To: Jeremy Rothfield

From: Neil Diamond

Subject: AER information request United Energy - #032 Return on debt

Date: 21st September 2015

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1 Background

In its draft decision for Jemena Gas Networks (JGN), the AER has adopted the method, described below, for estimating the return on debt for a benchmark efficient entity[1]:

- Adopting a 10-year term for the return on debt with a BBB+ credit rating.
- Applying a simple average of independent third party data from the Reserve Bank of Australia (RBA) and Bloomberg as follows:
  - The RBA broad BBB rated 10 year curve (the RBA curve[2]) – extrapolated to better reflect a 10 year estimate, and interpolated to produce daily estimates.
  - The Bloomberg broad BBB rated 7 year BVAL curve (the BVAL curve[3]) – extrapolated to 10 years.

The estimates of the cost of debt which are prepared by the RBA, and published as Table F3, are derived using a Gaussian kernel smoother, which is known to exhibit bias. ESQUANT (2014) suggested that local linear smoothing could remove the bias to first order, while Lally (2014) suggested an alternative method based on extrapolating the 7 year and 10 year estimates provided by the RBA. Finally the South Australian Power Networks (SA Power Networks, 2014) suggested another method based on a linear regression of the 3, 5, 7 and 10 year estimates provided by the RBA.

Diamond and Brooks (2015) evaluated the three methods. The three methods were shown to be linear smoothers, to be unbiased to first order, and expressions for the bias and variance of the three methods were given. Specifically, (Diamond and Brooks, Appendix D, 2015) for the Lally method the bias to second order is given by

$$\text{Bias} = \frac{G''(10)}{2} \times \sum_{i=1}^{N} u_i(\sigma)(T_i - 10)^2$$

while the variance is given by

$$\text{Variance} = \text{Variance}(\varepsilon_i) \times \sum_{i=1}^{N} u_i(\sigma)^2$$

where $G(T_i)$ is the spread curve at a tenor of T_i years, $u_i(\sigma)$ is the weight of the ith bond for the Lally method, and ε_i is the error from the model

$$S_i = G(T_i) + \varepsilon_i.$$

Additionally, the Root Mean Square Error (RMSE) is given by

$$\text{RMSE} = \sqrt{\text{Bias}^2 + \text{Variance}}.$$

Similar results apply to Local Linear Smoothing and the South Australian Power Networks method.

The AER has recently asked for some clarification, and this is the subject of this note.

[1] AER (2014), Draft decision, Jemena Gas Networks (NSW) Ltd, Access Arrangement 2015-20, Attachment 3: Rate of return, Australian Energy Regulator, November 2014; page 3-9.

[2] The RBA refers to this curve as "Non-financial corporate BBB-rated bonds".

[3] The Bloomberg ticker for this curve is: BVCSAB07.

2 AER Question

UED relies on the following report in relation to its proposed return on debt methodology:

> Esquant, Evaluation of methods for extrapolating Australian corporate credit spreads published by the RBA, 27 March 2015

Esquant's report contains root mean square error (RMSE) formulas for each of the three extrapolation methods examined. These formulas are intended to be for the spread (DRP) rather than the yield. Each such RMSE formula has a bias term common to all three methods (curvature of the true curve at 10 years), a bias multiplier peculiar to the method, a variance term common to all three methods (standard deviation of the residuals around the true curve), and a variance multiplier peculiar to the method. The empirical estimates of the two multiplier terms are for the spread but the other two terms seem to be taken from Nelson-Siegel curves for the bond yield rather than the spread. So, Esquant seem to have inserted parameters relating to yield into a formula for the spread.

We request that UED:

1. Confirm whether our above understanding of the Esquant methodology is correct, specifically in relation to whether Esquant have inserted parameters relating to yield into a formula for the spread?
2. Provide a brief justification for this approach?

3 Response

We can confirm that the AER's understanding of the ESQUANT methodology is correct. ESQUANT obtained values from a Nelson-Siegel curve which was applied to data on bond yields rather than to data on the spreads-to-swap.

The values used were the second derivative of the yield function (which measures the rate of change of the slope, and was recorded at 10 years), and the standard deviation of the regression residuals (which was assessed using the standard error of the regression). Thus, ESQUANT obtained estimates of the bias of the true function, and estimates of the variance of the true function from a Nelson-Siegel curve that was fitted to yield data rather than to spread data. However, the practical implication of using yields rather than spreads is almost negligible from the perspective of root mean squared error. As is explained over the remainder of the report, the use of yield data rather than spread data has only a moderate effect on the bias term, but has almost no effect on the variance term. In terms of the magnitude of the respective variables, the variance is larger than the square of the bias. Thus, the variance is of greater significance when considering the overall root mean squared error. The consequences of using yield data rather than spread data when working out the root mean squared error are therefore barely discernible.

A relevant consideration is that there are sound reasons for estimating Nelson-Siegel curves using data on yields rather than on spreads. The Nelson-Siegel model is a model for yields, not spreads. Our view is that it is better to fit the model to yields and to then subtract the corresponding risk-free rate. Evidence from the literature indicates that if the yields follow a Nelson-Siegel model, and the swap rates follow a Nelson-Siegel model, then the difference between the two only follows a Nelson-Siegel model if the non-linear parameter is the same for both models, a restrictive and unnecessary assumption.

Indeed, it should be noted that Diebold and Rudebusch (2013, p. 100-102) showed that Nelson-Siegel yield curves are closed under conversion to spreads,

> "That is, if two term structures of yields $y_t^1(\tau)$ and $y_t^2(\tau)$ follow DNS[4] with the same λ [5], then the term structure of *spreads* also follows DNS."

In addition, since the base interest rates at the various terms to maturity for the bonds in the sample are estimated using linear interpolation, conversion to spreads introduces an additional source of vari-

[4] Dynamic Nelson-Siegel.
[5] The non-linear parameter in the Nelson-Siegel model.

ability. The base interest rates may be either swap rates or the yields on Commonwealth Government Securities (CGS).

4 Notation

In this report, a comparison will be made between the swap rates that are reported by Bloomberg (ADSWAP series) and the swap rates, at longer tenors, that are estimated using extrapolation methods.

The notation used in this report is as follows:

$$
\begin{aligned}
S_i &= \text{Spread of the } i\text{th bond (measured in percent, \%)} \\
Y_i &= \text{Yield of the } i\text{th bond (measured in percent, \%)} \\
R_i &= \text{The swap rate with a tenor that corresponds to the remaining term to maturity of the } i\text{th bond (\%)} \\
T_i &= \text{Remaining term to maturity of the } i\text{th bond (years). } T_i \text{ is also the effective tenor for an estimate of the yield or spread.} \\
S_L(T) &= \text{Estimated Spread at target tenor } T \text{ using the Lally Method (\%)} \\
Y_L(T) &= \text{Estimated Yield at target tenor } T \text{ using the Lally Method (\%)} \\
R_L(T) &= \text{Swap rate at target tenor } T, \text{ estimated using the Lally Method (\%)} \\
S_{LL}(T) &= \text{Estimated Spread at target tenor } T \text{ using Local Linear Smoothing (\%)} \\
S_{SA}(T) &= \text{Estimated Spread at target tenor } T \text{ using the South Australian Power Networks Method (\%)} \\
G(t) &= \text{Spread vs. maturity curve} \\
H(t) &= \text{Yield vs. maturity curve} \\
K(t) &= \text{Swap vs. maturity curve}
\end{aligned}
$$

For a corporate bond, the observed spread over swap rates is typically measured or recorded in basis points. However, these values can be converted into per cent for analytical purposes.

5 The three methods of smoothing are linear

In Diamond and Brooks (2015), three methods of smoothing are compared: the Lally Method (Lally, 2014), Local Linear Smoothing (see, for example Hastie et al., 2009), and the South Australian Power Networks Method (SA Power Networks, 2014).

For the Lally method, the estimate of the spread at 10 years was shown to be

$$S_L(10) = \sum_{i=1}^{N} u_i(\sigma) S_i$$

with the weights given by

$$u_i(\sigma) = (1+a) w_i(10;\sigma) - a w_i(7;\sigma).$$

where S_i is the spread of the ith bond, $w_i(7;\sigma)$ and $w_i(10;\sigma)$ are the weights from Gaussian smoothing multiplied by the issue weights, with target tenors 7 and 10 years, respectively, and a is given by

$$a = \frac{10 - E(10)}{E(10) - E(7)}$$

where E(7) and E(10) are the effective tenors of the Gaussian smoothers for 7 and 10 years respectively. The RBA (Arsov et al. 2013) uses $\sigma = 1.5$.

The estimates of the spreads with the other two methods are also *linear* weighted averages:

$$
\begin{aligned}
S_{LL}(10) &= \sum_{i=1}^{N} l_i(10;\sigma) S_i \\
S_{SA}(10) &= \sum_{i=1}^{N} v_i(\sigma) S_i
\end{aligned}
$$

with the weights formulae being slightly more complicated than for the Lally method.

6 Bias with Smoothing of Spreads

The yield of bond i is given by:

$$Y_i = S_i + R_i$$

where R_i is the base interest rate for the ith bond, given by linearly interpolating the Bloomberg swap rates (from the Bloomberg ADSWAP series) or by linearly interpolating the yields on CGS, which are provided by the RBA's Table F16. For the Lally method, (the other methods give analogous results)

$$\begin{aligned} S_L(10) &= \sum_{i=1}^{N} u_i(\sigma) S_i \\ &= \sum_{i=1}^{N} u_i(\sigma)(Y_i - R_i) \\ &= \sum_{i=1}^{N} u_i(\sigma) Y_i - \sum_{i=1}^{N} u_i(\sigma) R_i \\ &= Y_L(10) - R_L(10) \end{aligned}$$

where $Y_L(10)$ is the estimated yield at a 10 year term to maturity, and $R_L(10)$ is the estimated swap rate (or CGS yield) at 10 years maturity, with both values obtained by using the Lally method. This shows that we can get the estimated spread at 10 years by applying the Lally method to the spreads, or, alternatively, by applying the Lally method to the yields and applying the Lally method to the swap rates (or CGS yields) and then taking the difference.

To obtain an expression for the bias, the expected value of $S_L(10)$ needs to be calculated. It is given by

$$\begin{aligned} E[S_L(10)] &= \sum_{i=1}^{N} u_i(\sigma) E(Y_i) - \sum_{i=1}^{N} u_i(\sigma) E(R_i) \\ &= \sum_{i=1}^{N} u_i(\sigma) H(T_i) - \sum_{i=1}^{N} u_i(\sigma) E(R_i) \\ &= \sum_{i=1}^{N} u_i(\sigma) \Big(H(10) + H'(10)(T_i - 10) + \\ &\qquad \frac{H''(10)}{2}(T_i - 10)^2 + \text{higher order terms} \Big) - \sum_{i=1}^{N} u_i(\sigma) E(R_i) \\ &= H(10) \sum_{i=1}^{N} u_i(\sigma) + H'(10) \sum_{i=1}^{N} u_i(\sigma)(T_i - 10) + \\ &\qquad \frac{H''(10)}{2} \sum_{i=1}^{N} u_i(\sigma)(T_i - 10)^2 - \sum_{i=1}^{N} u_i(\sigma) E(R_i) + \text{higher order terms} \\ &\approx \left(H(10) + \frac{H''(10)}{2} \sum_{i=1}^{N} u_i(\sigma)(T_i - 10)^2 \right) - \left(\sum_{i=1}^{N} u_i(\sigma) E(R_i) + K(10) - K(10) \right) \end{aligned}$$

and hence

$$\begin{aligned} E[S_L(10)] - H(10) + K(10) &\approx \left(\frac{H''(10)}{2} \sum_{i=1}^{N} u_i(\sigma)(T_i - 10)^2 \right) - \left(\sum_{i=1}^{N} u_i(\sigma) E(R_i) - K(10) \right) \\ E[S_L(10)] - S(10) &\approx \left(\frac{H''(10)}{2} \sum_{i=1}^{N} u_i(\sigma)(T_i - 10)^2 \right) - \left(\sum_{i=1}^{N} u_i(\sigma) E(R_i) - K(10) \right) \end{aligned}$$

and therefore an expression for the bias is

$$\text{Bias} \approx \left(\frac{H''(10)}{2} \sum_{i=1}^{N} u_i(\sigma)(T_i - 10)^2 \right) - \left(\sum_{i=1}^{N} u_i(\sigma) K(T_i) - K(10) \right) \tag{1}$$

since $E(R_i) = K(T_i)$, where T_i is remaining term to maturity of the ith bond.

The first composite term on the right hand side of Equation 1 corresponds to the expression that was used in Diamond and Brooks (2015). In that report, the authors fitted a Nelson-Siegel curve to the yields and obtained the second derivative of the fitted curve for a remaining term to maturity of ten years. The second composite term on the right hand side of Equation 1 is the bias that results from using an estimate of the swap rate (or base interest rate) instead of actual, reported swap rates.

The difference between the first and second composite terms on the right hand side of Equation 1 is a measure of the bias of the relevant method when using spreads rather than yields.

Figure 1 shows a plot of the actual swap rates, for vanilla interest rate swaps, as reported by Bloomberg for 30th January 2015. Bloomberg publishes actual swap rates at tenors of 1, 2, ..., 10, 12, 15, 20, 25, and 30 years. Under the ADSWAP series, swap rates are recorded at increments of one year, from a one year remaining term to maturity to a 10-year remaining term to maturity. An interpolated cubic spline can be fitted through the points. The cubic spline can be reasonably presumed to provide the correct representation of the curvature.

In order to obtain estimated swap rates at tenors corresponding to the remaining terms to maturity of bonds in the dataset, the rates were simply read off the cubic spline curve. The weights formulae for the three extrapolation methods are known, and so the following expression can be evaluated:

$$\sum_{i=1}^{N} u_i(\sigma) K(T_i).$$

The actual, reported swap rate at a 10-year tenor is then subtracted from the expression shown above so as to deliver an estimate of the "bias correction term":

$$\sum_{i-1}^{N} u_i(\sigma) K(T_i) - K(10).$$

The calculated values for the bias, obtained for the end of the month using Equation 1 are shown in Table 1, in respect of the period from November 2013 to January 2015. The bias correction terms are also shown. Note that the absolute values of the bias correction terms obtained under the three extrapolation methods are relatively small. The largest value to be reported is 0.15% which has been calculated using the SA Power Networks extrapolation method for 29th November 2013.

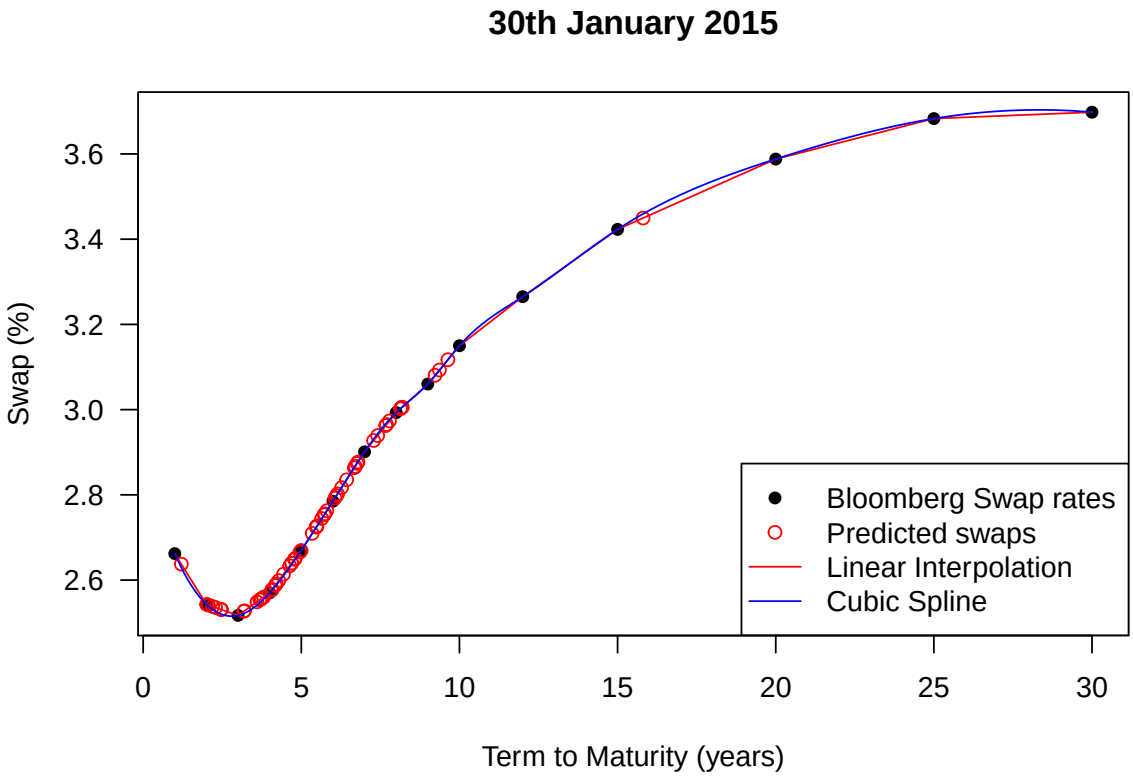

Figure 1: Bloomberg Swap rates for 30th January 2015, with linear interpolation and cubic spline.

		Bias Multiplier			$H''(10)\times$ Multiplier			Bias Correction Term			Bias		
	$H''(10)$	Local Linear	Lally	SA	Local Linear	Lally	SA	Local Linear	Lally	SA	Local Linear	Lally	SA
Nov13	-0.014	-2.668	-2.202	-4.892	0.038	0.031	0.069	0.079	0.064	0.150	-0.041	-0.033	-0.081
Dec13	-0.015	-2.799	-2.332	-5.048	0.043	0.036	0.077	0.078	0.063	0.144	-0.035	-0.027	-0.067
Jan14	-0.006	-2.987	-2.488	-5.299	0.017	0.014	0.030	0.085	0.073	0.141	-0.068	-0.059	-0.111
Feb14	-0.012	-3.160	-2.632	-5.525	0.039	0.033	0.069	0.076	0.062	0.130	-0.037	-0.029	-0.061
Mar14	-0.018	-3.354	-2.779	-5.876	0.061	0.051	0.107	0.073	0.059	0.134	-0.012	-0.008	-0.027
Apr14	-0.008	-2.211	-1.898	-4.485	0.017	0.015	0.035	0.044	0.038	0.083	-0.027	-0.023	-0.048
May14	-0.011	-2.365	-2.015	-4.667	0.027	0.023	0.053	0.040	0.035	0.066	-0.013	-0.012	-0.013
Jun14	-0.004	-1.676	-1.740	-4.139	0.007	0.007	0.017	0.029	0.030	0.054	-0.022	-0.023	-0.037
Jul14	-0.000	-1.714	-1.832	-4.028	0.001	0.001	0.002	0.024	0.025	0.052	-0.023	-0.024	-0.050
Aug14	-0.002	-1.843	-1.964	-4.201	0.003	0.003	0.006	0.025	0.025	0.050	-0.022	-0.022	-0.044
Sep14	-0.005	-1.543	-1.678	-3.431	0.008	0.008	0.017	0.018	0.017	0.043	-0.010	-0.009	-0.026
Oct14	-0.009	-1.653	-1.793	-3.653	0.015	0.017	0.034	0.027	0.027	0.049	-0.012	-0.010	-0.015
Nov14	-0.015	-1.774	-1.927	-3.776	0.027	0.029	0.057	0.022	0.022	0.031	0.005	0.007	0.026
Dec14	-0.026	-1.869	-2.060	-3.814	0.049	0.055	0.101	0.011	0.013	0.015	0.038	0.042	0.086
Jan15	-0.017	-1.992	-2.212	-3.964	0.033	0.037	0.066	0.006	0.008	0.010	0.027	0.029	0.056

Table 1: Bias Calculations for Local Linear Smoothing ($\sigma = 2.4$), the Lally extrapolation method, and the SA Power Networks extrapolation approach. The second derivative of the "true" yield curve at an effective tenor of 10 years is evaluated using the parameters from an estimated Nelson-Siegel yield curve.

7 Expression for the Variance

In section 6, an expression for the bias was derived and presented. In this section an expression for the variance is obtained. We use the models

$$\begin{aligned} S_i &= G(T_i) + \varepsilon_i \\ Y_i &= H(T_i) + \eta_i \\ R_i &= K(T_i) + \tau_i \end{aligned}$$

Then

$$\begin{aligned} S_i &= Y_i - R_i \\ &= H(T_i) + \eta_i - K(T_i) - \tau_i \\ &= G(T_i) + \varepsilon_i \end{aligned}$$

where

$$\varepsilon_i = \eta_i - \tau_i$$

and

$$\text{Var}(\varepsilon_i) = \text{Var}(\eta_i) + \text{Var}(\tau_i) - 2\text{Cov}(\eta_i, \tau_i). \tag{2}$$

The η_i were estimated from the regression residuals that were obtained by fitting the Nelson-Siegel curve to data on bond yields. In order to obtain an estimate of the variance for base interest rates, $\text{Var}(\tau_i)$, linear interpolation was applied to produce swap rates at tenors corresponding to the remaining terms to maturity of corporate bonds in the dataset used for the analysis. The τ_i were estimated by taking the difference between the swap rates estimated using the cubic spline function and the swap rates obtained by linear interpolation. Once the η_i and τ_i were estimated, the sample variances and sample covariance were calculated, and these values were then combined according to Equation 2 in order to get an estimate of $\text{Var}(\varepsilon_i)$. A degrees of freedom adjustment was made[6]. Note that $\text{Var}(\varepsilon_i) \approx \text{Var}(\eta_i)$ since the τ_i are very small.

Table 2 gives the variance calculations for the end of the month from November 2013 to January 2015.

		Multiplier of Variance(ε_i)			Variance		
	sd(ε_i)	Local Linear	Lally	SA	Local Linear	Lally	SA
Nov13	0.628	0.170	0.191	0.115	0.067	0.075	0.045
Dec13	0.600	0.192	0.216	0.130	0.069	0.078	0.047
Jan14	0.590	0.203	0.231	0.136	0.071	0.080	0.047
Feb14	0.468	0.214	0.246	0.141	0.047	0.054	0.031
Mar14	0.482	0.227	0.265	0.143	0.053	0.061	0.033
Apr14	0.509	0.239	0.247	0.150	0.062	0.064	0.039
May14	0.492	0.256	0.267	0.159	0.062	0.065	0.038
Jun14	0.458	0.201	0.219	0.138	0.042	0.046	0.029
Jul14	0.517	0.218	0.244	0.153	0.058	0.065	0.041
Aug14	0.503	0.226	0.256	0.161	0.057	0.065	0.041
Sep14	0.479	0.194	0.217	0.152	0.044	0.050	0.035
Oct14	0.458	0.205	0.234	0.158	0.043	0.049	0.033
Nov14	0.418	0.213	0.249	0.168	0.037	0.043	0.029
Dec14	0.421	0.226	0.270	0.182	0.040	0.048	0.032
Jan15	0.468	0.235	0.287	0.193	0.051	0.063	0.042

Table 2: Variance Calculations for Local Linear Smoothing ($\sigma = 2.4$), the Lally extrapolation method, and the SA Power Networks extrapolation approach. The standard deviation of the error terms, sd(ε_i), is obtained for each month using the calculations presented in section 7.

[6]The sample variance of the regression residuals needs to be multiplied by $(n-1)/(n-k)$ where k is the number of parameters estimated in the Nelson-Siegel model and n is the number of data points.

8 RMSE

The results for bias in Table 1 and the results for variance in Table 2 were combined to calculate the RMSE for the three methods for each month from November 2013 to January 2015. The values for RMSE are displayed in Table 3. The results only differ from those given in Table 9 of Diamond and Brooks (2015) at the third decimal point. A graphical display of the RMSE is given in Figure 2, which is almost identical to that shown in Figure 5 of Diamond and Brooks (2015).

	Bias			Variance			RMSE		
	Local Linear	Lally	SA	Local Linear	Lally	SA	Local Linear	Lally	SA
Nov13	-0.041	-0.033	-0.081	0.067	0.075	0.045	0.262	0.277	0.228
Dec13	-0.035	-0.027	-0.067	0.069	0.078	0.047	0.265	0.280	0.226
Jan14	-0.068	-0.059	-0.111	0.071	0.080	0.047	0.274	0.289	0.244
Feb14	-0.037	-0.029	-0.061	0.047	0.054	0.031	0.220	0.234	0.186
Mar14	-0.012	-0.008	-0.027	0.053	0.061	0.033	0.230	0.248	0.184
Apr14	-0.027	-0.023	-0.048	0.062	0.064	0.039	0.250	0.254	0.203
May14	-0.013	-0.012	-0.013	0.062	0.065	0.038	0.249	0.254	0.196
Jun14	-0.022	-0.023	-0.037	0.042	0.046	0.029	0.207	0.216	0.174
Jul14	-0.023	-0.024	-0.050	0.058	0.065	0.041	0.243	0.257	0.208
Aug14	-0.022	-0.022	-0.044	0.057	0.065	0.041	0.240	0.256	0.207
Sep14	-0.010	-0.009	-0.026	0.044	0.050	0.035	0.211	0.223	0.188
Oct14	-0.012	-0.010	-0.015	0.043	0.049	0.033	0.208	0.222	0.183
Nov14	0.005	0.007	0.026	0.037	0.043	0.029	0.193	0.209	0.173
Dec14	0.038	0.042	0.086	0.040	0.048	0.032	0.204	0.223	0.199
Jan15	0.027	0.029	0.056	0.051	0.063	0.042	0.228	0.252	0.213

Table 3: The results for Bias, Variance, and RMSE for three extrapolation methods: Local Linear Smoothing ($\sigma = 2.4$), the Lally extrapolation method, and the SA Power Networks extrapolation approach.

9 Conclusions

The results that were originally reported in ESQUANT (2015) withstand scrutiny and can be used with confidence.

Expressions for the bias and variance using spreads rather than yields were derived for the three extrapolation methods and these were applied to the data used in Diamond and Brooks (2015).

The bias term is now calculated completely using both yield and base rate components. The overall result for the bias is derived using a bias multiplier (which uses weights that are unique to the particular extrapolation method); the second derivative of the slope of the true yield curve; and a bias correction factor (which takes account of the slope of the curve for swap rates).

The variance term depends on the variance of the residuals from the Nelson-Siegel yield curve and the deviations of the linearly interpolated swap rates from the swap rates estimated using a cubic spline. These components were combined and then a multiplier, dependent on the extrapolation method, was applied.

Although the results for the bias were slightly different when using spreads rather than yields, the more important variance term was little changed, and therefore the RMSE altered by only a very small margin.

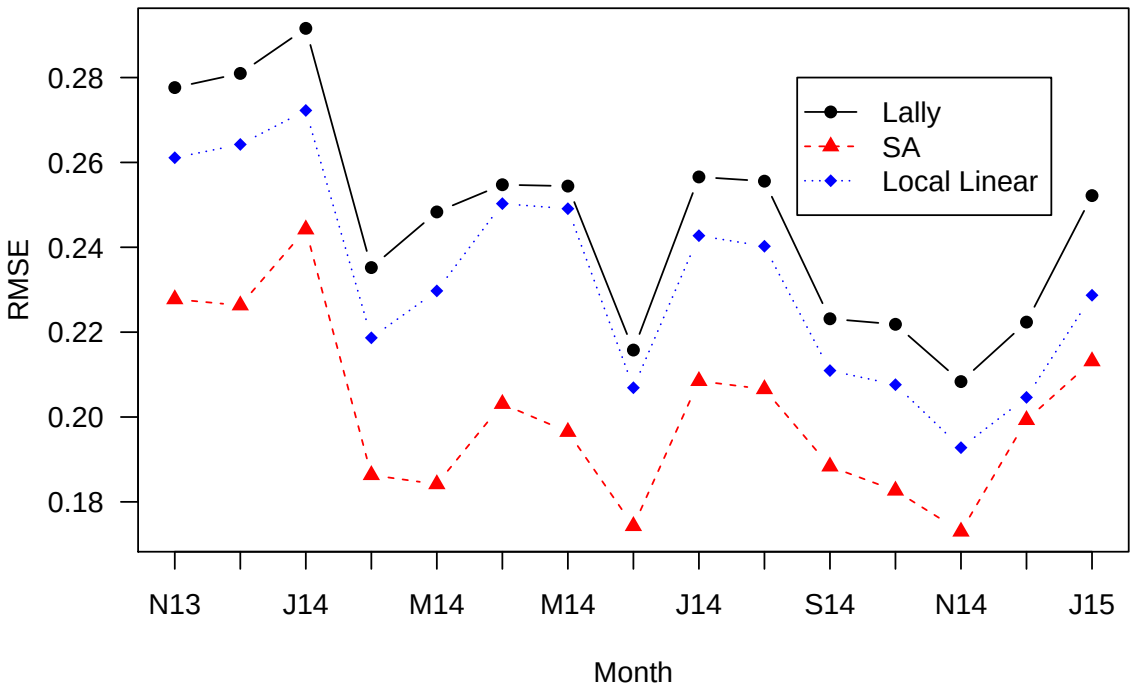

Figure 2: Comparison of RMSE for the Lally Method, SA Power Networks Method, and Local Linear Smoothing from November 2013 to January 2015. The results are partly underpinned by the variance of the true spread curve, by the second derivative of the Nelson-Siegel yield curve (evaluated at a 10-year term to maturity), and by a bias correction factor.

10 References

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Background

In its 2014 draft decision for Jemena Gas Networks (JGN), the Australian Energy Regulator (AER) has adopted an approach to estimating the return on debt for a benchmark efficient entity which makes use of "third party" measures of the cost of debt. You are asked to familiarise yourself with that part of the draft determination and also Rule 6.5.2 (of the National Electricity Rules (NER)) concerning the establishment of an allowed rate of return by the AER (see AER, Draft decision, Jemena Gas Networks (NSW) Ltd., Access arrangement 2015–20, Attachment 3: Rate of return, November 2014).

The AER's JGN draft determination uses both RBA data (from Table F3) and Bloomberg data (from the Bloomberg BVAL curve for BBB rated bonds). However, neither of the two curves provides cost of debt estimates that are commensurate with a ten year effective tenor. Therefore, to obtain an estimate for a benchmark 10 year corporate bond, the results from the published data sources should be subject to amendment through extrapolation.

A report from CEG titled "Critique of the AER's JGN draft decision on the cost of debt," March 2015, contains an assessment of at least two alternative extrapolation methods: The "AER approach" (which was provided by Martin Lally) and the SA Power Networks (SAPN) approach. You are asked to also familiarise yourself with that document. A further report to consider is that provided by Martin Lally, (Implementation Issues for the Cost of Debt, Martin Lally, Capital Financial Consultants, November 2014).

Engagement

You are engaged by Jones Day on behalf of United Energy and Multinet Gas (UEMG) to provide the work (set out below). UEMG will be directly responsible for your invoices.

Please provide all invoices via email to Jeremy.Rothfield@ue.com.au and addressed to:

Jeremy Rothfield
Economist
United Energy and Multinet Gas
Level 1
Pinewood Corporate Centre

43-45 Centreway Place
Mount Waverley VICTORIA 3149
P.O. Box 449
Mount Waverley VICTORIA 3149

Copied to njtaylor@jonesday.com

While UEMG has a strong track record of making payments on time, no interest shall be payable in any circumstances.

Scope of work

You are requested to undertake a review of the statistical properties of the various extrapolation methods. The properties of the different extrapolation or smoothing methods should also be compared with the attributes of yield curves, such as Nelson-Siegel yield curves. The review should be based on theory and also empirical application. If you conclude, after your review, that there are other extrapolation methods which might be more suitable for use than Nelson-Siegel yield curves, then answers to the questions below should be provided in relation to those methods, as well as in respect of Nelson-Siegel regressions.

Please provide responses to the following:

1. Derive formulae for the weights used in the various extrapolation methods.

2. Provide an assessment of whether any of the methods has a bias, or tendency to report results that are higher or lower than a fair value for a 10 year unexpired tenor. If there is a bias, or a tendency to over or under-estimate the true result, then please explain the causes of the over or under-statement .

3. Provide an analysis of the performance of the methods based on theory.

4. For the Lally (2014) and AER methods, give examples of the calculations involved in the extrapolation.

5. Use empirical methods to demonstrate the practical application of the approaches. If possible, produce a time series of results. We understand that the RBA produces results for Table F3 that are based on assessments done on or around the last business day of the month. Please explain the extent to which you have taken the RBA's approach into account in your response.

6. Compare the extrapolations based on yields with those that use spreads to swap, and spreads to Commonwealth Government Securities (CGS).

7. Apply methods based on Nelson-Siegel yield curves. Compare the results from yield curves with those obtained using the Lally and SAPN methods.

8. Evaluate the advantages and disadvantages of the different extrapolation or smoothing methods, drawing upon theory and empirical results.

9. Assess the merits of making adjustments to the underlying data so as to better control for the gradation of credit ratings within the broad BBB band. The credit ratings for bonds should be based on the ratings assigned by Standard and Poor's.

(the **Work**).

Reporting

Jeremy Rothfield at UEMG 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.

Conflicts

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

Compliance with the Code of Conduct for Expert Witnesses

Attached as **Annexure 1** 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 over 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 estimate for the project identifying 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.

The consultant will advise Jones Day in advance of any increase to the estimate that the consultant considers necessary, identifying the basis of the revised estimate and the consultant must receive approval of all estimates prior to undertaking work.

Contacts

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

Nick Taylor (Jones Day)

Email: njtaylor@jonesday.com

Phone: 02 8272 0500

Kind regards

Nicolas Taylor

Partner

Annexure

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.

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

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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.

3 Rule 23.13.

(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].

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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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