HOUSTONKEMP
Economists

Memo

To	Garth Crawford, Roxanne Smith
From	Simon Wheatley
Copy	Greg Houston
Subject	Forecasting dividend growth
Date	24 September 2018

The AER released its *Draft Rate of Return Guidelines* and an accompanying *Explanatory Statement* on 10 July 2018. In the statement, the AER discusses dividend growth models as one way to estimate the market risk premium (MRP), but does not alter its estimate of the MRP based on a dividend growth model (DGM) due to what it describes as increased (since 2013)[1]

> concerns about biases of the model and the divergent results from alternative versions of the model.

In particular, the AER states that DGM estimates of the MRP are[2]

> no longer sufficiently reliable

with the major concern being[3]

> the challenge of forecasting the growth rates in dividends, particularly the terminal growth rate.

The AER refers to potential growth rates ranging between one per cent and 5.5 per cent per annum.[4]

Energy Networks Australia has asked HoustonKemp its views on the following:

- Whether, and if so how, real dividend growth can be estimated or forecast by examining the relation between it and real gross domestic product (GDP) growth.
- Based on any such relation, and forecasts of real GDP growth, what is the best estimate or forecast of current real dividend growth?
- In relation to the best estimate or forecast, what is the confidence interval around this estimate, and how does this compare and contrast with the ranges of estimates derived by the AER (in both 2013 and 2018) for real dividend growth?

We provide our views on these questions below.

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[1] AER, *Draft rate of return guidelines: Explanatory statement*, July 2018, page 216.

[2] AER, *Draft rate of return guidelines: Explanatory statement*, July 2018, page 217.

[3] AER, *Draft rate of return guidelines: Explanatory statement*, July 2018, page 217.

[4] AER, *Draft rate of return guidelines: Explanatory statement*, July 2018, page 219.

Summary

1. The growth in real dividends per share can be forecast by examining the relation between it and real GDP growth.
2. Based on this relation, our best forecast of the long-run growth in real dividends per share is 3.815 per cent per annum.
3. A 90 per cent confidence interval around this forecast lies from 3.377 to 4.253 per cent per annum.
4. This range is considerably narrower than the range of one to 5.5 per cent per annum that the AER provides that is, inappropriately, based on a mixture of real and nominal dividend growth forecasts.

Introduction

A forecast of long-run real dividends per share (DPS) growth plays an important role in constructing an estimate of the MRP that relies on some version of the DGM. A common approach to producing a forecast of long-run real DPS growth is to use a forecast of long-run real GDP growth.[5] There is some controversy, however, as to whether one should set a forecast of long-run real DPS growth equal to a forecast of long-run real GDP growth or whether one should first subtract an amount from long-run real GDP growth to reflect the contribution to real GDP growth of the issuance of new shares.[6] Ultimately, whether long-run real DPS growth falls below long-run real GDP growth and if so by how much is an empirical issue.

In this memo, we examine the empirical issue using Australian data. We find no evidence in Australian data that long-run real DPS growth sits significantly below long-run real GDP growth.[7] This implies that it is reasonable to set a forecast of long-run real DPS growth equal to a forecast of long-run real GDP growth *without* subtracting an amount from long-run real GDP growth to reflect the contribution to real GDP growth of the issuance of new shares.

We also point out two deficiencies with the range that the AER provides for estimates of long-run real DPS growth. First, while the one per cent per annum estimate that represents the lower end of the range is an estimate of long-run *real* DPS growth, the 5.5 per cent estimate that forms the upper end of the range is almost surely an estimate of long-run *nominal* DPS growth. Producing a range for long-run real DPS growth by mixing together estimates of real DPS growth with estimates of nominal DPS growth will produce the appearance that there is more disagreement and more uncertainty about what long-run real DPS growth is than really exists.

Second, the one per cent estimate that represents the lower end of the AER's range for real DPS growth is a geometric mean. Since real DPS growth is volatile, an estimate of mean real DPS

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

[6] Bernstein, W.J. and R.D. Arnott, *Earnings growth: the two percent dilution*, Financial Analysts Journal, 2003, pages 47-55.

[7] This is true whether we use real DPS growth and real GDP growth that are continuously compounded or not continuously compounded.

growth that uses a geometric mean will sit some way below an estimate that uses an arithmetic mean and will be a downwardly biased estimate of mean real DPS growth over a single year. Were the AER to compound a return estimate delivered by the DGM and an estimate of mean real DPS growth that uses a geometric mean over many, many years, this downward bias might not pose a problem. While the AER will forecast the revenue that should flow to a firm over each of the several years of a typical regulatory period, however, the AER, to all intents and purposes, never compounds an estimate of a mean rate of return. [8] It follows that the AER, in using the DGM to estimate the MRP, should place *no weight* on estimates of long-run real DPS growth that use geometric means. [9]

Data

We examine the behaviour of real DPS growth and real GDP growth from 1981 to 2017. We use data over this period because daily price and accumulation indices for the S&P/ASX All Ordinaries are available from 1980 onwards that allow one to accurately compute a DPS series for the index. We use the quarterly All Groups CPI; Australia series (A2325846C) from the Australian Bureau of Statistics (ABS) to deflate the dividends that the All Ordinaries throws off each quarter. [10] We then, for each year, sum each quarter's real DPS to arrive at an annual measure. Similarly, we use the quarterly real Gross domestic product: Chain volume measures series (A2302459A) from the ABS and, for each year, sum each quarter's real GDP to arrive at an annual measure of GDP. [11] We temporally aggregate the data because we do not wish to be distracted by concerns over seasonality.

Figure 1 shows how real DPS and real GDP have evolved over time. In particular, the figure plots the logarithm of real DPS and the logarithm of real GDP against time. [12] The figure shows that both real DPS and real GDP have grown at about the same pace. While real GDP growth, however, has been relatively steady, real DPS growth has wandered. The figure suggests, though, that the difference between the logarithms of the two series (and so, also the ratio of DPS to GDP) is mean reverting and the difference has trended neither up nor down.

Confirmation of these observations appears in Table 1 which provides summary statistics for real DPS and real GDP growth. We use in our empirical analysis, for convenience, logarithms of real DPS, logarithms of GDP, continuously compounded real DPS growth and continuously compounded real GDP growth. As Campbell, Lo and MacKinlay (1997) point out, it is common to make this choice when examining time series because the use of logarithms turns multiplication into addition and:[13]

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[8] NERA, *Prevailing conditions and the market risk premium*, March 2012, pages 3-16.

[9] Appendices A and B to this memo examine the impact of using geometric means rather than arithmetic means to estimate, as an input to the DGM, mean real DPS growth.

[10] From TABLES 1 and 2. CPI: All Groups, Index Numbers and Percentage Changes, available at:
http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6401.0Jun%202018?OpenDocument

[11] From Table 1. Key National Accounts Aggregates, available at:
http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5206.0Mar%202018?OpenDocument

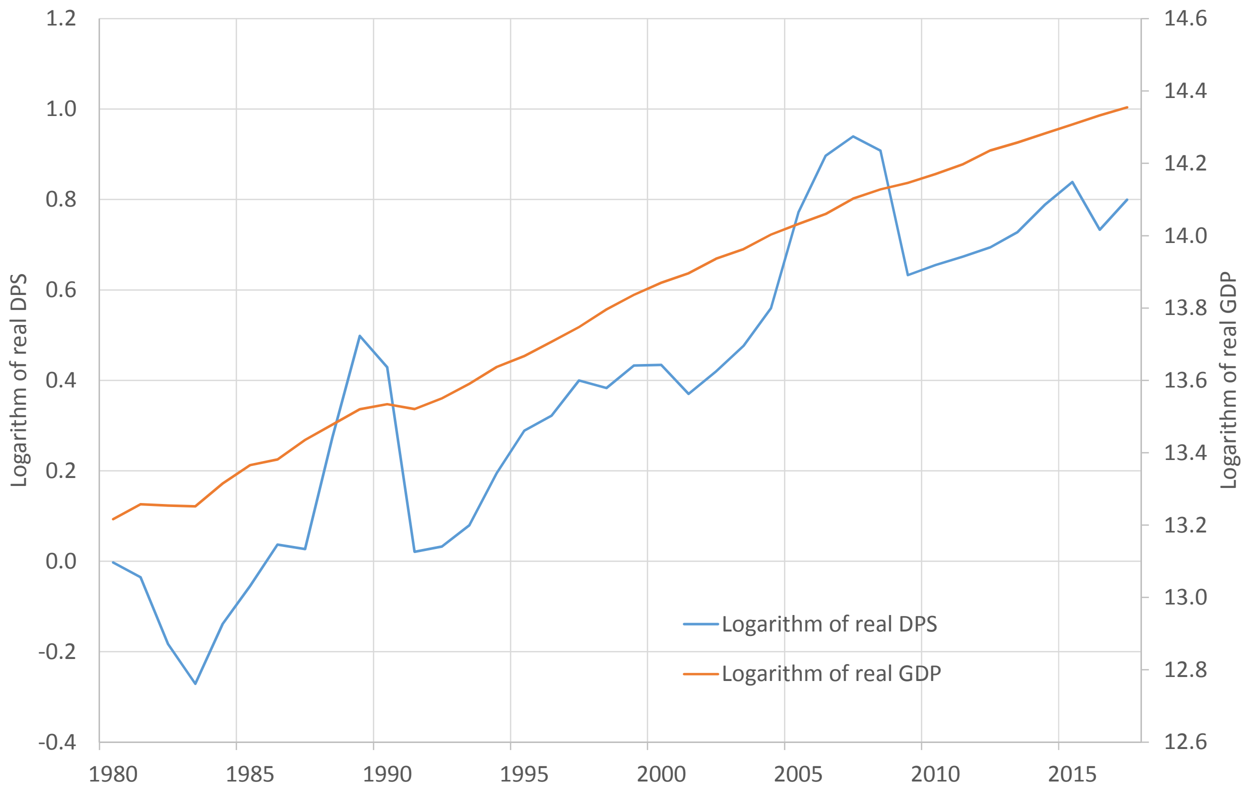
[12] All logarithms to which we refer in this memo are natural logarithms.

[13] Campbell, J.Y., A.W. Lo, and A.C. MacKinlay, *The econometrics of financial markets*, Princeton University Press, 1997, page 11.

it is far easier to derive the time series properties of additive processes than of multiplicative processes.

The use of logarithms also turns ratios into differences and it is often easier to derive the properties of differences than of ratios.

Figure 1: The evolution of real dividends and real gross domestic product through time



Notes: Data are from the ABS and S&P.

Table 1 shows that the means of not continuously compounded real DPS growth and real GDP growth differ little but that real DPS growth is much more volatile than real GDP growth.

Let:

D_t	=	real DPS;
d_t	=	the logarithm of real DPS; and
Δ	=	the first difference operator, so that Δd_t is real DPS growth.

It is well known that, approximately, mean not continuously compounded real DPS growth will be given by:

$$\mathrm{E}\left(\frac{D_t - D_{t-1}}{D_{t-1}}\right) \approx \mathrm{E}(\Delta d_t) + \mathrm{Var}(\Delta d_t) / 2, \qquad (1)$$

where E(.) denotes the expectation operator and Var(.) denotes a variance. A similar condition will also hold for real GDP growth. Equation (1) implies that mean continuously compounded real DPS growth will fall below mean not continuously compounded real DPS growth and that is what Table 1 shows to be the case. The DGM – if it is to be used to estimate the mean return to the market portfolio over a single year – requires an estimate of mean not continuously compounded real DPS growth and this should be borne in mind in what follows. Mean continuously compounded real GDP growth also falls below mean not continuously compounded real GDP growth but the gap between the two is smaller because real GDP growth is less volatile than is real DPS growth.

Table 1: Summary statistics

Variable	Mean	Standard deviation
	Panel A: Not continuously compounded	
Real DPS growth	2.910	11.830
Real GDP growth	3.137	1.614
	Panel B: Continuously compounded	
Real DPS growth	2.169	12.282
Real GDP growth	3.077	1.573

Notes: All statistics are in per cent per annum. Data are from the ABS and S&P.

Analysis

If long-run mean real DPS growth falls below long-run mean real GDP growth by a constant, then the difference between log real DPS and log real GDP should trend downward through time. If long-run mean real DPS growth falls below long-run mean real GDP growth by an amount that is not constant, then the difference between log real DPS and log real GDP may not be stationary. We test whether the difference between log real DPS and log real GDP has a unit root and whether the difference trends downward through time by estimating the parameters of the augmented Dickey-Fuller regression:

$$d_t - y_t = \alpha + \beta(d_{t-1} - y_{t-1}) + \gamma t + \sum_{s=1}^{S} \delta_s(\Delta d_{t-s} - \Delta y_{t-s}) + \varepsilon_t, \qquad (2)$$

where:

y_t	=	the logarithm of real GDP;
t	=	time;
ε_t	=	the regression disturbance; and
$\alpha, \beta, \gamma, \delta_s$	=	regression parameters.

For long-run mean real DPS growth to match long-run mean real GDP growth it must be the case that $\beta < 1$ and $\gamma = 0$. We test these hypotheses using, for the first hypothesis, inference based on the results of Fuller (1976).[14]

Since we are ultimately interested in using real GDP growth to forecast real DPS growth, we also estimate the parameters of the augmented Dickey-Fuller regression:

$$y_t = \psi + \rho y_{t-1} + \theta t + \sum_{w=1}^{W} \phi_s \Delta y_{t-s} + \eta_t, \tag{3}$$

where:

η_t	=	the regression disturbance; and
$\psi, \rho, \theta, \phi_s$	=	regression parameters.

We test whether $\rho < 1$ and $\theta = 0$ and, for the first hypothesis, we use inference, again, based on the results of Fuller.

Evidence

We choose values for the number of lagged changes using the Schwarz information criterion.[15] This criterion can be used to assess how well a model fits the data while striking a balance between a better fit and model parsimony. The use of this criterion leads to a choice of $S = 1$ for (2), the regression we use to test whether the difference between log real DPS and log real GDP has a unit root and whether the difference trends downward through time. The use of the Schwarz criterion leads to the jettisoning of all lagged changes from (3), the regression we use to test whether real GDP is nonstationary or trend stationary.

Table 2 provides the results of our unit root tests. The results indicate that we can reject the hypothesis that the difference between log real DPS and log real GDP has a unit root and that we cannot reject the hypothesis that the difference does not trend through time. On the other hand, we cannot reject the hypothesis that real GDP has a unit root while there is weak evidence that the series may also trend through time.

[14] Fuller, W.A., *Introduction to statistical time series*, Wiley, New York, 1976.

[15] Hayashi, F., *Econometrics*, Princeton University Press, 2000, pages 396-397.

Table 2: Unit root tests

$\hat{\alpha}$	$\hat{\beta}$	$100 \times \hat{\gamma}$	$\hat{\delta}$	$\hat{\psi}$	$\hat{\rho}$	$100 \times \hat{\theta}$
-7.290	0.453	-0.206	0.499	2.936	0.780	0.704
(1.757)	(0.132)	(0.158)	(0.154)	(1.577)	(0.120)	(0.389)
	[0.012]	[0.202]			[0.665]	[0.079]

Notes: The models are:

$$d_t - y_t = \alpha + \beta(d_{t-1} - y_{t-1}) + \gamma t + \delta(\Delta d_{t-1} - \Delta y_{t-1}) + \varepsilon_t, \quad y_t = \psi + \rho y_{t-1} + \theta t + \eta_t,$$

Estimates are outside of parentheses, standard errors are in parentheses, Fuller p-values for tests for a unit root are in brackets under estimates of the autoregressive parameters and p-values for tests of no trend are in brackets under estimates of the trend parameters.

In light of the evidence that the difference between log real DPS and log real GDP does not trend through time, we drop the trend term from (2) and search again across specifications using the Schwarz criterion. Use of the criterion suggests that we jettison all lagged changes from (2). In light of the evidence that real GDP has a unit root, we use the Schwarz criterion to assess models that regress real GDP growth on:

- a constant;
- a constant and lagged real GDP growth;
- a constant and a time trend; and
- a constant, lagged real GDP growth and a time trend.

Use of the Schwarz criterion suggests that the simplest of these models, one that uses as a regressor solely a constant, offers the best trade-off between fit and parsimony.

Table 3 below provides the results of estimating these models for the difference between log real DPS and log real GDP and for real GDP growth while Figure 2 provides forecasts of real DPS growth that use the two models and 90 per cent confidence intervals for these forecasts. Although the model for real GDP growth could not be simpler, forecasts that it produces come close to matching the forecasts that the Reserve Bank of Australia is currently making that range from 3 to 3.25 per cent per annum.[16, 17]

It is important to note that in Figure 2 the confidence intervals measure the uncertainty that surrounds the forecasts rather than the uncertainty that exists about what future real DPS growth will be. It is also important to note that the impact of a relatively low real DPS to real GDP ratio dissipates as the forecasting horizon rises. It is for this reason and, again, because the confidence intervals measure the uncertainty that surrounds the forecasts rather than the uncertainty that

[16] https://www.rba.gov.au/publications/smp/2018/aug/economic-outlook.html

[17] While the real GDP growth forecasts that the RBA reports are not continuously compounded, the forecasts that we report are continuously compounded. Differences between forecasts of continuously compounded and not continuously compounded real GDP growth will be small, however, because real GDP growth is relatively smooth.

exists about what future real DPS growth will be that the confidence intervals shrink as the forecast horizon lengthens.

Table 3: Evidence on the behaviour of real DPS growth and real GDP growth

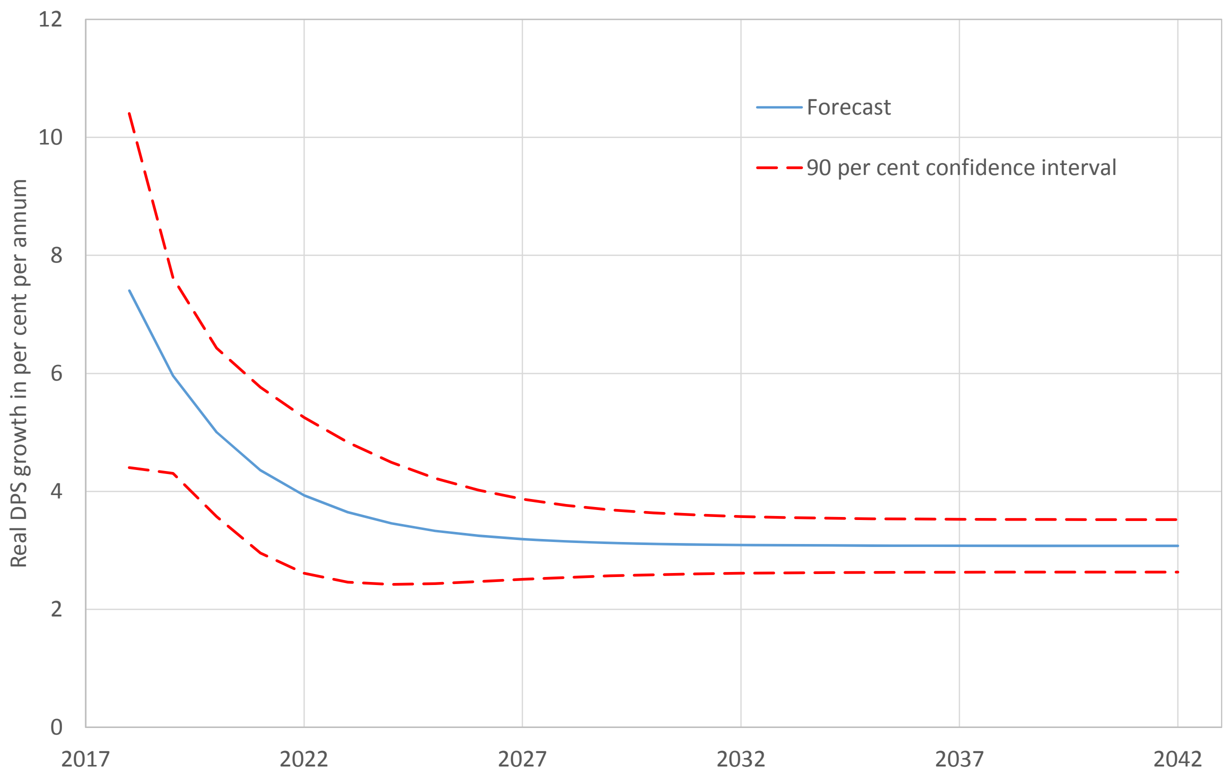
$\hat{\alpha}$	$\hat{\beta}$	$100 \times \hat{\mu}$
-4.473 (2.139)	0.667 (0.159)	3.077 (0.267)

Notes: The models are:

$$d_t - y_t = \alpha + \beta(d_{t-1} - y_{t-1}) + \varepsilon_t, \quad \Delta y_t = \psi + \eta_t$$

Estimates are outside of parentheses while heteroscedasticity and autocorrelation consistent standard errors are in parentheses.

Figure 2: Real DPS growth forecasts



Notes: The forecasts use the models

$$d_t - y_t = \alpha + \beta(d_{t-1} - y_{t-1}) + \varepsilon_t, \quad \Delta y_t = \psi + \eta_t$$

The models that we use forecast that short-run real DPS growth will be relatively high because the ratio of real DPS to real GDP is currently low relative to its past and the evidence suggests that the ratio is mean reverting. In the long run, however, the models predict that real DPS growth will match forecast real GDP growth, which sits at around three per cent per annum.[18] The standard error attached to this forecast is simply the standard error of the historical mean of real GDP growth over the period 1981 to 2017 of, from Table 3, 0.267 per cent per annum. Thus a 90 per cent confidence interval for long-run real DPS growth is 3.077 ± 1.645 × 0.267 per cent per annum, that is, 2.638 to 3.515 per cent per annum.

The predictions that appear in Figure 2 are of the continuously compounded growth in real DPS. Forecasts of the not continuously compounded growth in real DPS that the DGM requires – if the DGM is to be used to estimate the mean return to the market portfolio over a single year – will, because of relation (1), be higher. A 90 per cent confidence interval for long-run not continuously compounded real DPS growth is 3.815 ± 1.645 × 0.266 per cent per annum, that is, 3.377 to 4.253 per cent per annum.[19]

Discussion

The AER in its *Draft Rate of Return Guidelines* provides potential growth rates ranging between one per cent and 5.5 per cent per annum.[20] There are two deficiencies with the range that the AER provides. First, while the estimate of one per cent is an estimate of long-run real DPS growth, the estimate of 5.5 per cent is almost surely an estimate of long-run nominal DPS growth. We are not aware of anyone who has suggested that long-run real DPS growth is as high as 5.5 per cent per annum. The estimate of 5.5 per cent appears to be Lally's upper bound of 5.6 per cent for nominal DPS growth rounded down.[21] Producing a range for long-run real DPS growth by mixing together estimates of real DPS growth with estimates of nominal DPS growth will produce the appearance that there is more disagreement and more uncertainty about what long-run real DPS growth is than really exists.

Second, the estimate of one per cent comes from the work of Dimson, Marsh and Staunton (2011) who report that they find that mean real DPS growth in Australia is 1.10 per cent per annum over the years 1900 to 2010.[22] Although Dimson, Marsh and Staunton are not completely clear that this mean is geometric, detective work – described in Appendix B below – suggests that it is. Since real DPS growth is volatile, an estimate of mean real DPS growth that uses a geometric mean will sit some way below an estimate that uses an arithmetic mean and will be a downwardly biased

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[18] In earlier work, NERA, although it does not examine the tendency for the ratio of real DPS to real GDP to mean revert, reaches the same conclusion.

NERA, *Prevailing conditions and the market risk premium*, 2012, March 2012.

[19] Note that the standard error attached to an estimate of the long-run not continuously compounded growth in real DPS lies marginally below the standard error attached to an estimate of the long-run continuously compounded growth in real DPS. This is because the heteroscedasticity and autocorrelation consistent estimate generated of the covariance between an estimator of mean continuously compounded real GDP growth and an estimator of the unconditional variance of continuously compounded real DPS growth is negative.

[20] AER, *Draft rate of return guidelines: Explanatory statement*, July 2018, page 219.

[21] Lally, M., *The dividend growth model*, March 2013, pages 13-20.

[22] Dimson, E., P. Marsh and M. Staunton, *Equity premiums around the world*, in Hammond, P., M, Leibowitz and L. Siegel (eds), Rethinking the equity risk premium, The Research Foundation of the CFA Institute, 2011.

estimate of mean real DPS growth over a single year. Were the AER to compound a return estimate delivered by the DGM and an estimate of mean real DPS growth that uses a geometric mean over many, many years, this downward bias might not pose a problem. While the AER will forecast the revenue that should flow to a firm over each of the several years of a typical regulatory period, however, the AER, to all intents and purposes, never compounds an estimate of a mean rate of return. It follows that the AER, in using the DGM to estimate the MRP, should place no weight on estimates of long-run real DPS growth that use geometric means.

Recognising that an estimate of real DPS growth of one per cent per annum is too low and that an estimate of real DPS growth of 5.5 per cent per annum is too high will narrow the AER's range of estimates and, we believe, reduce the differences between that range and the range of estimates that we supply in this memo.

Finally, we note that the confidence intervals that we provide in Figure 2 measure solely the uncertainty that exists about the parameters of the models that we use. They do not measure the uncertainty that may exist about which model one should use. It is unclear, however, whether better models exist for forecasting long-run real DPS growth and so it is unclear whether accounting for model uncertainty would significantly widen the confidence intervals that we report.

Appendix A

In a simple version of the DGM, the mean return to the market portfolio is a linear function of long-run real DPS growth. Thus one would expect an estimate of the one-year mean rate of return to the market portfolio that uses the DGM and that uses an estimate of long-run real DPS growth that is based on an arithmetic mean to be unbiased. In contrast, one would expect an estimate of the mean rate of return to the market portfolio over many years that uses the DGM and that uses an estimate of long-run real DPS growth that is based solely on an arithmetic mean to be biased upwards. Also, one would expect an estimate of the one-year mean rate of return to the market portfolio that uses the DGM and that uses an estimate of long-run real DPS growth that is based on a geometric mean to be biased downwards. We illustrate that these expectations are borne out using simulations.

A simple version of the DGM states that the mean return to the market portfolio at time t will be:

$$Y_t(1+g)+g \tag{4}$$

where:

Y_t	=	the yield on the market portfolio at the end of year t; and
g	=	long-run nominal DPS growth.

We assume, for simplicity, that the yield on the market portfolio is four per cent and inflation is non-stochastic and known to be 2.5 per cent per annum. In addition, we assume that:

$$\Delta d_t \sim N(\mu,\sigma^2), \qquad \mu+\sigma^2/2=0.03 \tag{5}$$

Thus we assume that mean not continuously compounded real DPS growth is, approximately, three per cent per annum.

Table 4 shows that an estimate of the one-year mean rate of return to the market portfolio that uses the DGM and an estimate of long-run real DPS growth that is based on an arithmetic mean is unbiased. In contrast, the table shows that an estimate of the mean rate of return to the market portfolio over many years that uses the DGM and an estimate of long-run real DPS growth that is based solely on an arithmetic mean is biased upwards. The bias is more severe the more volatile is real DPS growth and the smaller the size of the sample on which the estimate is based. The table also shows that an estimate of the one-year mean rate of return to the market portfolio that uses the DGM and an estimate of long-run real DPS growth that is based on a geometric mean is biased downwards. The bias is more severe the more volatile is real DPS growth.

Table 4: Properties of DGM estimates of mean multi-period returns

	Horizon in years						
	1	2	3	4	5	10	20
Parameter	9.8	20.6	32.4	45.3	59.6	154.7	548.5
Panel A: $\mu = 2.219$ per cent per annum, $\sigma = 12.5$ per cent per annum, T=120							
Arithmetic mean	9.8	20.7	32.6	45.7	60.2	157.4	571.2
Geometric mean	9.0	18.8	29.6	41.3	54.1	138.2	474.8
Panel B: $\mu = 2.219$ per cent per annum, $\sigma = 12.5$ per cent per annum, T=40							
Arithmetic mean	9.8	20.7	32.7	46.0	60.6	160.4	605.6
Geometric mean	9.0	18.9	29.7	41.6	54.6	141.3	505.6
Panel C: $\mu = 1.875$ per cent per annum, $\sigma = 15.0$ per cent per annum, T=120							
Arithmetic mean	9.9	20.7	32.6	45.8	60.3	158.2	579.2
Geometric mean	8.6	18.0	28.3	39.4	51.6	130.9	443.1
Panel D: $\mu = 1.875$ per cent per annum, $\sigma = 15.0$ per cent per annum, T=40							
Arithmetic mean	9.8	20.7	32.7	46.0	60.8	162.2	627.5
Geometric mean	8.6	18.1	28.4	39.8	52.2	134.9	483.5

Notes: The simulation results are the averages across 100,000 replications of estimates, in per cent per annum, of the mean rate of return to the market portfolio over various horizons. T denotes the number of years in each sample.

While the AER will forecast the revenue that should flow to a firm over each of the several years of a typical regulatory period, at no stage, aside from in making minor adjustments to the regulated asset base and to the evolution of prices, does the AER compound an estimate of a mean rate of return.[23] It follows that the AER, in using the DGM to estimate the MRP, should place no weight on estimates of long-run real DPS growth that use geometric means.

Although the simulations examine a simple one-stage version of the DGM, we would not expect to find very different results using two-stage and three-stage models or models in which there is uncertainty about future inflation.

Appendix B

A key message of the work of Bernstein and Arnott (2003) is that empirically real DPS growth falls on average below real GDP growth.[24] For example, using data provided by Dimson, Marsh and Staunton and Maddison, they report that from 1900 to 2000 mean real DPS growth in Australia is 0.9 per cent annum while mean real GDP growth is 3.3 per cent per annum. While Bernstein and Arnott are not clear about whether the means that they report are arithmetic or geometric, detective work suggests that the means are geometric. Since real DPS growth is substantially more volatile than real GDP growth, this suggests that were Bernstein and Arnott to have compared arithmetic rather than geometric means, they would have found a significantly smaller gap between mean real DPS growth and mean real GDP growth.

The AER, in its *Explanatory Statement*, cites a report by Bianchi, Drew and Walk, sponsored by Challenger, as providing a similarly low estimate of real DPS growth of around one per cent per annum.[25] The estimate that Bianchi, Drew and Walk provide comes from the work of Dimson, Marsh and Staunton (2011) who report that they find that mean real DPS growth in Australia is 1.10 per cent per annum over the years 1900 to 2010.[26] Although Dimson, Marsh and Staunton are not completely clear that this mean is geometric, detective work, again, suggests that it is. While the estimates that Bernstein and Arnott report are after translating all relevant data into US dollars, the estimates that Dimson, Marsh and Staunton report are before translating all relevant data. Translating the data, however, evidently has little effect on the estimates that the two sets of authors provide.

As Appendix A makes clear, an estimate of the one-year mean rate of return to the market portfolio that uses the DGM and that uses an estimate of long-run real DPS growth that is based on an arithmetic mean will be unbiased. In contrast, an estimate of the one-year mean rate of return to the market portfolio that uses the DGM and that uses an estimate of long-run real DPS growth that is based on a geometric mean will be biased downwards. An estimate of the mean rate of return to the market portfolio over many years that uses the DGM and that uses an estimate of long-run real DPS growth that is based solely on an arithmetic mean will be biased upwards. However, while the AER will forecast the revenue that should flow to a firm over each of the several years of a typical regulatory period, the AER, to all intents and purposes, never compounds an estimate of a mean

[23] NERA, *Prevailing conditions and the market risk premium*, March 2012, pages 3-16.

[24] Bernstein, W.J. and R.D. Arnott, *Earnings growth: The two per cent dilution*, Financial Analysts Journal, 2003, pages 47-55.

[25] AER, *Draft rate of return guidelines: Explanatory statement*, July 2018, page 219.

Bianchi, R.J., M.E. Drew and A.N. Walk, *The (un)predictable equity risk premium*, Challenger, 2015, page 24.

[26] Dimson, E., P. Marsh and M. Staunton, *Equity premiums around the world*, in Hammond, P., M, Leibowitz and L. Siegel (eds), Rethinking the equity risk premium, The Research Foundation of the CFA Institute, 2011.

rate of return. [27] Thus the AER, in using the DGM to estimate the MRP, should place no weight on estimates of long-run real DPS growth that use geometric means.

In what follows we examine the difference between estimates of long-run real DPS growth, based on data that resemble the series that Dimson, Marsh and Staunton employ, that use arithmetic means and estimates that use geometric means. To do so, we use the data that Brailsford, Handley and Maheswaran (2012) provide and variants of the data. [28]

The data that Brailsford, Handley and Maheswaran provide employ a series of yields that Lamberton (1961) supplies.[29] Brailsford, Handley and Maheswaran (2008) suggest that the series that Lamberton supplies overstates the yield on the Commercial and Industrial/All Ordinaries price series that Lamberton (1958) also provides.[30] Evidence from original sources for the yields that NERA provides in June 2013, October 2013 and June 2015, however, suggests that some adjustments should be made to Lamberton's yield data but that the adjustments should be smaller, on average, than the adjustments that Brailsford, Handley and Maheswaran believe to be appropriate.[31]

We use three series:

- we update the data that Brailsford, Handley and Maheswaran provide;
- we produce NERA-adjusted data that employ the adjustments that NERA makes in its June 2015 report; and
- we produce unadjusted data that employ no adjustments to Lamberton's series of dividend yields.

We label the first series, the BHM series, the second series, the NERA series, and the third series, the Lamberton series. We note that Dimson, Marsh and Staunton, in their Credit Suisse Global Investment Returns Yearbooks, currently use Lamberton's yields and the NERA adjustments but that prior to 2016 they used the Lamberton yields without any adjustments. [32] At no stage did Dimson, Marsh and Staunton use the adjustments that Brailsford, Handley and Maheswaran employ. We also note that the dividend and price series that Dimson, Marsh and Staunton use

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[27] NERA, *Prevailing conditions and the market risk premium*, March 2012, pages 3-16.

[28] Brailsford, T., J. Handley and K. Maheswaran, *The historical equity risk premium in Australia: Post-GFC and 128 years of data*, Accounting and Finance, 2012, pages 237-247.

[29] Lamberton, D., *Ordinary share yields: A new statistical series*, Sydney Stock Exchange Official Gazette, 14 July 1961.

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

Lamberton, D., *Security prices and yields*, Sydney Stock Exchange Official Gazette, 14 July 1958.

Lamberton, D., *Share price indices in Australia*, Sydney: Law Book Company, 1958.

[31] NERA, *Market, size and value premiums: A report for the ENA*, June 2013.

NERA, *The market risk premium: Analysis in response to the AER's Draft Rate of Return Guidelines*, October 2013.

NERA, *Further assessment of the historical MRP: Response to the AER's final decisions for the NSW and ACT electricity distributors: A report for ActewAGL Distribution, AGN, APA, AusNet Services, CitiPower, Energex, Ergon Energy, Jemena Electricity Networks, Powercor, SA Power Networks and United Energy*, June 2015.

[32] Credit Suisse Global Investment Returns Yearbook 2015, February 2015, page 61.

Credit Suisse Global Investment Returns Yearbook 2018, February 2018, pages 86-87.

(and used prior to 2016) for the period 1958 to 1979 employ different sources than those that Brailsford, Handley and Maheswaran employ and the variants of the Brailsford, Handley and Maheswaran data that we produce employ.

Table 5 below provides the arithmetic and geometric means of real DPS growth using the three series over three periods:

- 1900 to 2000;
- 1900 to 2010; and
- 1883 to 2017.

We compute real DPS growth from year $t-1$ to year t as:

$$\left(\frac{R_t - X_t}{R_{t-1} - X_{t-1}}\right)\left(\frac{1+X_{t-1}}{1+\Pi_t}\right) - 1 \qquad (6)$$

where:

R_t	=	the with-dividend return to the market portfolio from year $t-1$ to year t;
X_t	=	the without-dividend return to the market portfolio from year $t-1$ to year t; and
Π_t	=	inflation from year $t-1$ to year t.

Computing real DPS growth in this way will not produce as accurate a measure as we produce in the text from 1981 to 2017 because the with-dividend return to the market over one year will include returns earned or losses incurred from re-investing dividends paid out during the year. We do not know, however, how Bernstein and Arnott and Dimson, Marsh and Staunton computed real DPS growth and so we use the simple formula (6).

Table 5 shows that geometric mean estimates of long-run real DPS growth sit well below their arithmetic mean counterparts and suggests that the estimates that Bernstein and Arnott and Dimson, Marsh and Staunton produce and the one per cent estimate to which the AER refers are geometric means. Again, the AER, to all intents and purposes, never compounds an estimate of a mean rate of return and so no weight should be placed on an estimate of long-run real DPS growth that uses a geometric mean. An estimate of long-run real DPS growth that uses an arithmetic mean and the AER's preferred series, the BHM series – which, again, is not the series that Dimson, Marsh and Staunton employ – is 2.74 per cent per annum using data from 1883 to 2017.

Table 5: Estimates of real DPS growth using annual data from 1883 to 2017

	Lamberton		NERA		BHM	
Period	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1900-2000	2.40	1.30	2.53	1.45	2.68	1.60
1900-2010	2.62	1.44	2.73	1.58	2.87	1.72
1883-2017	2.53	1.48	2.47	1.44	2.74	1.71