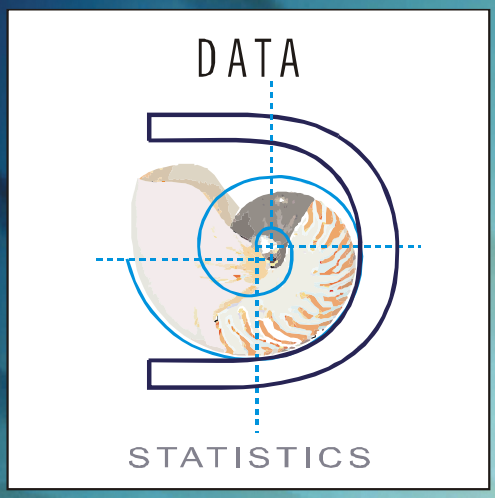

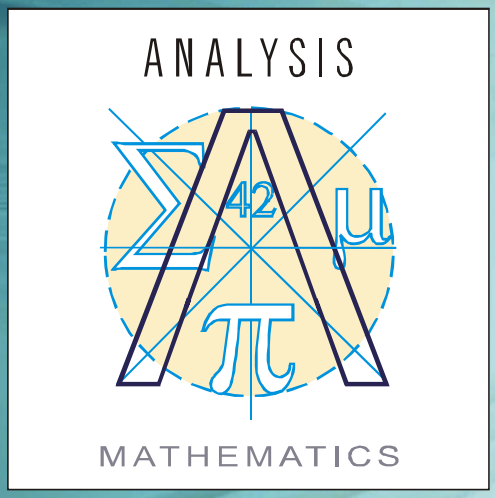

S T R A T E G I C
I N F O R M A T I O N
C O N S U L T A N T S

Review of Risk Free Rate Calculation

August 2013

Project: ECREGA/10

Review of Risk Free Calculation

August 2013

Client: Economic Regulation Authority

Project: ECREGA/10

Consultants: Dr Alethea Rea
Dr Kathy Haskard
Dr John Henstridge

Data Analysis Australia Pty Ltd
97 Broadway
Nedlands, Western Australia 6009
(PO Box 3258 Broadway, Nedlands 6009)
Website: www.daa.com.au
Phone: (08) 9386 3304
Facsimile: (08) 9386 3202
Email: daa@daa.com.au
A.C.N. 009 304 956
A.B.N. 68 009 304 956

Executive Summary

Data Analysis Australia was contracted to provide an expert opinion on a Briefing Note prepared by the Economic Regulation Authority (ERA). The Note seeks to provide an object rational for the use of the ERA's method for calculating the nominal risk free rate by using the Diebold-Mariano (DM) test to compare the ERA method with several alternatives.

Data Analysis Australia notes that the use of the DM test is industry standard for these comparisons. Based on discussions with ERA staff Data Analysis Australia concluded that:

- The forecast errors had been correctly calculated;
- The tests for stationarity **of the loss differentials** were carried out in an appropriate manner;
- It is appropriate to use the forecast package[1] and R to carry out the DM test; and
- That the dm.test function was correctly applied.

Therefore the analysis reported in the Note is based on appropriate methodology and the implementation has been carried out in an appropriate manner.

Data Analysis Australia was asked to comment on outcomes of the analysis. In our view:

- The 20 day averaging outperforms 5 year averaging and 10 year averaging; and
- There is little evidence to favour 20 day averaging over 1 year averaging and there is some evidence that for the period since 1993 the 1 year averaging is superior; and
- The optimal amount of time included in the average is likely to be between 20 days and 1 year.

Data Analysis Australia has identified three areas for potential improvements, from a statistical perspective; these are:

- The analysis could be reported on both Absolute Loss Error and Square Loss Error;
- An ARIMA based analysis could be applied to determine if 20 days is sufficient to reflect the current risk-free rate; and
- A breakpoint analysis could be applied to investigate whether there are any structural changes in the 5 and 10 year yields in Australian Government Bonds.

This report details the outcomes of the review carried out by Data Analysis Australia.

[1] http://cran.r-project.org/web/packages/forecast/index.html

Table of Contents

1. Scope of Work....1
2. Overall Recommendation....1
3. Comments on the Briefing Note....2
3.1 Comments on the Issue Section....3
3.2 Comments on the Methodology Section....3
3.3 Comments on the Data Section....3
3.4 Comments on the Results Section....4
3.5 Other Minor Comments....5

1. Scope of Work

Data Analysis Australia was contracted to provide an opinion on a Briefing Note prepared by the Economic Regulation Authority (ERA). The Note focuses on a method for calculating the nominal risk free rate and a test comparing its efficiency with other (related) methods.

Data Analysis Australia was asked to comment on:

1. Is the Diebold-Mariano (DM) test appropriate for evaluating forecast efficiency?
2. Was the DM test correctly applied?
3. Does the analysis support 20 day averaging?
4. Could the analysis be improved?

The comments made below reflect Data Analysis Australia's review of the Note and our discussions with ERA staff.

These four questions are commented on in Section 2 below while in Section 3 we provide general comments on the presentation of the Briefing Note.

2. Overall Recommendation

Based on a review of the literature Data Analysis Australia notes that the Diebold-Mariano test appears to be industry standard for testing forecast efficiency in an Econometrics setting. Therefore, it is appropriate for the ERA to use this test statistic. There are some who advocate for an information criteria based approach over a hypothesis testing framework; see Kunst 2003[2] for one such view point. As the primary goal is model selection this may be worthwhile considering.

The ERA provided Data Analysis Australia with the data and code used in the analysis. Based on this, and the discussions, with ERA staff Data Analysis Australia concluded that:

- The forecast errors had been correctly calculated;
- The tests for stationarity **of the loss differentials** were carried out in an appropriate manner;
- It is appropriate to use the forecast package and R to carry out the DM test; and
- That the dm.test function was correctly applied.

Therefore, Data Analysis Australia believes that the analysis was carried on in an appropriate manner. The details of the analysis and implementation should be given in the final version of the Note.

The analysis was carried out on four data sets; the full set and three regimes. The outcomes are sensitive to the time period. The final decision about which time

2 Kunst, Robert M. (2003) Testing for relative predictive accuracy: A critical viewpoint, Reihe Ökonomie/Economic Series, Institut für Höhere Studien (HIS), No. 130.

period is appropriate should be made on economic grounds about which regime (the full series or from July 1993 to the present) best represents the expected future behaviour.

Data Analysis Australia was asked to comment on outcomes of the analysis and in particular on the evidence for 20 days as an appropriate time interval for estimating the nominal risk free rate. On the full set of data the 20 day averaging outperforms both the 5 year averaging and 10 year averaging; and the 20 day averaging outperforms the 1 year averaging but only at the 10% level. For the third regime the 20 day averaging has equivalent performance to both the 5 year averaging and 10 year averaging; and the 1 year averaging outperforms the 20 day averaging. Consequently, Data Analysis Australia believes that the 5 and 10 year averaging is inferior to 20 day averaging but that is it not reasonable to make a definitive statement that 20 day averaging is superior to 1 year averaging or vice versa. Data Analysis Australia believes it is likely that the optimal time interval for averaging is likely to be between 20 days and 1 year.

Data Analysis Australia has identified several areas for potential improvements, namely:

- The analysis should be reported on both Absolute Loss Error and Square Loss Error;
- The Note should reference the R software and forecast package;
- The use of 20 days to reflect the current risk-free rate may be industry standard; however this choice is somewhat arbitrary from a statistical perspective. The Note explores only a limited set of alternatives and it would be worthwhile considering additional alternatives, particularly between 20 days and 1 year; and
- A breakpoint analysis could be carried out to investigate whether structural changes in the series occurred at the same time as the hypothesized market changes, where the market changes are changes to the way Australian Government Bonds were issued.

These potential improvements are all covered in further detail below along with other recommendations.

Data Analysis Australia makes no comment on the implicit assumption of efficient market hypothesis or on the method used to calculate the weighted average cost of capital, noting that these areas require expertise in finance and economics.

3. Detailed Comments on the Briefing Note

The Briefing Note could be enhanced by careful proof reading and editing, keeping in mind that some of the intended readers may not be familiar with industry standards. In particular, the Issue Section should be expanded to give a clearer understanding of the issue. In particular, providing more detail on the criticisms so it can be seen whether they are addressed.

Each section is commented on in turn.

3.1 Comments on the Issue Section

The Note highlights the position of the ERA. It is clear from the Issue Section that the ERA believes that forecasting efficiency is a key principle, and therefore it has chosen a method of calculating the nominal risk free rate that is consistent with that principle. The ERA calculates the predictor of the future risk free nominal rate as the 20 day average of the observed rate by using today's rate and the rate of the 19 days prior to today.

In the Issue Section there are a few oversights that make it difficult to be certain of the aims of the Note. These include:

- The Note states that "A number of regulated utilities have submitted that longer averaging periods in the order of 5 or 10 years should be used for a variety of reasons" but none of these reasons are described in the Note itself; and
- The Note states that "some utilities have claimed errors in the test" but does not state the nature of the claimed errors or criticisms.

If the purpose of the Note is to address the criticism raised by the other utilities, then both of these issues would benefit from a greater level of clarification. For example, the reasons others have suggested for a much longer period could be described. Furthermore, these reasons could be related to the criterion currently used, forecasting efficiency, in order to develop a case for the methodology used by the ERA. Additionally, the nature of the concerns on the test used by the ERA should be stated in full and then the Note could address these concerns directly.

Without this background information, the Note does not enhance confidence in the methodology.

3.2 Comments on the Methodology Section

The Methodology Section first defines the Diebold-Mariano (DM) test. This is a test for comparing two competing forecasting models. Typically there will be models from the ARIMA family. Here, the models being compared are, in a sense, ARIMA models with coefficients fixed rather than estimated. It could be worthwhile considering whether an ARIMA framework for estimating the number of lags and the coefficients would be beneficial in this instance. The equal weighting of the last 20 days, while well intentioned, is somewhat arbitrary. A more formal analysis may provide support for the choice of 20 days.

The Note does not provide any discussion on alternative tests for efficiency. Readers who are concerned about the methods being used would benefit from this.

3.3 Comments on the Data Section

The tests for stationarity are a key aspect of the analysis. They were applied to 10 years, 5 years and 60 day differentials but results are reported on 1 day, 5 days, 1 year, 5 years and 10 years. There should be a consistent approach to the time intervals used in the averaging.

This Section (rather than the Results Section) should also include a reference to the forecast package and R software. Additionally, the three distinct periods should be introduced in this Section.

The Data Section makes a case for the suitability of the 10 year government bond index series as a proxy for the 5 year government series. It is interesting to note in Figure 3 that the cointegration prior to March 1991 (where there are two series) seems to be different. Furthermore, during the global financial crisis it seems that the relationship between the two observed yields is the opposite of that observed outside this time. These two potential limitations may be worthwhile highlighting in the Note.

The investigation into cointegration could be implemented differently (for example it could be enhanced by directly testing if β is one), but the outcome is likely to remain unchanged.

A number of questions remain unanswered in the Data Section. These include, what is the range of t values in the calculation of the DM statistic in each of the four sets (full and three subsets) for each comparison? Is the number of forecast errors calculated as inputs for the DM test statistic the same for all comparisons on a given data set and what are the date ranges? These should be reported in the Data Section and/or Figure 4.

3.4 Comments on the Results Section

The three distinct periods referred to in this Section are based on potential changes in the market for Australian Government issued bonds. As noted above, a potential enhancement could investigate the series to identify if these market changes correspond to a structural change in the series (for both the 5 year and 10 year Government bonds). This would further the understanding of the validity of the analysis of the full series.

Data Analysis Australia notes that for both the Absolute Loss Function and the Square Loss Function the values for the DM statistics are extremely high in the second regime. These are based on output from the function dm.test in the forecast package. The detail in the manual is insufficient to determine the assumptions of the calculation and it is highly likely that the long term variance has been underestimated, giving extreme results. Data Analysis Australia believes that an alternative implementation would be unlikely to substantially alter the finding of statistical significance.

The Results Section could be enhanced by a plot comparing the 5 year average yield with the estimators (10 years, 5 years, 1 year, 20 days, 5 days and 1 day). This would allow further insights into the performance of the estimators.

The Results Section also contains the conclusion of the study. These could be moved to a separate Discussion Section. The discussion could be expanded to add commentary on the conditions under which 20 days is the most suitable choice. The shorter time periods better reflect current conditions, while the longer time periods give more stability in the estimates. For example, in the second regime, 20 days

outperforms estimators based on 1 year, 5 years and 10 years. This period is dominated by market decline and therefore an estimator which focuses on the current conditions has outperformed one which focuses on long term stability.

3.5 Other Minor Comments

The document would benefit from a thorough proof reading. For clarity, many changes could be made to enhance readability. These are:

- Introduce all acronyms by the convention of writing it in full the first time and placing the acronym in brackets after it, and using the acronym thereafter;
- More rigorously define what each element in the equations represent, either before or immediately after the equation is presented;
- Clearly define $y^1_{t+h|t}$ after Equation (2);
- Clarify that the other forecasts methods were based on 1 days, 5 days, 1 *year*, 5 *years* and 10 years;
- Replace *i* with *t* in Equation (4);
- Take a consistent stance on Square Loss Function. We would recommend defining it along with the Absolute Loss Function; remove the sentence stating that 'there is no reason to believe that forecast errors are quadratic'; and report results for both.
- At present, the Square Loss Function appears in the Results Section without being formally defined elsewhere;
- Instead of just referencing Enders 2004, place the relevant details into an Appendix (keeping the reference);
- Ensure that equations are kept within the relevant sentences by adjusting the punctuation;
- In the third sentence of the second paragraph under 'Forecasts' it is unclear what the word 'this' is referring to at the start of the sentence;
- Equation 8 should sum from *i*=0 to N-1;
- Equation 8 could be enhanced by a complete example;
- As the analysis should be repeatable, all the dates should be stated in full (in the Data Section, Results Section and in Appendix 1);
- The results table (Figure 4) would benefit from the p-values being reported; and
- The reason for the 507 observations deleted due to missingness should be made more explicit.

4. Summary

Data Analysis Australia believes that the use of the DM test was appropriate and has been applied appropriately. A number of recommendations have been provided for improving both the methodology and the presentation of the results.