Australian Gas Infrastructure Group

Submission on the ERA's implementation of the Debt Risk Premium estimation process

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1. Executive summary

The ERA have released a revised process for estimating the annually updated Debt Risk Premium (DRP) as part of its 2018 review of the Rate of Return Guidelines. This involves averaging three different numerical methods to estimate the DRP; the Gaussian Kernel; Nelson-Siegel (NS); and Nelson-Siegel-Svensson (NSS) models. These approaches are to be applied as a mechanistic process, free from discretion, in each year of the Access Arrangement to update the DRP under a binding Rate of Return instrument.

In addition, the ERA has revised its contingency approaches to data related issues. These approaches specify how data issues that may arise during the Access Arrangement will be addressed.

With respect to the process using the three estimation methods, we acknowledge that the NSS curve is popular among central banks for constructing yield curves. However, this model has proven to be difficult to implement over the current Access Arrangement, produces unexpected results and has brought about increased complexity in the process.

The ERA's revised process partially addresses some of these issues, and is probably the best that can be done under the circumstances. However, the track record of the NSS model, increased complexity of administration and uncertainty around whether it will produce trouble free outcomes over the next Access Arrangement make it unsuitable for mechanistic implementation. We recommend abandoning the NSS model as a first best option or alternatively modifying it as a second a second best option.

In the past the ERA has acknowledged that the DRP estimation process requires resourcing. The ERA should be mindful of these costs in the upcoming Access Arrangements, particularly as the process has become more complex to accurately replicate each year.

With respect to the contingencies, Contingency A seeks to include A- bonds in the sample in the event that the sample of target bonds (BBB+) has less than 15 observations. We request that the ERA outline steps under Contingency A to ensure that lower yielding A- bonds are not over-represented. Contingency C lists the RBA yields as a fall back data source if Bloomberg data becomes unavailable. We recommend including a fallback data source in addition to the RBA data such as Thompson Reuters.

We would welcome the opportunity to discuss any or all of the matters raised in this paper with the ERA at time that is convenient.

Yours sincerely

[redacted]

Craig de Laine

General Manager People and Strategy

Australian Gas Infrastructure Group

2. AGIG's recommendations on the DRP estimation process

We recommend the following in relation to the ERA's DRP estimation process:

- eliminate the Nelson-Siegel-Svensson (NSS) model as a first best option for the reasons outlined below. However, if the ERA is minded to keep NSS in the estimation process modify the Nelson-Siegel-Svensson (NSS) model as per independent literature;
- acknowledge that accessing the subscription, software and add-in requirements for the DRP process requires resourcing;
- modify Contingency A to ensure that bonds falling in a higher credit rating band are not over-represented; and
- modify Contingency C to include a fallback data source in addition to the RBA data.

3. Rationale for recommendations

3.1.1. Eliminate the Nelson-Siegel-Svensson Curve

The appeal of the Nelson-Siegel-Svensson Model

We appreciate the appeal of applying the Nelson-Siegel-Svensson (NSS) model in estimating the debt risk premium. It is popular among central banks for constructing yield curves. For example, de Pooter 2007, noted that:

> *Despite the drawback that they lack theoretical underpinnings, the Bank of International Settlements (BIS, 2005) reports that currently nine out of thirteen central banks which report their curve estimation methods to the BIS use either the Nelson-Siegel or the Svensson model to construct zero-coupon yield curves. As the Nelson-Siegel model is also widely used among practitioners, this ranks it among the most popular term structure estimation methods.* [1]

It also performs well empirically for particular countries. For example Xu 2017 compared a number of methods as estimators of the 'correct' price as the basis of a trading strategy. Xu found that the Nelson-Siegel class of models were preferred by the majority of countries and of those most were the 'four factor' type which includes the Nelson-Siegel-Svensson curve.[2]

The NSS model also provides an additional method to be averaged with the other two estimate, which in theory adds to the robustness of the estimate. George Box's quote aptly summarises why averaging three models is more robust than relying on one or two models:

> *Essentially, all models are wrong, but some are useful.*[3]

The method is known to be difficult to apply in practice, producing strange results

Despite its popularity among central banks, the NSS model does have significant drawbacks in practice that now appear to be outweighing the benefits outlined above (see the technical discussion below for details). The model is highly flexible in its non-linearity, however this advantage is also a weakness because the fitted curve can end up adopting some very unexpected shapes. de Pooter 2007 summarises this issue stating that:

> *The nonlinear [Svensson] model structure seems to pose serious difficulties for optimization procedures to arrive at reasonable estimates.*[4]

The drawbacks are particularly concerning in the context of a binding Rate of Return Guideline where deviation from the formulaic approach to resolve unexpected outcomes is not permitted.

The ERA have experienced some of these issues. In recent AGIG correspondence with the ERA the problem of some of the NSS model parameters approaching zero and the model not solving properly in Microsoft Excel was raised.[5]

The ERA has revised the DRP method

The ERA's revised DRP method, in R in particular, partially resolves some of these issues by:

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1 de Pooter, M, 2007, *Examining the Nelson-Siegel Class of Term Structure Models*, p.1.

2 Xu. J, 2017, *Global Yield Curve Arbitrage with Term Structure Modeling*, Erasmus University Rotterdam, p.35.

3 Box, G, Hunter, W and Hunter, *S, Statistics for Experimenters*, second edition, 2005, p. 440.

4 de Pooter, M, 2007, *Examining the Nelson-Siegel Class of Term Structure Models*, pp. 10-14.

5 AGIG memorandum to the Economic Regulation Authority on DRP updates following ERA Approach, October 2018.

- employing more sophisticated solving algorithms (Differential Evolution) within R using the population of potential parameter values; and
- applying constraints on some of the parameters (lambda 1 and 2) to avoid them taking on problematic values.

The improved solver partially addresses the issue of the model not solving properly in Microsoft Excel and is likely to consider a larger set of potential solutions for the parameters. From a technical standpoint, the adoption of this solver is a sensible and well thought out solution to a complex problem.

Applying the ERA's chosen constraints on the parameters (lambda 1 and 2) avoids them taking on problematic values, namely identical lambdas and a lambda 2 close to zero which results in the problems outlined in the technical discussion.

The ERA's revised process is probably the best that can be done under the circumstances, however, it still does not fully resolve the issues. While the improved solver increases the likelihood of finding an optimal solution to the NSS model, the ERA cannot reasonably assure it due to the complex nature of the model itself.

The ERA should note that the chosen lambda constraints in the ERA's 'DRP process for updating in R' are the same as those used in the ATCO Final Decision which the ERA ultimately abandoned in the ERA's Amended Final Decision.

Gilli et al 2010 chose these constraints only on the basis that they 'should result in acceptable correlations' in the context of experiments in fitting NSS curves on German government bond data.[6] These constraints may sometimes happen to work well in the context of fitting NSS curves to Australian corporate bond data, but not necessarily all the time.

While they prevent lambdas taking on identical values the same problems associated with this can result even when the lambdas become similar, that is, close to 2.5 in the context of the revised ERA R DRP process.[7] The constraints also do not prevent lambda 1 from approaching zero.

The conclusion that can be drawn from this discussion is as follows. In a research environment the ERA's proposed DRP estimation process can be fine-tuned, for example by choosing different lambda constraints, as required when unexpected results such as strange curve shapes occur. In the context of implementing a mechanistic approach for annually updating the DRP such fine-tuning is not permitted.

The ERA has included a contingency where the NSS and NS curves are abandoned when the standard deviation between the results of the 3 methods is 100 basis points or more.

This is of assistance if the NSS model produces extreme results above a certain point. However, given the track record of the NSS model, the increasing complexity in the DRP estimation process that it has bought about and the need to produce a trouble free, mechanistic annual updating approach it would be much simpler for all involved to abandon it.

Recent evidence shows Gaussian Kernel performs better in Australia.

In Xu's 2017 study mentioned above, although the Nelson-Siegel class of models were preferred for the majority of countries, the Gaussian Kernel outperformed both the NS and NSS model on Australian data.[8] This provides the ERA with some comfort that if it were to abandon the NSS model, it would not be abandoning the specification that performs best in the Australian context.

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[6] Gilli, M, Groβe, S and Schumann, 2010, E, *Calibrating the Nelson-Siegel-Svensson model,* COMISEF Working Papers Series, p.13

[7] Gilli et al. 2010 note that this 'becomes a problem well before the lambda values are equal'.

[8] Xu. J, 2017, *Global Yield Curve Arbitrage with Term Structure Modeling*, Erasmus University Rotterdam, p.35.

In any case it could still retain the NS model. Using the two simpler techniques (Gaussian Kernel and original Nelson-Siegel) through Excel would be easier for the ERA to administrate now and more particularly going forward.

3.1.2. Modify the Nelson-Siegel-Svensson Curve

We acknowledge that the ERA has invested significant resources in attempting to address the NSS model issues discussed above. Under these circumstances it would be understandably hesitant to abandon the solution developed.

In recognition of this, we propose an alternative, but what we consider is still a second best solution. The literature recognises the problems arising from the lambdas taking on similar values. In response an 'adjusted' NSS curve was developed by de Pooter 2007 that prevents the weight factors on beta 1 and beta 2 from becoming the same when the lambdas are the same.[9]

Alternatively, the Bjork and Christensen 1999 four factor model only requires one lambda and employs weight factors that avoid some of the problematic convergence in weight factor values experienced by the NSS model.[10] Naturally, one less parameter also means consideration of a smaller set of potential solutions for the parameters in model fitting, making optimization less difficult.

Again, it must be stressed that this is a second best solution. Abandoning the NSS model altogether and using the two simpler techniques (Gaussian Kernel and original Nelson-Siegel) through Excel would be easier for the ERA to administrate, particularly at each annual update where timeliness in implementation is important.

3.1.3. DRP estimation process resourcing

The ERA has made the R Code and Excel DRP template publically available to provide stakeholders with accessibility options. We view this a positive step forward in regulatory transparency and encourage the continued publication of such material.

With respect to accessibility, the Excel related software and skill set to operate it is readily available. The Bloomberg Anywhere subscription and R code skill set, however, are not as readily available. Bloomberg subscription is in the order of 30,000 AUD per year. This subscription then needs to be coupled with R code skills in order to accurately reproduce, and if need be, troubleshoot the results.

The typical solution to these availability issues is to engage the services of a consultant that has such access to the data and skills. For example, the Australian Energy Market Operator engaged the services of PricewaterhouseCoopers to estimate the debt risk premium using the ERA's approach.[11]

The ERA addressed this resourcing issue in the amended ATCO Final Decision as follows:

> *Following an investigation of likely costs in relation to annual update to the debt risk premium, the Authority has allocated an amount of [redacted] to allow for the ATCO's expense of checking the annually updated value of the DRP (refer to paragraph 1767 in the rate of return section). Given that there are four annual updates to check, a total cost of [redacted] has been*

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9 de Pooter, M, 2007, *Examining the Nelson-Siegel Class of Term Structure Models*, pp. 10-11.

10 Ibid, pp. 8-9.

11 For example see https://www.aemo.com.au/-/media/Files/Electricity/WEM/Reserve_Capacity_Mechanism/BRCP/2017/PwC-Estimated-debt-risk-premium-dated-25-October-2016.pdf

> *included into the Authority's approved corporate support operating expenditure forecast for the fourth access arrangement.*[12]

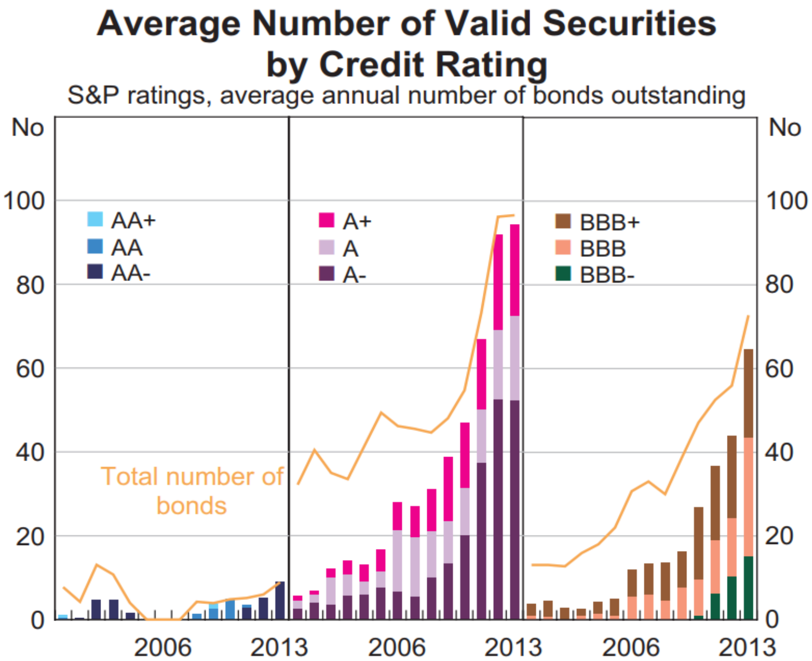
All stakeholders, including the ERA should be mindful of these costs in the upcoming Access Arrangements, particularly as the method now requires R coding skills to accurately replicate it each year.[13]

3.1.4. Modify Contingency A to ensure certain bonds are not over-represented

The ERA's Contingency A proposes combining credit rating bands in the event that the sample size for the BBB+ credit rating is less than 15 bonds. While it is common to combine notches within long-term credit rating bands, for example, A-, A and A+ it is not common to combine the bands themselves, for example BBB+ and A-.

History shows that A- rated bonds tend to substantially outnumber any one of the BBB band notches. Although Figure 1 below is somewhat outdated, it shows this to be the case. Fortunately, the ERA can easily verify that this is still the case by accessing Bloomberg data.

Figure 1 Number of Australian Corporate Bonds: A- versus the BBB notches.



Source: Reserve Bank of Australia, 2013

During the 2015 review of the WACC method for regulated rail networks the ERA acknowledged the issue of A- over-representation:

> *The estimate using the broader A+/A/A- sample, however, includes a large number of A- rated bonds representing around 41 per cent of the sample…*

12 Economic Regulation Authority, *Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution Systems*, As amended on 10 September 2015, p.93

13 The ERA notes that the Excel variant is only an approximation. See Economic Regulation Authority, *Appendix 1 DRP process for updating in Excel*, p.1. Stakeholders seeking precision in estimates for financing would need to implement the approach in R.

The ERA should outline steps to ensure that A- bonds are not over-represented under circumstances where Contingency A is triggered.

A second issue with combining credit rating bands is that the prices of higher grade bonds tend to behave very differently across time to that of lower grade bonds. During times of heightened market risk, demand for higher grade bonds, perceived as 'safe' assets increases while demand for lower grade bonds decreases.

The pricing differential between them increases under these circumstances. This results from a sharp increase in yields for lower grade bands and a relatively low increase in yields for lower grade bonds. The ERA acknowledges this effect in its 2015 review of the WACC method for regulated rail networks.

> *The Authority notes that it is not unusual for lower grade bonds to experience a proportionally greater drop in price (increase in yields) relative to higher grade bonds. Increased volatility and risk in financial markets often result in relatively higher demand for quality debt and conversely lower demand for low quality debt.*[14]

In addition, issuance and pricing for lower grade bonds becomes more sparse under conditions of increased volatility and financial risk. This means samples combining lower grade bands such as BBB/BBB+ and higher grade bands such as A- will tend to lose BBB/BBB+ observations at a higher rate than the sample loses A- observations. The final DRP result in this situation will be even more over-represented by low yielding A- bonds precisely at the time the yield required for finance at the benchmark BBB+ rating is higher than usual.

Again, the ERA should outline steps under Contingency A to ensure that A- bonds are not over-represented in the final DRP result. For example, the ERA could estimate two separate 10 year DRP estimates; one using 15 or more bonds from the A band and one using 15 or more bonds from the BBB band. For consistency with the weighting scheme outlined in the ERA's Contingency C (see below), 1/3rd weighting can be applied to the A band DRP estimate and 2/3rd weighting to the BBB band estimate.

3.1.5. Modify Contingency C to include an additional fallback data source

The ERA's Contingency C proposes using the RBA Table F3 “Aggregate Measures of Australian Corporate Bond Spreads and Yields” data in the event that Bloomberg stops producing bond data. Since the RBA only publishes 10-year broad A rated and broad BBB rated estimates the ERA will calculate the cost of debt estimate as the sum of 1/3rd of the broad A-rated estimate and 2/3rd of the broad BBB-rated estimate.

We acknowledge that unavailability of Bloomberg data is a very unlikely outcome, however, note that the RBA data itself is based on Bloomberg data. Although it is possible that the RBA would continue producing the series using a different data source, it is under no obligation to do so. We recommend modifying Contingency C to include a fallback data source in addition to the RBA data such as Thompson Reuters.

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[14] Economic Regulation Authority, *Review of the method for estimating the Weighted Average Cost of Capital for the Regulated Railway Networks – Final Decision*, 18 September 2015, p.99

3.1.6. Technical discussion of the Nelson-Siegel-Svensson Curve drawbacks

Estimation of the Nelson-Siegel-Svensson model is difficult because it is highly non-linear. There is a very large set of values for the parameters in the curve that need to be trialed to find the optimal fit (global optima). Readily available software will typically find what appears to be a global optima, but given the large number of values that need to be considered, it will frequently turn out to be an optimum only across the subset of values considered by the software (local optima).[15]

The ERA would need to be certain it has considered virtually all sets of values every time it undertakes an annual update in order to have full confidence in the results. We acknowledge that the ERA has employed more sophisticated solving algorithms in an attempt to overcome this issue. However, this provides little guarantee that an optimal solution will be found at each annual update without manual intervention. This is because the NSS model itself remains highly complex and the bond data evolves.

Another issue is that in practice, the factor loadings (the terms attached to the betas) in the model can take on values that cause parts of the model to 'drop out'. This happens when the two decay factors (lambda 1 and 2) become similar to each other or take on values that are close to zero or are very large.[16]

The ERA have reverted to using the constraints on lambda that they used in the ATCO Final Decision.[17] Lambda 1 is constrained to between 0-2.5, and lambda 2 to between 2.5-5.5, as per Gilli et al. 2010.[18] It should be noted that Gilli et al. 2010 chose these constraints based on a long time series of estimated NSS parameter observations where the underlying data was German government bonds.[19]

Formulating constraints for ERA's DRP process as per the Gilli et al. methodology would involve observing a time series of estimated NSS parameter observations where the underlying data is Australian Corporate bonds. Sensible results under the constraints formulated on German government bonds may be by luck instead of design. The ERA abandoned the Gilli et al. constraints in the Amended ATCO Final Decision.[20]

Under the Gilli et al. constraints as lambda 1 approaches zero the beta 1 and 2 weight factors effectively drop out and the model reduces to a two factor model consisting of a constant and 'medium term hump' or beta 3 weight factor. As lambda 1 and lambda 2 approach 2.5 a multicolinearity problem arises because the beta 2 and beta 3 weight factors become the same.

Gilli et al. 2010 note that this 'becomes a problem well before the lambda values are equal'.[21] The NSS model ends up reducing to the original NS specification. Since the final DRP result is based on an average of the NSS, NS and Gaussian Kernel, as lambda 1 and lambda 2 approach 2.5 the NSS specification starts to give the same results as the NS specification resulting in a double count.

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15 Bolder, D and Streliski, S, 1999, *Yield Curve Modelling at the Bank of Canada,* Technical Report No. 84, Bank of Canada, February 1999, p.12.

16 de Pooter, M, 2007, *Examining the Nelson-Siegel Class of Term Structure Models*, p. 14.

17 See Table 141 in Economic Regulation Authority*, Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System*, 30 June 2015, p.683.

18 Gilli, M, Groβe, S and Schumann, 2010, E, *Calibrating the Nelson-Siegel-Svensson model,* COMISEF Working Papers Series, p.5 and p.13.

19 Ibid, p.5.

20 See Table 152 in *Economic Regulation Authority, Final Decision on Proposed Revisions to the Access Arrangement for the Mid-West and South-West Gas Distribution System:* As amended on 10 September 2015, p.707.

21 Ibid, p.9.