Thomson Reuters Credit Curve Methodology

Note for the AER

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Regulatory Economic Unit,

Australian Competition and Consumer Commission

The Regulatory Economic Unit (formerly known as the Regulatory Development Branch) within the Australian Competition and Consumer Commission (ACCC) and Australian Energy Regulator (AER) was established in 2006 to increase the quality of economic analysis available to the ACCC/AER and promote the consistent use of economic principles across the different sectors subject to economic regulation.

The economic regulation of infrastructure is a relatively new area of activity in Australia and was integral to the implementation of the National Competition Policy. As the regulatory task undertaken by the ACCC/AER has developed there has been an increased need for input from specialist regulatory economists.

In response the ACCC established a group of economic specialists to

- provide wide ranging economic advice
- research and develop best practice regulatory techniques
- contribute to economic discussion, debate and training regarding regulatory issues.

The promotion of the use of best practice economic principles recognises that while the principles of regulation might have specific applications across the diversity of areas regulated by the ACCC/AER they are broadly shared. The Unit keeps abreast with latest thinking in regulatory economics and develops shared regulatory principles for the different sectors that the ACCC/AER regulates.

In addition the Regulatory Economic Unit has responsibility for a number of external activities such as the ACCC/AER annual Regulatory Conference, the Utility Regulators Forum, the Infrastructure Consultative Committee and the ACCC/AER Working Paper series.

The following paper is part of the Regulatory Economic Unit's commitment to contribute and foster discussion on regulatory economic issues.

Contents

1. Introduction

This note is prepared in response to a request for Regulatory Economic Unit (REU) advice from the Australian Energy Regulator (AER) rate of return team on implementing the AER's proposed approach for estimating the return on debt. The note aims to inform the AER's considerations regarding the future use of the Thomson Reuters (TR) credit curve data series, as well as its continuing use of the Reserve Bank of Australia (RBA) and Bloomberg data series to estimate the allowed return on debt.

1.1. AER rate of return guideline and previous decisions

In the rate of return guideline the AER proposed to set the allowed return on debt using a trailing average portfolio approach (following the completion of a transitional arrangement period). In particular, the AER proposed to apply the following:[1]

- A trailing average portfolio approach with the length of the trailing average to be 10 years.
- Equal weights to be applied to each annual element of the trailing average.
- The trailing average to be automatically updated every regulatory year within the regulatory control period.

For the estimation of the prevailing return on debt, the AER proposed the following:[2]

- Use the published yields from an independent third party data service provider.
- Use a credit rating of BBB+ from Standard and Poor's or the equivalent rating from other recognised rating agencies.[3]
- Use a term to maturity of debt of 10 years.[4]

Further, the AER defined the benchmark efficient entity (BEE) as 'a pure play, regulated energy network business operating within Australia' and set out criteria that it proposed to use to assess the merits of various sources of information in setting the allowed rate of return.[5,6]

The AER did not specify in the guideline which independent third party data service provider it proposed to use. The AER had previously expressed a preference for using a method that is transparent. However, in the guideline the AER also acknowledged that other factors—such as differences in debt instruments selection criteria—would need to be considered in assessing competing data providers.[7]

In 2015 the AER determined to use a simple average of RBA and Bloomberg data series to estimate the return on debt of the benchmark efficient entity in its decisions.[8] More recently,

1 See: AER, *Rate of return guideline*, December 2013, p. 19.

2 See: AER, *Rate of return guideline*, December 2013, p. 21.

3 If the published yields do not reflect the assumed credit rating of BBB+ (or its equivalent), the AER proposed to apply the published yields that are the closest approximation of the BBB+ credit rating.

4 Where the yield at a term to maturity of 10 years is not published by the third party service provider, the AER proposed to determine the method for extrapolation at each network service provider's determination.

5 See: AER, *Rate of return guideline: explanatory statement*, December 2013, p. 32.

6 See: AER, *Rate of return guideline*, December 2013, p. 6.

7 See: AER, *Rate of return guideline: explanatory statement*, December 2013, pp. 126–130.

8 See, for example, AER, Final decision – Ausgrid distribution determination – Attachment 3 – Rate of return – April 2015, p. 3-546. The series referred to are FNFYBBB10M (RBA statistical table F3) and BVCSAB10 Index (Bloomberg).

the AER has also indicated that it is '…open to further consideration of the Thomson Reuters curve in future determinations following a proper period of consultation'.[9]

1.2. Thomson Reuters series and the REU note

While Thomson Reuters began producing the corporate credit curves using its current methodology as early as 2007, the methodology has not previously been reviewed in detail by the AER. During the recent determinations, a number of stakeholders suggested using the series for cost of debt estimation in addition to the currently used RBA and BVAL series.[10] ESQUANT (2016) presents a comprehensive overview of the Thomson Reuters methodology prepared as a part of a submission to accompany United Energy's revised regulatory proposal.

There are two Australian Dollar (AUD) credit curves currently available for the broad BBB credit rating band. TR refers to them as the 'main' (or 'blended') and 'domestic' curves.[11]

In this note we examine the construction of these two curves along the following dimensions: input data and curve-fitting methodology. We also offer some considerations in relation to the AER's analysis of the third party data series.

During the preparation of the note, we routinely corresponded with Thomson Reuters fixed income and pricing specialists to ensure better understanding of the methodology. Some of the information we procured is confidential. The present analysis is based exclusively on non-confidential information available.

2. Input data

The process of estimating a credit curve for a set of financial instruments can, in general, be split into two stages: (1) selection and preliminary 'standardisation' of the data inputs, and (2) econometric estimation. This section elaborates on the first stage of the process.

2.1. Input data and sample selection criteria

Below, we summarise the bond selection criteria used by Thomson Reuters. For the readers' convenience, we also present a table summarising up-to-date bond selection criteria for all three data providers.

Thomson Reuters produces a wide range of sector and issuer credit curves. In particular, in 2013 there were around 480 curves covering 20 currencies.[12] All Thomson Reuters ratings and sector curves are based on a set of criteria that are standard across all curves. These criteria refer to bond type, seniority, sectors, debt type, conditions on bonds with guarantees and private placements. In addition to the standard criteria, there are some non-standard criteria that can be changed or modified according to the needs of specific markets. These

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9 AER. Final decision – CitiPower distribution determination – Attachment 3 – Rate of return – May 2016, p. 3-318.

10 See, for example, CEG, Criteria for assessing fair value curves, January 2016, Appendix 7B (Submitted with the AusNet Electricity Services Revised Regulatory Proposal). See also, Esquant Statistical Consulting, Estimating the yield on a benchmark corporate bond in January 2015, June/July 2015 and November/December 2015: Analysis to support the transition to a trailing average rate of return on debt, A report prepared for United Energy to accompany United Energy's revised regulatory proposal, January 5, 2016. Appendix A: Analysis of third party indicator series including credit curves from Thomson Reuters.

11 The respective Thomson Reuters RIC codes are BBBAUDBMK and BBBAUDDBMK.

12 Thomson Reuters Credit Curve Methods, 18 February 2013, p.4.

refer to credit ratings, amount outstanding, market of issue, and price sources used.[13] The following set of criteria applies to bonds used in construction of the BBB AUD credit curves:[14]

- **Currency:** AUD denominated bonds
- **Sector:** include corporate bonds, excluding bonds issued by sovereigns, supranationals, agencies, not-for-profit/charitable foundations, universities or colleges
- **Bond Type**: only plain vanilla, fixed rate or zero coupon bullet bonds; bonds with any form of embedded optionality and index-linked bonds are excluded; bonds with make-whole call option are included (only if there are no other embedded options)
- **Seniority:** only senior unsecured and unsecured issues
- **Debt type:** exclude commercial paper, certificates of deposits and covered bonds
- **Guarantee:** exclude bonds that are guaranteed by the sovereign government
- **Private placements:** exclude private placements
- **Amount outstanding:** a minimum amount outstanding greater than or equal to AUD150 million[15]
- **Credit rating:** broad BBB credit rating by S&P, Moody's, Fitch, or DBRS; generally more weight is put on the latest available ratings, however, to resolve the issue where a bond has split ratings on the same date, the minimum rating for that bond is taken
- **Market of issue:** bonds issued in Australia as a primary market; for the 'blended' curve (BBBAUDBMK), all such bonds, independent of country of risk or domicile of the issuing entity; for the 'domestic' curve (BBBAUDDBMK), only bonds issued by Australian-domiciled entities with Australia being the country of risk
- **Remaining time to maturity:** one month or more
- **Minimum number of bonds:** for a curve to be constructed, at least five bonds need to be in the group
- **Price sources:** only actively priced bonds[16]
- **Outliers:** exclude outliers using a Z-spread based procedure[17]

Table 1 summarises the key characteristics of the bond samples used by the RBA, Bloomberg, and Thomson Reuters.[18]

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13 Thomson Reuters Credit Curve Methods, 18 February 2013, pp.5-6.

14 Thomson Reuters Credit Curve Methods, 18 February 2013, pp.5-6; phone and electronic communication with the TR fixed income specialists [October 2016].

15 This condition can be changed, and it appears that a different condition (AUD100 million) is currently used for the BBB AUD domestic credit curve (as of February 2017).

16 If the bond's prices are not updated for two or more days, then the bond will be excluded.

17 The outlier detection procedure is discussed in more detail later (section 2.8). Bloomberg defines Z-spread as follows. Zero-volatility spread – Z-spread: the constant spread that will make the price of a security equal to the present value of its cash flows when added to the yield at each point on the spot rate Treasury curve where a cash flow is received. In other words, each cash flow is discounted at the appropriate Treasury spot rate plus the Z-spread. The Z-spread is also known as a "static spread".

18 The table is an updated and expanded (to include TR curves) version of Table 1 in our earlier report (ACCC, Regulatory Economic Unit, *Return on debt estimation: a review of the alternative third party data series – Report for the AER* – August 2014).

Table 1: Comparison of the RBA, BVAL, and TR bond samples

Bond characteristic	RBA series[19]	BVAL series[20]	TR series[21]
Size of issue / quality of pricing data	At least A$100 million (or equivalent) - outstanding	Ratings and BVAL prices available at the market close BVAL score of 6 or higher[22]	Only actively priced bonds[23] At least A$150 million outstanding
Residual term to maturity	Over 1 year	At least 3 months	At least 1 month
Issuing entity	Non-financial corporations only Incorporated in Australia	Both financial and non-financial corporations Australia is identified as the country of risk	Exclude sovereign and agency debt, bonds issued by non-profit/charitable foundations, supranationals, universities/colleges, bonds guaranteed by sovereign governments For the 'domestic' curve: Australian-domiciled entity with Australia being the country of risk. For the 'main'/'blended' curve: no restriction on ownership or country of risk
Secured / unsecured	Both secured and unsecured bonds	Senior unsecured bonds only	Senior unsecured and unsecured bonds only
Credit rating	Broad BBB: S&P bond rating, if available; S&P issuer rating otherwise – for unsecured bonds only	Broad BBB: broad BBB Bloomberg composite bond rating, if available; broad BBB or equivalent from S&P, Moody's, and Fitch credit rating agency	Broad BBB credit rating by S&P, Moody's, Fitch, or DBRS; generally more weight is put on the latest available ratings; to resolve the issue where a bond has split ratings on the same date, the minimum rating for that bond is taken.

19 RBA Statistical Table F3 (series FNFYBBB10M).

20 Bloomberg BS157 AUD Corporate BBB BVAL Curve series.

21 Thomson Reuters AUD BBB curves BBBAUDBMK ('blended' curve) and BBBAUDDBMK ('domestic' curve).

22 BVAL score is a Bloomberg measure of the BVAL pricing data quality. It is discussed in more detail in our 2014 report.

23 According to TR this condition means that 'the pricing on the bond should not be stale – if the bond's prices are not updated for 2 or more days then the bond will be excluded… "Actively priced" means that there are bid and ask prices published for those bonds'.

		otherwise	
Currency of issue	AUD, USD, Euro	AUD	AUD
Coupon type	Fixed rate bonds only	Fixed rate bonds only	Plain vanilla fixed rate or zero coupon bonds
Embedded options	Both bullet bonds and bonds with embedded options (callable, convertible and puttable bonds)	Bullet bonds and bonds with make-whole call option Note that bonds with a make-whole call option are included – even when they also have other type of embedded options	Bullet bonds and bonds with make-whole call option only
Other restrictions	Excludes bonds with some form of duplication[24] and credit wrapped securities The list of bonds in the sample is published by the RBA once a month together with the data release	Prior to the curve fitting, outliers are detected and removed from the bond sample. Once a bond is considered an outlier it remains out of the sample unless it is later re-added following a review by evaluators on a case by case basis	Only includes bonds issued into Australian bond market as a primary market Excludes private placements Excludes outliers (z-spread-based procedure)

Source: Bloomberg, Reserve Bank of Australia, Thomson Reuters.

2.2. Quality of input data

The estimated yield curve is to a large extent affected by the quality of the input data used in the estimation. For example, if bonds in the sample are traded very infrequently, their pricing data might be 'stale' and not reflective of the current market conditions. In addition, Chairmont Consulting emphasises the importance of comparing 'like with like' when estimating the return on a benchmark bond:[25]

> *Consistent with the principles of benchmarking, an appropriate proxy needs to have a similar degree of liquidity to the bond being benchmarked, all other things being equal.*

[24] Where USD-denominated bond line had both 144A and Regulation S series, Regulation S series were omitted; other excluded securities are duplicate securities available to accredited investors, bonds with warrants and a second series of a bond line.

[25] Chairmont Consulting, *Debt risk premium expert report*, February 2012, pp. 12-13.

For this reason, some measures of bond liquidity and/or the quality of the pricing data are often taken into account when estimating yield curves. For example, the European Central Bank (ECB) uses the following set of (typical) liquidity criteria to restrict a bond sample used to construct its yield curves for government bonds: total turnover (total volume of daily trades), average trade size, bid-ask spread. Further, only bonds with a minimum trading volume of €1 million per day are used.

The ECB further suggests that:[26]

> *Bonds with maturities below three months are less traded and thus typically have more volatile prices/yields than other bonds.*

Thomson Reuters addresses the issue of the pricing data quality and bond liquidity via its choice of the price sources and bond selection criteria.

It is our understanding that at present TR does not rely on any evaluated prices in construction of its Australian Dollar BBB credit curves; that is, the only pricing source used to construct these curves is the Thomson Reuters SuperRIC. The Thomson Reuters SuperRIC can be described as the super composite which represents the best available tolerance-checked price for a bond.[27]

Further, Thomson Reuters has bond selection criteria aimed to improve the consistency of the pricing data. In addition to giving preference to executable and indicative prices, TR excludes bonds with less than one month to maturity, bonds with an amount outstanding lower than AUD150 million, bonds that are not actively priced (that is, prices were not updated for two or more days) and private placements.[28]

2.3. Issuing entity: use of financial and non-financial corporate bonds

The next restriction on the bond sample deals with the question of whether the industry of the issuing entity has a significant effect on how bonds are priced.

Thomson Reuters bond samples for BBBAUDBMK ('blended') and BBBAUDDBMK ('domestic') credit curves include both financial and non-financial bonds.[29] In fact, as of 22 February 2017, the bond sample for the 'blended' TR curve included a total of 30 bonds[30], out of which 8 were financial sector bonds, including two bonds issued by banks. Similarly, the bond sample for the 'domestic' TR curve included a total of 19 bonds[31], out of which 6 were financial bonds[32].

There are a number of arguments suggesting that, even within the same credit rating band, yields of bonds issued by financial entities might behave differently from those issued by non-financials.

26 ECB, *The new euro are yield curves*, Monthly bulletin, February 2008, p.101.

27 Thomson Reuters Credit Curve Methods, 18 February 2013, p.6.

28 Based on our communication with TR, TR's reason for this is that secondary markets for private placements are limited, and price sources are often limited to internal evaluations.

29 We follow the Bloomberg Industry Classification (BBIC) to enable comparison with the relevant bond selection criteria imposed by the RBA and Bloomberg. Therefore, financial bonds are those issued in the following sectors, as identified by Bloomberg: banking, commercial finance, consumer finance, financial services, life insurance, property and casualty insurance, real estate, government agencies, government development banks, government regional or local, sovereigns, supranationals and winding-up agencies.

30 One out of them was identified as an outlier.

31 Three of them were identified as outliers.

32 One of them was identified as an outlier.

In its 2012 report Chairmont Consulting suggests that:[33]

> *Appropriate benchmarking must take into consideration that similar or same industry specific risks may impact similarly on the trading spread determination for debt in similar or same industries. Therefore, proxies should come from the same or similar industry as the entity issuing the debt being benchmarked.*

Chairmont Consulting further suggests that:[34]

> *Economic cycles are part of the capitalistic model. In downturn periods, default levels increase and it is the financial services sector, primarily banks that carry many of the losses that result. Traders consider this factor as well as other industry specific risks when they price bank and insurance company issued debt. It highlights why financial institution debt is not an appropriate proxy for infrastructure as the industry risks are different. Consequently, credit spreads of banks compensate for and are affected by different factors than credit spreads of entities from other industries that have their own specific risks.*

And finally:[35]

> *The industry of the debt issuer is of paramount importance in benchmarking and banking is not similar enough industry to infrastructure to qualify bank debt as an appropriate proxy for this process…*

In its report to the QCA, PwC states:[36]

> *We conclude that industry membership is generally not important for estimating the debt risk premium, but single out the finance industry as an exception. Market participants consider that the yields of the bonds of banks and finance companies trade materially differently from operating non-financial businesses.*

PwC further refers to the following evidence:[37]

> *In relation to this matter we interviewed Mr. Michael Bush, Head of Fixed Interest Securities at National Australia Bank, who confirmed that the industry practice is to remove the bonds of financial institutions when estimating FVCs for corporate bonds. Formal empirical analysis confirms this.*

PwC refers to an empirical study using the US bond data (for 1987-1996), that observes that:[38]

> *…in general, the corporate spread for a rating category is higher for financials than it is for industrials.*

While this observation was made for the US sample of 1987-1996, similar observation can be made for the post-GFC period based on the comparison of Bloomberg BVAL curves for the USD bonds within the broad BBB credit rating issued by US financial and non-financial corporations. Figure 1 below demonstrates that for the period from mid-2009 till present the

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33 Chairmont Consulting, *Debt risk premium expert report*, February 2012, p.11.

34 Chairmont Consulting, *Debt risk premium expert report*, February 2012, p.13.

35 Chairmont Consulting, *Debt risk premium expert report*, February 2012, p.17.

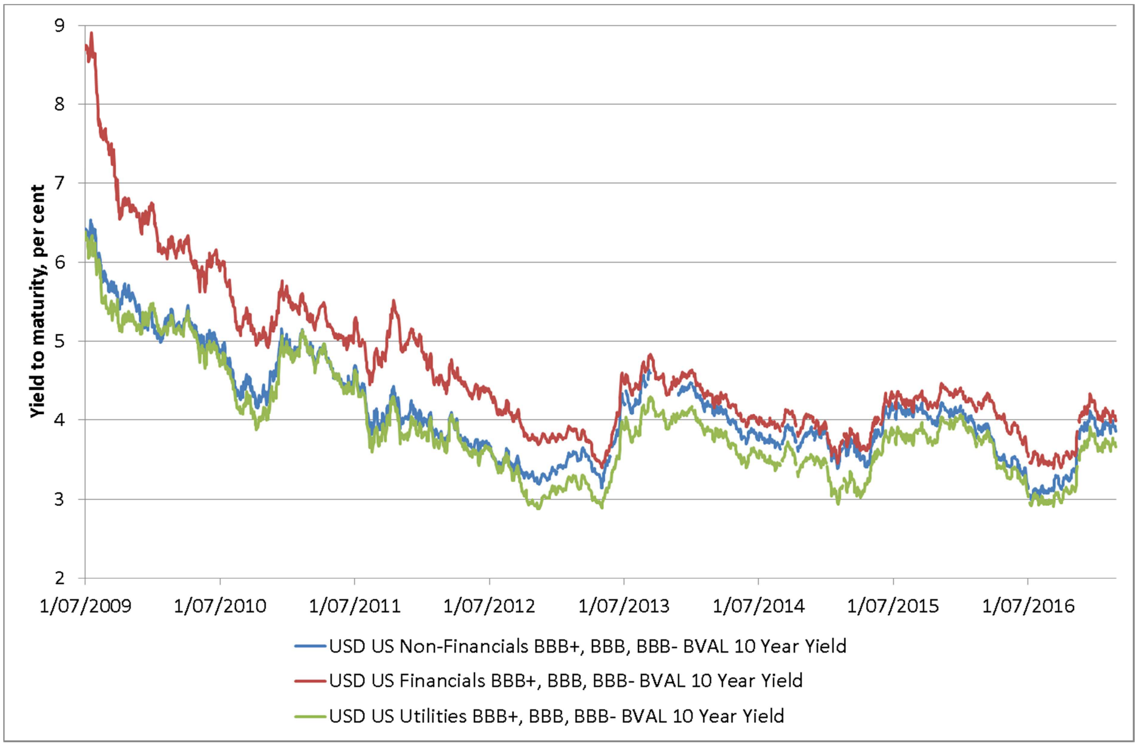
36 PwC*, A cost of debt estimation methodology for businesses regulated by the Queensland Competition Authority*, June 2013, p.9.

37 PwC*, A cost of debt estimation methodology for businesses regulated by the Queensland Competition Authority*, June 2013, p.9.

38 Edwin Elton, Martin J. Gruber, Deepak Agrawal, and Christopher Mann, *Explaining the rate spread on corporate bonds*, February 2001, Journal of Finance, Vol. LVI, No. 1, p.253.

BVAL curve 10-year yield for US USD-denominated (broad) BBB financial bonds has always been higher than the corresponding yield for non-financial bonds. Further, the relevant US utility sector 10-year yield has also been consistently below the financial sector yield – and closer in values to the non-financial sector yield. Figure 2 illustrates that similar observations hold for the Euro-denominated (broad) BBB-rated bonds issued by European corporations.

Figure 1: Comparison of USD US BBB+, BBB, BBB- 10 year BVAL curve yields for financial, non-financial, and utility sectors

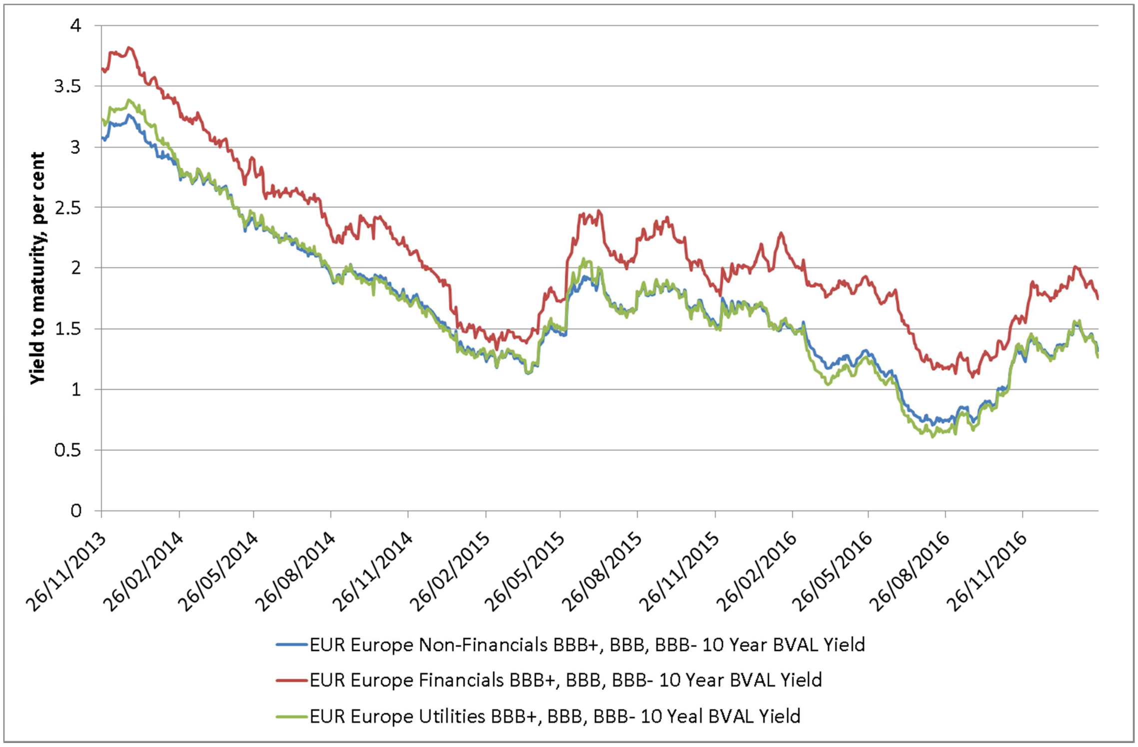


Source: Bloomberg.

We are not aware of an empirical study that would make similar observations using current Australian bond data – specifically those in the broad BBB credit rating range. While Bloomberg produces a BVAL curve for the (broad) BBB-rated AUD Australian bonds issued by financial corporations, the corresponding curves for the non-financial and utility sectors are not available. In addition, the AUD financial (broad) BBB BVAL curve has relied on a sample of at most four (and currently, two) constituent BBB-rated bonds for the last two years. We consider that such empirical evidence does not allow us to draw strong conclusions based on the AUD bonds data.

To the extent the evidence from the US and Euro market is informative, it suggests that 10 year yields of non-financial – and, in particular, utility bonds in the broad BBB credit rating range tend to be lower than the corresponding yields of financial bonds post-GFC, and, therefore, a curve that combines both financial and non-financial bonds would tend to over-estimate the yield of non-financial and utility bonds with the same credit rating. Further evidence from the Australian corporate bond market would be desirable to confirm this observation.

Figure 2: Comparison of EUR Europe BBB+, BBB, BBB- 10 year BVAL curve yields for financial, non-financial, and utility sectors



Source: Bloomberg.

In his 2014 report for the AER, Dr Lally comments that ‘the usual criterion in selecting an estimator or combination is minimising the Mean Squared Error (MSE)’.[39] The MSE of an estimator can generally be presented as a sum of both the square of its bias and its variance. With respect to including financial bonds in a credit curve sample – and in the context of the AER’s decisions – Lally suggests that ‘even if financial corporations do have different costs of debt at the same credit [rating] level and term to maturity, the expansion in the sample size (and therefore possible reduction in standard deviation) from including them might compensate for the bias from including them’.[40] As noted above, empirical evidence suggests possible existence of such a bias for some of the foreign bond markets, however, current empirical evidence for the relevant Australian bond market, in our opinion, does not allow to establish either the existence of such a bias or quantify it. As a result, it is not possible to provide a recommendation of whether the AER should rely on a curve based on non-financial bonds only or on a curve based on both financial and non-financial bonds, other things being equal.

2.4. Bonds issued by non-resident entities

As noted earlier, Thomson Reuters estimates two credit curves based on BBB rated AUD bonds: (1) the ‘blended’ (or ‘main’) curve (BBBAUDBMK) uses all qualifying bonds issued in Australia as a primary market, independent of country of risk or domicile of the issuing entity; (2) the ‘domestic’ curve (BBBAUDDBMK) only uses a subset of those bonds issued by Australian-domiciled entities with Australia being the country of risk. Including bonds issued

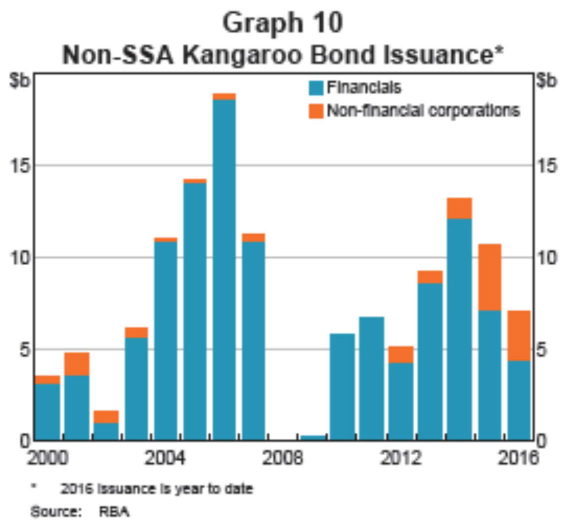
[39] M. Lally, *Implementation issues for the cost of debt*, 20 November 2014, p.19.

[40] M. Lally, *Implementation issues for the cost of debt*, 20 November 2014, p.10.

by ‘non-resident’ companies allows Thomson Reuters to expand the ‘blended’ curve bond sample (relative to the ‘domestic’ curve bond sample).[41]

It is conceivable that non-resident bond issuers may be facing different risks to those faced by domestic bond issuers[42] and – to the extent that those risks are priced – this can lead to differences in prices and yields between non-resident and domestic bonds that are otherwise similar (for instance, in terms of credit ratings, currency, seniority).

Figure 3: Non-SSA Kangaroo Bond Issuance



According to the RBA, the non-SSA[43] Kangaroo bond[44] issuance (see Figure 3) is still dominated by financial corporations, ‘with sizeable issuance from both European and US-domiciled banks’.[45] Further:[46]

> *Following an extended absence precipitated by the global financial crisis,* ***non-financial*** *corporate Kangaroo issuance resumed in 2012… Initial activity was supported by issuance from* ***a handful of larger British and US companies as well as Korean entities*** *(often with strong government links). …Issuance by non-financial corporations increased substantially in 2015 and 2016. Much of the increase was driven by* ***a small number of very large deals by US corporations****. [Emphasis added]*

Therefore, the composition of the non-resident bonds in the ‘blended’ TR bond sample – and in particular, the proportion of bonds issued by banks and other financials – may be different from the composition of domestic issues. If this is the case, it can potentially result in a discrepancy between the ‘domestic’ and ‘blended’ curves. At present, however, we do not consider that there is sufficient evidence of a persistent bias in the ‘blended’ TR curve relative to the ‘domestic’ TR curve.

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41 We refer to companies that neither are domiciled/incorporated in Australia nor have Australia as the country of risk as the ‘non-resident’ companies. Similarly, we refer to companies either domiciled/incorporated in Australia or with Australia being the country of risk as ‘domestic’. We also refer to bonds issued by the non-resident companies into the Australian market as ‘non-resident’ bonds, and to bonds issued by the domestic companies – as ‘domestic’ bonds.

42 For example, due to differences in taxation, regulatory/legislative requirements, etc.

43 SSA stands for supranational, sovereign or quasi-sovereign agency entities.

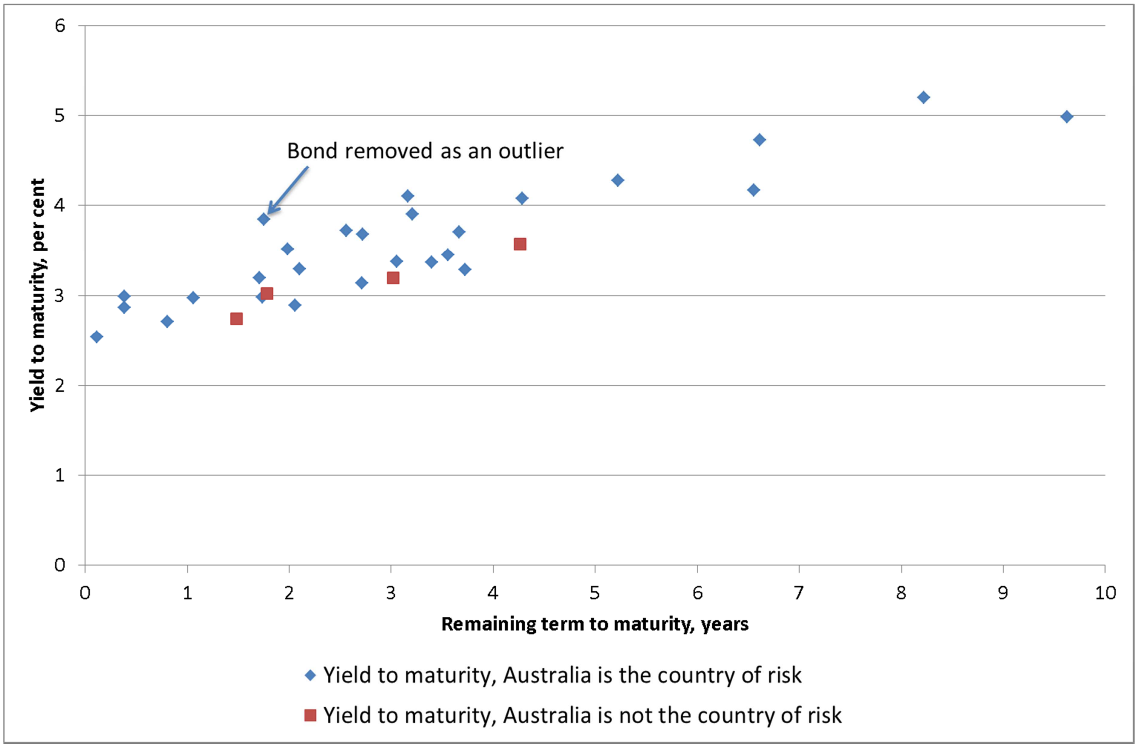
44 The RBA uses the (standard) term ‘Kangaroo bonds’ to refer to Australian dollar-denominated bonds issued into the domestic market by non-resident issuers.

45 M. Bergmann, A. Nitschke, *The Kangaroo bond market*, Bulletin, September Quarter 2016, p.51.

46 M. Bergmann, A. Nitschke, *The Kangaroo bond market*, Bulletin, September Quarter 2016, p.52.

Firstly, the proportion of the non-resident bonds in the TR current ‘blended’ bond sample is relatively low (both in terms of number of bonds and amount outstanding). As Figure 4 illustrates, currently (27 February 2017) the ‘blended’ bond sample comprises four non-resident bonds and 27 bonds issued by Australian companies.[47] While the non-resident bonds’ yields in Figure 4 appear to be somewhat lower than the **average** yields for domestic bonds with similar maturities, it would be necessary to observe the series for a longer period of time before drawing any conclusions regarding a possible pattern.

Figure 4: Bond sample for the 'blended' Thomson Reuters credit curve BBBAUDBMK, 27 February 2017

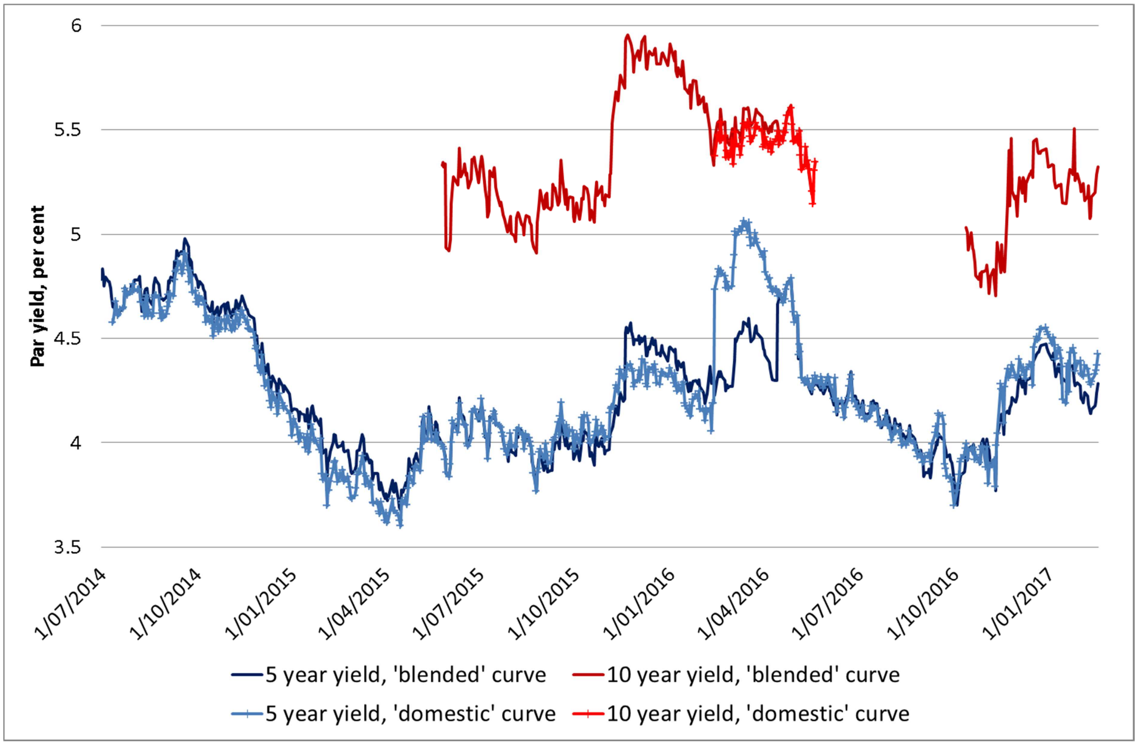


Source: Thomson Reuters.

Secondly, while the TR ‘domestic’ and ‘blended’ yields at five year tenor differed in the past by as much as 50 basis points, this difference does not appear to be consistently positive (negative) (see Figure 5).

47 One of the 27 bonds is removed from the sample as an outlier prior to curve estimation.

Figure 5: Historical series for Thomson Reuters BBBAUDBMK ('blended') and BBBAUDDBMK ('domestic') credit curves, 5 and 10 year par yields



Source: Thomson Reuters.

Given that the AER defined a BEE as 'a pure play, regulated energy network business operating within Australia', the BEE would likely be an entity with Australia as a country of domicile / incorporation / risk.[48] Therefore, all other things being equal, Australian-domiciled bond issuers / bond issuers with Australia being the country of risk would be closer comparators to the BEE than non-resident issuers. Thus, as was the case with bonds of financial institutions, the relevant consideration for the AER is whether including non-resident bonds in the bond sample would result in a smaller MSE. Similarly to our conclusion on financial bonds, however, we consider that the evidence at present does not allow us to quantify a possible effect on the MSE.

If the AER makes a decision to use the TR 'blended' curve for the purposes of estimating the BEE's cost of debt, we suggest periodically reviewing new evidence on the proportion of the non-resident bonds in the bond sample and their effect on the overall yield estimates as such information becomes available. An alternative option could be to use the TR 'domestic' series rather than the 'blended' series. However, in that case, the availability of 10 year yields might be reduced (and extrapolation would be required more frequently and to a greater extent): Figure 5 suggest that in 2014-2016 the 'domestic' series rarely extended to 10 year tenor in the past 2.5 years.

48 See: AER, *Rate of return guideline: explanatory statement*, December 2013, p. 32.

2.5. Use of foreign currency bonds data

Thomson Reuters includes only AUD-denominated bonds in both 'blended' and 'domestic' curve sample. The issue of whether it is appropriate to expand the bond sample to include foreign currency bonds has been raised in the past.[49]

The appropriateness of inclusion of foreign currency bonds in a credit curve depends on:

- the difference between the yields on the AUD bonds and hedged yields on similar foreign currency bonds, and
- how the curve is used and interpreted.

To enable comparison between AUD and foreign currency denominated bonds, one could use interest rate swaps and cross currency swaps to construct synthetic (or, hedged) AUD bond yield equivalents for the foreign currency bonds.[50] Whether or not these synthetic yields would be similar to yields for AUD bonds with like characteristics, is determined by whether or not covered interest parity (CIP) condition holds for the relevant bond category, or, equivalently:

- whether or not CIP condition holds for the base rate component of the bond yields;
- whether or not the debt risk premia (DRPs) for the foreign currency bonds (once they are swapped into AUD) and for the AUD-denominated bonds with similar characteristics are comparable.

With regards to CIP, Du, Tepper, and Verdelhan explain:[51]

> *The cross-currency basis measures the deviation from the CIP condition. It is the difference between the direct [US] dollar interest rate from the cash market and the synthetic dollar interest rate from the swap market obtained by swapping the foreign currency into U.S. dollars. A positive (negative) currency basis means that the direct [US] dollar interest rate is higher (lower) than the synthetic [US] dollar interest rate. When the basis is zero, CIP holds.*

They analyse CIP post-GFC using a wide range of currencies and financial instruments and find that:[52]

> *…the CIP condition is systematically and persistently violated among G10 currencies, leading to significant arbitrage opportunities in currency and fixed income markets since the 2008 global financial crisis.*
>
> *…Libor bases persist after the global financial crisis among G10 currencies and remain large in magnitude… In the current economic environment, the cross-currency basis can be of the same order of magnitude as the interest rate differential.*

Their Figure 5 (reproduced below in Figure 6) illustrates this result.

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[49] See, for example, CEG, *Criteria for assessing fair value curves*, January 2016, Appendix 7B (Submitted with the AusNet Electricity Services Revised Regulatory Proposal).

[50] See, for example, I. Arsov, M. Brooks, M. Kosev, *New Measures of Australian Corporate Credit Spread*, Bulletin, December Quarter 2013, p. 25; Bloomberg YAS function also has similar functionality.

[51] Wenxin Du, Alexander Tepper, Adrien Verdelhan, *Deviations from Covered Interest Rate Parity*, January 2017 [accessed at https://ssrn.com/abstract=2768207 on 8 March 2017], p. 2.

[52] Wenxin Du, Alexander Tepper, Adrien Verdelhan, *Deviations from Covered Interest Rate Parity*, January 2017 [accessed at https://ssrn.com/abstract=2768207 on 8 March 2017], pp. 1-2.

Figure 6: Long-term Libor-based deviations from CIP

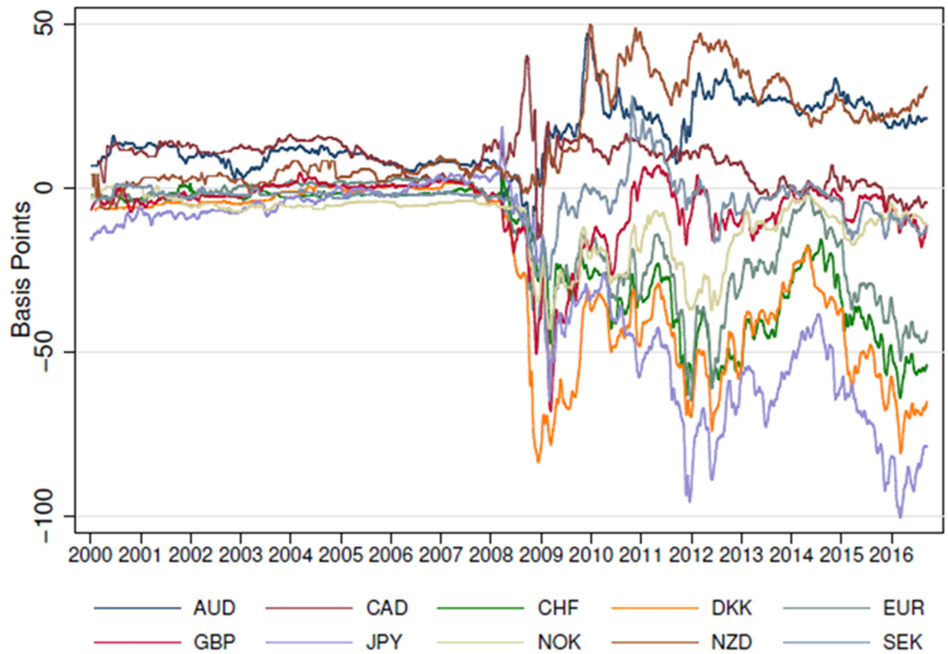

Figure 5: **Long-Term Libor-Based Deviations from Covered Interest Rate Parity**: This figure plots the 10-day moving averages of the five-year Libor cross-currency basis, measured in basis points, for G10 currencies. The covered interest rate parity implies that the basis should be zero. One-hundred basis points equal one percent.

Du et al further suggest:[53]

> *We hypothesize that persistent CIP deviations can be explained by the combination of the increased cost of financial intermediation post-crisis and persistent international imbalances in investment demand and funding supply across currencies.*

They find that the empirical evidence is supportive of this hypothesis:[54]

> *First, CIP deviations increase at the quarter ends post crisis, especially for contracts that appear in banks' balance sheets. Second, proxies for the banks' balance sheet costs account for two-thirds of the CIP deviations. Third, CIP deviations co-move with other near-risk-free fixed income spreads. Fourth, CIP deviations are highly correlated with nominal interest rates in the cross section and time series.*

The analysis of Du et al implies that, even if the DRPs for otherwise similar risky AUD-denominated bond and foreign currency denominated bond were identical, the AUD synthetic yield on the foreign currency bond would not likely be equal to the yield on the risky AUD-denominated bond. Further, the discrepancy would vary over time – for example, with changes in monetary policies.

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53 Wenxin Du, Alexander Tepper, Adrien Verdelhan, *Deviations from Covered Interest Rate Parity*, January 2017. Accessed at https://ssrn.com/abstract=2768207 on 8 March 2017, p. 4.

54 Wenxin Du, Alexander Tepper, Adrien Verdelhan, *Deviations from Covered Interest Rate Parity*, January 2017. Accessed at https://ssrn.com/abstract=2768207 on 8 March 2017, pp. 1-2.

Further, there are reasons to believe that the DRPs of AUD and foreign currency BBB bonds – even when issued by the same entity – would likely differ. Dr Lally notes that since DRP 'comprises allowances for expected default losses, the illiquidity of the bonds relative to government bonds, and systematic risk':[55]

> *…the DRPs on a given Australian bond arising on a secondary market transaction may differ across the nationality of the buyer because perceptions of the default risk of Australian firms may differ across markets, premiums for the relative illiquidity of the bonds may differ across markets, and the premiums for systematic risk are likely to be different.*

Therefore, it appears unlikely that (hedged) yields on foreign currency bonds would provide a good proxy for yields on AUD-denominated bonds with similar tenor, credit rating, and other characteristics.

If the credit curve is **to reflect the yields or credit spreads on the AUD-denominated bonds with certain characteristics**, then adding synthetic spreads on foreign currency bonds is likely to result in a bias that would likely be highly variable over time, depending, for instance, on countries' monetary policies, regulations, etc. For this reason, we consider that it would be prudent not to include foreign currency bonds into estimation sample.

It is possible to consider a different exercise. For example, an entity may choose to issue debt in different markets – and in different currencies – taking into account the relative issuance and transaction costs – and, possibly, other considerations. To estimate an average cost associated with issuing such **a portfolio of bonds denominated in different currencies**, one does not need to rely on CIP condition holding. One of the substantial challenges of this exercise would be, however, to determine the weights to apply to foreign currency and AUD-denominated bonds in such a portfolio. As mentioned earlier, the cross-currency bases have become highly volatile post-GFC and, presumably, the same entity would make different issuance decisions at different points in time. That is, to reflect such a debt portfolio, the relative weights of instruments denominated in different currencies would need to vary over time. Further, the current issuance pattern might be a poor indicator of issuance, for instance, six months into the future.

It follows then that if the AER defines a benchmark debt instrument as an AUD fixed rate bond, then a series based on a sample of AUD-denominated bonds would be preferred.

On the other hand, the AER might be interested in establishing the cost of debt for a broader portfolio of instruments, including not only AUD-denominated bonds, but also bank debt and foreign currency debt. We suggest that in this case assembling and maintaining a series reflective of instruments' optimal weights in such a portfolio would be a complex and costly exercise. A further challenge would be to develop an algorithm that would allow for an automatic annual updating of such series.

2.6. Secured and unsecured bonds

TR curves include only senior unsecured and unsecured issues into both its 'blended' and 'domestic' curve samples. We note that, according to Bloomberg's classification, all the bonds in the current two TR bond samples ('blended' and 'domestic') are senior unsecured.[56]

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55 M. Lally, *Implementation issues for the cost of debt*, 20 November 2014, p.13.

56 To facilitate bond sample comparison between data providers we use Bloomberg classification. The classification process applied in the TR database is different from that used by Bloomberg: if the term sheet or prospectus explicitly states that the bond issue is 'senior', it will be classified as 'senior', otherwise if the term sheet states that the issue 'represents the unsubordinated and unsecured obligations' of the issuer, it will be classified as 'unsecured'.

In its 2012 report Chairmont Consulting noted that while 'there are two components market practitioners consider when forming expectations about total credit risk', specifically, probability of default and the loss given default, 'the ratings that [credit] Agencies publish are an indicator of the Probability of Default only'.[57] Further:[58]

> *All other things equal (like ratings), potential holders of debt will always require greater compensation for being lower down the capital structure… The marketplace is not and should not be indifferent to a security position ranking in the capital structure.*

Diagram I in the Chairmont's report (reproduced in Figure 7 below) puts senior secured debt higher (i.e., as less risky) in the capital structure than senior (unsecured) debt.[59]

Figure 7: Chairmont's Diagram I

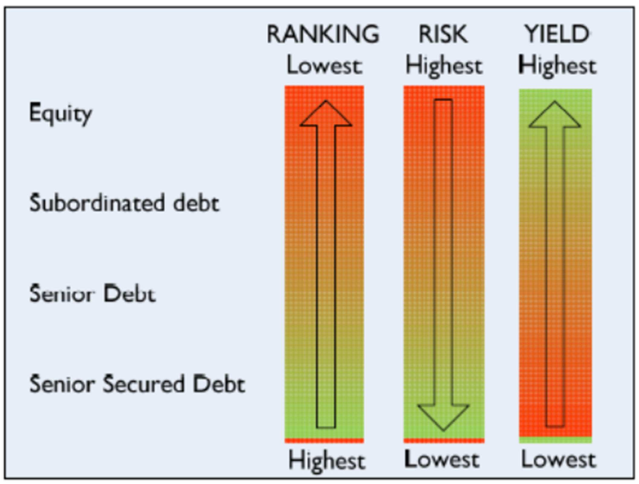

Diagram I: Ranking & Risk/Return Continuum

Our past correspondence with S&P confirms that S&P evaluates primarily probability of default while assigning a credit rating to a bond issue, whereas the security of a bond is related predominantly to the recovery of loss given default:[60]

> *From our view point security is a recovery issue and independent of default probability. We give credit to this in sub investment grade but not investment grade.*

Therefore, if an unsecured bond and a secured bond have the same characteristics (credit rating, maturity, coupon, etc.) and the same probability of default, we would generally expect the secured bond to trade at a higher price (lower yield) than the unsecured one. Similarly, we would generally expect an unsubordinated bond to trade at a higher price (lower yield) than a subordinated bond (other things being equal).

With respect to the AER's decision, Dr Lally points out that it would not be necessary to impose any requirement for the benchmark firm that relates to the matter of its debt security:[61]

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57 Chairmont Consulting, *Debt risk premium expert report*, February 2012, p.10.

58 Chairmont Consulting, *Debt risk premium expert report*, February 2012, p.12.

59 We note that the 'Senior Debt' category on the diagram corresponds to the debt classified as either 'senior unsecured' or 'unsecured' in TR database.

60 E-mail correspondence with S&P, June 3, 2014.

61 Dr Martin Lally, *Implementation issues for the cost of debt*, 20 November 2014, p.10.

> *…the granting of security to some bonds comes at the expense of others and lowers the cost of debt on the secured bonds whilst raising on the others. However the overall cost of debt on all of a firm's bonds will not be affected by such an action.*

It appears that while the above statement would hold approximately, its accuracy would depend on the benchmark's entity obligations to its priority unsecured creditors which are ranked higher than the entity's unsecured debt holders. In case of liquidation secured creditors have priority over unsecured creditors – and among those, **priority unsecured creditors**, including employees, have higher priority.[62] That is, if the BEE issues any unsecured debt, other things being equal, its overall cost of debt would be higher the higher are its obligations to the priority unsecured creditors.

Further, Dr Lally notes:[63]

> *…that uniform cost of debt must be estimated from a compatible set of bonds, i.e., if any bond from a particular firm is included in the sample, all bonds from the same firm should also be included in the sample and these bonds should be weighted in proportion to their values.*

We consider the following points may be of relevance to the AER's decision:

- Unsecured (and senior unsecured) bonds' yields are likely to carry a premium relative to secured bonds with similar characteristics.
- A credit curve that is only based on a sample of unsecured (and senior unsecured) bonds for a set of issuers is likely to over-estimate the cost of debt for those issuers – unless all the bonds they issue are unsecured and included in the sample.
- If bonds of the same issuer have different credit ratings and if a credit curve is based on a sample of unsecured bonds within a certain credit rating, then such a credit curve may generally under- or over-estimate the cost of debt of the issuing entities.

2.7. Use of bonds with embedded options

Thomson Reuters excludes bonds with embedded structures and index-linked bonds from its bond samples, but includes bonds with a make whole call option (as long as that is the only embedded option).[64]

Optionality – with a possible exception of a make whole call option – generally affects the value of a bond, and, as such, yields and spreads of bonds with embedded options are not directly comparable to those of bullet bonds.[65] Theoretically, it is possible to make an adjustment for a bond's optionality by estimating an option-adjusted spread (OAS).

The question of whether it is possible to strip the value of the embedded option effectively so that the resulting yield/credit spread of a bond is comparable to the yield/credit spread of a similar bullet bond has been discussed in the past regulatory decisions.

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62 ASIC, Information sheet 45, *Liquidation: a guide for creditors*, http://download.asic.gov.au/media/1340240/Liquidation_guide_for_creditors.pdf (accessed 6 April 2017).

63 Dr Martin Lally, *Implementation issues for the cost of debt*, 20 November 2014, p.10.

64 A make whole call is a provision that allows a borrower to prepay the remaining fixed rate term debt. The borrower, however, has to make an additional payment that is derived from a formula based on the net present value of the future debt payments.

65 As we discussed in our earlier report, theory and empirical evidence suggests that incremental yields for a make whole call option are small. For more detail, see E. Powers, S. Tsyplakov, *What is the Cost of Financial Flexibility? Theory and Evidence for Make-Whole Call Provisions*, Financial Management, Vol. 37, No. 3 (Autumn, 2008), pp. 485-512.

For example, in its 2013 report to the QCA, PwC removes callable bonds from its study sample with the following justification:[66]

> *Call options were excluded since the observed yield needs to be adjusted to remove the effect of the option, which adds complexity and the potential for analyst-induced error.*

In its 2012 report Chairmont Consulting points out the following problems with estimating an OAS of a (callable) bond in the context of Australian BBB corporate bond market:[67]

- *the type of options embedded in the instruments are not the type of option that can be valued by a [sic] options pricing model like Black-Scholes; and*
- *there is no observable credit curve from the issuers that reflects "standard" (unstructured non-callable) debt to which a structured bond can be compared.*

It is our understanding that estimation of an OAS – for example, that performed by Bloomberg OAS1 function – relies on choosing a term structure model and analysing different scenarios of interest rate evolution over time to arrive at the value of the option adjusted spread for a bond. Naturally, the outcome of the option adjustment depends on the modelling assumption – and, as such, would only be as good as the underlying model. Such models, generally, tend to have very few parameters – as the estimation procedure is very resource-intensive. Therefore, expanding a bond sample to include bonds with embedded options comes at the expense of an added source of estimation error.

If the AER considers the benchmark debt instrument to be a bond with no embedded features, then, other things being equal, bonds with no embedded features would be closer comparators than those with embedded features. Performing an option adjustment relies on the underlying modelling assumptions and therefore the benefit of expanding the bond sample should be considered against the possible increase in the estimation error.

2.8. Accounting for outliers and other restrictions

In this section we consider some other restrictions imposed by TR on the bond samples.

With respect to a bond's credit rating, Thomson Reuters puts more weight on the latest available ratings from S&P, Moody's, Fitch and DBRS; however, to resolve the issue where a bond has split ratings on the same date, the minimum rating for that bond is taken.

This approach is justified to the extent the credit ratings of the four agencies are close substitutes. While credit rating methodologies of the above agencies differ, they are often viewed as substitutes. For example, Bloomberg computes the Bloomberg composite credit rating by aggregating the bonds' ratings from S&P, Moody's, Fitch and DBRS using equal weights.

The TR credit rating criterion also deals with a possibility of a credit rating given by an individual agency going 'stale'. A potential problem with relying on a bond's rating by only one agency is illustrated below, using an example of two bonds from the RBA BBB bond sample.[68]

Example. The RBA included two bonds issued by Adani Abbot Point Terminal in its January and February 2017 samples. The bonds are both rated BBB- by S&P. S&P has not reviewed these ratings since their issuance (that is, at least since 2014), however, Moody's downgraded these bonds to a junk rating (Ba2) in March 2016. The yields to maturity of

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[66] PwC, *A cost of debt estimation methodology for businesses regulated by the Queensland Competition Authority*, June 2013, p.34.

[67] Chairmont Consulting, *Debt risk premium expert report*, February 2012, p.28.

[68] RBA Statistical Table F3 and the associated bond list – 'Bonds used to construct aggregate measures of Australian corporate bond spreads and yields – F3', accessed at http://www.rba.gov.au/statistics/tables/ .

these bonds as of 31 January 2017 were substantially higher than those of the other bonds in the RBA sample with comparable term to maturity, which reflects the market participants' perception of their riskiness. Arguably, these bonds' yields are no longer representative of the yields on BBB-rated bonds with similar term to maturity and should be removed from the sample.

The situation similar to that described above is not likely to occur under TR's bond criteria.

Thomson Reuters also has an outlier detection and monitoring procedure, which is documented and is available to the subscribers.[69] The check for outlier bonds is conducted by the credit curve application prior to the curve fitting stage. The methodology is based on the Z-spread of individual bonds. This procedure is somewhat similar to one used by the ECB in construction of the Euro area government bond yield curves, though the latter is based on bond yields rather than Z-spreads:[70]

> *Despite the …selection criteria, the yields of a few bonds may still deviate significantly from the rest. To prevent noise in the yield curve estimation, these outliers are removed from the sample. Outliers are traced separately for a number of residual maturity brackets. Bonds with yields that deviate more than two standard deviations from the average are considered as outliers and are removed from the sample. Within each of these brackets, the average yield and standard deviation are calculated. This procedure is iterated in order to reduce the sensitivity of the analysis to potentially large outliers eliminated in the first round that could have distorted the average yield level and the standard deviation.*

In addition to the outlier removal, TR has a 'dedicated team of data analysts that monitor the credit curves' and investigate and resolve alerts that may be generated by the system in the process of curve fitting.[71] If an alert is generated, a TR analyst would investigate the reasons it occurred and whether the issue could be resolved by adjusting the tolerance level (that is, the acceptable range of Z-spreads) for the outlier detection procedure.

It is a difficult task to describe an exhaustive set of bond sample selection criteria up front. Thus, whichever third party data provider(s) the AER uses, the provider(s) would likely exercise a degree of discretion to adjust a data sample over time. Ultimately, the AER needs to decide whether it is comfortable with the chosen data provider(s) exercising discretion on such occasions.

3. Analysis of the curve-fitting methodologies

This section describes the econometric technique employed by TR to estimate the yield curves, given a sample of bonds.

3.1. Par yield curves versus averaging of yields to maturities or credit spreads

A yield curve is a graphical representation of the term structure of interest rates, that is, a relationship between residual maturities of a homogenous set of financial instruments and their computed interest rates.[72] This computation is made on the basis of market prices of underlying financial instruments, as well as information on the future promised payments for these financial instruments, such as bond coupon rate and redemption payment in case of fixed rate bonds.

69 Thomson Reuters Credit Curve Methods, 18 February 2013, pp.12-15.

70 ECB, *The new euro are yield curves*, Monthly bulletin, February 2008, p.102.

71 Thomson Reuters Credit Curve Methods, 18 February 2013, p.13.

72 See, for example, ECB, *The new euro are yield curves*, Monthly bulletin, February 2008, p.97.

One commonly used measure of ex ante (promised) return on a bond is yield to maturity (YTM), or redemption yield. It is the bond's internal rate of return — 'the single interest rate at which the dirty price of a bond is equal to the present value of the stream of cashflows discounted at this rate'.[73]

While YTMs are relatively straightforward to compute, their use in informing us about the underlying term structure is limited. In particular, a YTM on a zero coupon bond is simply equal to the interest rate corresponding to the remaining term to maturity on that bond. Therefore, if we have enough data on zero coupon bonds, maturing at different points in time, we can recover the underlying term structure from the YTMs of such bonds. However, in practice, such bonds are not always available and most bonds issued by Australian corporations are coupon-bearing bonds. The relationship between the interest rates and YTM of a coupon-bearing bond is more complex:[74]

> *When calculating the yield to maturity of coupon-bearing bonds, all payment flows (coupons and redemptions) are discounted to current values at the same rate – i.e. the yield to maturity. Unless a constant discount rate applies to all maturities, i.e. the term structure is flat, the (zero coupon) interest rates – also referred to as spot rates – and yields to maturity of coupon bonds will differ.*

In other words, YTMs on coupon-bearing bonds cannot be aggregated into a yield curve (or term structure) in a straightforward manner:[75]

> *…since yields depend on the coupon, yields of bonds with different coupons will not generally lie along a smooth curve. Fitting a curve through points that do not and should not lie along a curve is unlikely to be a profitable exercise…*
>
> *…Since we can deduce so little from a direct comparison of redemption yields, it is perhaps not surprising that more elaborate calculations based on these measures yield little further information. As we have already indicated, the redemption yield depends not only on the spot rates and term to maturity, but also on the size of the coupon.* ***In general, two bonds with the same maturity but different coupons will have different redemption yields. Trying to fit a smooth curve through a set of points that do not lie on the same curve is therefore pointless, and it is even more pointless to try to read omens in the deviations from the curve.*** *[Emphasis added.]*

Fortunately, interest rates (a.k.a. 'spot' rates or zero coupon rates) can be recovered if we observe prices and promised coupon and redemption payments for a large enough bond sample. In fact, there exists a variety of financial models and econometric techniques for estimation of zero coupon yield curves. For example, the ECB and several other central banks use the Svensson model (which is an extension of the Nelson-Siegel model), the Nelson-Siegel model, or smoothing splines to estimate zero coupon yield curves.[76] The RBA uses the Merrill Lynch Exponential Spline model to estimate risk-free zero-coupon yield curves.[77] Other approaches such as non-parametric econometric methods have also been suggested.[78]

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[73] J. James and N. Webber (2000), *Interest rate modelling* (Wiley Series in Financial Engineering), p.6. The dirty price is the price of a bond including any interest that has accrued since the issue of the most recent coupon payment.

[74] ECB, *The new euro are yield curves*, Monthly bulletin, February 2008, p.98.

[75] Stephen M. Schaefer, *The problem with redemption yields*, Financial Analysts Journal, Vol. 33, No. 4 (Jul. - Aug., 1977), p.59-60.

[76] Bank for International Settlements, *Zero-coupon yield curve estimated by central banks: technical documentation*, BIS Papers No 25, October 2005; ECB, *The new euro are yield curves*, Monthly bulletin, February 2008, pp.95-103.

[77] R.Finlay, D. Olivan, *Extracting Information from Financial Market Instruments*, Bulletin, March Quarter 2012, pp. 45-54.

[78] Linton O., E. Mammen, J. Nielsen and C. Tanggard (2001*), Yield Curve Estimation by Kernel Smoothing Methods*, Journal of Econometrics, 105, pp. 185–223.

In addition to using zero-coupon yield curves, there are two other commonly used ways to represent the estimated yield curve: as an instantaneous forward yield curve and as a par yield curve. The ECB, for example, generally reports all three curves for euro area government bonds.

The par yield and forward yield curves can be easily derived from the zero coupon yield curve. The par yield curve is often favoured by market practitioners, as they typically trade coupon-bearing bonds. It represents a yield on a bond that is priced at par, that is, its current market price is equal to its face (or redemption, or par) value.[79]

Thomson Reuters estimates par yield curves by first estimating an instantaneous forward yield curve and then transforming the estimated forward rates to result in a par yield curve (section 3.2).

Dr Lally points out that it is appropriate to use par yields in the context of a 'building block' regulatory model (such as one used by the AER), though his stylised analysis demonstrates that 'the error from failing to use a par yield curve is … not very substantial', using examples based on the RBA's available sample (from 2005 to 2014).[80]

3.2. Use of econometric techniques

Thomson Reuters provides a detailed description of their curve construction method for its subscribers.[81] In addition, the bond constituents (as well as a list of bonds removed as outliers) for a given curve are available daily through the TR terminal. It is also our understanding that the curve construction can be replicated in Excel using a TR (subscriber-only) Adfin tool.[82]

Thomson Reuters uses a non-parametric model to derive a term structure – the basis spline model. For each curve, TR reports a par yield, zero yield, the benchmark spread, swap spread and asset swap spread.

TR provides the following explanation of its choice of a model:[83]

> *We prefer spline methods, in particular cubic basis splines, over parametric methods to extract the term structure.*
>
> *This model provides a good estimation of forward rates at all points on the curve whilst also providing a degree of smoothness. The spline-based model also tends to generate more accurate pricing of the constituent bonds as the curve reflects exceptionally well the market's current term structure.*

Below we present a detailed description of the model. The model formulation follows the work of Waggoner and Anderson and Sleath.[84,85]

First, we introduce some notation. The **discount function**, $\delta(t)$, is the current price of a zero-coupon bond paying one dollar at time t. Let the **instantaneous forward rate curve** be

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79 For a bond trading at par, its YTM is equal to its coupon.

80 M. Lally, *Implementation issues for the cost of debt*, 20 November 2014, pp. 17-18.

81 Thomson Reuters Curves, 9 Feb 2015; Thomson Reuters Credit Curve Methods, 18 February 2013; Thomson Reuters Eikon Adfin Term Structure Calculation Guide, Document Number 601637.4, March 2011.

82 We however have not engaged in this exercise.

83 Thomson Reuters Credit Curve Methods, 18 February 2013, pp. 7-8.

84 Daniel F. Waggoner, *Spline methods for extracting interest rate curves from coupon bond prices*, Federal Reserve Bank of Atlanta, Working Paper 97-10, November 1997.

85 Nicole Anderson, John Sleath, *New estimates of the UK real and nominal yield curves*, Bank of England Working Paper Series, 2001.

denoted *f(t)* and the **zero-coupon (or, spot) yield curve** – *y(t)*. Then, the relationship between those three interest rate curves is defined by the following equations:

$$\delta(t) = exp\left(-\int_0^t f(s)ds\right)$$

$$\delta(t) = exp\big(-ty(t)\big)$$

With complete markets and no taxes or transaction costs, absence of arbitrage implies that the price of any coupon bond can be computed from an interest rate curve as the present value of its future principal and interest payments. In the real world, we would expect such a relationship would hold only approximately:

$$P_i + A_i = \sum_{j=1}^{n_i} c_{ij} \times \delta\big(m_{ij}\big) + \varepsilon_i = \sum_{j=1}^{n_i} c_{ij} \times exp\left(-\int_0^{m_{ij}} f(s)ds\right) + \varepsilon_i$$

where P_i is the clean price of bond *i*, A_i is the accrued interest, c_{ij} is the *j*-th (principal or interest) cash flow of bond *i*, n_i is the number of cash flows, and m_{ij} is the time to cash flow *j* of bond *i*, ε_i is the error term.

Given a set of bond prices and their principal and interest payments it is possible therefore to estimate the underlying interest rate curve. Basis spline model used by Thomson Reuters approximates the instantaneous forward rate curve by a linear combination of basis splines φ_k (or, B-splines):

$$f(t) = \sum_k \beta_k \varphi_k(t)$$

$\varphi_k(t)$ are piecewise cubic polynomial functions defined on a set of 'node points'. At each node they are restricted to be twice continuously differentiable. The node points are chosen from the maturities of the input bonds and evenly distributed between them.[86]

TR uses 'smoothing splines' approach to control the estimated forward rate curve from oscillating by imposing a roughness penalty in the objective function, that is, the coefficients β_k are chosen to minimise the following objective function:

$$\sum_i \left(P_i - \widehat{P_i}(\beta)\right)^2 + \int_0^T \lambda(t)\,[f''(t)]^2 dt$$

where $\widehat{P_i}(\beta)$ is the price of bond *i* estimated using the cubic B-spline model with coefficients β and $\lambda(t)$ is a time-varying roughness penalty function. The functional form of the roughness penalty follows the paper of Anderson and Sleath and was derived for estimating the UK real and nominal yield curves:[87]

$$\log \lambda(m) = L - (L - S)exp(-m/\mu)$$

where *L*, *S*, and μ are constants estimated using the UK data.

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86 The default choice for the number of nodes is *N*/3+2, where *N* is the number of distinct maturities. Thomson Reuters caps the number of nodes at 20.

87 Nicole Anderson, John Sleath, *New estimates of the UK real and nominal yield curves*, Bank of England Working Paper Series, 2001, p.16.

Anderson and Sleath found that their model outperformed the competing methods with respect to smoothness, flexibility and stability criteria they developed for the estimated yield curve.[88]

Overall, the TR curve fitting method is well-documented and based on academic research and is employed by market practitioners (central banks in particular[89]). One possible criticism relates to the fact that the roughness penalty function is calibrated using the UK data and, as such, the optimal parameters for Australia might differ. However, to quantify the difference, we would need to replicate the analysis performed by Anderson and Sleath, and this exercise is outside the scope of this note.

An implication of the curve-fitting approach taken by Thomson Reuters is that it only continues up to the tenor of the last node used to fit the model. That is, if the longest tenor in the credit curve bond sample is, for example, seven years, then the credit curve will only be available up to seven years; if the longest bond tenor is between seven and eight years, then the credit curve will only be extended to eight years. In the context of the AER regulatory decisions, this implies that if the AER were to use a TR credit curve, it would need to develop an extrapolation approach to obtain a ten year yield. Such a limitation is not however exclusive to the TR credit curves: in fact, in the past the AER had to develop extrapolation approaches to be used with the RBA and Bloomberg BVAL series.

[88] Nicole Anderson, John Sleath, *New estimates of the UK real and nominal yield curves*, Bank of England Working Paper Series, 2001, p.10.

[89] Bank for International Settlements, *Zero-coupon yield curve estimated by central banks: technical documentation*, BIS Papers No 25, October 2005.