Comments on Incenta Economic Consulting Report: Methods for extrapolation of the debt risk premium

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1 Introduction

Incenta Economic Consulting have been engaged by Jemena to undertake a review of alternative debt risk premium extrapolation methodologies, and to recommend a methodology that that could be applied in a mechanistic manner to estimate a trailing average cost of debt. Specifically, this relates to extrapolation of the 7 year Bloomberg BBB fair value curve.

In Incenta (2014), they evaluated five alternative extrapolation methodologies: Using straight line extrapolation, using the US BBB Composite Index, using the US BBB+ Utilities Index, using the RBA BBB Series, and using QTC methodology. They compared the various methods to various benchmarks based on the average difference between the extrapolated DRP and the DRP based on the benchmark and what they call the root mean square error (R.M.S.E). Based on their study, they recommend the use of the QTC methodology.

The terminology used in the Incenta report is non-standard. In this report, I have aligned the terms used in the Incenta report with those conventionally used. I have also calculated the mean square error. Based on this calculation, the US BBB Composite Index appears to be a good method of extrapolation.

2 Connection between terminology used in the Incenta report and conventional terminology

In the Incenta report, The R.M.S.E is defined as

$$\text{R.M.S.E} = \sqrt{\frac{\sum(\hat{y} - y)^2}{n}}$$

where

$\hat{y}$ = is the average difference between the benchmark debt risk premium and the debt risk premium estimated by each alternative methodology,

y = is the difference between the benchmark debt risk premium and the debt risk premium estimated by each alternative methodology.

To be more precise, the definition should be

$$\text{R.M.S.E} = \sqrt{\frac{\sum_{i=1}^{n}(\hat{y} - y_i)^2}{n}}$$

where i denotes the ith day and

y_i = is the difference between the benchmark debt risk premium and the debt risk premium for the ith day estimated by each alternative methodology.

Note that

$$\hat{y} = \frac{1}{n}\sum_{i=1}^{n} y_i.$$

The square of the R.M.S.E is given by

$$\begin{aligned}
\text{R.M.S.E}^2 &= \frac{1}{n}\sum_{i=1}^{n}(\hat{y} - y_i)^2 \\
&= \frac{1}{n}\left\{\sum_{i=1}^{n}\hat{y}^2 - 2\hat{y}\sum_{i=1}^{n} y_i + \sum_{i=1}^{n} y_i^2\right\} \\
&= \frac{1}{n}\left\{n\hat{y}^2 - 2n\hat{y}^2 + \sum_{i=1}^{n} y_i^2\right\} \\
&= \frac{1}{n}\sum_{i=1}^{n} y_i^2 - \hat{y}^2.
\end{aligned}$$

The first term on the right hand side is called the Mean Square Error (MSE), since the y_i denote the errors, and these are squared and averaged. The second term is the bias. So we have

$$\text{R.M.S.E}^2 = \text{MSE} - \text{Bias}^2$$

or

$$\text{MSE} = \text{Bias}^2 + \text{R.M.S.E}^2.$$

Table 1 gives the conventional terminology (see, for example, Kuhn and Johnson, 2013) and that used in the Incenta report. Specifically

Table 1: Conventional terminology and that used in the Incenta report

Conventional Terminology	Terminology Used in Report
Bias	Average
Variance	R.M.S.E^2
MSE=Bias^2 + Variance^2	Not used but given by Average^2 + R.M.S.E^2
RMSE=$\sqrt{\text{MSE}}$	Not used but given by $\sqrt{\text{Average}^2 + \text{R.M.S.E}^2}$

- The MSE (Mean Square Error) combines the bias and the variability[1] to give a measure of the average squared error.
- The R.M.S.E, as used in the report, is essentially the standard deviation[2].
- The square root of the MSE is conventionally called the root mean square error (RMSE), (see, for example Kuhn and Johnson, p.95).

Tables 2 and 3, give revisions to Tables 1 and 2 in the Incenta report, including the calculated square root of the mean square error. Based on the square root of the mean square error:

- The US BBB composite index is better than the QTC methodology using the Bloomberg 10 year BBB fair value curve benchmark.
- The US BBB composite index is almost as good as the QTC methodology using the 2006-2013 QTC Survey
- The US BBB composite index is not as good as the QTC methodology using AER's paired bond analysis.
- The US BBB composite index is better than the QTC methodology for periods 1 and 2.
- The US BBB composite index is not as good as the QTC methodology for periods 3 and 4.

[1]Note that Kuhn and Johnson, 2014, p.97, additionally break down the variance into two components, the "irreducible noise" and the "model variance".

[2]However, to get an unbiased estimator of the variance, the divisor needs to be $n-1$ not n. On the other hand, despite the bias, using a divisor of n gives an estimate of the MSE which is closer to the true value. Assuming n is a reasonable size, there is no effective difference.

Table 2: Alternative extrapolation methodologies-differences from benchmarks (basis points)

Period/Benchmark	2005-2007/Bloomberg 10 year BBB			2006-2013/QTC Survey			2012-2013/Paired Bonds (AER)		
	Average	R.M.S.E	$\sqrt{MSE}$	Average	R.M.S.E	$\sqrt{MSE}$	Average	R.M.S.E	$\sqrt{MSE}$
1) QTC Methodology	26.2	5.4	26.8	−2.7	12.0	12.3	−4.4	7.0	8.3
2) RBA BBB	11.2	8.1	13.8	−14.2	22.5	26.6	1.2	11.1	11.2
3) US BBB Composite	12.6	4.5	13.4	−9.1	9.2	12.9	−18.3	11.0	21.4
4) US BBB+ Utilities	12.9	11.2	17.1	−14.4	9.2	17.1	−27.1	11.3	29.4
5) Straight Line	26.3	12.7	29.2	15.4	33.8	37.1	−26.6	10.2	28.5

Source: Bloomberg, RBA, QTC, AFMA, Incenta, and ESQUANT Analysis

Table 3: Alternative DRP extrapolation methodologies-differences from the QTC survey benchmarks (basis points)

Period	1: Jan06-Sept07			2: Aug07-Dec09			3: Jan10-Feb12			4: Mar12-Dec13		
	Average	R.M.S.E	$\sqrt{MSE}$	Average	R.M.S.E	$\sqrt{MSE}$	Average	R.M.S.E	$\sqrt{MSE}$	Average	R.M.S.E	$\sqrt{MSE}$
1) QTC Methodology	10.5	4.1	11.3	−13.3	64.2	65.6	−9.8	1.3	9.9	6.2	5.2	8.1
2) RBA BBB	−4.7	1.7	5.0	−26.5	161.5	163.7	−34.0	4.7	34.3	11.3	10.5	15.4
3) US BBB Composite	−4.3	2.8	5.1	−7.2	21.9	23.1	−14.9	4.9	15.7	−5.8	8.4	10.2
4) US BBB+ Utilities	−0.4	1.3	1.4	−18.4	66.3	68.8	−15.9	5.0	16.7	−16.0	8.2	18.0
5) Straight Line	7.7	3.6	8.5	−0.7	34.8	34.8	54.4	14.3	56.2	−14.7	6.6	16.1

Source: Bloomberg, RBA, QTC, AFMA, Incenta, and ESQUANT Analysis

3 Aspects of the QTC Survey

3.1 R.M.S.E and $\sqrt{MSE}$ are probably understated

The values for R.M.S.E and $\sqrt{MSE}$ in Table 1 of the Incenta report (Table 2 of this report) are probably undervalued because the same data is being used as is being assessed. I suggest that these values be computed using leave one out calculations (see, for example, Hastie et al., 2009, p. 242) to get a fair comparison.

Similarly, the values in Table 2 of the Incenta report (Table 3 of this report) should also be recalculated using leave one out calculations.

3.2 Effect of QTC Survey being quarterly

Unlike the other extrapolation methodologies, the QTC survey is only done on a quarterly basis, with linear interpolation being applied. In this section the effect of this is addressed.

I do not see this particular issue affecting the empirical testing that has been applied in the report-the QTC methodology, which is combination of the quarterly measurements and linear interpolation, may indeed work well or poorly. However, the fact that many of the figures in Tables 1 and 2 of the Incenta report may be based on a comparatively small number of observations raises some questions about how the tables should be interpreted.

To help with the interpretation, all the values in Tables 1 and 2 should have confidence intervals attached to them, or, probably preferably, there should be figures prepared showing the confidence intervals. This would show which of the differences are statistically significant. An example of the calculations involved is given in the appendix.

4 Other Comments

- Using the RBA Methodology is not advised, since the RBA series is downwardly biased (see Diamond and Brooks, 2014).
- A particular advantage of using Nelson-Siegel methods is that it is possible to give a confidence interval for the differences between the Debt Risk premium at 7 and 10 years maturity.
- Whether all the Nelson-Siegel parameters are statistically significant or not may not affect the estimate of the difference between between the Debt Risk premium at 7 and 10 years maturity.
- On pages 8/9 of the Incenta report, it is claimed that

  > "Extrapolation of the yield from 7 to 10 years is inappropriate and unnecessary owing to the fact that the underlying CGS yield is known, and it is only the debt risk premium component that needs to be estimated. Furthermore, concavity in the shape of the normal CGS yield curve means that a linear extrapolation of yield from 7 to 10 years will generally imply convexity in the debt risk premium over this range of terms, which is unsupported by theory."

  I agree that this applies with the straight line extrapolation method, but does not necessarily apply when the other extrapolation methods are used, since for these methods the extrapolation of the 7 year Bloomberg BBB fair value curve is based on a different index. Additionally, it *does not* apply to Nelson-Siegel estimates. If the Yields follows a Nelson-Siegel model, and the CGS follows a Nelson-Siegel model, then the difference only follows a Nelson-Siegel model if the non-linear parameter is the same for both models, a restrictive and unnecessary assumption. It is better to fit the Nelson-Siegel model to the Yields.

References

N.T. Diamond and R. Brooks. A review of measures of Australian corporate credit spreads published by the Reserve bank of Australia: Submission to the issues paper (Return on debt: Choice of third party data service provider) released by the Australian Energy Regulator (April 2014). Technical report, ESQUANT Statistical Consulting in conjunction with Statistical Consulting Service, Department of Econometrics and Business Statistics, Monash University, 2014. For United Energy and Multinet Gas. 19 May 2014.

Hastie, T., Tibshirani, R., and Friedman, J. (2009). *The Elements of Statistical Learning: Data Mining, Inference and Prediction*, 2nd Edition. Springer: New York.

Incenta Economic Consulting (2014). "Methodology for extrapolation of the debt risk premium". Draft report for Jemena. June 2014.

Kuhn, M. and Johnson, K. (2013). *Applied Predictive Modelling*, Springer: New York.

A Calculation of confidence intervals

A.1 Confidence interval for Bias

A 95% confidence interval for the Bias is given by

$$\left(\text{Ave} - qt(.975, n-1)\sqrt{\frac{\text{R.M.S.E}^2}{n-1}}, \text{Ave} + qt(.975, n-1)\sqrt{\frac{\text{R.M.S.E}^2}{n-1}} \right)$$

where $qt(.975, n-1)$ is the 97.5th percentile of a t distribution with $n-1$ degrees of freedom, where n is the number of observations.

A.2 Confidence interval for R.M.S.E

A 95% confidence interval for the R.M.S.E is given by

$$\left(\sqrt{\frac{n\text{R.M.S.E}^2}{qchisq(.975, n-1)}}, \sqrt{\frac{n\text{R.M.S.E}^2}{qchisq(.025, n-1)}} \right)$$

where $qchisq(.025)$ and $qchisq(.975)$ are the 2.5th and 97.5th percentiles of the χ^2 distribution with $n-1$ degrees of freedom, respectively.

A.3 Confidence interval for $\sqrt{MSE}$

A 95% confidence interval for the $\sqrt{MSE}$ can be calculated by simulation. The steps are:

1. Generate a large number (say $N = 100,000$) observations from a χ^2 distribution with $n-1$ degrees of freedom, and call them x_i, $i = 1, \ldots, N$
2. For each value of x_i, calculate σ_i as
$$\sigma_i = \sqrt{\frac{(n-1)\text{R.M.S.E}^2}{x_i}}$$
3. Generate N observations from a normal distribution with a mean of Ave and a standard deviation of $\sigma_i/\sqrt{n}$, and call them y_i.
4. The simulated $\sqrt{MSE}$ values are given by
$$z_i = \sqrt{y_i^2 + \frac{n\sigma_i^2}{n-1}}$$
5. The 95% confidence interval for $\sqrt{MSE}$ is given by the 2.5th and 97.5th percentiles of the z_i.

A.4 Example

The bias for the US BBB+ Utilities index, as compared to the Bloomberg 10 year BBB Fair value curve benchmark, is given as 12.9 with a R.M.S.E of 11.2, leading to a $\sqrt{MSE}$ value of 17.1. In the following I'm assuming that the number of observations is $n = 500$.

A.4.1 Confidence interval for Bias

The value of qt(.975,499)=1.9647 and hence the confidence interval is $(11.91, 13.89)$.

A.4.2 Confidence interval for R.M.S.E

The values of qchisq(.025,499) and qchisq(.975,499) are 438.998 and 562.7895, respectively. The confidence interval is hence $(10.56, 11.95)$.

A.4.3 Confidence interval for $\sqrt{MSE}$

Using the steps given above with $N = 100,000$ simulations the 95% confidence interval is given by $(16.26, 18.00)$.

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 RBA CORPORATE BOND SPREADS IN RESPONSE TO AER ISSUES PAPER ON THIRD PARTY DATA PROVIDERS

Background

In April 2014, the Australian Energy Regulator, (AER), published an Issues Paper in which it set out its considerations about the methods that it would employ to estimate the return on debt. The AER noted that there were aspects of the estimation of the spot cost of debt which hadn't been adequately addressed in the rate of return guideline[1]. The AER therefore sought to explain:

- The attributes of the third party data series which are currently available to be used for estimating the return on debt. The available cost of debt information includes data series published by the Reserve Bank of Australia (RBA) and by Bloomberg.

- The particular matters that would need to be addressed if the RBA corporate bond spread series were to be used to estimate the return on debt. Those matters would include the interpolation of monthly estimates, and the selection of an averaging period over which the return on debt would be calculated.

The AER stated in its Issues Paper that it wasn't proposing to use a specific data series or source, rather the decision about the sources of information would be made at the time of a regulatory determination[2].

The RBA published its new measures of corporate bond spreads in December 2013, with data initially available up to November 2013[3]. The RBA has also endeavoured to back-cast its data, with historical corporate bond spreads having been produced back to January 2005. An article in the Reserve Bank Bulletin serves to explain the methods that have been used to create the composite corporate bond

[1] AER (2014), Return on debt: Choice of third party data service provider, Issues Paper, Australian Energy Regulator, April 2014, section 1.

[2] United Energy will be submitting a regulatory proposal in April 2015. The AER is currently expected to release a final determination for United Energy in April 2016.

[3] The RBA's corporate bond series is published as Table F3, Aggregate Measures of Corporate Bond Spreads and Yields: Non-financial Corporate (NFC) Bonds.

spreads and yields[4]. The data from the RBA is currently produced as a set of monthly figures, with daily data releases not yet available.

Replication of RBA component bond yield information

The Competition Economists Group, (CEG), has attempted to re-create the source data that the RBA has used to calculate its summary measures of corporate bond spreads. CEG has also sought to repeat the exercise undertaken by the RBA, and to compile aggregate corporate bond indices, stratified by broad credit rating class. CEG has followed the methods which have been documented by the RBA in the Bulletin article. CEG has provided the results of its empirical work to United Energy and Multinet Gas, and has also supplied data. A number of spread sheet workbooks from CEG will be made available to the consultant that is appointed to undertake the current assignment for UE and MG. In summary, the data from CEG is made up as follows:

- A spread sheet workbook with separate worksheets for each business day recorded over the period from 1st November 2013 until 28th April 2014.
- Each worksheet contains a list of bonds with unique identifiers. The list has been determined through a screening process, using the filtering criteria applied by the RBA.
- The data available for the individual bonds includes credit rating, remaining term to maturity, the spread over swap rates, and the face value of the bond (or the amount issued). Foreign currency bonds are included in the sample, with their spreads or option-adjusted spreads having been converted into Australian dollar equivalent spreads, after implementing the transformations that are documented in the Bulletin article.
- A fully worked example of the application of the Gaussian kernel method, using data from a single day, 28th February 2014. The example shows the weighted average spreads for BBB rated bonds at target tenors of 3, 5, 7 and 10 years. The effective tenors, corresponding to each of the four categories, are also shown.

Scope of work

There are three broad dimensions to the work to be undertaken:

(1) The consultant should investigate the properties of the data that has been put together by the RBA, and consider whether the methods that have been applied are appropriate and fit-for-purpose.

(2) The series of corporate bond spreads derived by the RBA should be compared with other proxy measures for the cost of debt. Specifically, the variables to be considered should be those that have been assembled and condensed into composite indices or curves that can be regarded as "third party sources of data". The comparisons should be based on methodological differences and empirical results.

(3) Evaluate alternative techniques for determining the cost of debt for a benchmark corporate bond

[4] Arsov, I., Brooks, M., and Kosev, M. (2013). 'New Measures of Australian Credit Spreads', Bulletin, Reserve Bank of Australia, December Quarter 2013.

with a BBB credit rating from Standard and Poor's. Consider methodological rigour and empirical tractability.

When performing tasks that fall under category (1) above, the main question to be addressed is whether the RBA corporate bond spread series is amenable to the task of producing an unbiased, objective estimate of the return on debt. The National Electricity Rules provide the over-arching framework, with the most pertinent clauses being 6.5.2 (a) to 6.5.2 (l). The allowed rate of return objective is paramount:

> The allowed rate of return is to be determined such that it achieves the allowed rate of return objective[5];

and

> The return on debt for a regulatory year must be estimated such that it contributes to the achievement of the allowed rate of return objective[6].

Timeframe

The consultant is to provide a draft report which discusses the results of the analysis by Wednesday 7th May 2014. A final report should be provided by no later than Wednesday 14th May.

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.

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:

[5] National Electricity Rules, clause 6.5.2 (b) (current since version 53).

[6] National Electricity Rules, clause 6.5.2 (h) (current since version 53).

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