Review of CEG Report: Estimating the debt risk premium

A REPORT FOR UNITED ENERGY

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COMPETITION ECONOMISTS' GROUP

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1 Introduction

In early 2013, the Energy Networks Association (ENA) commissioned the Competition Economists' Group (CEG) to assess indicators of the Debt Risk Premium for benchmark 10 year corporate bonds rated BBB+ by Standard & Poors consistent with the current benchmark used by the Australian Energy Regulator (AER). CEG prepared a report (CEG, 2013a) which was lodged with the AER. The Victorian electricity distributors[1] are relying on CEG (2013a), together with an associated addendum memorandum (CEG, 2013b). These documents are to be presented to the AER as part of the cost of capital submissions by the businesses for advanced metering infrastructure (AMI).

We have been asked to conduct a review of the empirical work presented in the CEG reports so as to determine whether the methods applied to estimate the yield curves were reasonable and defensible. In our review we have re-estimated the yield curves using a different software package and algorithms, and have given standard errors for the estimated Debt Risk Premiums.

We acknowledge that we have read, understood and complied with the Federal Court of Australia's Practice Note CM 7, Expert Witnesses in Proceedings in the Federal Court of Australia.

2 Terms of Reference - Review of Yield Curves

2.1 Background

The Victorian electricity distribution businesses are required, pursuant to the AMI Cost Recovery Order (as amended) to make revised charges applications (charges revision applications) to set revised changes in respect of advanced metering infrastructure (AMI) for the year commencing 1 January 2014 by 31 August 2013.

The AMI Cost Recovery Order provides that the return on capital to be applied in determining charges for 2014 and 2015 is to be determined as a weighted average cost of capital (WACC), calculated in accordance with the formula set out in clause 6.5.2(b) of the National Electricity Rules (NER). Note that the references to the NER in the AMI Cost Recovery Order should be read as references to the version of the NER that applied before those rules were amended in November 2012 (in other words, the references should be to version 52 of the NER). As you would be aware, the rules relating to the rate of return were significantly amended in November 2012. These amendments included the replacement of the obligation on the Australian Energy Regulator (AER) to issue a statement of regulatory intent dealing with various cost of capital matters, with an obligation to issue cost of capital guidelines. The expectation is that the forthcoming cost of capital guidelines will be quite different in substance and presentation from the previous statement of regulatory intent. In these terms of reference, a description of the National Electricity Rules (NER) should be construed as being a reference to version 52 of the NER. In relation to the measurement of individual parameters within the WACC formula, the AMI Cost Recovery Order provides that:

- Measurement of "market observables (defined as the nominal risk free rate and the debt risk premium) is to occur in a period in 2013 proposed by the relevant business and agreed to by the AER; and
- Market observables and non-market observables are to be determined in accordance with the Statement of Regulatory Intent (SoRI) issued by the AER pursuant to clause 6.5.4 of the NER and as if clause 6.5.4(g) of the NER applied. Clause 6.5.2(b) of the NER provides that the return on capital must be calculated as a nominal post-tax weighted average cost of capital, in accordance with a prescribed formula, as follows:

$$\text{WACC} = k_e(E/V) + k_d(D/V)$$

[1] The Victorian electricity distributors are: Citipower, Jemena, Powercor, SP AusNet, and United Energy.

where: k_e is the return on equity (determined using the Capital Asset Pricing Model) and is calculated as

$$r_f + \beta_e \times \text{MRP}$$

where: r_f is the nominal risk free rate for the regulatory control period. It is to be calculated on a moving average basis from the annualised yield on Commonwealth Government Securities (CGS); β_e is the equity beta with a value in the SoRI of 0.8; and MRP is the market risk premium. k_d is the return on debt and is calculated as:

$$r_f + \text{DRP}$$

where: DRP is the debt risk premium for the regulatory control period. The debt risk premium for a regulatory control period is the premium determined for that regulatory control period by the AER as the margin between the annualised nominal risk free rate and the observed annualised Australian benchmark corporate bond rate for corporate bonds which have a maturity equal to that used to derive the nominal risk free rate and a credit rating from a recognised credit rating agency. E/V is the value of equity as a proportion of the value of equity and debt, which is $1 - D/V$; and D/V is the value of debt as a proportion of the value of equity and debt.

Clause 6.5.4 of the NER details the basis upon which the AER must develop a SoRI in relation to the rate of return. On 1 May 2009, the AER issued its SoRI in accordance with clause 6.5.4 of the NER. The SoRI set out (among other things) a value for the MRP of 6.5%. Clause 6.5.4(g) of the Rules states that a distribution determination to which a SoRI is applicable must be consistent with the statement unless there is persuasive evidence justifying a departure, in the particular case, from a value, method or credit rating level that is written into the statement. As noted above, the relevant market observables are to be determined as if this clause applied, which implies that the determination of these parameters for the purposes of the charges revision applications of the Victorian electricity distributors must be consistent with the SoRI unless there is persuasive evidence justifying a departure. United Energy is seeking a suitably qualified consultant to undertake specific analysis in relation to the current cost of debt, as measured over a recent 20 to 30 day averaging period. The consultant will be supplied with:

- A spread sheet database containing information about the characteristics of bonds used in the empirical analysis. The attributes covered will include credit ratings, maturity dates, and yields. Data covering plain vanilla bonds will, in the main, be provided, although there may also be results for callable bonds and other types of bonds. Both domestic and foreign currency bonds will be supplied, although the yields on the latter will have been swapped into Australian dollar yields.
- A report from CEG which will contain empirical estimates of yield curves. A pro forma of the CEG report is currently available: Estimating the debt risk premium, a report prepared by Dr Tom Hird for the Energy Networks Association, Competition Economists Group, June 2013. The report will contain yield curves that have been estimated according to the methods of Nelson and Siegel (1987) . The report will also contain an assessment of the performance of the Bloomberg fair value curve for BBB+ corporate debt.
- Regression results will have been reported in a spread sheet workbook. Program code may be supplied if it is available.

2.2 Scope of work

The consultant is required to undertake a review of the yield curves that have been estimated by CEG, with a view to assessing the merits of the overall approach. The yield curves are a tool for working out the benchmark cost of debt corresponding to a particular term to maturity. The Nelson-Siegel model is non-linear in the parameters and is therefore more complicated to fit than a normal regression model.

Preliminary review of CEG methods

1. Investigate the equations which have been estimated by CEG and seek to reproduce the reported results using a suitable software package. For the purposes of this exercise, concentrate on the main regression equations, those which have been estimated over the larger bond samples.

2. Examine and report on the accuracy and correctness of the results from the estimated equations. Review the regression diagnostics, calculate standard errors and report on the precision of the parameter estimates.

3. Assess whether the estimates of the cost of debt that have been presented by CEG are justifiable in the context of the estimated yield curves.

The consultant is expected to provide a report that should:

- Attach these terms of reference and the qualifications (in the form of curriculum vitae) of the person(s) preparing the report.
- Identify any current or potential future conflicts of interest.
- Comprehensively set out the bases for any conclusions made.
- Only rely on information or data that is fully referenced and that could be made reasonably available to the AER or others.
- Document the methods, data, adjustments, equations, statistical package specifications, printouts and assumptions that are used in preparing your opinion .
- Include specified wording at the beginning of the report stating that "[the person(s)] acknowledge(s) that [the person(s)] has read, understood and complied with the Federal Court of Australias Practice Note CM 7, Expert Witnesses in Proceedings in the Federal Court of Australia" as if your brief was in the context of litigation;
- Include specified wording at the end of the report to declare that [the person(s)] has made all the inquiries that [the person(s)] believes are desirable and appropriate and that no matters of significance that [the person(s)] regards as relevant have, to [the person(s)] knowledge, been withheld;
- Contain an acknowledgement that the opinions in the report are based wholly or substantially on the specialised knowledge which the person(s) preparing the report has; and
- State that the person(s) have been provided with a copy of the Federal Court of Australias "Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia" and that the Report has been prepared in accordance with those Guidelines, refer to Annexure A to these Terms of Reference or alternatively online at `http://www.federalcourt.gov.au/law-and-practice/practice-documents/practice-notes/cm7`.

2.3 Timeframe

The consultant is to provide a draft report by 15 August 2013 and a final report by 28 August 2013.

2.4 Fees

The consultant is requested to:

- Propose a fixed total cost of the project and hourly rates for the proposed project team should additional work be required;

- Provide details of the staff who will undertake the analysis and formulate opinions;
- Declare the absence of any relevant conflict of interest in undertaking the project; and
- Indicate preparedness to enter into a confidentiality agreement regarding research and findings.

Miscellaneous costs such as travel and accommodation will be reimbursed, by prior arrangement.

2.5 Contacts

Any questions regarding these terms of reference should be directed to:
Catherine Dermody
Email: CDermody@gtlaw.com.au
Phone: 03 8656 3320.

3 Review of CEG methods

In our review of the CEG report, outlined below, we have:

- Confirmed that the estimated parameters of the yield curves provided by CEG for the various bond samples generally match those which we calculate.
- Given standard errors of the parameters in order to measure the precision with which yield curves are estimated.
- Based on this empirical work, given an opinion on whether the estimates for the cost of debt provided by CEG are justifiable.

3.1 Confirmation of CEG Parameter Estimates

Table 4A of CEG (2013b) gives Debt Risk Premiums (DRPs) for 32 different groups of bonds. In the CEG report, for each group of bonds, defined by the rating class (BBB+ only; or A-, BBB+ and BBB), currency(AUD or All), type (i.e. options or no options), source (Bloomberg only or both Bloomberg and UBS), and country of origin (Australia or All), the Nelson-Siegel curve (Nelson and Siegel, 1987) was fitted, and the 7 year DRP and 10 year DRP were calculated with

$$\begin{aligned} \text{DRP}_7 &= \text{Yield}(7) - 3.244 \\ \text{DRP}_{10} &= \text{Yield}(10) - 3.515 \end{aligned} \tag{1}$$

and

$$\Delta\text{DRP} = \frac{100(\text{DRP}_{10} - \text{DRP}_7)}{3}.$$

The values 3.244 and 3.515 are the average yields on 7-year and 10-year Commonwealth Government Securities, measured over February, 2013. These yields were calculated by CEG using an interpolation method that was applied to daily data sourced from Table F16 from the RBA website. A monthly average was taken of the daily results for 7-year and 10-year CGS.

The Nelson-Siegel model can be written as

$$\begin{aligned} \text{Yield}(t, \text{rank}) &= \beta_{1,\text{rank}} + (\beta_2 + \beta_3)\frac{1 - \exp(-t/\beta_0)}{t/\beta_0} - \beta_3 \exp(-t/\beta_0) \\ &= \beta_1 + (\beta_2 + \beta_3)\frac{1 - \exp(-t/\beta_0)}{t/\beta_0} - \beta_3 \exp(-t/\beta_0) + \beta_4 \text{A-} + \beta_5 \text{BBB} \end{aligned}$$

where t is the remaining term to maturity of the bond, and A- and BBB are dummy variables for A- and BBB bonds respectively. Hence the asymptote of the Nelson-Siegel curve as $t \to \infty$ is β_1 for BBB+ bonds, $\beta_1 + \beta_4$ for A- bonds, and $\beta_1 + \beta_5$ for BBB bonds.

Table 1 gives the comparison between the results obtained in the CEG report[2] and those using the `optim`[3] command in the R environment for statistical computing and graphics (R Core Team, 2013) for the four main groups of bonds considered by CEG. The results from the report, obtained using Excel Solver, are very similar to the results using R `optim`.

							Report			R optim		
Row	Ratings	Curr.	Type	Source	Country of domicile	# Bonds	7 year DRP	10 year DRP	Δ DRP (bppa)	7 year DRP	10 year DRP	Δ DRP (bppa)
1	All	All	All	BB	All	260	2.76	2.99	7.62	2.76	2.99	7.59
2	All	All	All	BB	AU	221	2.76	2.99	7.38	2.76	2.98	7.35
3	All	All	All	BB & UBS	All	307	2.78	2.98	6.67	2.78	2.97	6.64
4	All	All	All	BB & UBS	AU	258	2.76	2.96	6.71	2.76	2.96	6.68

Table 1: Comparison of Table 4 in the report, and the results calculated using the R `optim` package.

Tables 2 and 3 give the parameter estimates using Solver and those obtained by R `optim`, as well as the Residual Sum of Squares (RSS) and calculated DRP_7, DRP_{10}, and ΔDRP.

3.1.1 Method of Estimation

The four rows are called Data 1, Data 2, Data 3, and Data 4 in this report. In the CEG report, the individual yields for each day and each bond were used as input to the Excel Solver. The dataset was essentially therefore non-linear panel data. The use of daily data in this way would be unlikely to have much effect on the parameter estimates, but would almost certainly affect the calculation of

[2]Note that the results given in the Report columns actually correspond to those given in the Addendum report issued by CEG.

[3]`optim` is a general purpose optimisation method. The BFGS quasi-Newton method was used, (from the user guide: "specifically, that published in 1970 by Boyden, Fletcher, Goldfarb, and Sharmo. This uses function values and gradients to build up a picture of the surface to be optimised."

Row	Source	$\hat{\beta_0}$	$\hat{\beta_1}$	$\hat{\beta_2}$	$\hat{\beta_3}$	$\hat{\beta_4}$	$\hat{\beta_5}$	RSS	DRP_7	DRP_{10}	ΔDRP
1	Report	1.405	7.771	-2.928	-6.162	-0.461	0.577	1604.391	2.76	2.98	7.59
1	R optim	1.405	7.771	-2.928	-6.163	-0.461	0.577	1604.355	2.76	2.99	7.59
2	Report	1.365	7.737	-2.869	-6.263	-0.471	0.572	1395.284	2.76	2.98	7.35
2	R optim	1.364	7.737	-2.868	-6.264	-0.471	0.572	1395.259	2.76	2.98	7.35
3	Report	1.556	7.722	-3.206	-4.794	-0.507	0.524	1888.033	2.77	2.97	6.64
3	R optim	1.556	7.722	-3.206	-4.794	-0.507	0.524	1888.006	2.49	2.97	6.64
4	Report	1.541	7.708	-3.207	-4.858	-0.517	0.542	1629.828	2.76	2.96	6.68
4	R optim	1.541	7.708	-3.207	-4.858	-0.517	0.542	1629.808	2.76	2.96	6.68

Table 2: Parameter estimates and Residual Sum of Squares using R `optim` package for Rows 1 to 4.

the standard errors because there is usually very little change in the yield of an individual bond from day-to-day. To overcome the limitations of the use of daily data in this manner, the average yield and average term to maturity were calculated over the month of February 2013, with the resulting values then employed as inputs.

Standard errors from a non-linear regression rely on an assumption that the non-linear mean function can be approximated locally by a linear function. To examine whether the linear approximation is appropriate, the profile t function (see, for example, Bates and Watts, 1988) defined by

$$\tau_j = \text{sign}(\beta_j - \hat{\beta}_j)\frac{\sqrt{\text{RSS}(\beta_j) - \text{RSS}(\hat{\beta})}}{s}$$

is plotted, where β_j is a parameter of interest with estimate $\hat{\beta}_j$, $\text{RSS}(\hat{\beta})$ is the residual sum of squares at the solution, $\text{RSS}(\beta_j)$ is the residual sum of squares holding the jth parameter at β_j, and s is the residual standard error. By default, the absolute value of τ_j is plotted.

Figure 1 shows the profile t functions for all six parameters. The x-axis shows the value of β_j while the y-axis shows the corresponding absolute value of τ_j. The parameters β_1 to β_5 are well-behaved. However, β_0 shows some curvature, suggesting that confidence intervals based on standard errors for this parameter will not be accurate. In addition, confidence intervals for functions of the parameters, such as

$$\text{DRP}_{10} = \beta_1 + (\beta_2 + \beta_3)\frac{1 - \exp(-10/\beta_0)}{10/\beta_0} - \beta_3 \exp(-10/\beta_0)$$
$$\text{DRP}_7 = \beta_1 + (\beta_2 + \beta_3)\frac{1 - \exp(-7/\beta_0)}{7/\beta_0} - \beta_3 \exp(-7/\beta_0)$$

and

$$\Delta\text{DRP} = \frac{100(\text{DRP}_{10} - \text{DRP}_7)}{3},$$

will also not be appropriate, because of the non-linear behaviour of β_0.

To overcome this, β_0 was re-parameterised as

$$\beta_6 = \log(\beta_0).$$

This re-parameterisation does not change the model, but improves the estimation of it. The re-parameterised Nelson-Siegel model is

$$\text{Yield}(t, \text{rank}) = \beta_1 + (\beta_2 + \beta_3)\frac{1 - \exp(-t/\exp(\beta_6))}{t/\exp(\beta_6)} - \beta_3 \exp(-t/\exp(\beta_6)) + \beta_4 \text{A-} + \beta_5 \text{BBB}.$$

Figure 2 gives the profile t functions for the revised model. The curvature shown in Figure 1 has almost been entirely removed.

Under the original parameterisation, the estimated β_0 parameter is 1.4510 with a standard error of 0.2119. A 95% confidence interval based on $\pm$ 1.96 standard errors would be inappropriate since the correct confidence interval, based on the profile t function, is (1.1408,1.9022)[4]. The asymmetry of the

[4]The limits of the confidence interval can be read from the profile t graphs or, equivalently but with more precision, by using the `confint` function in R.

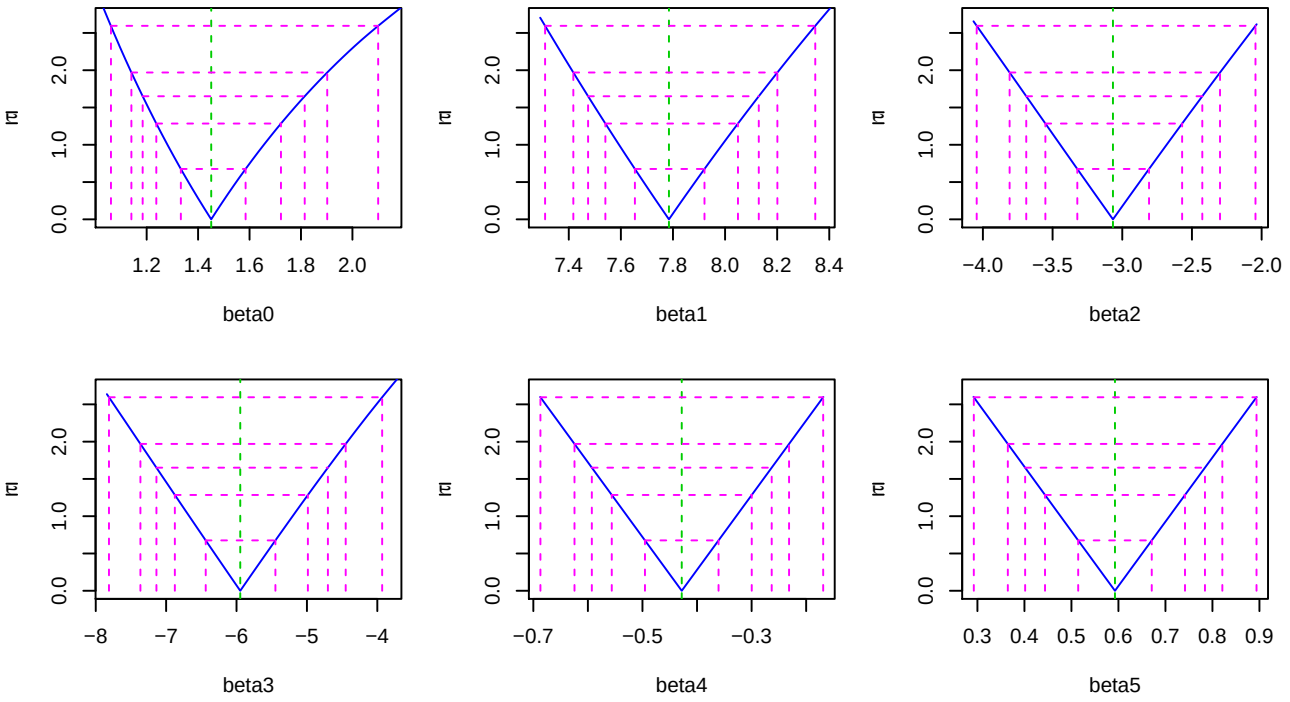

Figure 1: Profile t plots for the original Nelson-Siegel model. The dotted lines correspond to 50%, 80%, 90%, 95%, and 99% confidence intervals.

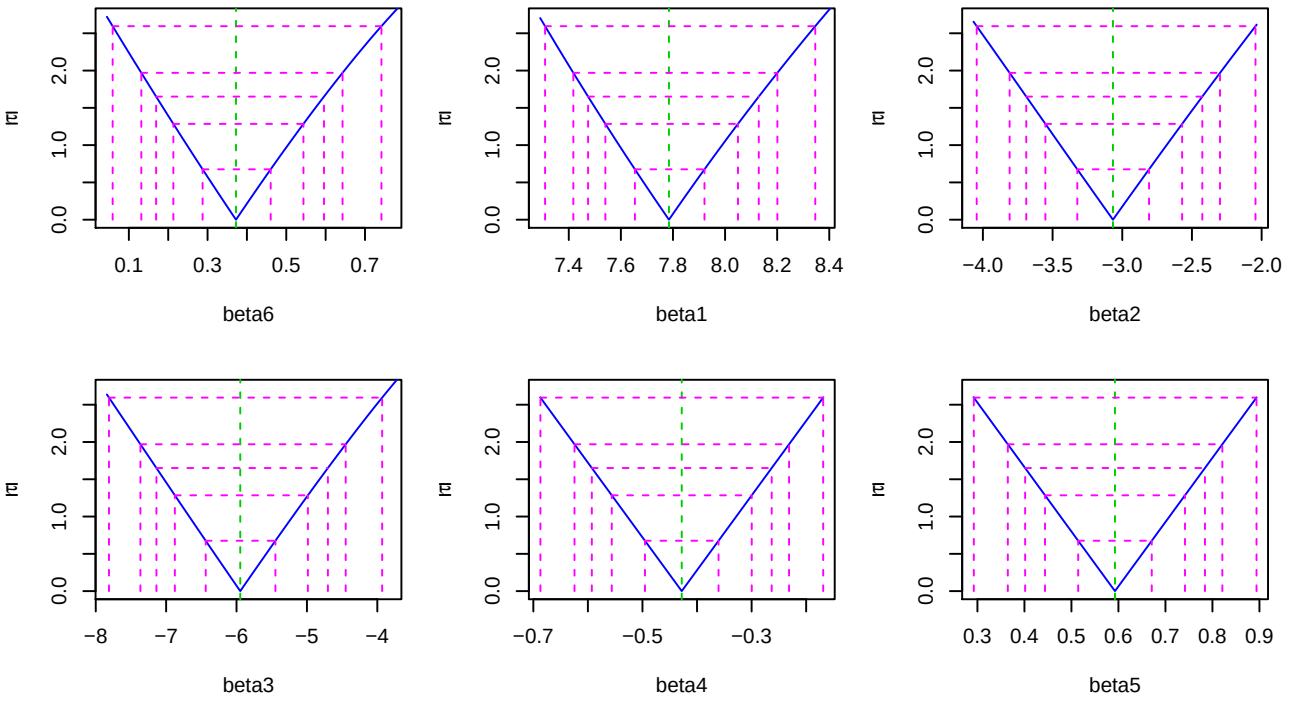

Figure 2: Profile t plots for the revised Nelson-Siegel model

correct confidence interval can be computed as

$$\frac{(\text{Upper Limit} - \text{Estimate})}{(\text{Estimate} - \text{Lower Limit})} = \frac{(1.9022 - 1.4510)}{(1.4510 - 1.1408)} = 1.4545.$$

so clearly, a symmetric confidence interval is not a good summary of the uncertainty attached to the β_0 parameter. On the other hand, the estimated β_6 parameter is 0.3722 with a standard error of 0.1460.

The correct confidence interval, based on the profile t function, is (0.1317,0.6430), with an asymmetry of

$$\frac{(0.6430 - 0.3722)}{(0.3722 - 0.1377)} = 1.1548.$$

which is clearly closer to 1.

3.2 Fitting the Nelson-Siegel model to the Four Data Sets

The reparameterised Nelson-Siegel model was fitted to the Data1, Data2, Data3, and Data4 data sets. Estimates of the DRP_7, DRP_{10} and $\Delta(DRP)$ were found by substituting the parameter estimates into the relevant formula. Standard errors were found using the delta method[5]. Estimates and standard errors are given in Table 3. Similar results are obtained using robust methods.

One point to notice is that the standard errors for ΔDRP appear to be large. However, the units for ΔDRP are bppa. If the units were quoted as percentages, then for Data1 the standard error would be 0.0163.

			7 year DRP		10 year DRP		Δ DRP	
Data Set	Source	Data	Estimate (%)	Std.err	Estimate (%)	Std.err	(bppa)	Std.err
Data1	Report	Individual	2.76		2.99		7.62	
	optim	Individual	2.76		2.99		7.59	
	nls	Average	2.73	0.1	2.97	0.09	7.8	1.63
Data2	Report	Individual	2.76		2.99		7.38	
	optim	Individual	2.76		2.98		7.35	
	nls	Average	2.73	0.11	2.96	0.1	7.58	1.72
Data3	Report	Individual	2.78		2.98		6.67	
	optim	Individual	2.49		2.97		6.64	
	nls	Average	2.76	0.09	2.96	0.09	6.78	1.49
Data4	Report	Individual	2.76		2.96		6.71	
	optim	Individual	2.76		2.96		6.68	
	nls	Average	2.75	0.1	2.95	0.09	6.79	1.57

Table 3: Comparison of results in Report with fitting the model in R, using average data: Data sets Data1, Data2, Data3, and Data4.

Figure 3 shows the data and the fitted curve with 95% confidence limits based on ± 1.96 standard errors. The confidence intervals are quite narrow.

3.3 Value of Curve Fitting

We agree with CEG about the value of curve fitting to estimate the Debt Risk Premium at 10 years. The usefulness of this technique is amplified when standard errors are calculated. As shown in the previous section, the estimates of the Debt Risk Premiums at 7 years and at 10 years are estimated relatively precisely. However the increase in the DRP (bppa) is estimated less precisely.

One issue that needs to be addressed is how to extrapolate the Bloomberg fair value curve from 7 to 10 years. Two methods have been suggested:

1. Using the bond pairs analysis, as suggested by the AER.

2. Using the increase implied by the fitted curve.

CEG identified five bond pairs that could be applied to the task of paired bond analysis. The increases in the DRP were 5.613, 4.221, 5.908, 6.802, and 3.304[6] bppa with an average of 5.170 bppa and a standard error of 0.624. This is less than the standard errors for the increase in the DRP from

[5]In one dimension, $\text{Var}(g(x)) \approx [g'(\mu)]^2\text{Var}(x)$; In higher dimensions $\text{Var}(g(x)) \approx d'\Sigma d$ where Σ is the variance-covariance matrix of x and d is the vector of first derivatives of g evaluated at μ, implemented in the `delta.method` command in the package `alr3`.

[6]These numbers showing the increments to the debt risk premium implied by different pairs of bonds are reported to two decimal places in Table 5 of CEG (2013a).

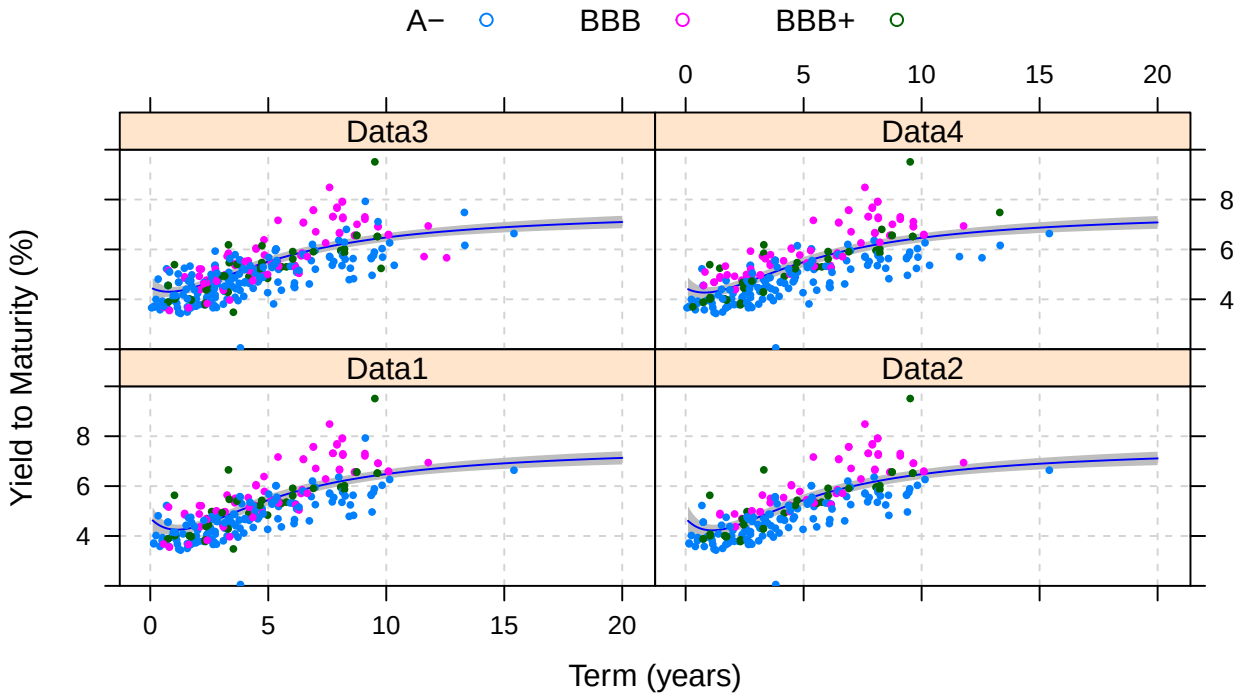

Figure 3: Scatter plots of Yield to Maturity vs. Term, with fitted Nelson-Siegel curve for Data1, Data2, Data3, and Data4 with 95% pointwise confidence intervals, based on average values.

the curve fitting. It should be borne in mind that the standard error of 0.624 is estimated with only 4 degrees of freedom and hence is subject to some variability. In addition, we have obtained reduced standard errors for the increase implied by the yield curves by fitting a non-linear mixed effects model (see, for example, Pinheiro and Bates, 2004) with random effects for each bond issuer. Based on our analysis, there is no clear statistical superiority of one method over the other. However, both methods of extrapolating the debt risk premium are reasonable and appropriate.

3.4 Opinion

The results show good agreement with those given by CEG. We agree with CEG in the value of using curve fitting to estimate the Debt Risk Premium at 10 years. The calculation of standard errors is a necessary and useful addition to the fitted curves. The standard errors for the Debt Risk Premiums at 7 and 10 years are relatively small and therefore the estimates can be used with confidence.

4 References

Bates, D.M. and Watts, D.G. (1988), *Nonlinear Regression Analysis and its Applications*, Wiley: New York.

Hird, T. (2013a). "Estimating the debt risk premium," prepared by Competition Economists' Group for the Energy Networks Association," June 2013.

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Nelson, C.R. and Siegel, A.F. (1987). "Parsimonious Modeling of Yield Curves," *The Journal of Business*, **60** 473-489.

Pinheiro, J.C. and Bates, D.M. (2004). *Mixed-Effects Models in S and S-Plus*, Springer: New York.

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5 Statement

We have made all the inquiries that we believe are desirable and appropriate and that no matters of significance that we regard as relevant have, to our knowledge, been withheld.

We acknowledge that the opinions in the report are based wholly or substantially on the specialised knowledge that we have; and indicate that we have been provided with a copy of the Federal Court of Australia's "Guidelines for Expert Witnesses in Proceedings in the Federal Court of Australia" and that the Report has been prepared in accordance with those Guidelines, available online at `http://www.federalcourt.gov.au/law-and-practice/practice-documents/practice-notes/cm7`.

A Neil Diamond

Neil Diamond CV

Curriculum Vitae
Neil Diamond March 2013

Full Name:	Neil Thomas Diamond
Date of Birth:	2/2/1956
Academic Qualifications:	B.Sc (Hons) (Monash), Ph.D. (Melbourne), A.Stat

Career History

1977-78	Statistician, ICI Explosives Factory, Deer Park
1979-86	Research Officer, Research Scientist, Senior Research Scientist And Statistics and Computing Team Leader, ICI Central Research Laboratories, Ascot Vale
1987-1989	Lecturer, Department of Mathematics, Computing and Operations Research, Footscray Institute of Technology
(1989)	Visiting Scientist, Center for Quality and Productivity Improvement, University of Wisconsin-Madison, USA.
1990-2003	Senior Lecturer, Department of Computer and Mathematical Sciences, Victoria University of Technology
(1995)	Visiting Fellow, Center for Quality and Productivity Improvement, University of Wisconsin-Madison, USA.
2003-2004	Senior Statistician, Insureware
2004-2006	Senior Lecturer and Deputy Director of Consulting, Department of Econometrics and Business Statistics, Monash University.
2007- 2012	Senior Lecturer and Director of Consulting, Department of Econometrics and Business Statistics, Monash University.
2011- 2012	Associate Professor and Co-ordinator of Statistical Support, Victoria University.
2012-	Director, ESQUANT Statistical Consulting

Research and Consulting Experience

- A Ph.D. from the University of Melbourne entitled "Two-factor interactions in non-regular foldover designs."
- Ten years with ICI Australia as an industrial statistician initially with the Explosives group and eventually with the research group.
- Two six month periods (Professional Experience Program and Outside Studies Program) at the Center for Quality and Productivity Improvement, at the University of Wisconsin-Madison. The Center, founded and directed by Professor George Box, conducts innovative practical

research in modern methods of quality improvement and is an internationally recognised forum for the exchange of ideas between experts in various disciplines, from industry and government as well as academia.

- Extensive consulting and training on behalf of the Centre for Applied Computing and Decision Analysis based at VUT for the following companies:

Data Sciences	Initiating Explosives Systems
Analytical Science Consultants	Saftec
Glaxo Australia	Datacraft Australia
Enterprise Australia	ICI Australia
The LEK partnership	Kaolin Australia
BP Australia	AMCOR
Melbourne Water	Kinhill Group
Australian Pulp and Paper Institute	

- Operated the Statistical Consulting Service at Victoria University of Technology from 1992-2003.

- From 2003-2004 worked as a Senior Statistician with Insureware on the analysis of long-tailed liability data.

- From December 2004 to December 2006 Deputy Director of Consulting of Monash University Statistical Consulting Service based in the Department of Econometrics and Business Statistics.

- From January 2007 Director of Consulting of Monash University Statistical Consulting Service based in the Department of Econometrics and Business Statistics.

- Extensive consulting and training on behalf of the Monash University Statistical Consulting Service for the following companies and organisations:

Australian Tax Office	Department of Human Services
J D McDonald	IMI Research
Port of Melbourne Corporation	Incitec Pivot
Agricola, Wunderlich & Associates	Parks Victoria
Australian College of Consultant Physicians	ANZ
Department of Justice	CRF(Colac Otway)
Australian Football League Players' Association	United Energy
ETSA	ENA

Postgraduate Supervision

Principal Supervisor

Gregory Simmons (1994-1997). M.Sc. completed. "Properties of some minimum run resolution IV designs."

Tony Sahama (1995-2003). Ph.D. completed. "Some practical issues in the design and analysis of computer experiments."

Ewa Sztendur (1999-2005). Ph.D. completed. "Precision of the path of steepest ascent in response surface methodology." [As a result of this thesis, Ewa was awarded the 2006 Victoria University Vice-Chancellor's Peak Award for Research and Research Training-Research Degree Graduate.]

Co-supervisor

Keith Hart (1996-1997). M.Sc. completed. "Mean reversion in asset prices and asset allocations in funds management."

Jyoti Behera (1999-2000). M.Eng. completed. "Simulation of container terminals."

Ray Summit (2001-2004). Ph.D. completed. "Analysis of warranty data for automobile data."

Rob Moore (2001-2007). Ph.D. completed. "Computer recognition of musical instruments.

M.Sc. Minor Theses

Milena Shtifelman (1999). Completed. (Monash University Accident Research Centre). "Modelling interactions of factors influencing road trauma trends in Victoria."

Rohan Weliwita (2002). Completed. "Modelling road accident trauma data."

Theses Examination

One M.Sc. major thesis (University of Melbourne) and one M.Sc minor thesis (Victoria University).

Workshops

Victoria University

- Experimental Design.
- Longitudinal Data Analysis.
- Statistics for Biological Sciences.
- Introductory Statistics for Research.
- Software Packages for Statistics.
- Design and Analysis of Questionnaires and Sample Surveys.
- Introductory SPSS.
- Statistics for Biological Sciences using R.
- Statistics for Biological Sciences using SPSS.
- Research Design and Statistics.

Monash University

- Expert Stats Seminars for higher degree research students on Software Packages for Statistics, Questionnaire Design, Analysis of Survey Data, and Multivariate Statistics.
- Introduction to Statistics for Pharmacy (5 hours).

Other

- Design of Experiments for ICI Australia (One day course).
- Design of Experiments for Quality Assurance-including Taguchi Methods. A 2-day professional development short course on behalf of the Centre for Manufacturing Advanced Engineering Centre.
- Design of Experiments for the Australian Pulp and Paper Institute.
- Statistical Methods for ANZ Analytics.

Teaching Experience

Monash University

- Business Statistics (First Year), Marketing Research Analysis (Second Year), Survey Data Analysis (Third Year-Clayton and Caulfield).

Victoria University of Technology

- Applied Statistics (First Year), Linear Statistical Models, Sampling and Data Analysis (Second Year), Experimental Design (Third Year).
- Statistics for Engineers, Statistics for Nurses, Statistics for Occupational Health.
- Forecasting (Graduate Diploma in Business Science)

Sessional Teaching

- RMIT (1991, 1996-2002) Design of Experiments for Masters in Quality Management.
- AGSM (1993-1997): Total Quality Management for Graduate Management Qualification.
- Various other: The University of Melbourne, Enterprise Australia, Swinburne Institute of Technology.

Industry Projects

Over 30 projects for the following companies and organisations:

Gas and Fuel Corporation	Ford Australia
Mobil Australia	Fibremakers
ICI Australia	Western General Hospital
Data Sciences	Keilor City Council
AMCOR	Composite Buyers
Davids	Email Westinghouse
Craft Coverings	Australian Wheat Board
CSL	Holding Rubber
Viplas Olympic	Melbourne Water
Federal Airports Corporation	

Publications

Chapters in Books

1. Sztendur, E.M. and Diamond, N.T., (2001). "Inequalities for the precision of the path of steepest ascent in response surface methodology," in Cho, Y.J, Kim, J.K., and Dragomir, S.S. (eds.) *Inequality Theory and Applications Volume 1*, Nova Publications.

Journal Articles

1. Diamond, N.T., (1991). "Two visits to Wisconsin," *Quality Australia*, **7**, 30-31.
2 Diamond, N.T., (1991). "The use of a class of foldover designs as search designs," *Austral. J. Statist*, **33**, 159-166.
3 Diamond, N.T., (1995). "Some properties of a foldover design," *Austral. J. Statist*, **37**, 345-352.
4 Watson, D.E.R., Hallett, R.F., and Diamond, N.T., (1995). "Promoting a collegial approach in a multidisciplinary environment for a total quality improvement process in higher education, " *Assessment & Evaluation in Higher Education*, **20**, 77–88.
5 Van Matre, J. and Diamond, N.T., (1996). "Team work and design of experiments," Quality Engineering, 9, 343–348.
6 Diamond, N.T., (1999). "Overlap probabilities and delay detonators," *Teaching Statistics*, **21**, 52–53. Also published in "Getting the Best from Teaching Statistics", one of the best 50 articles from volumes 15 to 21 of *Teaching Statistics*.
7 Cerone, P. and Diamond, N.T., (2000). "On summing permutations and some statistical properties," *The International Journal of Mathematical Education in Science and Technology*, **32**, 477-485.
8 Behera, J.M., Diamond, N.T., Bhuta, C.J. and Thorpe, G.R.,(2000). "The impact of job assignment rules for straddle carriers on the throughput of container terminal detectors," *Journal of Advanced Transportation*, **34**, 415-454.
9 Sahama, T. and Diamond, N.T., (2001). "Sample size considerations and augmentation of computer experiments," *The Journal of Statistical Computation and Simulation*, **68**, 307-319.
10 Paul, W. and Diamond, N.T., (2001). "Designing a monitoring program for environmental regulation: Part 1-The operating characteristic curve," *Water*: Journal of Australian Water Association, October 2001, 50-54.
11 Sztendur, E.M. and Diamond, N.T., (2002). "Extension to confidence region calculations for the path of steepest ascent," *Journal of Quality Technology*, **34**, 288-295.
12 Paul, W. and Diamond, N.T., (2002). "Designing a monitoring program for environmental regulation: Part 2-Melbourne Water case study," *Water*: Journal of Australian Water Association, February 2002, 33-36.
13 Steart, D.C., Greenwood, D.R., Boon, P.I. and Diamond, N.T., (2002) "Transport of leaf litter in upland streams of Eucalyptus and Nothofagus forests in South Eastern Australia," *Archiv Für Hydrobiologie,* **156***, 43-61.*
14 Peachey, T. C., Diamond, N. T., Abramson, D. A., Sudholt, W., Michailova, A., and Amirriazi, S. (2008). "Fractional factorial design for parameter sweep experiments using Nimrod/E," *Sci. Program.*, **16**(2-3), 217–230.

15 Sahama, T.R. and Diamond, N.T. (2009) "Computer Experiment-A case study for modelling and simulation of Manufacturing Systems," *Australian Journal of Mechanical Engineering*, **7**(1), 1–8.

16 Booth, R., Brookes, R., and Diamond, N. (2012) " The declining player share of AFL clubs and league revenue 2001-2009: Where has the money gone?," *Labour and Industry* 22:4, 433–446.

17 Booth, R., Brookes, R., and Diamond, N. (2012) "Theory and Evidence on Player Salaries and Revenues in the AFL 2001-2009," Accepted for publication in *Economics and Labour Relations Review*.

18 Chambers, J.D., Bethwaite, B., Diamond, N.T., Peachey, T.C., Ambramson, D., Petrou, S., and Thomas, E.A. (2012) "Parametric computation predicts a multiplicative interaction between synaptic strength parameters controls properties of gamma oscillations," *Frontiers in Computational Neuroscience* Volume 6, Article 53 doi:103389/fncom.2012.00053.

Refereed Conference Papers

1. Behera, J., Diamond, N.T., Bhuta, C. and Thorpe, G., (1999). "Simulation: a decision support tool for improving the efficiency of the operation of road vehicles in container terminals," 9th ASIM Dedicated Conference, Berlin, February 2000, 75-86.

2. Jutrisa, I., Diamond, N.T. and Cerone. P., (1999). "Frame size effects on throughput and return traffic in reliable satellite broadcast transmission, " 16th International Teletraffic Congress, Edinburgh, Scotland.

3. Diamond, N.T. and Sztendur, E.M. (2002). "The use of consulting problems in introductory statistics classes", *Proceedings of the 6th International Conference on the Teaching of Statistics*.

4. Summitt, R.A., Cerone. P., and Diamond, N.T. (2002). "Simulation Reliability Estimation from Early Failure Data, *Proceedings of the Fourth International Conference on Modelling and Simulation*, 368-390.

5. Summitt, R.A., Cerone. P., and Diamond, N.T. (2002). "Simulation Reliability Estimation from Early Failure Data II, *Proceedings of the Fourth International Conference on Modelling and Simulation*, 391-396.

6. Sahama, T. And Diamond, N.T. (2008). "Computer Experiment-A case study for modelling and simulation of Manufacturing Systems," 9th Global Conference on Manufacturing and Management.

Reports

A number of confidential reports for ICI Australia from 1977-1987.

Victoria University

VU1. Diamond, N.T (1990). "Professional Experience Program at the Center for Quality and Productivity Improvement," Footscray Institute of Technology.

VU2. Bisgaard, S. and Diamond, N.T (1991). "A discussion of Taguchi's methods of confirmatory trials," Report No. 60. Center for Quality and Productivity Improvement, University of Wisconsin-Madison.

VU3. Diamond, N.T (1996). "Outside Studies Program at the Center for Quality and Productivity Improvement," Victoria University of Technology.

VU4. Diamond, N.T (1996). "Statistical Analysis of EPA compliance of the western treatment plant," prepared for Melbourne Water on behalf of Kinhill Engineers.

VU5. Diamond, N.T (1996). "Statistical Analysis of EPA compliance of the western treatment plant," prepared for Melbourne Water on behalf of Kinhill Engineers.

VU6. Diamond, N.T (1998). "Statistical Analysis of BOD and SS compliance rates and license limits at ETP and WTP," prepared for Melbourne Water.

VU7. Diamond, N.T (1998). "Fate of pollutants at WTP-method for determining safety margins," prepared for Egis consulting group.

VU8. Bromley, M. and Diamond, N.T (2002). "The manufacture of Laboratory coreboard using various chip furnishes," prepared for Orica adhesives and resins.

Monash University

M1. Hyndman, R.J, Diamond, N.T. and de Silva, A. (2004). "A review of the methodology for identifying potential risky agents," prepared for the Australian Tax Office.

M2. Diamond, N.T. and Hyndman, R.J. (2005). "Sample Size for Maternal and Child Heath Service Evaluation," prepared for the Department of Human Services.

M3. Diamond, N.T. (2005). "Analysis of Customer Satisfaction Survey 2005," prepared for JD Macdonald.

M4. Diamond, N.T. (2005). "Analysis of 2005 Orientation Survey," prepared for Monash Orientation.

M5. Diamond, N.T. (2005). "Analysis of Before and After and Sequential Monadic Concept Consumer Surveys," prepared for IMI-Research.

M6. Diamond, N.T. and Hyndman, R.J. (2005). "The Monash Experience Questionnaire 2003: First Year Students," prepared for CHEQ, Monash University.

M7. Diamond, N.T. and Hyndman, R.J. (2005). "The Monash Experience Questionnaire 2003: The Best and Worst, " prepared for CHEQ, Monash University.

M8. Diamond, N.T. and Hyndman, R.J. (2005). "The Monash Experience Questionnaire 2003: The Best and Worst for First Year Students," prepared for CHEQ, Monash University.

M9. Diamond, N.T. (2005). "Technical Document for DUKC Uncertainty Study," prepared for Port of Melbourne Corporation.

M10. Diamond, N.T. (2005). "DUKC Uncertainty Study-Summary of Results," prepared for Port of Melbourne Corporation.

M11. Diamond, N.T. (2005). "Number of Ship trials for DUKC Uncertainty Study," prepared for Port of Melbourne Corporation.

M12. Diamond, N.T. (2005). "Threshold Criteria for Touch Bottom Probabilities," prepared for Port of Melbourne Corporation.

M13. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: The Best and Worst," prepared for CHEQ, Monash University.

M14. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: The Best and Worst for First Year Students," prepared for CHEQ, Monash University.

M15. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: A Statistical Analysis," prepared for CHEQ, Monash University.

M16. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: 2005 vs. Pre-2005 Students," prepared for CHEQ, Monash University.

M17. Diamond, N.T. (2006). "Agreement of 110/116 and 111/117 items by Consultant Physicians," prepared for the Australian College of Consultant Physicians.

M18. Diamond, N.T. (2006). "Analysis of Statistical Issues regarding Cornish v Municipal Electoral Tribunal, " prepared for Agricola, Wunderlich & Associates.

M19. Diamond, N.T. (2006). "Analysis of Parks Victoria Staff Allocation," prepared for Parks Victoria.

M20. Diamond, N.T. and Hyndman, R.J. (2006). "Summary of Results of IPL Sales Forecasting Improvement Project," prepared for Incitec Pivot.

M21. Sztendur, E.M. and Diamond, N.T. (2007) "A model for student retention at Monash University", prepared for University retention committee.

M22. Sztendur, E.M. and Diamond, N.T. (2007) "An extension to a model for student retention at Monash University", prepared for University review of coursework committee.

M23. Sztendur, E.M. and Diamond, N.T. (2007) "A model for student academic performance at Monash University", prepared for University review of coursework committee.

M24. Diamond, N.T. (2007). "Analysis of IB student 1st year results at Monash University 2003-2005", prepared for VTAC.

M25. Diamond, N.T. (2008). "Effect of smoking bans on numbers of clients utilising problem gambling counselling and problem gambling financial counselling", prepared for Department of Justice

M26. Diamond, N.T. (2008). "Development of Indices Based Approach for Forecasting Gambling Expenditure at a Local Government Area Level", prepared for Department of Justice

M27. Diamond, N.T. (2008). "Orientation 2007- Analysis of Quantitative results", prepared for University Orientation committee.

M28. Diamond, N.T. (2008). "Orientation 2007- Analysis of Qualitative results, prepared for University Orientation committee.

M29. Diamond, N.T. (2008). "Analysis of Clients presenting to Problem Gambling Counselling Services-2002/03 to 2005/06", prepared for the Department of Justice.

M30. Diamond, N.T. (2008). "Analysis of Clients presenting to Problem Gambling Financial Counselling Services-2001/02 to 2005/06", prepared for the Department of Justice.

M31. Diamond, N.T. (2008). "Analysis of Clients presenting to Problem Gambling Counselling and Problem Gambling Financial Counselling Services-2006/07", prepared for the Department of Justice.

M32. Diamond, N.T. (2008). "The effect of changes to Electronic Gaming Machine numbers on gambling expenditure", prepared for the Department of Justice.

M33. Diamond, N.T. (2009). "Adjustment of Mark Distributions", prepared for the Faculty of Law.

M34. Diamond, N.T. (2009). "Summary of Results for Dyno Nobel Sales Forecasting Improvement Project," prepared for Incitec Pivot.

M35. Diamond, N. and Brooks, R. (2010). "Determining the value of imputation credits: Multicollinearity and Reproducibility Issues", prepared for the Victorian Electricity Distributors.

M36. Booth, R., Diamond, N., and Brooks, R. (2010). "Financial Analysis of Revenues and Expenditures of the AFL and of the AFL Clubs", prepared for the Australian Football League Players' Association.

M37. Diamond, N. and Brooks, R. (2010). "Determining the value of imputation credits: Sample Selection, and Standard Errors", prepared for the Victorian Electricity Distributors.

M38. Diamond, N. and Brooks, R. (2010). "Determining the value of imputation credits: Joint Confidence Region and Other Multicollinearity Issues", prepared for the Victorian Electricity Distributors.

M39. Diamond, N. and Brooks, R. (2010). "Reconstructing the Beggs and Skeels Data Set", prepared for the Victorian Electricity Distributors.

M40. Diamond, N. and Brooks, R. (2010). "Response to AER Final Decision", prepared for the Victorian Electricity Distributors.

M41. Diamond, N. and Sztendur, E. (2011). "The Student Barometer 2010. Faculty Results", prepared for Victoria University (6 reports).

M42. Diamond, N. and Sztendur, E. (2011). "The Student Barometer 2010. Campus Results", prepared for Victoria University.

M43. Diamond, N. and Sztendur, E. (2011). "The Student Barometer 2010. Qualitative analysis of comments", prepared for Victoria University (17 reports).

M44. Diamond, N. and Brooks, R. (2011). 'Review of SFG 2011 Dividend Drop-off Study'. prepared for Gilbert and Tobin on behalf of ETSA.

M45. Diamond, N. (2011). 'A review of "Using capture-mark-recapture methods to estimate fire starts in the United Energy distribution area", by Rho Environmetrics Pty.Ltd. and John Field Consulting Pty.Ltd', prepared for United Energy.

M46. Diamond, N., Brooks, R., and Macquarie, L. (2013). 'Estimation of Fair Value Curves', prepared for APA Group, Envestra, Multinet Gas, and SP AusNet.

ESQUANT Statistical Consulting

E1. Diamond, N.T. and Sztendur, E.M. (2013). "Assistance with Data Mining", prepared for confidential accounting firm.

E2. Diamond, N.T. (2013). "A review of NERA's analysis of McKenzie and Partington's EGARCH analysis,' prepared for Multinet Gas.

E3. Brooks, R., Diamond, N., Gray, S., and Hall, J. (2013). 'Comparison of Beta Estimation Techniques,' prepared for Energy Networks Association in conjuction with SFG Consulting and Monash University Statistical Consulting Service.

R Packages (Extensions to R Programming Environment)

R1. Diamond, N.T. (2010), VizCompX, http://cran.r-project.org/web/packages/VizCompX

Professional Service

- President, Victorian Branch, Statistical Society of Australia, 2001-2002.
  - Terms as Council Member, Vice-President, and Past President.
- Referee: *Australian and New Zealand Journal of Statistics*, *Biometrika*, *Journal of Statistical Software*

B Professor Robert Brooks

Robert Brooks is a professor in the Department of Econometrics and Business Statistics and Deputy Dean, Education in the Faculty of Business and Economics.

Robert obtained his honours and PhD degrees from Monash University and has previously worked at RMIT University.

His primary area of research interest is in financial econometrics, with a particular focus on beta risk estimation, volatility modelling and the analysis of the impacts of sovereign credit rating changes on financial markets. His research in the financial econometrics area has produced a number of publications in top-tier journals, along with research funding from ARC Discovery and ARC Linkage and industry sources.

Given his education management role, Robert also works in areas of educational research relating to pedagogy of teaching business statistics and in particular applications of problem based learning in that setting.

Publications

Books

Brooks, R.D., Morley, C.L., Kam, B., Stewart, M., Diggle, J., Gangemi, M., 2003, *Benefits of Road Investment to Assist Tourism*, Austroads Incorporated, Sydney NSW Australia.

Brooks, R.D., Fausten, D.K., 1998, *Macroeconomics in the Open Economy*, Longman, Melbourne Vic Australia.

Book Chapters

Iqbal, J., Brooks, R., Galagedera, D., 2011, Testing the lower partial moment asset-pricing models in emerging markets, in *Financial Econometrics Modeling: Market Microstructure, Factor Models and Financial Risk Measures*, eds Greg N Gregoriou and Razvan Pascalau, Palgrave Macmillan, Basingstoke UK, pp. 154-175.

Booth, D., Brooks, R., 2011, Violence in the Australian Football League: Good or bad?, in *Violence and Aggression in Sporting Contests: Economics, History and Policy*, eds R Todd Jewell, Springer Science+Business Media, New York NY USA, pp. 133-151.

Lim, K., Brooks, R.D., 2010, Are emerging stock markets less efficient? A survey of empirical literature, in *Emerging Markets: Performance, Analysis and Innovation*, eds Greg N Gregoriou, CRC Press, Boca Raton FL USA, pp. 21-38.

Iqbal, J., Brooks, R.D., Galagedera, D.U.A., 2010, Asset pricing with higher-order co-moments and alternative factor models: The case of an emerging market, in *Emerging Markets: Performance, Analysis and Innovation*, eds Greg N Gregoriou, CRC Press, Boca Raton FL USA, pp. 509-531.

Woodward, G., Brooks, R.D., 2010, The market timing ability of Australian superannuation funds: Nonlinearities and smooth transition models, in *The Risk Modeling Evaluation Handbook: Rethinking Financial Risk Management Methodologies in the Global Capital Markets*, eds Greg N Gregoriou, Christian Hoppe and Carsten S Wehn, McGraw-Hill, USA, pp. 59-73.

Bissoondoyal-Bheenick, E., Brooks, R.D., 2010, Volatility asymmetry and leverage: Some U.S. evidence, in *The Risk Modeling Evaluation Handbook: Rethinking Financial Risk Management*

Methodologies in the Global Capital Markets, eds Greg N Gregoriou, Christian Hoppe and Carsten S Wehn, McGraw-Hill, USA, pp. 115-123.

Dimovski, W., Brooks, R.D., 2007, Differences in underpricing returns between REIT IPOs and industrial company IPOs, in *Advances in Quantitative Analysis of Finance and Accounting - Volume 5*, eds Cheng-Few Lee, World Scientific, Singapore, pp. 215-225.

Brooks, R.D., Faff, R., Fry, T.R.L., Gunn, L.D., 2005, Censoring and its impact on beta risk estimation, in *Advances in Investment Analysis and Portfolio Management (New Issue) Volume 1*, eds Cheng F. Lee and Alice C. Lee, Center for Pacific Basin Business, Economics, and Finance Research, New Jersey, pp. 111-136.

Brooks, R.D., Merlot, E.S., 2005, Changing candidature approval processes: a review of the RMIT business panel review of candidature process, in *Supervising postgraduate research: contexts and processes, theories and practices*, eds Pam Green, RMIT University Press, Melbourne Vic Australia, pp. 178-201.

Boucher, C., Brooks, R.D., 2005, Changing times, changing research, changing degrees: supervising and managing the first PhD by project undertaken in a business faculty, in *Supervising postgraduate research: contexts and processes, theories and practices*, eds Pam Green, RMIT University Press, Melbourne Vic Australia, pp. 73-88.

Brooks, R.D., Faff, R.W., Fry, T.R.L., Maldonado-Rey, D., 2004, Alternative beta risk estimators in emerging markets: the Latin American case, in *Latin American Financial Markets: Developments in Financial Innovations*, eds H Arbelaez, R Click, Elsevier Ltd, Oxford UK, pp. 329-344.

Brooks, R.D., Sayers, R., 2002, Trends in printed matter exports, in *The International Publishing Services Market: Emerging Markets for Books, from Creator to Consumer*, eds Bill Cope and Christopher Ziguras, Common Ground, Altona Vic Australia, pp. 27-38.

Faff, R., Brooks, R.D., Tan, P.F., 2001, A test of a new dynamic CAPM, in *Advances in Investment Analysis and Portfolio Management Volume 8*, eds Cheng Few Lee, Elsevier Science, Oxford, pp. 133-159.

Journal Articles

Treepongkaruna, S., Brooks, R.D., Gray, S., 2012, Do trading hours affect volatility links in the foreign exchange market?, *Australian Journal of Management [P]*, vol 37, issue 1, Sage Publications Ltd, London UK, pp. 7-27.

Chan, K., Treepongkaruna, S., Brooks, R., Gray, S., 2011, Asset market linkages: Evidence from financial, commodity and real estate assets, *Journal of Banking and Finance [P]*, vol 35, issue 6, Elsevier BV, Amsterdam Netherlands, pp. 1415-1426.

Brooks, R., 2011, CO2 emissions and economic growth: Structural breaks and market reforms in the case of China, *The International Journal of Climate Change: Impacts and Responses [E]*, vol 2, issue 3, Common Ground Publishing, Altona Vic Australia, pp. 25-36.

Luo, W., Brooks, R., Silvapulle, P., 2011, Effects of the open policy on the dependence between the Chinese 'A' stock market and other equity markets: An industry sector perspective, *Journal of International Financial Markets, Institutions and Money [P]*, vol 21, issue 1, Elsevier BV, Amsterdam Netherlands, pp. 49-74.

Bissoondoyal-Bheenick, E., Brooks, R., Hum, X., Treepongkaruna, S., 2011, Sovereign rating changes and realized volatility in Asian foreign exchange markets during the Asian crisis, *Applied Financial Economics [P]*, vol 21, issue 13, Routledge, Abingdon UK, pp. 997-1003.

Masters, T., Russell, R., Brooks, R., 2011, The demand for creative arts in regional Victoria, Australia, *Applied Economics [P]*, vol 43, issue 5, Routledge, Abingdon UK, pp. 619-629.

Lim, K., Brooks, R., 2011, The evolution of stock market efficiency over time: A survey of the empirical literature, *Journal Of Economic Surveys [P]*, vol 25, issue 1, Wiley-Blackwell Publishing Ltd, Oxford UK, pp. 69-108.

Guo, H., Brooks, R., Fung, H., 2011, Underpricing of Chinese initial public offerings, *The Chinese Economy [P]*, vol 44, issue 5, M E Sharpe Inc, Armonk NY USA, pp. 72-85.

Dimovski, W., Philavanh, S., Brooks, R., 2011, Underwriter reputation and underpricing: Evidence from the Australian IPO market, *Review of Quantitative Finance and Accounting [P]*, vol 37, issue 4, Springer, Secaucus NJ USA, pp. 409-426.

Brooks, R., Di Iorio, A., Faff, R., Fry, T., Joymungul, Y., 2010, Asymmetry and time variation in exchange rate exposure: An investigation of Australian stocks returns, *International Journal of Commerce and Management [P]*, vol 20, issue 4, Emerald Group Publishing Ltd, UK, pp. 276-295.

Guo, H., Brooks, R.D., Shami, R.G., 2010, Detecting hot and cold cycles using a Markov regime switching model-Evidence from the Chinese A-share IPO market, *International Review of Economics and Finance [P]*, vol 19, issue 2, Elsevier BV, North-Holland, Netherlands, pp. 196-210.

Bissoondoyal-Bheenick, E., Brooks, R.D., 2010, Does volume help in predicting stock returns? An analysis of the Australian market, *Research in International Business and Finance [P]*, vol 24, issue 2, JAI Press Inc, USA, pp. 146-157.

Iqbal, J., Brooks, R.D., Galagedera, D.U.A., 2010, Multivariate tests of asset pricing: Simulation evidence from an emerging market, *Applied Financial Economics [P]*, vol 20, issue 5, Routledge, UK, pp. 381-395.

Iqbal, J., Brooks, R.D., Galagedera, D.U.A., 2010, Testing conditional asset pricing models: An emerging market perspective, *Journal of International Money and Finance [P]*, vol 29, issue 5, Pergamon, UK, pp. 897-918.

Suntah, N., Brooks, R., 2010, The stock exchange of Mauritius: A study of segmentation versus integration at the regional and global level, *African Journal of Accounting, Economics, Finance and Banking Research [P]*, vol 6, issue 6, Global Business Investments and Publications LLC, USA, pp. 32-41.

Nguyen, H., Dimovski, W., Brooks, R., 2010, Underpricing, risk management, hot issue and crowding out effects: Evidence from the Australian resources sector initial public offerings, *Review of Pacific Basin Financial Markets and Policies [P]*, vol 13, issue 3, World Scientific Publishing Co Pte Ltd, Singapore, pp. 333-361.

Hill, P., Brooks, R.D., Faff, R., 2010, Variations in sovereign credit quality assessments across rating agencies, *Journal of Banking and Finance [P]*, vol 34, issue 6, Elsevier BV, North-Holland, Netherlands, pp. 1327-1343.

Zhang, X., Brooks, R.D., King, M.L., 2009, A Bayesian approach to bandwidth selection for multivariate kernel regression with an application to state-price density estimation, *Journal of Econometrics [P]*, vol 153, issue 1, Elsevier BV, North-Holland, Netherlands, pp. 21-32.

Brooks, R.D., Fry, T.R.L., Dimovski, W., Mihajilo, S., 2009, A duration analysis of the time from prospectus to listing for Australian initial public offerings, *Applied Financial Economics [P]*, vol 19, issue 3, Routledge, United Kingdom, pp. 183-190.

Lim, K., Brooks, R.D., 2009, Are Chinese stock markets efficient? Further evidence from a battery of nonlinearity tests, *Applied Financial Economics [P]*, vol 19, issue 2, Routledge, United Kingdom, pp. 147-155.

Brooks, R.D., Faff, R., Mulino, D., Scheelings, R., 2009, Deal or no deal, that is the question: The impact of increasing stakes and framing effects on decision-making under risk, *International Review of Finance [P]*, vol 9, issue 1-2, Wiley-Blackwell Publishing Asia, Richmond Vic Australia, pp. 27-50.

Woodward, G., Brooks, R.D., 2009, Do realized betas exhibit up/down market tendencies?, *International Review of Economics and Finance [P]*, vol 18, issue 3, Elsevier BV, North-Holland, The Netherlands, pp. 511-519.

Mulino, D., Scheelings, R., Brooks, R.D., Faff, R., 2009, Does risk aversion vary with decision-frame? An empirical test using recent game show data, *Review of Behavioral Finance [P]*, vol 1, issue 1-2, John Wiley & Sons Ltd, UK, pp. 44-61.

Guo, H., Brooks, R.D., 2009, Duration of IPOs between offering and listing: Cox proportional hazard models-Evidence for Chinese A-share IPOs, *International Review of Financial Analysis [P]*, vol 18, issue 5, Elsevier BV, North-Holland, Netherlands, pp. 239-249.

Brooks, R.D., Harris, E.M., Joymungul, Y., 2009, Market depth in an illiquid market: Applying the VNET concept to Victorian water markets, *Applied Economics Letters [P]*, vol 16, issue 13, Routledge, UK, pp. 1361-1364.

Nandha, M.S., Brooks, R.D., 2009, Oil prices and transport sector returns: An international analysis, *Review of Quantitative Finance and Accounting [P]*, vol 33, issue 4, Springer New York LLC, United States, pp. 393-409.

Lim, K., Brooks, R.D., 2009, On the validity of conventional statistical tests given evidence of nonsynchronous trading and nonlinear dynamics in returns generating process: A further note, *Applied Economics Letters [P]*, vol 16, issue 6, Routledge, United Kingdom, pp. 649-652.

Lim, K., Brooks, R.D., 2009, Price limits and stock market efficiency: Evidence from rolling bicorrelation test statistic, *Chaos, Solitons and Fractals [P]*, vol 40, issue 3, Pergamon, United Kingdom, pp. 1271-1276.

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C Daniel Young

Curriculum Vitae

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Key Practice Areas

Daniel is a Senior Economist working in CEG's Sydney office with extensive experience in the economic analysis of firms and markets. He has advised regulators, law firms and businesses on a range of issues across industry sectors including electricity, gas, telecommunications, transport, mining and finance.

Daniel has particular expertise in the application of mathematical and computational modelling techniques in economic analysis. His experience spans the design and construction of telecommunications cost models, building regulatory cost models, merger modelling, estimation of the cost of capital, calculating economic damages and econometric modelling. These techniques have formed the basis of expert reports provided to courts and regulators in Australia, New Zealand, the United Kingdom, the Netherlands, Hong Kong, Macau and Samoa.

Daniel was previously an analyst at NERA Economic Consulting. Daniel has a Masters of Commerce (in Economics) with first class honours and Bachelor degrees in Commerce and Science, majoring in Economics and Operations Research respectively.

Selected Projects

- Advised Chorus New Zealand on the Commerce Commission's proposed method of determining the UCLL price in New Zealand by benchmarking against prices in other jurisdictions
- Advice to the Australian Energy Market Commission on barriers to entry in electricity generation
- Assisting the ACCC in developing its analysis about the competitive effects of two recent proposed acquisitions in the media sector
- Advised Everything Everywhere UK on its submissions and appeal in respect of Ofcom's decision on mobile termination rates
- Advising Optus on appropriate principles for fixed line pricing and the formation of a roll-forward regulatory regime. Responding to and identifying a critical error in the proposed pricing principles
- Developing mobile cost models for Digicel in Samoa, Papua New Guinea and Tahiti for submission in regulatory proceedings.
- Estimating benchmarks for mobile termination prices using econometric analysis for Digicel in Vanuatu and Tonga
- Making adjustments to the ACCC's fixed line cost model to estimate the cost of a fibre to the premise roll out in Australia for Optus

- Estimating the potential cost improvements that could be achieved within the ACCC's fixed line cost model by the use of Steiner trees rather than minimum spanning trees on behalf of the Competition Carriers' Coalition
- Constructing spreadsheet models of the price effects of a major proposed merger in the European pharmaceutical industry
- Estimating a reserve price in Commercial Radio Australia's auction of unallocated multiplexer capacity
- Assisted in the preparation of expert statements on the likely impact of the joint venture of the Pilbara iron ore assets of BHP Billiton and Rio Tinto and before that the proposed merger between these parties
- Assisted in the preparation of an expert report on the competitive implications of a merger in the industrial packaging sector
- Analysis of the appropriate cost of capital to be used proposed damages claim being brought by Deutsche Telecom against Vivendi in relation to alleged unlawful activity in a Polish mobile telephony joint venture
- Assisted a European firm examining the implications for competition in the United Kingdom electricity generation market of a number of proposed transactions
- Developed a mobile cost model for an Australian telecommunications company.
- Estimating the likely response in the demand for electricity to the increased proliferation of time of day and critical peak tariffs as part of the MCE's cost/benefit analysis of the introduction of smart meters
- Assisted in the preparation of expert reports for Telecom New Zealand on the correct methodology for calculating the cost of providing the TSO (universal service obligation) using new entrant costs
- Prepared estimates of the potential damages faced by Telstra under a class action lawsuit from shareholders
- Provided drafting and analytical assistance for an expert report examining the effect of Foxtel's proposed special access undertaking on competition in the market for subscription television services
- Contributed to an analysis of the extent of competition in the auto-fuel retail sector in Hong Kong by estimating the margins of local firms and developing international comparisons as benchmarks
- Development of a modelling framework for the ACCC analysing the effect on competition of a merger between electricity generator and advised on potential divestitures

FEDERAL COURT OF AUSTRALIA
Practice Note CM 7
EXPERT WITNESSES IN PROCEEDINGS IN THE FEDERAL COURT OF AUSTRALIA

Practice Note CM 7 issued on 1 August 2011 is revoked with effect from midnight on 3 June 2013 and the following Practice Note is substituted.

Commencement

1. This Practice Note commences on 4 June 2013.

Introduction

2. Rule 23.12 of the Federal Court Rules 2011 requires a party to give a copy of the following guidelines to any witness they propose to retain for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based on the specialised knowledge of the witness (see **Part 3.3 - Opinion** of the *Evidence Act 1995* (Cth)).

3. The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence[1], and to assist experts to understand in general terms what the Court expects of them. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.

Guidelines

1. General Duty to the Court[2]

1.1 An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise.

1.2 An expert witness is not an advocate for a party even when giving testimony that is necessarily evaluative rather than inferential.

1.3 An expert witness's paramount duty is to the Court and not to the person retaining the expert.

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[1] As to the distinction between expert opinion evidence and expert assistance see *Evans Deakin Pty Ltd v Sebel Furniture Ltd* [2003] FCA 171 per Allsop J at [676].

[2] The "*Ikarian Reefer*" (1993) 20 FSR 563 at 565-566.

2. The Form of the Expert's Report[3]

2.1 An expert's written report must comply with Rule 23.13 and therefore must

(a) be signed by the expert who prepared the report; and

(b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and

(c) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge; and

(d) identify the questions that the expert was asked to address; and

(e) set out separately each of the factual findings or assumptions on which the expert's opinion is based; and

(f) set out separately from the factual findings or assumptions each of the expert's opinions; and

(g) set out the reasons for each of the expert's opinions; and

(ga) contain an acknowledgment that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c) above[4]; and

(h) comply with the Practice Note.

2.2 At the end of the report the expert should declare that "[the expert] has *made all the inquiries that* [the expert] *believes are desirable and appropriate and that no matters of significance that* [the expert] *regards as relevant have, to* [the expert's] *knowledge, been withheld from the Court*."

2.3 There should be included in or attached to the report the documents and other materials that the expert has been instructed to consider.

2.4 If, after exchange of reports or at any other stage, an expert witness changes the expert's opinion, having read another expert's report or for any other reason, the change should be communicated as soon as practicable (through the party's lawyers) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court[5].

2.5 If an expert's opinion is not fully researched because the expert considers that insufficient data are available, or for any other reason, this must be stated with an indication that the opinion is no more than a provisional one. Where an expert witness who has prepared a report believes that it may be incomplete or inaccurate without some qualification, that qualification must be stated in the report.

2.6 The expert should make it clear if a particular question or issue falls outside the relevant field of expertise.

2.7 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports[6].

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[3] Rule 23.13.

[4] See also *Dasreef Pty Limited v Nawaf Hawchar* [2011] HCA 21.

[5] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565

[6] The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565-566. See also Ormrod *"Scientific Evidence in Court"* [1968] Crim LR 240

3. Experts' Conference

3.1 If experts retained by the parties meet at the direction of the Court, it would be improper for an expert to be given, or to accept, instructions not to reach agreement. If, at a meeting directed by the Court, the experts cannot reach agreement about matters of expert opinion, they should specify their reasons for being unable to do so.

J L B ALLSOP
Chief Justice
4 June 2013

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TERMS OF REFERENCE – REVIEW OF FAIR VALUE CURVES AND AN ASSESSMENT OF METHODS USED TO DETERMINE THE SPOT COST OF DEBT

Background

On 30th August 2013, the Australian Energy Regulator (AER) published its draft rate of return guideline that will form the basis of the regulated rate of return to be applied in energy network decisions made from 2014 onwards. Previously the AER published an Issues Paper on 18th December 2012 and a Consultation Paper on 10th May 2013.

Under the new Rules, promulgated by the Australian Energy Market Commission, (AEMC), in December 2012, fundamental changes have been made to the way in which the allowance for the return of debt can be determined. Clause 6.5.2(j) of the National Electricity Rules (NER) provides that, at each determination, the allowance for the return of debt can be computed in one of three different ways:

(1) The return that would be required by debt investors in a benchmark efficient entity if it raised debt at the time or shortly before the making of the distribution determination for the regulatory control period.

(2) The average return that would have been required by debt investors in a benchmark efficient entity if it raised debt over an historical period prior to the commencement of a regulatory year in the regulatory control period; or

(3) Some combination of the returns referred to in subparagraphs (1) and (2). Implicit in these considerations is that the regulatory framework should encourage efficient financing practices that the former approach did not explicitly consider.

Implicit in these considerations is that the regulatory framework should encourage efficient financing practices that the previous approach did not explicitly consider.

The calculation of the spot cost of debt, or the market cost of debt at a particular point in time remains an essential component of all three of the aforementioned approaches. Option one, which is known as the rate-on-the day approach, uses an estimate of the cost of debt that is determined over a limited number of days in advance of the commencement of a new regulatory period. Option two calculates a form of historical average cost of debt, using historic information on spot rates. Under option three, the base cost of debt may be estimated separately from the debt risk premium.

United Energy and Multinet Gas are seeking a suitably qualified consultant to undertake specific analysis in relation to the current cost of debt, as measured over a recent 20 to 30 day averaging period. The purpose of the current exercise is to investigate whether yield curves can be used to derive robust estimates of the cost of debt for a benchmark corporate bond with a ten-year tenor.

The consultant will be supplied with:

- A spread sheet database containing information about the characteristics of bonds used in the empirical analysis. The attributes covered will include credit ratings, maturity dates, and yields. Data covering plain vanilla bonds will, in the main, be provided, although there may also be results for callable bonds and other types of bonds. Both domestic and foreign currency bonds will be supplied, although the yields on the latter will have been swapped into Australian dollar yields.

- A report from CEG which contains empirical estimates of yield curves. Please refer to: *Estimating the debt risk premium* (Incorporating CEG notice of errata, 22nd August 2013), prepared for the Energy Networks Association by the Competition Economists Group, August 2013. The report discusses yield curves that have been estimated according to the methods of Nelson and Siegel (1987)[1]. The report also contains an assessment of the performance of the Bloomberg fair value curve for BBB+ corporate debt.

- Regression results will have been reported in a spread sheet workbook. Program code may be supplied if it is available.

Scope of work

The consultant is required to undertake a detailed review of the yield curves that have been estimated by CEG, with a view to assessing the merits of the overall approach. The yield curves are a tool for working out the benchmark cost of debt corresponding to a particular term to maturity. The Nelson-Siegel model is non-linear in the parameters and is therefore more complicated to fit than a normal regression model.

The consultant should assess the case for using yield curves by comparison with the method of direct averaging of observed bond yields. The direct averaging technique takes a simple arithmetic average of bond yields, and has been applied by the AER and the Economic Regulation Authority (Western Australia).

The consultant should also develop yield curves for zero coupon bonds, and par yield curves. A zero coupon bond is a fixed income investment that provides only one payment at maturity. Bonds which trade at par are those for which the calculated yield is equal to the coupon rate. Par yield curves provide a theoretically correct specification for the term structure of the cost of debt.

Preliminary review of CEG methods

(1) Investigate the equations which have been estimated by CEG and seek to reproduce the reported results using a suitable software package. Categorise the results from yield-to-maturity curves separately from the results for par value yield curves. Assess how the estimated equations vary according to the bond samples used.

[1] Nelson, C.R. and Siegel, A.F. (1987). "Parsimonious Modeling of Yield Curves," The Journal of Business, 60, pages 473-489.

(2) Examine and report on the accuracy and correctness of the results from the estimated equations. Check whether outliers are present, and review the regression diagnostics. Note the standard errors and report on the precision of the parameter estimates.

(3) Assess whether the estimates of the cost of debt that have been presented by CEG are justifiable in the context of the estimated yield curves.

Refinements to the analysis – for both types of yield curve

(4) Investigate the case for the use of alternative estimation methods, such as robust regression techniques, for the daily regressions. Compare the results from different estimation methods.

(5) Examine the day-to-day drift of the parameter estimates over the nominated days of the averaging period. Suggest an alternative method for combining the daily results for the estimated benchmark 10-year corporate bond yield.

(6) Examine the validity of restrictions that may be imposed upon the Nelson-Siegel curves. The types of restriction are likely to include different intercept terms for bonds in different credit rating bands.

(7) The empirical methods that are applied to derive par value yield curves are more advanced. Firstly, a zero coupon yield curve is estimated. Secondly, a further non-linear equation has to be solved in order to determine par value yields. Diagnostic tests are needed for the overall model, and these should be developed by the consultant. The consultant should also investigate the impact of the weighting scheme based on Macaulay duration[2].

(8) Evaluate the results for the cost of debt that have been determined as par value yields. Comment on the methods that have been applied.

Comparison of results from yield curves with those obtained using the methods applied separately by the AER and the Economic Regulation Authority (WA).

(9) Critically assess the statistical properties of the cost of debt estimators developed separately by the AER and the ERA (WA). Consider the use of an overall measure of usefulness such as mean squared error (which is equal to the sum of the variance and the bias squared).

(10) Undertake a simulation analysis and apply other methods as appropriate.

Timeframe

The consultant is to provide a draft report which discusses the results of the analysis by Monday 23rd September 2013. A final report should be provided by no later than Monday 7th October.

[2] CEG (2012), Estimating the regulatory debt risk premium for Victorian gas businesses, a report prepared by Dr Tom Hird for APA Group, Envestra, Multinet Gas, and SP AusNet, Competition Economists Group, March 2012; page 31. A standard measure of risk is the Macaulay duration which computes the average maturity of a bond using the present values of its cash flows as weights.

Reporting

Jeremy Rothfield will serve as the primary contact for the period of the engagement. The consultant will prepare reports showing the work-in-progress on a regular basis. The consultant will make periodic presentations on analysis and advice as appropriate.

The consultant is likely to be called upon to present analysis and advice to the cost of capital sub-group of the Energy Networks Association (ENA).

Conflicts

The consultant is to identify any current or potential future conflicts.

Compliance with the Code of Conduct for Expert Witnesses

Attached is a copy of the Federal Court's Practice Note CM 7, entitled "Expert Witnesses in Proceedings in the Federal Court of Australia", which comprises the guidelines for expert witnesses in the Federal Court of Australia (Expert Witness Guidelines).

Please read and familiarise yourself with the Expert Witness Guidelines, and comply with them at all times in the course of your engagement with United Energy and Multinet Gas.

In particular, your report prepared for United Energy and Multinet Gas should contain a statement at the beginning of the report to the effect that the author of the report has read, understood and complied with the Expert Witness Guidelines.

Your report must also:

1. Contain particulars of the training, study or experience by which the expert has acquired specialised knowledge.

2. Identify the questions that the expert has been asked to address.

3. Set out separately each of the factual findings or assumptions on which the expert's opinion is based.

4. Set out each of the expert's opinions separately from the factual findings or assumptions.

5. Set out the reasons for each of the expert's opinions; and

6. Otherwise comply with the Expert Witness Guidelines.

The expert is also required to state that each of the expert's opinions is wholly or substantially based on the expert's specialised knowledge.

The declaration contained within the report should be that "[the expert] has made all the inquiries that [the expert] believes are desirable and appropriate and that no matters of significance that [the expert] regards as relevant have, to [the expert's] knowledge, been withheld from the report".

Please also attach a copy of these terms of reference to the report.

Fees

The consultant is requested to submit:

- A fixed total fee for the project and hourly rates for the proposed project team should additional work be required; and
- Details of the individuals who will provide the strategic analysis and advice.

Contacts

Any questions regarding this terms of reference should be directed to:

Jeremy Rothfield, telephone (03) 8846 9854, or via email at Jeremy.Rothfield@ue.com.au