 1.1125}{1+\mathrm{E}(R)} \left(\frac{1}{\mathrm{E}(R) - 0.0565} \right). \qquad (52)$$

Table 6.3
Consensus forecasts of DPS

June 2011	June 2012	June 2013
197.698	216.738	234.301

Note: Data are from Bloomberg. The DPS forecasts are for the All Ordinaries and correspond to the All Ordinaries Price Index.

The value of E(R) that satisfies (52) is 10.53 per cent per annum, 115 basis points below the corresponding estimate of 11.68 per cent constructed at the end of December 2011. The 10-year yield at the end of February 2011 was 5.47 per cent per annum and the yield at the end of December 2011 was 3.67 per cent. So estimates of the *MRP* using these yields would have been 5.06 per cent in February 2011 and 8.01 per cent in December 2011 – a difference of 295 basis points.

Asher's (2011) published paper does not reveal how many respondents there were to his survey – although one can infer roughly how many from the graphs that he provides – and importantly the published paper does not provide the number of individuals surveyed – and so the number of non-respondents.[109] We have, however, contacted Asher and he has graciously provided this information and other information that was missing from the published paper.

The mean imputation-adjusted 10-year *MRP* across the 49 respondents to Asher's survey was 4.70 per cent with a standard deviation of 2 per cent and so a standard error of $2/\sqrt{49} = 0.29$ per cent. In private correspondence, Asher has told us that 37 respondents revealed whether they made an adjustment for imputation credits and that the average adjustment made by these 37 individuals was to add 81 basis points to the *MRP*. It follows that the mean imputation-unadjusted 10-year *MRP* across the 49 respondents would have been 3.89 per cent if those who did not reveal whether they adjusted for credits behaved in the same way as those that did reveal whether they made an adjustment. On the other hand, the mean imputation-unadjusted 10-year *MRP* across the 49 respondents would have been 4.09 per cent if those who did not reveal whether they adjusted for credits made no adjustment. Either way, the mean imputation-unadjusted *MRP* that Asher reports lies significantly below the mean response across the other six surveys.

Interestingly, Asher finds that 27 of the 37 respondents who revealed whether they made an adjustment for imputation credits made an adjustment that implied that they place a value on

[109] Asher, *Equity Risk Premium Survey – results and comments*, Actuary Australia 2011 Issue 161, July 2011, pages. 13-15.

a one-dollar credit of almost one dollar. One should not, however, infer from this evidence that the market places a value of close to one dollar on a one-dollar credit. Asher reports that most of the respondents work in Insurance, Investments or Superannuation. An Australian fund manager will place a value of almost one dollar on a one-dollar credit distributed regardless of what value the market places on a one-dollar credit. Foreign fund managers will place little value on credits distributed, again, regardless of what value the market places on a one-dollar credit. The low value that foreign investors place on credits strongly suggests that the value that a long-term representative investor will place on credits will be around zero. Even if the market places essentially no value on credits distributed, however, Australian investors will continue to place a value on the credits. The value that they place on credits, however, will have little impact on the cost of equity.

6.5 AMP Views

The AER cites the views of AMP Chief Economist Shane Oliver to support its views. The AER notes that: [110]

> 'recent research completed by Shane Oliver, Head of Investment Strategy and Chief Economist at AMP Capital Investors, suggested that the likely equity risk premium for a 5 to 10 year period is 5.9 per cent based on historical data. However, Oliver noted that this realised equity risk premium is probably exaggerated by a low starting point for the price to earnings ratio, making it easier for shares to provide decent returns. Oliver stated that AMP Capital Investors estimate of the prospective required equity risk premium for shares is around 3.5 per cent.'

It is not clear from where the 5.9 per cent to which Oliver refers came. He states that: [111]

> 'A more formal way to compare the prospective return from shares versus bonds is to calculate what is known as the equity risk premium (ERP). Over very long periods, the excess return of shares over bonds has varied. Over the period since 1900 it has averaged 4.4% p.a. in the US and 5.9% p.a. in Australia.'

If the estimate came from the same data that the AER employs, then it is not clear that this estimate of 5.9 per cent provides additional information beyond the information that Brailsford, Handley and Maheswaran (2011) provide.

Oliver provides no explanation about from where the 3.5 per cent came and so it is difficult to know what to make of the estimate. [112] It is also difficult to know what to make of the distinction that he draws in the same article to which the AER refers between the likely risk premium and the required risk premium. If these two quantities were really to differ, then investors would be ignoring opportunities to increase their welfare. If the likely risk premium were to exceed the required risk premium, for example, investors would improve their welfare by increasing their position in equities. If the required risk premium were to exceed the likely risk premium, on the other hand, investors would do better to reduce their position in equities.

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110 AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, page 230.

111 Oliver, Shane, *Are shares good value & what about bank deposits*? AMP Capital Investors, September 2010.

112 Oliver, Shane, *Are shares good value & what about bank deposits*? AMP Capital Investors, September 2010.

Interestingly, more recent advice from Oliver is that the return to Australian shares is likely to be around 12 per cent in 2012.[113, 114] This forecast is 32 basis points above the forecast we generate in Section 4 using the DGM and Bloomberg consensus forecasts of DPS and so as of the end of December 2011 is approximately consistent with the DGM forecasts that we generate. The forecast, on the other hand, is 43 basis points below the average forecast of the return to the market portfolio over the next five years generated by the regime switching model of 12.43 per cent per annum.[115]

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113 Oliver, Shane, *2011 in review: Should we be concerned about 2012*? AMP Capital Investors, December 2011.

114 An enquiry as to how the forecast was generated received a response from AMP that advised that it was based on:

‘a view on capital values based on a partial recovery in PE multiples and likely earnings growth and adds this with dividend yields to derive a total return.’

115 12.43 per cent is the average of the five forecasts in the fourth row of Table 3.2.

7 Conclusions

This report has been prepared for APA Group, Envestra, Multinet and SP AusNet by NERA Economic Consulting (NERA). APA Group, Envestra, Multinet and SP AusNet have asked NERA to examine a number of issues concerning the market risk premium (*MRP*) that arise from the Australian Energy Regulator's recently published *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17* and from the Australian Competition Tribunal's decision *Application by Envestra Limited (No 2) [2012] ACompT 4* (*11 January 2012*).

In particular, APA Group, Envestra, Multinet and SP AusNet have asked NERA to assess:

- whether an estimate of the *MRP* computed using historical data should be based on the arithmetic mean of a sample of returns to the market portfolio, on the geometric mean or on some weighted average of the two means;
- whether the historical evidence indicates, given current market conditions, that an *MRP* of 6 per cent per annum inclusive of the value of imputation credits is appropriate;
- what forecasts of the *MRP* are generated by the Dividend Growth Model (DGM), current consensus forecasts of future dividend growth and the current yield on the market portfolio; and
- whether the survey evidence that the AER summarises provides support for an *MRP* of 6 per cent per annum inclusive of the value of imputation credits.

Regulators use an estimate of the *MRP* to compute an estimate of the cost of equity and an estimate of the cost of equity to compute an estimate of the weighted average cost of capital (*WACC*). Regulators use an estimate of the *WACC* to compute an estimate of the return that the market requires on the regulated asset base (*RAB*) in each year. We emphasise that:

- an estimate of the *WACC* that is based on the arithmetic mean of a sample of annual excess returns to the market portfolio will – so long as the other components of the *WACC* have been correctly computed and ignoring minor adjustments to the *RAB* and to the evolution of prices – produce an *unbiased* estimate of the revenue that the market requires in any one year on the *RAB*. In contrast, an estimate of the *WACC* that is in part based on an estimate of the *MRP* that places a positive weight on the geometric mean of a sample of annual excess returns to the market portfolio will – so long as the other components of the *WACC* have been correctly computed – produce a *downwardly biased* estimate of the revenue that the market requires in any one year;
- the downwards bias associated with an estimate of the *MRP* that uses the geometric mean can be *substantial*. We show using simulations, for example, that the downward bias associated with an estimate of the *MRP* over any single year that uses the geometric mean computed using data, generated to have the same characteristics

as the data that Brailsford, Handley and Maheswaran provide and that we update, from 1883 through 2011 (1958 through 2011) is 130 (250) basis points; [116] and

- while an estimate of the *WACC* compounded over more than one year, based on the arithmetic mean of a sample of annual excess returns to the market portfolio, will be biased, the AER, aside from some minor adjustments to the *RAB* and to the evolution of prices over the regulatory period, *never* compounds the *WACC* over more than one year.

The volatility of the return to the Australian market portfolio – or at least a typical choice of a proxy for the portfolio, the All Ordinaries – has been far from constant over time. We find that:

- the historical evidence indicates that the Australian market portfolio has been typically riskier over the last half century than it was over the 75 years or so before. Estimates of the parameters of a regime-switching model that allows for episodes of high volatility and episodes of low volatility suggest that over the last half century the standard deviation of the return to the market portfolio has typically been around twice what it was over the 75 years or so before. The Capital Asset Pricing Model (CAPM) – the model on which the AER relies to compute the cost of equity – implies that there should be a positive relation between the *MRP* and the volatility of the return to the market portfolio. Merton (1973) develops a model that makes this relation explicit; [117] and

- estimates that use the regime-switching model and the restriction that Merton's model places on the relation between the *MRP* and the volatility of the return to the market portfolio suggest that the *MRP* is currently *above* its long-term average. Estimates that use the regime-switching model and Merton's model indicate that the *MRP* for the next five years, relative to the 10-year government bond yield, is 8.44 per cent per annum.

The DGM provides, in principle, an attractive way of estimating the *MRP*. In practice, the model requires reliable forecasts of future dividend growth. We find that

- estimates of the *MRP* provided by the DGM that use current data lie *above* 6 per cent per annum. These relatively high estimates reflect the high current forward dividend yield on the market portfolio and the low yield on 10-year bonds. They do *not* rely on high forecasts of long-run growth in dividends per share (DPS); and

- Bloomberg consensus forecasts indicate that a conservative estimate of the *MRP*, adjusted for the value that the market places on imputation credits, for the next five years, relative to the 10-year government bond yield, is 7.69 per cent per annum. [118]

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116 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance*,* 2011.

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

118 We adjust for the provision of imputation credits under the assumption that the value of a one-dollar credit distributed has a market value of 35 cents. This market value is the value laid down by the Australian Competition Tribunal in its recent decision on the market value of a one-dollar credit distributed. We also assume, like Brailsford, Handley and Maheswaran (2008), that 75 per cent of dividends distributed are franked.

This estimate is *conservative* in that it uses as a forecast of long-run DPS growth a number, based on past real DPS growth and Reserve Bank of Australia (RBA) targets for inflation, that lies marginally below the forecast for long-run DPS growth that the AER uses and well below current consensus forecasts of short-term DPS growth.

An estimate of the *MRP* computed using the regime-switching model lies above an estimate computed using the DGM. Note, however, that:

- the regime-switching model provides an estimate of the *MRP* in *each* future year. Because the data suggest that there is a high probability that we are currently in the high-volatility regime, the *MRP* forecast for 2012 is high. After 2012, however, the *MRP* is expected to decline as the probability increases that we will move from the high-volatility regime to the low-volatility regime;

- the DGM, on the other hand, provides a single estimate of the *MRP* that is based on the internal rate of return that will discount back the market's expectations of the dividends that the market portfolio will pay in *all* future periods – not just over the next five years – back to the current market value of the market portfolio. The value for the *MRP* that the DGM attempts to estimate will be a complicated average of the *MRP* over the next year and over all future years. Thus an estimate that the DGM provides will tend to lie below the current *MRP* when the current *MRP* lies above its long-run mean and above the current *MRP* when the current *MRP* lies below its long-run mean; and

- so, for these reasons, we judge the estimate of the *MRP* provided by the regime-switching model of 8.44 per cent per annum to provide the most suitable guide as to the *MRP* prevailing in the market over the five years of the regulatory period.

The AER places some emphasis on survey evidence. [119] We see a number of problems with the surveys that the AER cites:

- the surveys that the AER cites typically do not explain how those surveyed were chosen and a majority of those surveyed do not respond. Thus it is unclear whether the sample of respondents that the surveys use is representative of the population;
- it is unclear what incentives have been provided to individuals contacted by the surveys that the AER cites to ensure that respondents provide accurate responses; and
- it is unclear how relevant some of the surveys that the AER cites are because of changes in market conditions since the time at which the surveys were conducted.

As an example of the problems that can arise, we note that with regard to the survey conducted by Asher (2011), that the AER cites, that: [120]

Australian Competition Tribunal, Application by Energex Limited (Gamma) (No 5) [2011] ACompT 9, May 2011.

Brailsford, T., J. Handley and K. Maheswaran, *Re-examination of the historical equity risk premium in Australia*, Accounting and Finance 48, 2008, pages 73-97.

[119] AER, *Draft Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17*, November 2011, pages 229-230.

- only 49 of 2,000 surveyed responded; and that
- the survey was conducted in February 2011 when bond yields and stock prices were relatively high and when a DGM forecast of the *MRP* would have been 295 basis points lower than an otherwise identical forecast constructed in December 2011.

We also note that:

- Asher stated in a seminar in May 2010 in front of individuals whom he later surveyed that 'the implied equity premium is more or less equal to the dividend yield which is probably at this stage somewhere between 3 and 4 per cent – I think that may be a reasonable thing to work on.' [121, 122]

This public statement about the surveyor's view of what would be a correct response to the primary question he plans to ask in a survey he plans to conduct raises the possibility that the results of the survey will merely mirror his own views.

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[120] Asher, *Equity Risk Premium Survey – results and comments*, Actuary Australia 2011 Issue 161, July 2011, pages. 13-15.

[121] http://www.actuaries.asn.au/Library/6b_Asher_Ashe.mp3

[122] Asher, like many academics, refers to the *MRP* as the equity premium.

Appendix A. Serial Dependence

This appendix examines the impact of serial dependence on the bias associated with estimates of the unconditional expected excess return to the market portfolio and the bias associated with estimates of unconditional discount factors. Again, an unconditional expectation ignores currently available information like past returns.

Here, we assume that:

$$R(t) \mid R(t-1) \sim \text{NID}(\alpha + \beta R(t-1), \omega) \tag{A.1}$$

Estimates of the parameter β computed using the data that Brailsford, Handley and Maheswaran (2011) provide and we update appear in Table A.1 below. [123] Both estimates differ significantly from zero at the 10 per cent level but neither differs from zero at the five per cent level. Thus the evidence for serial dependence is weak. We choose α and ω so that the unconditional mean and standard deviation of returns in the simulations that follow match the mean and standard deviation of returns in the simulations of Section 2.

Table A.1
Estimates of the parameters of the distribution of returns

Period	β
1883-2011	-0.160 (0.088)
1958-2011	-0.253 (0.135)

Note: Standard errors are in parentheses.

Table A.2 provides the results of simulations that examine the bias that can arise when arithmetic and geometric mean returns are used to estimate expected multi-period returns. Panel A uses 129 years of data to estimate the returns and is calibrated to the data that Brailsford, Handley and Maheswaran (2011) provide and we update from 1883 through 2011.[124] Panel B uses 54 years of data and is calibrated to the data that they provide and we update from 1958 through 2011.

The table shows that, as is well known, the arithmetic mean of a sample of annual excess returns to the market portfolio is an unbiased estimator of the unconditional expected excess return to the market portfolio over any one year regardless of whether returns are serially dependent. Thus the use of the arithmetic mean will deliver an unbiased estimate of the

[123] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

[124] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

unconditional return on capital necessary for a regulated firm to recover its costs in any one year – so long as the other components of the *WACC* have been correctly computed.

Table A.2 also shows, like Table 2.1, that estimates of the expected return over more than one year that use the arithmetic mean are upwardly biased although the bias is lower than the bias that arises when returns are serially independent. Again, at no stage in the regulatory process is the *WACC* compounded and so the observation is purely academic.

In contrast, the geometric mean provides a downwardly biased estimator of the unconditional expected excess return to the market portfolio over any one year. The downward bias associated with the geometric mean using 129 years of simulated data is 6.1 – 4.7 per cent, that is, 140 basis points while using 54 years of simulated data it is 6.1 – 3.4 = 2.7 per cent, that is, 270 basis points.

Table A.2
Bias in estimating multi-period returns in the presence of serial dependence

	1	2	3	4	5	10
	Panel A: $\alpha = 1.231$, $\beta = -0.160$, $\omega = 0.164$, $T = 129$ years					
Parameter	6.1	12.1	18.6	25.4	32.5	75.2
Arithmetic	6.1	12.6	19.5	26.8	34.6	81.9
Geometric	4.7	9.7	14.9	20.4	26.2	59.8
	Panel B: $\alpha = 1.329$, $\beta = -0.253$, $\omega = 0.219$, $T = 54$ years					
Parameter	6.1	11.3	16.9	22.8	29.0	65.1
Arithmetic	6.1	12.6	19.7	27.2	35.2	85.3
Geometric	3.4	6.9	10.7	14.6	18.8	43.4

Notes: Simulation results are in per cent per annum. Each simulation uses 100,000 replications. Parameter values are determined from simulations that use 1,000,000 replications.

Table A.3 provides the results of simulations that examine the bias that can arise when returns exhibit negative serial dependence and arithmetic and geometric mean returns are used to estimate discount factors. The table shows that unconditional discount factor estimates that use the arithmetic mean are downwardly biased while estimates that use the geometric mean are upwardly biased. These results imply that if the excess return to the market portfolio is negatively serially dependent, then an unbiased estimator of an unconditional discount factor will require one use an estimate of the *MRP* that falls below the arithmetic mean of a sample of annual excess returns to the market portfolio. Thus there is an argument – albeit very weak – for using an estimate of the *MRP* that falls below the arithmetic mean – not to determine the return on capital necessary for a regulated firm to recover its costs – but to determine how that return should be distributed across time so as to smooth prices.

Table A.3
Bias in estimating discount factors in the presence of serial dependence

	1	2	3	4	5	10
	Panel A: $\alpha = 1.231$, $\beta = -0.160$, $\omega = 0.164$, $T = 129$ years					
Parameter	0.943	0.892	0.844	0.798	0.755	0.571
Arithmetic	0.943	0.889	0.838	0.790	0.746	0.558
Geometric	0.955	0.912	0.871	0.833	0.796	0.636
	Panel B: $\alpha = 1.329$, $\beta = -0.253$, $\omega = 0.219$, $T = 54$ years					
Parameter	0.943	0.899	0.855	0.814	0.775	0.606
Arithmetic	0.943	0.890	0.840	0.794	0.750	0.570
Geometric	0.968	0.938	0.909	0.882	0.856	0.746

Notes: Parameter values are determined from simulations that use 1,000,000 replications. Otherwise, each simulation uses 100,000 replications. Estimates that use the arithmetic mean are computed using (8). Estimates that use the geometric mean are computed using (11).

Appendix B. Historical Volatility

In our April 2011 report, *The market risk premium: A report for Multinet Gas and SP AusNet,* we emphasise that the evidence shows that the market portfolio was substantially less risky in the later part of the 19th century and the earlier part of the 20th century than in the later part of the 20th century and the early part of the 21st century. The AER's response to our analysis in its June 2011 report *Envestra Ltd Access arrangement proposal for the SA gas network, 1 July 2011 – 30 June 2016: Final Decision* is to suggest that:

- the observation that we make about a substantial change in the risk of the market portfolio is ours alone;
- there are problems with the data that we use;
- the shift in the risk of the market portfolio can be attributed to chance; and
- it is unreasonable to expect that a shift in the risk of the market portfolio will be accompanied by a shift in the *MRP* if one cannot identify why the risk of the market portfolio has changed.

We address each of these issues in turn below.

B.1. Originality

In our submission, we were careful to state that the observation that the market portfolio was substantially less risky in the later part of the 19th century and the earlier part of the 20th century than in the later part of the 20th century was first made by Kearns and Pagan in a paper that they published in the Economic Record in 1993.[125] Brailsford, Handley and Maheswaran (2008) cite the work of Kearns and Pagan but do not investigate the implications of the work for estimating the *MRP*. [126]

In updating the work of Kearns and Pagan, we were careful to use the same time series that they had used – which apart from the fact that the series that Kearns and Pagan use is without dividends is precisely the same series that Brailsford, Handley and Maheswaran (2011) employ. [127] The AER do not mention Kearns and Pagan but do, however, raise several issues with the use of this time series.

B.2. Data

The AER states in its *Final Decision* that:[128]

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[125] Kearns, P. And A. Pagan, Australian stock market volatility: 1875-1987, Economic Record, pages 163-178.

[126] Brailsford, T., J. Handley and K. Maheswaran, *Re-examination of the historical equity risk premium in Australia*, Accounting and Finance 48, 2008, page 76.

[127] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance*,* 2011.

[128] AER, *Envestra Ltd Access arrangement proposal for the SA gas network, 1 July 2011 – 30 June 2016: Final Decision*, June 2011, page 186.

> 'The Lamberton data series uses an equal weighted rather than value weighted average of stock returns'

This statement is incorrect. As Kearns and Pagan (1993) point out: [129]

> 'Lamberton sought to create an index that
>
> > ... intended to show what would have happened to an investor's funds, if at the beginning of 1875, he had bought all shares quoted on the Sydney Stock Exchange, allocating his purchases among the individual issues in proportion to their total monetary value, and each month by the same criterion redistributed his holdings among all quoted shares (1958c, p. 254).
>
> Hence the series was designed to be comparable to the All Ordinaries Index.'

It is the dividends that Lamberton attaches to the series (that neither we use in our April 2011 report nor Kearns and Pagan use) that are equally weighted.

The AER also states that: [130]

> 'the Lamberton data series comprises dividend paying stocks only, which results in an overstatement of the market average. This is because not all stocks pay dividends.'

This statement is also incorrect. It is the equally weighted dividend series that is an average of the yields of only stocks that pay dividends. The price index is based on both stocks that pay dividends and stocks that do not pay dividends. Brailsford, Handley and Maheswaran (2008) report that the ASX creates an estimate of the value-weighted yield on the All Ordinaries by multiplying the Lamberton equally weighted yield series by 0.75. [131]

The AER suggests that using without-dividend returns will produce meaningfully different results than using with-dividend returns. For example, the AER states that: [132]

> 'The AER has considered the period 1958 onwards based on the analysis by Brailsford et. al., which suggested that the post-1958 period contains the highest data quality. However, the data used to estimate historical excess returns is actually different to the data used by NERA to estimate stock market variance and volatility (which does not incorporate dividend yield data). As a result it does not seem appropriate for NERA to segment this different dataset at 1958.'

We follow Kearns and Pagan in using without-dividend returns and, as they point out, dividends barely contribute to the volatility of stock returns so excluding them should not

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[129] Kearns, P. And A. Pagan, Australian stock market volatility: 1875-1987, Economic Record, page 164.

[130] AER, *Envestra Ltd Access arrangement proposal for the SA gas network, 1 July 2011 – 30 June 2016: Final Decision*, June 2011, page 186.

[131] Brailsford, T., J. Handley and K. Maheswaran, *Re-examination of the historical equity risk premium in Australia*, Accounting and Finance 48, 2008, page 80.

[132] AER, *Envestra Ltd Access arrangement proposal for the SA gas network, 1 July 2011 – 30 June 2016: Final Decision*, June 2011, page 189.

affect the results in any important way. [133] To address fully this point that the AER raises, though, we use the data that Brailsford, Handley and Maheswaran (2011) provide and that we update to test, later in this section, whether the volatility of the market portfolio has been stable over the last 129 years. [134] We find, as we did in our submission and as Kearns and Pagan found well before us, that the market portfolio was substantially less risky in the later part of the 19th century and the earlier part of the 20th century than in the later part of the 20th century and the early part of the 21st century.

Finally, the AER suggests that there are changes to the pre-1958 price data that Brailsford, Handley and Maheswaran (2008) make. For example, the AER states that: [135]

> 'NERA's data does not incorporate dividend yield data, nor is it clear if it incorporates adjustments to pre-1958 data noted by Brailsford et. al., which is discussed above.'

Brailsford, Handley and Maheswaran make no adjustments to the price data. As Brailsford, Handley and Maheswaran state: [136]

> 'The price index is an aggregation of the following three series: (i) the Commercial and Industrial index from 1882 to 1936; (ii) the Sydney All Ordinary Shares price index from 1936 to 1979; and (iii) the Australian Stock Exchange (ASX) All Ordinaries price index from 1980 to 2005.'

This is precisely the same series that Kearns and Pagan (1993) use. Kearns and Pagan, for example, describe the data that they use in the following way: [137]

> 'From January 1875 to June 1936 the index is the Commercial and Industrial Index; from July 1936 to December 1979 the Sydney All Ordinaries Index; and from January 1980 to December 1987, the Australian Stock Exchange All Ordinaries Index.'

B.3. Significance

The AER suggests that the observation that the market portfolio was substantially less risky in the later part of the 19th century and the earlier part of the 20th century than in the later part of the 20th century and the early part of the 21st century may be attributable to chance. For example, the AER states that: [138]

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133 Kearns, P. And A. Pagan, Australian stock market volatility: 1875-1987, Economic Record, page 164.

134 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

135 AER, *Envestra Ltd Access arrangement proposal for the SA gas network, 1 July 2011 – 30 June 2016: Final Decision*, June 2011, page 189.

136 Brailsford, T., J. Handley and K. Maheswaran, *Re-examination of the historical equity risk premium in Australia*, Accounting and Finance 48, 2008, page 78.

137 Kearns, P. And A. Pagan, Australian stock market volatility: 1875-1987, Economic Record, page 164.

138 AER, *Envestra Ltd Access arrangement proposal for the SA gas network, 1 July 2011 – 30 June 2016: Final Decision*, June 2011, page 188.

> 'NERA's analysis simply shows that there have been periods of high and low stock market variance and volatility over time'

This statement is incorrect. There was – as Kearns and Pagan point out – a dramatic increase in volatility in the latter part of the 20th century. [139] The update that we provided in our April 2011 report, *The market risk premium: A report for Multinet Gas and SP AusNet,* shows that this increase has on average been maintained in the first decade of the 21st century.

Since the AER appears to believe that our results are in part an artefact of the data that we and Kearns and Pagan use, we conduct tests here that use the data that Brailsford, Handley and Maheswaran (2011) supply and that we update. [140] The sample standard deviation of the returns computed using data from 1883 through 1957 is 10.4 per cent while the sample standard deviation computed using data from 1958 through 2011 is 22.7 per cent. [141] Thus the sample standard deviation of the returns from 1958 through 2011 is more than twice the sample standard deviation of the returns from 1883 through 1957.

Under the null hypothesis that there has been no change in the risk of the market portfolio over the last 129 years, the ratio

$$\frac{\hat{\sigma}^2_{1958-2011}}{\hat{\sigma}^2_{1883-1957}} \qquad \text{(B.1)}$$

will be F distributed with 54 – 1 = 53 and 75 – 1 = 74 degrees of freedom. The numerator is an estimate of the variance of the return to the market portfolio computed using the 54 years of data from 1958 through 2011 and the denominator is an estimate computed using the 75 years of data from before 1958. The ratio is $22.7^2 \div 10.4^2 = 4.72$ and the p-value associated with the statistic is 5.72×10^{-10}. This p-value is the probability that one would observe a ratio of 4.72 or larger if the risk of the market portfolio had not changed over the last 129 years. The fact that the p-value is so low indicates that one can reject the null hypothesis that there has been no change in the risk of the market portfolio over the last 129 years at all conventional levels of significance. Thus the difference between the risks of the market portfolio after 1957 and before 1958 is statistically significant whether one uses the data that Kearns and Pagan (1993) employ or the data that Brailsford, Handley and Maheswaran (2011) supply and that we update. [142]

It is possible that the AER may also be concerned that the shift in risk that Kearns and Pagan (1993) document is the result of data snooping. In other words, it may be that the AER is concerned that Kearns and Pagan have used the data to construct a hypothesis and it is this use of the data that is responsible for the apparent evidence against the hypothesis.

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139 Kearns, P. and A. Pagan, Australian stock market volatility: 1875-1987, Economic Record, page 163.

140 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

141 These estimates use the return to the All Ordinaries. Estimates that use the return in excess of the 10-year bond yield are very similar. They are 10.6 per cent and 22.6 per cent.

142 Kearns, P. And A. Pagan, Australian stock market volatility: 1875-1987, Economic Record, pages 163-178.

Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

To assess whether data snooping could produce a p-value as low as we compute, we conduct simulations. The simulations use 100,000 replications. For each replication, we draw 129 annual excess returns at random from a normal distribution that has the same mean and standard deviation, 6.1 per cent and 16.6 per cent, as the imputation-adjusted data that Brailsford, Handley and Maheswaran (2011) supply and that we update.[143] We split each set of 129 annual excess returns into two subsets. The first subset contains the first *n* observations while the second subset contains the last 129 – *n* observations. We set *n* = 2, 3, ..., 127. So we split each set of 129 annual excess returns in 126 different ways. We also compute 126 *F*-test statistics and the 126 p-values associated with the statistics. Thus, in total, we compute 12.6 million p-values. We find that none of these 12.6 million p-values is as low as 5.72×10^{-10}, the value that we compute using the data that Brailsford, Handley and Maheswaran (2011) supply and that we update.[144] Thus we conclude that data snooping cannot explain the shift in risk that Kearns and Pagan find and that we confirm exists. The evidence indicates that the shift is real.

Besides assessing the statistical significance of the shifts in the risk of the market portfolio that have taken place, it is also useful to assess the economic significance of the shifts. One way of assessing the significance of the shifts is to ask what portfolio of stocks and bonds would have the same risk from 1958 onwards as the market portfolio from 1883 through 1957. The answer to the question is that a portfolio with a weight of 10.4 ÷ 22.7 = 0.46 in stocks and 0.54 in bills would have the same estimated risk from 1958 onwards as the market portfolio from 1883 through 1957. The substantial weight that one would have to place in bills after 1957 to mimic the behaviour of the market portfolio before 1958 is a measure of the economic significance of the shift in the volatility of the market portfolio

B.4. Risk and Return

The AER argues that it is unreasonable to expect that a shift in the risk of the market portfolio will be accompanied by a shift in the *MRP* if one cannot identify why the risk of the market portfolio has changed. For example, the AER states that:

> 'If NERA's data was segmented at 1958 on an economically justifiable basis, its analysis may be relevant. However, NERA did not posit any economic reason why volatility would be greater after 1958 in particular'

Merton's model (17) indicates that there should be a positive relation between the market risk premium and the volatility of the market regardless of what is responsible for the volatility. Thus an observation that the volatility of the market before 1958 was far lower than the volatility after suggests that the market risk premium should have been lower before 1958 than after – regardless of what was responsible for the change in volatility.

So if the risk of the market portfolio computed from the earlier years of the data that Brailsford, Handley and Maheswaran (2011) supply is lower than the risk calculated from the

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143 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

144 Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

later years of the data and Merton's model is true, then an estimate of the *MRP* that ignores the change will underestimate the current *MRP*. [145]

[145] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data,* Accounting and Finance, 2011.

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