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6 May 2022

Dear Jason,

Thank you for the opportunity to comment on your recent discussion paper which focused on beta and the MRP within the wider context of the Rate of Return Instrument, and for the opportunity to discuss these issues with you at your recent stakeholder forum.

Questions – Equity beta

As we point out in our original submission, we believe that the ERA has taken an important step to address what has long been a problem for Australian regulators, but which has now become acute; the lack of comparator companies to robustly estimate beta.[1] No source of data will ever be perfect and it remains our view that international comparators provide useful information for this purpose.

We commend the work done by CEG for APGA, and submitted as part of the AER's RoRI process, which seeks to test some of the commonly raised potential problems associated with the use of international firms.[2] We acknowledge the work by CEG is not the only way to do such tests, but we think it is an important step forward. It also shows that many of the potential problems that have been identified in the past are probably not particularly major.

We now turn to answering the ERA's questions

1. *Are the firms selected by the ERA in the discussion paper appropriate? If there are firms which are inappropriate, what characteristics make them inappropriate?*

Broadly-speaking, we believe that the ERA has produced a reasonable list of comparator companies from the different jurisdictions. We understand that the ERA has used a filtering mechanism similar to that used by the New Zealand Commerce Commission, which we understand has operated reasonable robustly for a number of years. We would suggest that the ERA also examine the filtering mechanisms used by the Alberta Utilities Commission and Queensland Competition Authority to see if they also provide useful information.

We would like to make three additional points:

- Some stakeholders have noted that the ERA's filtering mechanism does not control for the degree to which the firms in question have regulated income and that this may impact the degree to

[1] *See our submission of 16 February, available here, pp26-7.*
[2] *See CEG 2022, Use of Foreign Asset Beta Comparators, available here*

which they are comparable to Australian regulated firms.[3] Although regulatory risk is not a systematic risk (see below), we agree that this is an important dimension to the "like with like" comparison. To this end, we would suggest the CEG filter for regulated income, described in the APGA submission as an additional filter the ERA might consider.[4]

- We understand that the ERA intends to filter the international data for merger and acquisition events as these may impact beta estimates. This is appropriate, but Australian firms have also been subject to merger and acquisition activity and should thus have the same filter applied to them. We note that all of the firms in the ERA's sample set have been subject to merger and acquisition activity which may have affected beta estimates, which underscores the problem of using solely Australian data.
- The ERA's task is to estimate a gas beta. In the past, Australian regulators pooled domestic gas and electricity firms because the sample size was small and because of an assumption of regulators that the systematic risk exposure of both types of firm is likely to be similar. That assumption was never tested. However, with access to international data, it is arguably not one which needs to be made, as the sample size of gas-only firms internationally is likely to be sufficient for statistical robustness.

2. *Are there any additional jurisdictions that should be considered by the ERA?*

We believe that the sample set chosen by the ERA is likely to be sufficient to obtain a robust statistical estimate. If additional countries are chosen, the ERA should consider the trade-off between representativeness and statistical robustness. That is, if a country less similar to Australia than those chosen by the ERA is considered, the ERA should use its judgement to ascertain whether the reduction in similarity is worth the additional statistical robustness.

We also do not think that any of the countries in the ERA's sample set should be removed. We note that Economic Insights, in a recent report for the AER, suggests a geographic filter, rejecting all comparators other than New Zealand.[5] Not only does this produce little additional statistical robustness (New Zealand has but one energy company in the ERA's sample set at present), but we can see no reason why being geographically close to Australia is in any way a proxy for (still less superior to) similar economic and legal environments. Indonesia, Papua New Guinea and Timor Leste, for example, are all closer to Australia than New Zealand, and we are not aware of anyone suggesting them as comparators to determine beta.

3. *Should the ERA consider reweighting foreign market indices to be reflective of the ASX, or would this create distortions and interpretation issues as the market beta would no longer be one?*

We do not think the ERA should consider re-weighting indices. We think the point that the ERA made in its presentation on this issue was particularly apt; that investors in different markets are buying and selling the stocks of the relevant companies considering risk against the *actual* market in that country and not some imaginary market derived by re-weighting an index. It is unclear what meaning, if any a beta calculated against an imaginary index would have in respect off the expectations of investors.

Additionally, calls to somehow re-weight international indices to match the structure of the ASX ignore a very important point; the ASX itself does not have a constant structure, but rather one which changes through time. This might not matter much over the short 5-year period the ERA uses for its beta estimates, but, as the evidence presented by APGA from CEG shows, over a longer time period,

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[3] See ERA CRG, 2022, Submission on ERA 2022 Gas Rate of Return Instrument Review Discussion Paper of December 2021, available here, p 18&67.
[4] See CEG 2022, Use of Foreign Asset Beta Comparators, available here, p6. Further detail on the CEG approach can be found in CEG 2013 Information on equity beta from US companies, a report for the ENA, available here.
[5] See Economic Insights, 2021, Methodological Issues in Estimating the Equity Beta for Australian Network Energy Businesses, available here, pp 65-6

the composition of the Australian stock market changes markedly.[6] We can see no logical distinction between adjusting for differences between markets structures in space, and adjusting for differences in market structures in time. We think that doing both is wrong.

4. *What adjustments, if any, should be made to estimates of international equity betas?*

Aside from the obvious adjustment to ensure that leverage is at the level the ERA believes is appropriate, we believe that no other adjustment should be made. We agree with the ERA's view in the consultation session that choosing the right set of filters is a better approach than making arbitrary adjustments to beta, because it is much more transparent, and one can see the consequences of making a particular filtering choice very easily.

One example of this is the call by the ERA's CRG and South 32 to adjust returns for the supposed low risk of regulated firms which occurs, supposedly, by virtue of their regulatory status.[7] Not only is this supposed low level of risk not established via any robust evidence,[8] but regulatory risk is not a systematic risk, because it is not a factor pervasive through the economy. To the extent that the degree of regulatory exposure is considered important, we believe it is better given effect by using a filter like that proposed by CEG to control for regulatory revenues which we mention above, than by some arbitrary adjustment to beta.

Although arbitrary adjustments of beta to reflect hypothesised risks is inappropriate, we note that any empirical beta estimate will have a confidence interval, and we believe it is valid for the ERA to use its judgement to understand whether there are reasons to use anything other than the mean of the beta estimate. Some important recent evidence in this context includes:

- Economic Insights, in a report for the AER note that investors do not generally use the mechanistic CAPM, but rather use it as a starting point and complement it with judgement, including consideration of problems with the model like low beta bias. To the extent that the ERA is seeking to replicate investor expectations, this may be an important consideration.[9]
- A recent paper by suggests that it is appropriate for regulators to use a WACC estimate above the mean under most circumstances because of the consequences on consumer surplus (including the value of lost load) of producing an estimate which turns out to be too low.[10] This paper extends an earlier literature which formed the basis by which the New Zealand Commerce Commission formalised its approach of choosing the 67th percentile of its beta estimate, rather than its mean.[11]

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[6] *See CEG 2022, Use of Foreign Asset Beta Comparators, available here, p17-18.*

[7] *These submissions are available here and here respectively. We note the ERA CRG appears to suggest (p39) that the low risk is due in part to revenue caps. Gas businesses regulated by the ERA are subject to price cap, and not revenue cap regulation.*

[8] *In their presentation on April 28th, the CRG presented a graph, attributed to the AER, which purported to show more highly regulated firms have a lower beta. This graph has been used a number of times, including by the AER in the Explanatory Statements of its Draft and Final Decisions for its 2018 RoRI. In the former (see p109 here) the sources and timing of each estimate is listed, whilst in the latter (see p174 here) the detail is missing. The detail shows that the individual beta estimates occur at different times, up to a decade apart, and, since beta is not constant through time, the figure is likely showing little more than the effects of time, not regulation.*

[9] *See Economic Insights, 2021, Methodological Issues in Estimating the Equity Beta for Australian Network Energy Businesses, available here, p28. We note in the immediately following paragraph that Economic Insights suggest that the mechanistic CAPM may be appropriate for regulators to use, but their reasoning relates to their presumption of low risk for regulated companies and those with market power. Not only is regulatory risk not a systematic risk (see above), but it is unclear why regulators should use a simpler model for regulated firms when investors apparently do not.*

[10] *See Romeijnders, W and Mulder M, 2022, "Optimal WACC in Tariff Regulation Under Uncertainty", Journal of Regulatory Economics, 61:89–107*

[11] *See NZCC, 2014, Amendment to the WACC percentile for price-quality regulation for electricity lines services and gas pipeline services: Reasons paper (available here). We understand this approach was developed in response to a New Zealand court decision which rejected the previous, higher adjustment that did not have a sufficient basis in evidence.*

5. *Once the sample has been selected and individual betas have been estimated, how should the ERA best use this information to determine an equity beta point estimate? Should this be done in a mechanical way or should regulatory discretion be used?*

Any purely mechanistic method of determining beta is likely to face some issues. For example, in the context of the approaches suggested by the ERA:

- Full pooling – we think this is likely to end up with essentially a US energy firm beta, which may not be as representative as the ERA might like, and might not give sufficient weight to the full global spread of data.
- Country pooling – this solves the US beta issue above, but it would seem that some countries (UK with 2 firms, New Zealand with 1) are likely to face the same robustness problems that Australia faces, and thus it might not be prudent to give, effectively, 60 percent weight to beta estimates that are highly imprecise.
- Domestic anchoring – it is unclear what the justification for doing this would be; we are moving away from a wholly domestic beta because of sample size problems, and yet we still propose to give the most weight to this problematic estimate? This does not seem particularly prudent.

We note that both the ENA and CEG for APGA suggest different ways of using ranges (of averages in the first instance and confidence intervals in the second) and their overlap as a means of determining beta.[12] These avoid problems of deciding how much weight to put on what estimate.

Regardless of which approach the ERA ultimately uses, we believe it will need to make use of a degree of regulatory discretion and judgement; none of the approaches outlined above are likely to be perfect. In so doing, the key issue is the degree to which the process of using judgement has been carefully and transparently explained and ensuring it is replicable. We suggest that the ERA could meet this objective by testing whether the outcomes are replicated using different datasets.[13]

Questions – Market risk premium

In the stakeholder consultation session, the ERA characterised the choices in respect of MRP as being a choice of a fixed or varying MRP and a choice or a mechanistic or discretionary method of determining an MRP. Conceptually, this gives rise to four possibilities for the approach to the MRP:

- A fixed MRP which is determined mechanistically.
- A fixed MRP which is determined using discretion.
- A varying MRP which is determined mechanistically.
- A varying MRP which is determined using discretion.

The last choice on this list is effectively precluded by the binding nature of the RoRI and the restriction on the exercise of discretion when it is applied. The first seems unnecessarily restrictive as it seems to prevent the ERA from using any discretion when forming its MRP estimate, which it is able to do in the formation of the RoRI, and it is not clear what the benefits of doing so would be in the context of data which is sometimes challenging.

In keeping with our previous submission, we would favour a varying MRP. This means that the way in which it varies must, because of the requirements under the National Gas Law, be mechanistic, but it does not mean that the ERA cannot use its discretion and judgement when, as part of the RORI process, it determines the rules by which the MRP is calculated at each AA determination.

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[12] *See ENA, 2022, Rate of Return Instrument Review: Response to AER's Final Omnibus and Information papers, available here, pp111-2 and See CEG 2022, Use of Foreign Asset Beta Comparators, available here, p19-20.*

[13] *For example, the ERA could develop a simple test for itself in this regard. Derive a beta in its draft decision and explain how regulatory judgement was used to determine that beta. Then provide all stakeholders with a different set of data, and ask them to determine a beta estimate following the steps the ERA has outlined in its draft decision. This is much more challenging than simply writing dozens of pages justifying a particular decision without considering its replicability.*

In terms of how it might vary, in our original submission, we suggested it could either be some form of weighted average of historical and forward-looking information, or take advantage of known and reasonably robust relationships between the MRP and risk-free rate. We still maintain this view, and point to some new evidence in respect of the relationship between the risk-free rate and MRP which does not rely on the DGM, provided by the QTC to the AER process.[14]

If the ERA's views about the relationship between the risk-free rate and MRP do not change, then we are left with a weighted average between forward-looking information and historical information. In this context, two new pieces of information are useful:

- The conceptual nature of this weighted average is explored in some detail in the Sapere report for the AER CRG, and its focus on different ways of combining unconditional and conditional means. Although Sapere favour the Wright model for conditional means, and we disagree with their conclusions on the robustness of the DGM, there are aspects of the overall framework discussed which may assist the ERA frame its own weighted average and in particular, the way in which it forms its judgements on weights.[15]
- We maintain our view that the relevant data points are the *arithmetic* historical mean and the DGM, with the geomean playing no role. Sapere, for the AER CRG show that the geometric mean only has a role to play if there is serial correlation in the sample set.[16] Work undertaken by CEG suggests that there is not (see memorandum from CEG appended to this letter).

6. *What are stakeholder views on the calibrated DGM proposed by Energy Networks Australia? Does this amended model provide additional confidence in the DGM and how?*

We believe the Frontier approach to the DGM is an excellent way of addressing many of the problems which have been put forward in respect of the DGM in the past. We refer to the ENA Submission for details on the Frontier model.

7. *Is it possible to combine inputs in a more formulaic manner when estimating a forward-looking market risk premium?*

Yes, not only is it possible, but a relatively simple approach, akin to that which the ERA used in 2013, seems to be the best way forward, viz:

- Specify the method for determining the historical MRP in the RoRI. We believe this should be, following Sapere for the AER CRG, just one time period and, based on the advice of Sapere and evidence of CEG (as well as past evidence from Lally, the ENA and others, detailed in our earlier submission) this should be the arithmetic mean only.
- Specify the method for determining the DGM in the RoRI. We believe this method should be the Frontier method, noting that this is essentially the AER's existing 3-stage DGM with the long run growth rate *g* determined using Frontier's approach. We do not think that *g* should be re-estimated during the course of the RoRI as this is likely to make little difference to the number and is likely to create a lot more complexity.
- Specify the weight given to each estimate in the RoRI. Here, other sources of information and the ERA's regulatory judgement and discretion can be used to determine the weight. This weight should remain fixed during the RoRI.
- Periodically, during the RoRI, update the estimates of the DGM and historical MRP and use these, with the given weight, to determine the MRP at each regulatory determination.

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[14] *An expert report produced by Synergies Consulting, available here.*
[15] *The expert report, by Sapere, is available here.*
[16] *See Sapere, 2022. Estimation of the market risk premium and its relationship to the risk free rate in the context of regulation of electricity and gas energy networks: A report to the Australian Energy Regulator Consumer Reference Group, available here, pp44-6. We note that Sapere also suggest there should be just one unconditional mean estimate, and it should be the longest available time period. This may influence the ERA's proposal to use only post 1958 data, though we can still see the pragmatic benefits of doing so, and it doesn't change the average much.*

This approach largely mirrors the approach the ERA took in 2013, except that the ERA also used the Wright model in 2013.

If the ERA does change its mind on the relationship between the risk-free rate and MRP, a simple formulaic approach is still possible, and the ENA provides detail on how this is formed (see our earlier submission).[17]

8. *What weight, if any, should be assigned to the historic market risk premium, DGM and conditioning variables in estimating the market risk premium?*

We believe that the starting position the ERA ought to adopt in respect of the historical MRP and DGM is equal weight. In 2018, the ERA downwardly-weighted the DGM after a merit-based assessment. We disagreed with this assessment at the time, largely because it was primarily based on potential problems which were not tested, and we note that the historical MRP was not (and, to our knowledge had not been previously) subject to a similar test by either the ERA or AER.

Since that time, Frontier have developed a version of the DGM which seeks to address most of the concerns raised about other versions of the DGM as best they can be addressed. At the same time, consultants for the AER have provided empirical evidence that there is no sound basis for an assumption of a near-fixed MRP based solely on the unconditional mean of an historical time series,[18] and the experts in the AER's sessions re-iterated their belief that the MRP has an unconditional and a conditional element.[19] On this basis, we consider there is no basis for a starting position which gives more weight to the historical MRP.

This does not mean, however, that the ERA could not use other evidence to consider a weighting different from 50/50, such as long-range economic forecasts or business cycle studies. It is unclear in this context how much of a role conditioning variables could play in this respect. Firstly, as we point out in our original submission, it is not clear how closely they are actually related to the MRP, and secondly, it is not clear whether the current position of any of the conditioning variables has any relationship to the MRP beyond a few months.[20] Using them to set a weighting for four years seems somewhat challenging.

As with the choice of beta, the choice of the weight will involve judgement, and the key will be explaining such judgement in such a way that a third party, following the ERA's approach and using different data, could replicate the result the ERA would obtain in that new situation. As with beta, the ERA could easily test the replicability of its approach.

9. *Do you support a fixed or updating market risk premium being used over the four-year term of the gas instrument?*

As is clear from our discussion above, we support adjusting the MRP through time and not leaving it fixed. As noted in our original submission, it is somewhat illogical to use forward-looking information and then to fix an MRP.

10. *Is it possible to estimate a forward looking market risk premium in a completely mechanical way with no use of regulatory discretion?*

Yes, as discussed above, it is not only possible, but relatively easy to establish a weighted average of two data sources. Moreover:

- The ERA has done this before, in 2013.
- The data sources themselves are easy to update; the AER already does so every year on its estimates of the historical MRP and DGM. Provided the *g* remains fixed, there would be no

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[17] *See our submission of 16 February, available here, pp24-5.*

[18] *See our submission of 16 February, available here, pp22-4.*

[19] *See the transcript of the third session, available here, pp25, 68-70.*

[20] *See our submission of 16 February, available here, pp18-21.*

greater complexity for the ERA to do this. Indeed, because we propose one historical average and one DGM, the ERA's task would be simpler than that the AER currently has.

We note an issue raised by the ERA in the consultation sessions in respect to the DGM, being the degree that a short-run estimate might capture a transitory shock that is not relevant for the forthcoming five-year period. The historical MRP, by virtue of its construction, is less susceptible to this because adding one data point to a long time series does not affect the average much.

We understand the ERA's concern, but make two points:

- The ERA's approach to equity estimation proceeds as if equity is raised anew for the forthcoming AA period in the averaging period prior to that AA period; it is an "on the day" approach. If a shock does happen to occur during that time, then this is, by assumption in the ERA's approach, the right cost of equity on that day.
- The way the ERA estimates the risk-free rate is already subject to exactly the same issue the ERA appears concerned about in respect of the DGM. Moreover, if the DGM and risk-free rate continue their empirical inverse correlation, adjusting one by using a longer averaging period and not the other may introduce a variation in the return on equity estimate that is not actually part of the true required cost of equity.

These concerns suggest that, if the DGM and the risk-free rate are estimated over different time horizons, since they are both estimating different parts of the same thing (the cost of equity), they should not deviate by too much. For example, a 10-day risk-free rate estimate coupled with a 12-month DGM estimate would likely have too much mismatch. We understand that, given the availability of broker forecast, the maximum frequency with which the DGM can be realistically estimated is monthly. There may be some merit in using, say, a two or three month DGM estimate along with a 20-day risk-free rate estimate as a compromise solution which addresses the ERA's concerns without producing too much artificial variation in the cost of equity estimate, but any more than that would appear, potentially, to be problematic. We would encourage the ERA to experiment with different DGM estimates and report its findings in the draft decision.

We hope that the above is beneficial to the ERA as it considers the evidence for its draft decision. We thank the ERA for this additional opportunity to address these more detailed aspects of the return on equity, and look forward to the opportunity of further engagement. If you would like to discuss any aspect of this submission further, please do not hesitate in contacting either Nick Wills-Johnson or myself.

Yours sincerely,

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Memorandum

To:	Nick Wills-Johnson, Australian Gas Infrastructure Group
From:	Samuel Lam, CEG – Asia Pacific
Date:	4 May 2022
Subject:	**Analysis on the autocorrelation of the market risk premium**
Status:	FINAL

1 Overview

1. It has been argued that evidence of serial correlation in the BHM historical excess return series would support giving positive weight to the geometric mean of the BHM historical excess return series. By contrast, it has been suggested that absence of such autocorrelation implies sole weight should be given to the arithmetic average. [1]

2. CEG was asked to consider the economic logic and the practical application of this to estimating the historical average excess return using the BHM dataset.

3. The first point to note is that the logic for this position does not apply to the excess return series but to the total market return series (TMR). That is, the economic logic applies to the series that an equity investor would compound if they invested over multiple years. This is the total market return – not the realised excess return.

4. In any event, we have replicated ERA's excess return "MRP series" adjusting the BHM dataset to use 5-year bonds as the risk free rate and analysed the three series (TMR, risk free rate (RFR) and MRP) for autocorrelation. We find that:

   - The MRP series exhibits evidence of autocorrelation (albeit weak evidence);.
   - The TMR series does not have statistically significant evidence of autocorrelation;
   - The RFR series has strong statistically significant evidence of autocorrelation.

[1] *Estimation of the market risk premium and its relationship to the risk free rate in the context of regulation of electricity and gas energy networks: A report to the Australian Energy Regulator*, Consumer Reference Group, 25 February 2022, paragraph 132-133.

5. This is consistent with the evidence (albeit weak) of the MRP series exhibiting autocorrelation is driven, in part, by the autocorrelation in the risk free rate series.

6. Two implications follow our conclusion;

   - First, the evidence of autocorrelation in the TMR series is not sufficiently strong to justify giving material weight to the geometric average; and
   - Second, if, nonetheless, weight is to be given to the geometric average MRP it should be estimated by taking the difference between the geometric average of the two portfolio it is open to investors to invest in. That is, the geometric historical average MRP should be estimated as:
     - The geometric average of the TMR series; less
     - The geometric average of the RFR series.

Equation 1: Correct method for estimating geometric mean excess return

$$MRP = \prod_{t=1}^{T}(1 + TMR_t)^{1/T} - \prod_{t=1}^{T}(1 + RFR_t)^{1/T}$$

Where: MRP = market risk premium, TMR = total market return, RFR = risk free rate, t = time or year

7. This method considers that investors can only compound the total market return and the risk free rate over time but not the MRP.

2 Auto correlation analysis

8. In a report to the AER, the Consumer Reference Group (CRG) mentioned that:

> *"...as shown by Mindlin (2011), if returns are serially uncorrelated (as in Cochrane, 2014, p34), the arithmetic average converges to the true expected return in large samples, whereas the geometric average does not."*[2]

9. With this in mind, we analysed both the MRP and total market return series based on the three most widely used serial correlation tests: Durbin-Watson test (DW test), Breusch-Godfrey test (or the LM test) and the Box-Ljung test.[3]

[2] *Estimation of the market risk premium and its relationship to the risk free rate in the context of regulation of electricity and gas energy networks: A report to the Australian Energy Regulator*, Consumer Reference Group, 25 February 2022, paragraph 132.

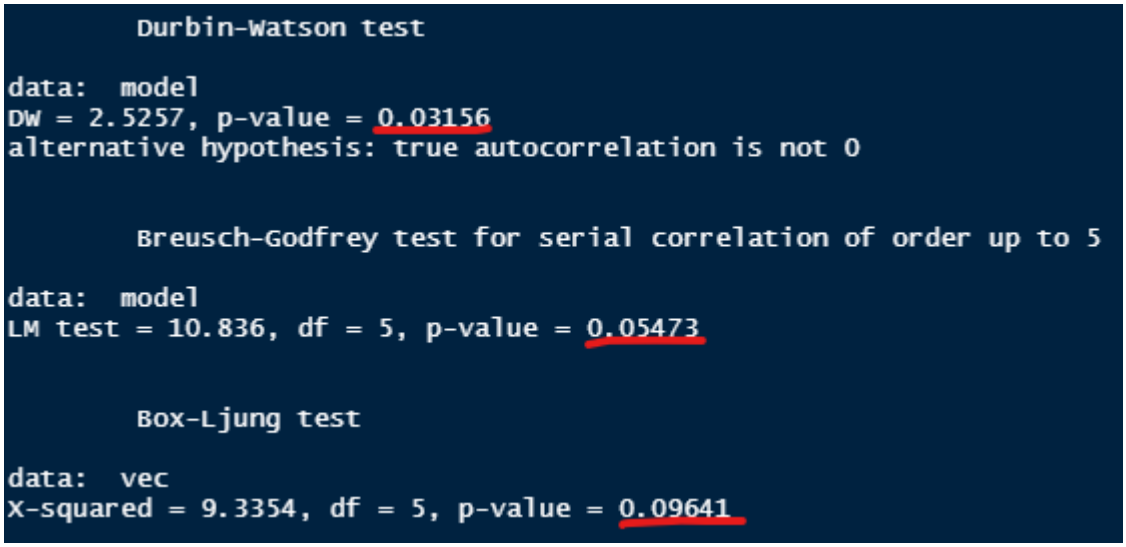
[3] All of the data series used are based on the BHM dataset.

10. In essence, these three tests attempt to test for autocorrelation by regressing the model's residuals with its lags. Their methodologies differ on the number of lags tested at once and the definition of the test statistics/scores.

11. After computing the test statistics/scores, each method performs a similar hypothesis test of no autocorrelation (null hypothesis). The null hypothesis is to assume that the coefficients of the lagged residuals are zero, which is then evaluated by the p-value to draw a conclusion.

12. Figure 2-1 below shows the autocorrelation analysis on the MRP series.

Figure 2-1: Autocorrelation test on the MRP



Source: CEG analysis

13. The values of interest are the p-values underlined in red. If the p-value is below a certain significance threshold, then the null hypothesis (no autocorrelation) can be rejected with confidence. Similarly, if the p-value is above the threshold, then the null hypothesis of no autocorrelation cannot be rejected with confidence. Not rejecting the null hypothesis does not mean there is definitely no autocorrelation but suggests that there is not sufficient evidence to conclude there is autocorrelation.

14. The most common threshold used is a 5% significance level. According to the tests in Figure 2-1, the DW test rejected the null hypothesis and suggests that the MRP series exhibits autocorrelation, while the LM test and Box-Ljung test cannot reject the null hypothesis at 5% significant level (but are able to reject the null hypothesis at 10% significant level). We consider that this evidence suggests that there is evidence of autocorrelation within the MRP series but this evidence is relatively weak.

15. Since the MRP is not a directly observed series but is derived as the difference in the TMR less RFR series, we analysed both of those series with the above method.

Figure 2-2: Autocorrelation test on the total market return

```
        Durbin-Watson test

data:  model
DW = 2.4708, p-value = 0.05506
alternative hypothesis: true autocorrelation is not 0


        Breusch-Godfrey test for serial correlation of order up to 5

data:  model
LM test = 7.5314, df = 5, p-value = 0.184


        Box-Ljung test

data:  vec
X-squared = 8.0312, df = 5, p-value = 0.1545
```

Source: CEG analysis

Figure 2-3: Autocorrelation test on the risk free rate (5-year bonds)

```
        Durbin-Watson test

data:  model
DW = 0.12223, p-value < 2.2e-16
alternative hypothesis: true autocorrelation is not 0


        Breusch-Godfrey test for serial correlation of order up to 5

data:  model
LM test = 56.469, df = 5, p-value = 6.507e-11


        Box-Ljung test

data:  vec
X-squared = 221.54, df = 5, p-value < 2.2e-16
```

Source: CEG analysis

16. With all of the p-values above 5%, one cannot confidently conclude that the total market return series is autocorrelated (one cannot confidently reject the null hypothesis of no autocorrelation). This suggests that there is no strong case for estimating the expected return on this series using the geometric average.

17. By contrast, the p-values for the RFR series are not materially different to zero and thus far below the 5% significance level. This provides strong evidence of it exhibiting

serial correlation (which explains the difference in the estimated autocorrelation for the MRP and TMR series).

3 Alternative geometric mean for MRP

18. Nonetheless, if the geometric mean is to be used, the current method of estimating the geometric mean MRP (by simply computing the geometric mean of the MRP series) is inaccurate and underestimates the actual MRP. This is because investors cannot invest in the MRP series over multiple years. Rather, investors who compound returns over multiple years need to invest in the TMR series. Their excess return, relative to the risk free rate portfolio, over multiple years will be estimated by comparing the geometric mean of the TMR series with the geometric mean of the RFR series.

19. The current method, illustrated in Equation 2, has an implicit assumption that investors can compound the MRP over the years. However, as there is no instrument that replicates only the MRP, this assumption cannot hold in practice.

Equation 2: current method for estimating MRP

$$MRP = \prod_{t=1}^{T}(1 + TMR_t - RFR_t)^{1/T}$$

Where: MRP = market risk premium, TMR = total market return, Rfr = risk free rate, t = time or year

20. In actual practice, investors can only compound the total market return and the risk free rate over time. The equation that reflects this (actually replicable practice) is illustrated below:

Equation 3: Alternative method for estimating MRP

$$MRP = \prod_{t=1}^{T}(1 + TMR_t)^{1/T} - \prod_{t=1}^{T}(1 + RFR_t)^{1/T}$$

Where: MRP = market risk premium, TMR = total market return, RFR = risk free rate, t = time or year

21. This alternative method effectively removes the irreplicable compounding effect of the MRP. The differences between the MRP estimates using the current and alternative method, based on the BHM dataset[4] are set out below in Table 3-1: Comparing the current and alternative method of estimating the MRP Table 3-1:

[4] Brailsford, Handley and Maheswaran (2012), *The historical equity risk premium in Australia: Post-GFC and 128 years of data.*

Table 3-1: Comparing the current and alternative method of estimating the MRP

Estimation of MRP under geometric mean			
Time Period	Current ERA method	Alternative method	Differences (Alternative - Current)
1958-2021	4.81%	5.05%	0.24%
1980-2021	5.00%	5.23%	0.23%
1988-2021	5.35%	5.48%	0.13%
2000-2021	5.54%	5.58%	0.04%

Source: BHM dataset, CEG analysis

22. Table 3-1 illustrates our replication of the MRP estimation under the two geometric mean methodologies and their differences, presented under the time periods the ERA currently considering.

23. It shows that under the first 3 time periods, those that the ERA have always included, the alternative method increases the geometric mean estimates by 13 to 24 bps. If we include the post-GST period (2000-2021) that ERA is currently considering, the geometric mean MRP estimate will increase by 4bp.